IT2024

XVIII međunarodna konferencija
INFORMACIONE TEHNOLOGIJE
Sadašnjost i budućnost

Urednik: Prof. dr Božo Krstajić

IT'24

INFORMACIONE TEHNOLOGIJE

- SADAŠNJOST I BUDUĆNOST –

Urednik
Božo Krstajić

Zbornik radova sa XXVIII međunarodne konferencije
INFORMACIONE TEHNOLOGIJE - sadašnjost i budućnost
održane na Žabljaku od 21. do 24. februara 2024. godine

Zbornik radova
INFORMACIONE TEHNOLOGIJE – sadašnjost i budućnost 2024

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CIP - Katalogizacija u publikaciji
Nacionalna biblioteka Crne Gore, Cetinje
ISBN 978-9940-8707-4-4
COBISS.CG-ID 28964100

Podgorica 2024.

Organizator

IT društvo, Crna Gora

Skup podržali

The Institute of Electrical and Electronics Engineers – IEEE
Elektrotehnički fakultet, Univerzitet Crne Gore
Fakultet za informacione sisteme i tehnologije, Univerzitet Donja Gorica
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P R E D G O V O R

Dragi učesnici i čitaoci,

Pred vama je zbornik prezentovanih radova na XXVIII naučno-stručnoj konferenciji „INFORMACIONE TEHNOLOGIJE – sadašnjost i budućnost 2024“. Programski odbor je tokom procesa anonimne međunarodne recenzije radova odabrao 68, od kojih su pred vama 16 kompletnih i 52 sažetka radova koji su dostupni u IEEE Xplore bazi. U zborniku su i sažeci 2 predavanja po pozivu. Učešće u konferenciji su imali autori iz 20 zemalja i to: Crne Gore, Srbije, Bosne i Hercegovine, Hrvatske, Slovenije, Mađarske, Rumunije, Grčke, Kipra, Italije, Španije, Slovačke, Ukrajine, Estonije, Ujedinjenog Kraljevstva, Turske, Egipta, Jordana, Indonezije i Filipina. Programski odbor se zahvaljuje autorima koji kvalitetom svojih radova doprinose kvalitetu i ugledu same konferencije prezentujući originalna dostignuća svojih istraživanja. Procenat radova koji su prihvaćeni za prezentovanje je bio 66 %. Opšti utisak je da se kvalitet radova poboljšava iz godine u godinu, a teme su veoma aktuelne i raznovrsne.

Ova konferencija je, po mnogo čemu, imala svoje osobitosti i opet okupila pasionirane poklonike i nove učesnike, uz veliki broj online učesnika. Čudno je bilo bez snijega u gradu, iako ga je obilovao Durmitor kojeg su učesnici posjetili i popeli se na Savinu vodu provog dana konferencije. Obzirom da nije bilo skijanja, radni dio konferencije je prevazižao raniju ustaljenu praksu pa su učesnici imali više od 36 časova raznih programskih sadržaja u 3 dana. No, ostalo nam je i dosta prostora za druženje i degustacije lokalnih specijaliteta u prijatnoj atmosferi i toplom dočeku provjerenih i novih ugostiteljskih objekata i turističkih radnika. Možemo reći da su durmitorci prihvatili ovu konferenciju kao jedan mali dio svoje društvene baštine i kao jednog od najboljih promotera Durmitora širom svijeta. Sinegija prirode, nauke i dobre volje među ljudima je okrijepila sve nas učesnike i nadahnula nas za nove životne i naučne izazove u očekivanju sledećih druženja i zajedničkog rada.

Sve detalje o ovom, prošlim i narednim skupovima možete naći na zvaničnoj web stranici konferencije www.it.ac.me.

Prof. dr Božo Krstajić

SADRŽAJ

PREDAVANJA PO POZIVU

Korišćenje naprednih statističkih metoda u oblasti informacionih tehnologija

Marina P. Ignjatović, Univerzitet u Beogradu, Fakultet organizacionih nauka, Srbija

U oblasti informacionih tehnologija (IT), koja se brzo razvija, primena naprednih statističkih tehnika i algoritama mašinskog učenja postala je ključna u pokretanju inovacija i optimizaciji procesa. Ovo predavanje će prikazati kako se algoritmi mašinskog učenja mogu primeniti na IT podatke, unapređujući rešavanje problema i donošenje odluka u ovom sektoru. Biće istraženo korišćenje ovih algoritama za prediktivnu analitiku i povećanje efikasnosti IT sistema. Značajan deo diskusije biće posvećen inovativnoj metodologiji kompozitnih indikatora, uz primenu na Indeks razvoja IKT (ICT Development Index - IDI). Biće predložen inovativni pristup formulisanju ovog indikatora korišćenjem napredne statističke metode Kompozitnog indikatora zasnovanog na Ivanovićevom odstojanju (Composite I-distance Indicator - CIDI) za procenu i praćenje napretka razvoja IKT u različitim regionima. Ovo će uključiti analizu komponenti IDI, pristupa, upotrebe i veština, i načina na koji su integrisani da bi se pružila sveobuhvatna slika razvoja IKT. Predavanje će se ukratko pozabaviti sve većom ulogom veštačke inteligencije (AI) u analizi podataka, pokrivajući njen transformativni potencijal u tumačenju složenih skupova podataka, identifikaciji obrazaca i predviđanju. Diskusija će uključiti praktične primere AI aplikacija u obradi podataka, pokazujući kako se AI može iskoristiti za donošenje vrednih zaključaka iz podataka. Predavanje će istaći izazove korišćenja mašinskog učenja i veštačke inteligencije u IT. Cilj je da se pruži sveobuhvatan pregled primene ovih naprednih statističkih tehnika.

Leveraging Advanced Statistical Techniques in the Field of Information Technologies

Marina P. Ignjatović, University of Belgrade, Faculty of Organizational Sciences

In the rapidly evolving Information Technologies (IT) field, applying advanced statistical techniques and machine learning algorithms has become pivotal in driving innovation and optimizing processes. This lecture presents how machine learning algorithms can be applied to IT data, revolutionizing problem-solving and decision-making in this sector. Utilizing these algorithms for predictive analytics and enhancing the efficiency of IT systems will be explored. A significant part of the discussion will be dedicated to the innovative methodology of composite indicators, with the application to the ICT Development Index (IDI). An innovative approach will be proposed to formulating this indicator using advanced statistical method of Composite I-distance Indicator (CIDI) to evaluate and track the progress of ICT development across different regions. This will include an analysis of components of the IDI, the access, use, and skills, and how they are integrated to provide a comprehensive picture of ICT development. The lecture will briefly address the expanding role of Artificial Intelligence (AI) in data analysis, covering the transformative potential of AI in interpreting complex datasets, identifying patterns, and making predictions. The discussion will include practical examples of AI applications in data processing, demonstrating how AI can be leveraged to extract valuable insights from data. The lecture will highlight the challenges of using machine learning and AI in IT. The aim is to provide a comprehensive overview of applying these advanced statistical techniques.

Primena standarda kvaliteta u softverskom inženjerstvu

Miloš Milić, Univerzitet u Beogradu, Fakultet organizacionih nauka, Srbija

U oblasti softverskog inženjerstva mogu se primeniti različiti modeli, strategije i metode razvoja softvera koji su usmereni ka razvoju softverskih sistema. Ovi softverski sistemi se mogu razlikovati prema nameni, oblasti u kojoj se koriste, domenu problema koji rešavaju itd. Takođe, pored funkcionalnih zahteva softverski sistemi trebaju da zadovolje različite nefunkcionalne zahteve. Imajući u vidu da je razvoj softvera složen proces kojim je potrebno upravljati na odgovarajući način, u ovom predavanju će biti razmatrana primena standarda kvaliteta u softverskom inženjerstvu. Polazeći od kvaliteta kao vanvremenskog koncepta, kroz predavanje će biti razmatrani opšti standardi kvaliteta koji se mogu primeniti u softverskoj organizaciji. Značajan deo diskusije biće usmeren ka standardima kvaliteta softvera koji definišu modele i atribute kvaliteta, kao i softverske metrike koje se koriste za operativno merenje kvaliteta. Kroz izlaganje će biti razmotrena veza atributa kvaliteta i softverske arhitekture koja predstavlja važan artifakt u procesu razvoja softvera. U tom kontekstu će biti prikazan model koji omogućava optimizaciju softverske arhitekture. Cilj predavanja je da ukaže na značaj kvaliteta softvera, istakne ključne standarde i prikaže primenu u procesu izbora softverske arhitekture.

Application of Quality Standards in Software Engineering

Miloš Milić, University of Belgrade, Faculty of Organizational Sciences

In the field of Software Engineering, different models, strategies and methods of software development can be applied, which are aimed at developing software systems. These software systems can differ according to their purpose, the area in which they are used, the domain of the problem they solve, etc. Furthermore, in addition to functional requirements, software systems should satisfy various non-functional requirements. Taking into account that software development is a complex process that needs to be managed appropriately, this lecture will discuss the application of quality standards in software engineering. Starting from quality as a timeless concept, the lecture will discuss general quality standards that can be applied in a software organization. A significant part of the discussion will focus on software quality standards that define quality models and attributes, as well as software metrics used to operationally measure quality. The presentation will discuss the relationship between quality attributes and software architecture, which is an important artifact in the software development process. In this context, a model that enables the optimization of the software architecture will be presented. The aim of the lecture is to present the importance of software quality, highlight key standards and introduce application in the process of software architecture selection.

AUTORSKI RADOVI

Koeficijent iznesenog potencijala iz postrojenja

Milica Đukić

***Sadržaj*—U radu je prikazan postupak izračunavanja koeficijenta iznesenog potencijala iz postrojenja. Obrađen je slučaj transformatorske stanice visoki/srednji napon. Na strani visokog napona nalazi se nadzemni vod, dok je na srednjenaponskoj strani kablovski vod sa neprovodnim spoljnim omotačem. Proračun je sproveden za slučaj oba pomenuta voda. U radu su dati teorijski osvrti na uzrok pojave iznesenog potencijala, rizike i opasnosti koje donosi i načine njegovog smanjenja. U prilogu je MATLAB program sa grafičkim interfejsom, koji implementira proračun koeficijenta iznesenog potencijala.**

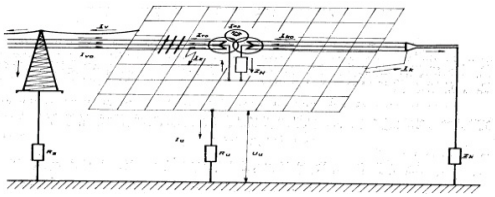
I. Uvod

Izneseni potencijal predstavlja potencijal uzemljivačkog sistema postrojenja koji se provodnim putevima (metalnim omotačem kabla, zaštitnim užetom, telekomunikacionim vodovima, željezničkom infrastrukturom, niskonaponskim neutralnim provodnicima i sl.) prenosi u područje malog ili nikakvog potencijala prema referentnoj zemlji [1]. Kvarovi koji izazivaju napon na uzemljivaču su jednopolni ili dvopolni kratki spoj sa zemljom. Da li će doći do iznošenja opasnog potencijala, za vrijeme nastanka kvara, zavisi od inteziteta dijela struje kvara koji se zatvara kroz zemlju. Ova pojava je opasna zato što može da dovede do rizično visokih vrijednosti napona dodira i koraka u susjednim postrojenjima, koja su električno povezana sa postrojenjem u kom se kvar dogodio.

U ovom radu primijenjene su neuprošćene krajnje relacije, sa mogućnošću variranja određenih parametara od strane korisnika u MATLAB programu.

II. Opis postrojenja

Za potrebe izračunavanja koeficijenta iznesenog potencijala (*ki*), koristiće se primjer transformatorske stanice visoki/ srednji napon. Na sl. 1 prikazan je slučaj postrojenja sa jednim vazdušnim vodom na visokonaponskoj strani i jednim kablovskim vodom na srednjenaponskoj strani. Proračun je izveden pod pretpostavkom da napajanje dolazi, isključivo, sa visokonaponske strane.



Slika 1. Transformatorsko postrojenje visoki/srednji napon [2]

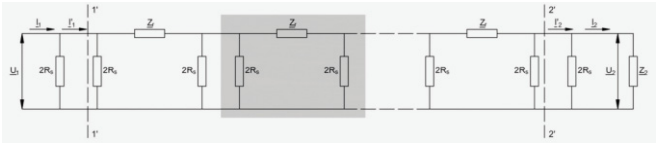
III. Proračun koeficijenta iznesenog potencijala

A. Nadzemni vod

U cilju određivanja koeficijenta iznesenog potencijala vazdušnog voda razmatra se njegovo zaštitno uže, sa sl. 2, koje predstavlja provodni put za iznošenje potencijala sa uzemljenja postrojenja 1. Pri struji kvara koja protiče kroz uzemljenje postrojenja 1, dolazi do pojave napona na uzemljivaču. Za njega je vezano zaštitno uže, te i ono dolazi pod isti napon u odnosu na zemlju. Usled tog napona $\underline{U_1}$, zaštitnim užetom protiče struja $\underline{I_1}$ prema postrojenju 2. Odnos napona $\underline{U_1}$ i struje $\underline{I_1}$ predstavlja impedansu uzemljenja zaštitnog voda $\underline{Z_v}$. Usled otočnih gubitaka, u postrojenje 2 dolazi struja $\underline{I_2}$. Usled rednih gubitaka, dešavaju se padovi napona i kao posledica toga, impedansa $\underline{Z_2}$ uzemljivača postrojenja 2 dolazi pod napon $\underline{U_2}$.

Slika 2. Zaštitno uže nadzemnog voda [3]

Na sl. 3 je zamjenska šema zaštitnog užeta. $\underline{Z_r}$ predstavlja impedansu užeta na jednom rasponu, dok je $\underline{R_s}$ impedansa uzemljenja stubova, koje povezuje zaštitno uže. Svaki raspon prikazan je šemom sa koncentrisanim parametrima, i to π šemom. U modelu je zanemarena otpornost tla između uzemljivača stubova, s obzirom na to da je mnogo manja od $\underline{R_s}$. Ona se može, zarad dodatne preciznosti, uzeti u obzir povećanjem aktivnog dijela impedanse $\underline{Z_r}$ ili otpornosti $\underline{R_s}$.



Slika 3. Zamjenska šema zaštitnog užeta nadzemnog voda [3]

Impedansa $\underline{Z_r}$ se može izraziti na sledeći način:

$$\underline{Z_r} = \underline{Z_{r1}} \cdot d_1 \qquad (1)$$

gdje je d_1 dužina jednog raspona, a $\underline{Z_{r1}}$ podužna impedansa zaštitnog provodnika za konturu koju on obrazuje sa tlom. Podužna impedansa ima svoj otporni i reaktantni dio:

$$\underline{Z_{r1}} = R_1 + j \cdot X_1 \qquad (2)$$

Podužna otpornost za provodnike okruglog poprečnog

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presjeka (koji je korišćen u proračunu) se računa na sledeći način:

$$R_1 = \rho_u \cdot \frac{10^3}{q_u} \left[\frac{\Omega}{km}\right] \quad (3)$$

gdje je ρ_u specifična električna otpornost provodnog dijela užeta u $\Omega mm^2/m$, a q_u predstavlja površinu provodnog dijela presjeka užeta u mm^2. Podužna reaktansa zaštitnog užeta se dobija iz sledeće relacije:

$$X_1 = \omega \cdot \left(\frac{\mu_1}{8\pi} + \frac{\mu_2}{2\pi} \cdot ln\frac{D_e}{r_u}\right) \left[\frac{\Omega}{km}\right] \quad (4)$$

gdje je $\omega(ugaona\ učestanost) = 2\pi f$, $\frac{\mu_1}{8\pi}$ sopstvena induktivnost provodnika od magnetnog fluksa unutar provodnika po jedinici dužine, član $\frac{\mu_2}{2\pi} \cdot ln\frac{D_e}{r_u}$ predstavlja induktivnost konture provodnik – zemlja po jedinici dužine. U drugom članu je D_e ekvivalentno rastojanje do povratnog toka struje u tlu, a r_u je spoljašnji poluprečnik užeta. S obzirom na to da se kontura uže – zemlja nalazi u vazduhu, važi da je $\mu_2 = \mu_0$, gdje je μ_0 magnetna permeabilnost vazduha. Prema tome, izraz (4) se može pisati kao:

$$X_1 = 2\pi f \cdot \frac{\mu_0}{2\pi} \cdot \left(\frac{\mu_r}{4} + ln\frac{D_e}{r_u}\right) \quad (5)$$

$$X_1 = 0.016 \cdot \mu_r + f \cdot \mu_0 \cdot ln\frac{D_e}{r_u} \quad (6)$$

$$X_1 = 0.016 \cdot \mu_r + f \cdot \mu_0 \cdot \frac{log_{10}\frac{D_e}{r_u}}{log_{10}e} \quad (7)$$

$$X_1 = 0.016 \cdot \mu_r + 0.1447 \cdot log_{10}\frac{D_e}{r_u} \quad (8)$$

gdje je μ_r relativna magnetna permeabilnost provodnog dijela zaštitnog užeta. Sa sl. 3 se vidi da se zaštitno uže sastoji iz više raspona, od kojih je svaki predstavljen zamjenskom π šemom, odnosno π četvoropolom. Ukupan broj raspona nadzemnog voda, time i zaštitnog užeta, označen je sa n. Jednačine telegrafičara, odnosno prenosne jednačine voda, omogućavaju određivanje struja i napona na početku, odnosno kraju voda (u zavisnosti od poznatih promjenljivih). One su date sledećim dvijema relacijama:

$$\underline{U_1} = \underline{U_2} \cdot ch(n \cdot \underline{g}) + \underline{I_2'} \cdot \underline{Z} \cdot sh(n \cdot \underline{g}) \quad (9)$$

$$\underline{I_1'} = \frac{\underline{U_2}}{\underline{Z}} \cdot sh(n \cdot \underline{g}) + \underline{I_2'} \cdot ch(n \cdot \underline{g}) \quad (10)$$

gdje je $\underline{I_1'}$ ulazna struja prvog četvoropola, a $\underline{I_2'}$ izlazna struja n-tog četvoropola (to se može vidjeti na slici 3). Parametar $\underline{g}$ i impedansa $\underline{Z}$ se izračunavaju iz sledeće dvije relacije:

$$\underline{g} = ln\left(\underline{A_{11}} + \sqrt{\underline{A_{11}^2} - 1}\right) \quad (11)$$

$$\underline{Z} = \frac{\underline{A_{12}}}{\sqrt{\underline{A_{11}^2} - 1}} \quad (12)$$

$\underline{A_{11}}$ i $\underline{A_{12}}$ predstavljaju konstante četvoropola i računaju se na sledeći način:

$$\underline{A_{11}} = 1 + \frac{\underline{Z_r}}{2 \cdot R_s} \quad (13)$$

$$\underline{A_{12}} = \underline{Z_r} \quad (14)$$

Na osnovu zamjenske šeme, koja se nalazi na sl. 3, slijedi:

$$\underline{I_2'} = \frac{\underline{U_2}}{\underline{Z_2'}} \quad (15)$$

$$\underline{Z_2'} = \frac{2R_s \cdot \underline{Z_2}}{2R_s + \underline{Z_2}} \quad (16)$$

Zamjenom relacije (15) u relaciju (9) dobijamo:

$$\underline{U_1} = \underline{U_2} \cdot ch(n \cdot \underline{g}) + \frac{\underline{U_2}}{\underline{Z_2'}} \cdot \underline{Z} \cdot sh(n \cdot \underline{g}) \quad (17)$$

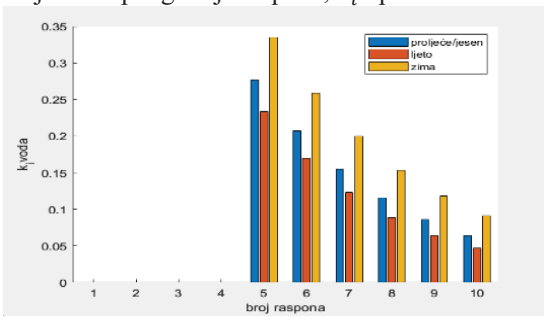
$$\underline{U_1} = \underline{U_2} \cdot \left(ch(n \cdot \underline{g}) + \frac{\underline{Z}}{\underline{Z_2'}} \cdot sh(n \cdot \underline{g})\right) \quad (18)$$

Kako je koeficijent iznesenog potencijala odnos napona U_2 i U_1, iz relacije (18) slijedi:

$$k_i = \left|ch(n \cdot \underline{g}) + \frac{\underline{Z}}{\underline{Z_2'}} \cdot sh(n \cdot \underline{g})\right|^{-1} \quad (19)$$

[2], [3].

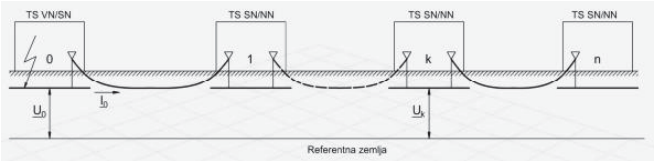
Na sl. 4 se uočava da k_i, za pet raspona i optimalne temperature, dostiže vrijednost 0.277 (ljeti 0.233 jer se dužina užeta povećava, a zimi 0.334 jer se dužina smanjuje). Sa povećanjem ukupnog broja raspona, k_i opada.



Slika 4. Poređenje k_i za slučaj ljetnjeg, zimskog i proljećno/jesenjeg perioda, u zavisnosti od broja raspona

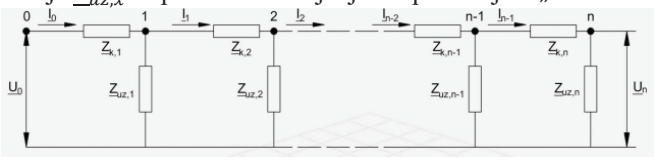
B. Kabl sa neprovodnim omotačem

U distributivnim mrežama, kablovi imaju značajan uticaj na karakteristike uzemljivača sistema. Oni povezuju susjedna postrojenja i povezani su sa njihovim uzemljivačima. Kablovi mogu biti sa izolovanim metalnim plaštom, odnosno sa neizolovanim metalnim plaštom (kada su sastvni dio uzemljenja). Mogu imati provodni ili neprovodni spoljni omotač. Danas se u praksi najčešće koriste kablovski vodovi sa neprovodnim spoljnim omotačem. Takav kabl je i razmatran u ovom proračunu. Na sl. 5 je dat prikaz jedne napojne i više distributivnih transformatorskih stanica (čiji broj je označen sa n). Prva u nizu ima transformator koji visoki napon svodi na srednji, a ostale srednji napon na niski. One su međusobno povezane kablovskim vodom sa neprovodnim omotačem. U slučaju zemljospoja u napojnoj transformatorskoj stanici, uzemljivač tog postrojenja dolazi pod napon $\underline{U_0}$ u odnosu na referentnu zemlju. Zbog toga će preko spoljnjeg omotača kabla proteći električna struja $\underline{I_0}$. Ona će prouzrokovati pojavu napona na uzemljivačima susjednih postrojenja. Najveći izneseni potencijal pojaviće se na prvoj susjednoj transformatorskoj stanici i opadaće duž kabla, udaljavajući se od mjesta kvara, zavisno od dužine dionica i otpora uzemljivača ostalih postrojenja.



Slika 5. TS povezane kablovima sa neprovodnim omotačem [3]

Na sl. 6 nalazi se zamjenska električna šema kojom se modeluju transforamtorske stanice (TS) i kabl sa sl. 5. Ova zamjenska šema je napravljena za potrebe računanja veličina pomoću kojih se određuje koeficijent iznesenog potencijala. $\underline{Z}_{k,x}$ predstavlja impedansu kabla između TS „$x-1$" i TS „x", dok je $\underline{Z}_{uz,x}$ impedansa uzemljenja TS pod brojem „x".



Slika 6. Zamjenska šema transformatorskih stanica i kabla za potrebe proračuna koeficijenta iznesenog potencijala [3]

Usvajaju se dvije pretpostavke koje ne unose značajnu grešku, a olakšavaju proračun:

$$\underline{Z}_{k,1} = \underline{Z}_{k,2} = \cdots = \underline{Z}_{k,n} = \underline{Z}_k \tag{20}$$

$$\underline{Z}_{uz,1} = \underline{Z}_{uz,2} = \cdots = \underline{Z}_{uz,n} = \underline{Z}_{uz} \tag{21}$$

Prva pretpostavka je opravdana jer su kablovi iste dužine ili se, ukoliko to nije slučaj, uzima srednja vrijednost njihovih dužina. S obzirom na to da se koriste isti tipovi kablova, slijedi da i njihove impedanse mogu da se izjednače. Druga pretpostavka je opravdana jer su tipovi uzemljivača TS isti, a specifična otpornost tla kod TS je približno ista. Redna impedansa kabla se predstavlja:

$$\underline{Z}_k = (r + j \cdot x) \cdot d \tag{22}$$

gdje je d dužina dionice kabla, r je podužna redna otpornost kabla, dok je x podužna redna reaktansa kabla. r i x se izračunavaju na sledeći način:

$$r = R_{pa,1} + r_a \tag{23}$$

gdje je $R_{pa,1}$ podužna ekvivalentna otpornost plašta (i armature ukoliko postoji), dok je r_a podužna vrijednost čisto aktivnog dijela magnetnog uticaja armature kabla (ukoliko ona postoji). Preko plašta energetskog kabla može, ali ne mora, da se nalazi armatura. Ona se sastoji iz pljosnatih, najčešće čeličnih, traka – spiralno uvijenih oko kabla. U praksi se često koriste dvije trake, namotavajući jednu preko druge. $R_{pa,1}$ se izračunava na sledeći način:

$$R_{pa,1} = \frac{R_{pa}}{d} = \left(\frac{1}{R_p} + \frac{1}{R_a}\right)^{-1} \tag{24}$$

gdje je R_p ukupna otpornost plašta kabla, a R_a ukupna otpornost armature kabla. Ovdje je data relacija pogodna za izračunavanje R_p okruglog poprečnog presjeka provodnika:

$$R_p = \rho_u \cdot \frac{10^3}{q_u} \cdot d\ [\Omega] \tag{25}$$

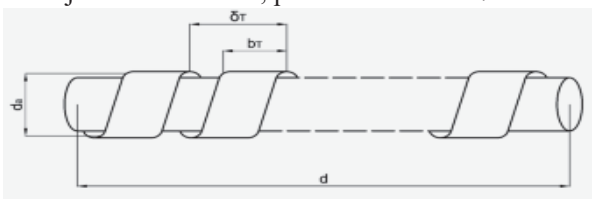
ρ_u i q_u su definisane odmah ispod relacije (3) u kojoj konfigurišu (s tom razlikom da se ovdje odnose na kabl, a ne na zaštitno uže), dok je d definisano ispod relacije (22). R_a se računa po sledećoj relaciji:

$$R_a = \rho_T \cdot \frac{l_T}{q_T} \tag{26}$$

$$l_T = \pi \cdot d_a \cdot \frac{d}{\delta_T} \tag{27}$$

$$q_T = n \cdot b_T \cdot d_T \tag{28}$$

gdje je l_T – dužina trake za armaturu (za čije se računanje koristi: d_a – srednji prečnik zavojnice koju obrazuju trake, δ_T – korak uvijanja trake i prethodno definisano d), q_T – ukupni presjek trake (za čije se računanje koristi: b_T – širina trake, d_T – debljina trake i n – broj traka) i ρ_T specifična otpornost materijala od kog je napravljena traka (najčešće čelik). Opisane veličine iz relacija (26) – (28), koje su karakteristike geometrije armaturne trake, prikazane su na sl. 7.



Slika 7. Prikaz jedne trake zaštitne armature energetskog kabla [3]

r_a iz relacije (23), se računa na sledeći način:

$$r_a = \mu_a'' \cdot \frac{\omega}{\pi \cdot d_a} \cdot n \cdot b_T \cdot d_T \tag{29}$$

gdje je μ_a'' komponenta kompleksne magnetne permeabilnosti materijala armature (koja obuhvata magnetne gubitke usled histerezisa i vrtložnih struja), dok su ostale veličine prethodno definisane.

x iz relacije (22), se računa na sledeći način:

$$x = X_{k,1} + x_a \tag{30}$$

gdje je $X_{k,1}$ podužna induktivna otpornost plašta, a x_a podužna vrijednost reaktivnog dijela magnetnog uticaja armature kabla (ukoliko ona postoji). $X_{k,1}$ se računa na sledeći način:

$$X_{k,1} = \frac{X_k}{d} \tag{31}$$

$$X_k = 0.1447 \cdot log_{10}\frac{D_e}{r_k} \tag{32}$$

gdje je D_e ekvivalentno rastojanje do povratnog toka struje u tlu i računa se na sledeći način:

$$D_e = 658 \cdot \sqrt{\frac{\rho}{f}} \tag{33}$$

pri čemu je ρ srednja specifična otpornost tla, f frekvencija, a r_k je poluprečnik plašta. x_a se računa po sledećoj relaciji:

$$x_a = \mu_a' \cdot \frac{\omega}{\pi \cdot d_a} \cdot n \cdot b_T \cdot d_T \tag{34}$$

gdje je μ_a' komponenta kompleksne magnetne permeabilnosti materijala armature koja odražava induktivnost armature, dok su ostale veličine prethodno definisane. Sada se može odrediti redna impedansa kabla $\underline{Z}_k$. Sa sl. 6 se uočava da se kabl sastoji iz n četvoropola prikazanih „⍰" šemom. Veličine na početku i kraju kabla su obilježene indeksima „0" i „n", respektivno. Shodno jednačinama telegrafičara, datih relacijama (9) i (10), važi:

$$\underline{U}_0 = \underline{U}_n \cdot ch(n \cdot \underline{g}) + \underline{I}_n \cdot \underline{Z} \cdot sh(n \cdot \underline{g}) \quad (35)$$

$$\underline{I}_0 = \frac{\underline{U}_n}{\underline{Z}} \cdot sh(n \cdot \underline{g}) + \underline{I}_n \cdot ch(n \cdot \underline{g}) \quad (36)$$

$\underline{A}_{11}$ i $\underline{A}_{12}$ su konstante četvoropola kabla i izračunavaju se na sledeći način:

$$\underline{A}_{11} = 1 + \frac{\underline{Z}_k}{\underline{Z}_{uz}} \quad (37)$$

$$\underline{A}_{12} = \underline{Z}_k \quad (38)$$

Parametar $\underline{g}$ i impedansa $\underline{Z}$ se, uvrštavanjem prethodne dvije relacije u (11) i (12), izračunavaju na sledeći način:

$$\underline{g} = ln\left[1 + \frac{\underline{Z}_k}{\underline{Z}_{uz}} + \sqrt{2 \cdot \frac{\underline{Z}_k}{\underline{Z}_{uz}} - \left(\frac{\underline{Z}_k}{\underline{Z}_{uz}}\right)^2}\right] \quad (39)$$

$$\underline{Z} = \frac{\underline{Z}_{uz}}{\sqrt{2 \cdot \frac{\underline{Z}_{uz}}{\underline{Z}_k} + 1}} \quad (40)$$

U ovom slučaju je $\underline{I}_n = 0$. Shodno tome i relaciji (35), koeficijent iznesenog potencijala za „n"-tu TS-u je:

$$k_{i,n} = \frac{U_n}{U_0} = \left|ch(n \cdot \underline{g})\right|^{-1} \quad (41)$$

Koeficijent k_i za k-tu TS-u se dobija kada se iskoriste relacija (35) i relacija (35) - napisana tako da je početak kabla k-ta, a kraj n-ta TS-a. Sve to uz uslov da je $\underline{I}_n = 0$:

$$\underline{U}_0 = \underline{U}_n \cdot ch(n \cdot \underline{g}) \rightarrow \underline{U}_n = \frac{\underline{U}_0}{ch(n \cdot \underline{g})} \quad (42)$$

$$\underline{U}_k = \underline{U}_n \cdot ch((n-k) \cdot \underline{g}) \quad (43)$$

$$k_{i,k} = \frac{U_k}{U_0} = \left|\frac{ch((n-k) \cdot \underline{g})}{ch(n \cdot \underline{g})}\right| \quad (44)$$

[2], [3].

U tabeli 1 se uočava da se k_i smanjuje sa povećanjem dužine dionica (opada po kolonama) i da se smanjuje sa udaljavanjem od napojne TS (opada po vrstama).

TABELA 1.
k_i KABLA ZA SLUČAJ 5 TS I 7 OPCIONIH DUŽINA DIONICA

↓ Br TS / →Smjer porasta dužina svih dionica						
	0.6211	0.5923	0.5677	0.5460	0.5267	0.5092
	0.3929	0.3554	0.3251	0.2999	0.2784	0.2597
	0.2641	0.2252	0.1954	0.1717	0.1525	0.1366
	0.2021	0.1640	0.1356	0.1139	0.0968	0.0831
	0.1845	0.1470	0.1194	0.0984	0.0822	0.0693

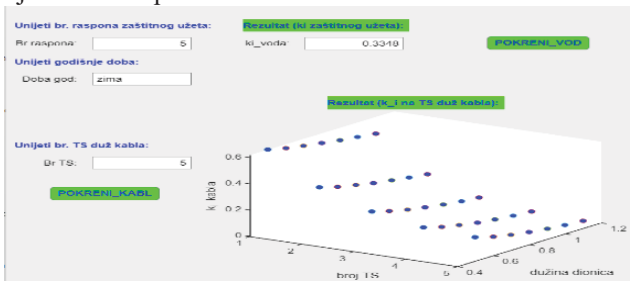
U tabeli 2 se uočava da k_i, na pr, treće TS ima nižu vrijednost kada je veći ukupan broj dionica.

TABELA 2.
k_i KABLA ZA SLUČAJ 8 TS I 7 OPCIONIH DUŽINA DIONICA

↓ Br TS / →Smjer porasta dužina svih dionica						
0.6198	0.5926	0.5686	0.5472	0.5279	0.5103	0.4941
0.3838	0.3509	0.3232	0.2993	0.2786	0.2603	0.2441
0.2376	0.2076	0.1835	0.1636	0.1469	0.1327	0.1205
0.1476	0.1230	0.1042	0.0893	0.0774	0.0676	0.0594
0.0934	0.0738	0.0597	0.0491	0.0409	0.0345	0.0293
0.0627	0.0468	0.0358	0.0281	0.0224	0.0181	0.0148
0.0480	0.0341	0.0249	0.0186	0.0142	0.0110	0.0087
0.0438	0.0305	0.0219	0.0161	0.0121	0.0092	0.0071

IV. REZULTATI MATLAB PROGRAMA

Uz pomoć MATLAB-ovog grafičkog interfejsa se mogu vidjeti rezultati proračuna na sl. 8:



Slika 8. Korisnički interfejs sa rezultatima

Karakteristike zaštitnog užeta i kablovskog voda:

Zaštitno uže: napravljeno od čelika, poprečnog presjeka provodnog dijela 35 mm^2, unutrašnjeg poluprečnika 3.5 mm, dužine raspona 200 m. Otpor rasprostiranja uzemljivača stuba je 10 Ω, srednja specifična otpornost tla je 100 Ωm. Impedansa uzemljenja susjednog postrojenja, gdje se iznosi potencijal, je 6 Ω, uzeta je sa aproksimacijom, da je čisto aktivna veličina.

Kabl iz proračuna je jednožilni XHE 41-A 1*150 mm^2/25 mm^2, sa neprovodnim omotačem. Kabl je sa izolacijom od umreženog polietilena (oznaka X), sa poluprovodnim slojem iznad i spod izolacije (oznaka H), sa plaštom od polietilena (oznaka E), armaturom od dvije čelične trake ispod neprovodnog plašta (oznaka 41), provodnici su aluminijumski (oznaka A), presjek provodnog dijela je 25 mm^2. Srednja specifična otpornost tla je 60 Ωm. Impedansa uzemljenja susjednih TS je 4 Ω.

V. ZAKLJUČAK

Mjere za smanjenje k_i su: snižavanje napona uzemljenja napojne TS, smanjenje vremena trajanja zemljospoja u mreži visokog napona, smanjenje impedanse uzemljenja dodavanjem vertikalnih uzemljivača, smanjenje struje zemljospoja korišćenjem pogodnih konfiguracija mreže, smanjenje redukcionih faktora korišćenjem provodnijih zaštitnih užadi sa minimum pet do šest raspona itd. [1]

ZAHVALNICA

Zahvaljujem se profesoru dr Vladanu Raduloviću na savjetima i sugestijama pri pisanju ovog rada.

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Komparativna analiza nekoliko literaturnih analitičkih metoda za estimaciju parametara jednodiodnog modela fotonaponske ćelije

Sara Vukotić, Martin Ćalasan

***Sadržaj* - U ovom radu izvršeno je poređenje četiri literaturno poznate analitičke metode za estimaciju parametara jednodiodnog modela solarnih ćelija. Izlazne strujno-naponske karakteristike dobijene primjenom analitičkih metoda su upoređene sa mjerenim rezultatima na primjeru RTC France solarne ćelije. Takođe, izvršena je uporedna analiza dobijenih vrijednosti parametara i izvedeni zaključci o tome koja metoda ima najveću preciznost za određivanje vrijednosti nepoznatih parametara solarnih ćelija pojedinačno.**

I. Uvod

Moderno doba praćeno je povećanjem populacije, industrijalizacijom, elektrifikacijom koja je uvedena u sve sfere života, smanjenjem rezervi neobnovljivih izvora energije, brojnim pitanjem održivog razvoja i zaštite životne sredine od šetnih uticaja konvencionalnih izvora energije. Sprječavanje energetske krize, prouzrokovane nabrojanim faktorima, jedan je od najvećih izazova 21 – og vijeka.

Razvojem novih tehnologija dolazi do povećane upotrebe obnovljivih izvora energije, među kojima najveći potencijal ima solarna energija [1]. Povećana potreba za korišćenjem solarne energije dovela je do razvoja novih načina proizvodnje fotonaponskih ćelija, korišćenja različitih poluprovodničkih materijala, sprovođenja analiza performansi i dimenzionisanja, a sve u cilju veće efikasnosti i optimizacije korišćenja solarne energije. Prilikom proizvodnje PV panela sprovode se eksperimenti u specijalizovanim laboratorijama, koji proizvođačima daju podatke poput napona praznog hoda, struje kratkog spoja, napona i struje pri kojima se dobija maksimalna snaga.

Kako bi se pravilno dimenzionisao PV (*engl*. photovoltaic) panel, podaci dobijeni od proizvođača nijesu dovoljni. Zato su razvijena ekvivalentna kola PV sistema, kao i metode na osnovu kojih je moguće izvršiti estimaciju parametara i sagledavanje stanja istih pri različitim uslovima sredine (temperaturi i iradijaciji) [2-3]. Fotonaponska ćelija, kao osnovna jedinica fotonaponskog sistema, može se modelovati uz pomoć jednodiodnog, dvodiodnog i trodiodnog modela. Korišćenjem analitičkih, numeričkih (metaheurističkih i determinističkih) i hibridnih metoda [2] moguće je izvršiti estimaciju parametara koji opisuju stvarne karakteristike fotonaponske ćelije [4-11].

U ovom radu biće prikazane i upoređene četiri literaturno poznate analitičke metode opisane u [4], [6], [7] i [9] za estimaciju parametara jednodiodnog modela fotonaponske ćelije. U tom slučaju posmatraće se dobro poznata RTC France solarna ćelija [11]. Primjenom svake od pomenutih metoda estimiraće se strujno-naponska karakteristika koja će se uporediti sa eksperimentalnom karakteristikom ove ćelije.

Rad je organizovan iz nekoliko poglavlja. U drugom poglavlju predstavljena je ekvivalentna šema jednodiodnog modela ćelije. U trećem poglavlju opisane su četiri različite analitičke metode uz pomoć kojh se vrši estimacija nepoznatih parametara solarnih ćelija. U četvrtom poglavlju sprovedena je uporedna analizu dobijenih rezultata. Na kraju, u zaključku je dat osvrt na cjelokupan rad i smjernice budućih istraživanja.

II. Jednodiodni model fotonaponske ćelije

Jednodiodni model fotonaponske ćelije je najjednostavniji i najpogodniji model za estimaciju parametara analitičkim metodama, koji uprkos jednostavnosti daje dovoljno precizne rezultate. Na Sl. 1 prikazana je ekvivalentna šema jednodiodnog modela fotonaponske ćelije koja se sastoji od strujnog izvora struje I_{pv}, diode koja karakteriše svojstva poluprovodničkog materijala, serijske otpornosti R_s i paralelne otpornosti R_p. Jednačina koja opisuje ekvivalentnu šemu prikazanu na Sl. 1 je:

$$I = I_{pv} - I_0 \left(e^{\frac{R_s I + V}{a V_t}} - 1 \right) - \frac{R_s I + V}{R_p} \qquad (1)$$

gdje je a faktor idealnosti diode, I_0 - inverzna struja zasićenja diode, $Vt = kT/q$ - termički napon, k= 1.3806505 · 10^{-23}J/K Bolcmanova konstanta, q=1.6·10^{-19}C naelektrisanje elektrona i T - temperature sredine.

Jednačina (1) je transcedentna nelinearna jednačina sa pet nepoznatih parametara R_s, R_p, I_0, a i I_{pv}. Postoji veliki broj metoda za estimaciju ovih nepoznatih parametara. Generalno, sve metode se mogu grupisati u dvije kategorije - analitičke i metaheurističke [11]. Analitičke metode, opisane u ovom radu, za proračun parametara koriste isključivo sisteme jednačina.

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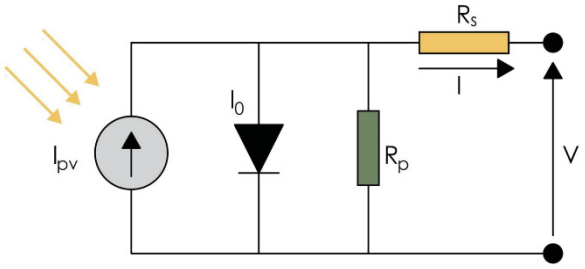


Slika 1. Ekvivalentna šema jednodiodnog modela fotonaponske ćelije

Kako bi se odredili nepoznati parametri, osim (1), potrebno je kreirati dodatan set relacija. Jednačine se obezbjeđuju iz podataka krive zavisnosti struja (I) - napon (V) dobijene iz od strane proizvođača, eksperimentima u specijalizovanim laboratorijama. Ovdje spadaju struja kratkog spoja I_{ks}, napon praznog hoda V_{ph}, struja i napon tačke maksimuma snage I_m, V_m, strujna konstanta k_i, nominalna vrijednost temperature T_n, nominalna vrijednost iradijacija G_n. U nastavku su opisane tri karakteristične tačke:

- Kratak spoj $V = 0$, $I = I_{ks}$

$$I_{ks} = I_{pv} - I_0\left(e^{\frac{R_s I_{ks}}{a\,Vt}} - 1\right) - \frac{R_s I}{R_p} \qquad (2)$$

$R_{p0} = -\,dV/dI_{ks}$ je vrijednost nagiba I – V krive u tački kratkog spoja.

- Prazan hod $V = V_{ph}$, $I=0$

$$0 = I_{pv} - I_0\left(e^{\frac{V_{ph}}{a\,Vt}} - 1\right) - \frac{V_{ph}}{Rp} \qquad (3)$$

$R_{s0} = -\,dV_{ph}/dI$ je vrijednost nagiba krive u tački praznog hoda.

- Tačka maksimalne snage $V=V_m$, $I=I_m$

$$I_m = I_{pv} - I_0\left(e^{\frac{R_s I_m + V_m}{a\,V_t}} - 1\right) - \frac{R_s I_m + V_m}{R_p} \qquad (4)$$

Vrijednost izvoda $d(IV)/dI$ u tački maksimalne snage jednaka je nuli.

Maksimalna snaga se dobija iz relacije

$$P_m = V_m[I_{pv} - I_0\left(e^{\frac{R_s I_m + V_m}{a\,V_t}} - 1\right) - \frac{R_s I_m + V_m}{R_p}] \qquad (5)$$

U zavisnosti od metode koja se koristi za rješavanje problema, (2) – (5) se kombinuju i služe za rješavanje (1). Da bi se u obzir uzele promjene temperature i iradijacije struje I_0 i I_{pv} dalje mogu zapisati u sljedećem obliku:

$$I_{pv} = \left(I_{pv,n} * k_i \Delta T\right) * G/G_n \qquad (6)$$

$$I_0 = I_{0,n}\,(T_n/T)^3\,[e^{\frac{qE_g}{ak}} * (1/T_n - 1/T)] \qquad (7)$$

gdje su: $I_{pv,n}$ i $I_{0,n}$ generisana struja strujnog izvora i inverzna struja zasićenja diode pri nominalnim uslovima sredine (25°C i 1000W/m^2) respektivno, ΔT razlika stvarne temperature T i nominalne temperature T_n u Kelvinima, E_g=1.12eV energija energetske barijere za silikonske poluprovodnike.

III. Analitičke metode za estimaciju parametara

A. Metoda 1 –Villalva [4]

Proračun parametara solarnih ćelija koju je predložio Villalva u [4], a koja je data u nastavku, vrši se iterativnim postupkom baziranim na činjenici da postoji tačno jedan par R_s i R_p koji uvršten u (5) daje maksimalnu snagu jednaku maksimalnoj eksperimentalno određenoj snazi $P_{max,e}$. Postupak za estimaciju parametara je sljedeći:

1. Inicijalna vrijednost struje strujnog izvora jednaka je struji kratkog spoja $I_{pv} = I_{ks}$. Početna vrijednost $R_s = 0$, a $R_p = U_m/(I_{ks}-I_m)-(U_{ph}-U_m)/I_m$.

2. Nominalna vrijednost struje strujnog izvora dobija se korišćenjem relacije:

$$I_{pv,n} = I_{ks} * (R_s + R_p)/R_p \qquad (8)$$

3. Nominalna vrijednost struje I_0 određuje se iz (3), a zatim se njena stvarna vrijednost odredi za tačno zadate vrijednosti temperature i iradijacije iz (6).

4. Vrijednost paralelne otpornosti se dobija iz (4).

5. Koraci 2. – 4. se ponavljaju sve dok razlika između proračunate maksimalne snage P_m i maksimalne eksperimentalno određene snage ne bude zadovoljila uslove konvergencije. Vrijednost R_s se u svakoj novoj iteraciji inkrementira.

Poznato je da se vrijednost faktora idealnosti diode za Si materijale obično kreće u opsegu $1 \leq a \leq 1.5$ [4]. Ovaj podatak daje grubu aproksimaciju za vrijednost parametra a, što predstavlja nedostatak metode.

B. Metoda 2 – Celik [6]

Metoda 2, koju je predlozio Celik u [6], uzima u obzir stvarne vrijednosti temperature T i insolacije G, pa se struja kratkog spoja može proračunati relacijom:

$$I_{ks} = I_{ks,n}\frac{G}{G_n} + k_i(T - T_n) \qquad (8)$$

gdje je $I_{ks,n}$ struja kratkog spoja pri nominalnim uslovima sredine u kojim se vrši laboratorijsko ispitivanje.

Na osnovu eksperimentalno dobijenog grafika, računa se R_{s0} nagib krive u tački praznog hoda (V_{ph},0) i R_{p0} nagib krive u tački kratkog spoja (0, I_{ks}).

Iz (3) se dobija vrijednost struje zasićenja diode, I_0, pod pretpostavkom da je $I_{pv} = I_{ks}$. Dalje se I_{pv} računa iz jednačine kratkog spoja (2), a faktor idealnosti diode a iz (4).

Za paralelnu otpornost koristi se aproksimacija da je $R_p = R_{p0}$, a serijska otpornost se računa korišćenjem relacije:

$$R_s = R_{s,0} - \frac{aV_t}{I_0}\,e^{(-\frac{V_{ph}}{a\,V_t})} \qquad (9)$$

C. Metoda 3 - De Blas [7]

Metoda 3 opisana u [7] koristi iste inicijalne uslove i isti set relacija za proračun I_0, I_{pv} i a kao Metoda 2. Ova metoda je u odnosu na prethodnu unaprijeđen iterativnim postupkom za pronalaženje R_p i R_s.

Iteracija počinje sa pretpostavljenom inicijalnom vrijednošću serijske otpornosti. Paralelna otpornost se računa

kao $R_p = R_{p0} - R_s$, a faktor idealnosti diode relacijom (4) kao u prethodnom poglavlju. Nova vrijednost R_s, dobijena rješavanjem jednačine (10), se računa na sljedeći način

$$R_s = \frac{R_{s0}(V_{ph}/(aV_t)-1)+R_{p0}*(1-\frac{R_{s0}I_{ks}}{aV_t})}{\frac{V_{ph}-I_{ks}*R_p}{aV_t}} \quad (10)$$

Iterativni postupak se nastavlja sve dok vrijednost R_s iz tekuće iteracije ne bude jednaka vrijednosti R_s iz prethodne iteracije.

Na osnovu parametara dobijenih u iterativnom postupku struje I_0 i I_{pv} računaju se iz (3) i (2) respektivno.

D. Metoda 4 - Brano [9]

Metoda opisana u [9] za estimaciju parametara uvodi novu formu jednačine (1) na sljedeći način

$$I(\alpha,T) = \alpha I_{pv}(T) - I_0(\alpha,T)\left(e^{\frac{\alpha*(V+ki(T-T_n)+R_sI)}{\alpha*a*T}} - 1\right) - \frac{\alpha(V+ki(T-T_n)+R_s}{R_p} \quad (11)$$

gdje $\alpha = G/G_n$ predstavlja odnos između stvarne iradijacije G i nominalne iradijacije G_n. Jednačina (11) uzima u obzir stvarne uslove sredine u kojoj se nalazi PV ćelija. Za rješavanje ove metode koristi se set relacija (2)-(4).

Procedura za određivanje parametara prevashodno zahtijeva estimaciju R_{s0} i R_{p0} iz grafika dobijenog eksperimentalno od proizvođača PV ćelije. Algoritam korišćen za estimaciju parametara ovom metodom baziran je na dvostrukom, ugniježdenom, iterativnom procesu i opisan je sljedećim koracima:

1. Inicijalni uslovi: $I_{pv,n} = I_{ks}$, $R_p = R_{p0}$, $R_s = 0$
2. Struja I_0 se dobija iz (4), struja strujnog izvora I_{pv} iz (2), a R_p iz relacije (12) koja predstavlja izvod struje po naponu u tački kratkog spoja:

$$\frac{dI}{dV}\Big|_{(0,I_{ks})} = -\frac{(I_{0,n}/aV_t)e^{I_{ks}R_s/aV_t}+\frac{1}{R_p}}{1+R_s\left((I_{0,n}/aV_t)e^{\frac{I_{ks}R_s}{aV_t}}+\frac{1}{R_p}\right)} = -\frac{1}{R_{p0}} \quad (12)$$

3. Korišćenjem (3) proračuna se faktor idealnosti diode. Vrijednost faktora a iz tekuće iteracije se uporedi sa vrijednošću iz prethodne iteracije.
4. Koraci 2-3 se ponavljaju dok konvergencija ne zadovolji željenu tačnost.
5. Kada je vrijednost parametra a proračunata, zajedno sa I_{pv} i I_0 uvrsti se u relaciju (13) koja predstavlja izvod struje po naponu u tački praznog hoda i izračuna se novo R_s:

$$\frac{dI}{dV}\Big|_{(V_{ph},0)} = -\frac{(I_{0,n}/aV_t)e^{V_{ph}/aV_t}+\frac{1}{R_p}}{1+R_s\left((I_{0,n}/aV_t)e^{\frac{V_{ph}}{aV_t}}+\frac{1}{R_p}\right)} = -\frac{1}{R_{s0}} \quad (13)$$

6. Vrijednost R_s iz tekuće iteracije se uporedi sa vrijednošću ovog parametra iz prethodne iteracije. Ukoliko nije zadovoljen zadati uslov konvergencije koraci 2 – 5 se ponavljaju.

IV. REZULTATI I UPOREDNA ANALIZA ESTIMACIJE PARAMETARA

U Tabeli I prikazani su rezultati estimacije nepoznatih parametara dobijeni primjenom četiri prethodno opisane analitičke metode, kao i rezultati dobijeni primjenom algoritma HISA (*engl*. Hybridized Interior Search Algorithm) [11] na primjeru fotonaponske ćeliji RTC France. Ova metoda, upoređena sa još 68 metoda u [11], dala je vrijednosti sa najmanjim odstupanjem od rezultata mjerenja.

Na osnovu rezultata prikazanih u Tabeli I, jasno je da ni jedna od opisanih analitičkih metoda nije dovoljno precizna za određivanje svih nepoznatih parametara, što je i očekivano zbog primjene određenih aproksimacija. Međutim, svaka od metoda može naći primjenu za određivanje pojedinačnih parametara.

TABELA I
REZULTATI ESTIMACIJE PARAMETARA ANALITIČKIM METODAMA

Parametri	HISA	Metoda 1	Metoda 2	Metoda 3	Metoda 4
a	1.4772	1.3000	1.4195	1.4504	1.5201
I_0 (μA)	0.3106	0.0423	0.1705	0.1529	0.3158
I_{pv} (A)	0.7607	0.7620	0.7603	0.7609	0.7603
R_s (Ω)	0.0365	0.0370	0.0418	0.04190	0.0387
R_p (Ω)	52.8897	17.5895	50.8485	50.8066	28.9292

Poređenjem rezultata iz Tabele I može se zaključiti da najveću preciznost pri određivanju faktora idealnosti diode ima Metoda 3. Metodom 1 unesena je fiksna vrijednost parametra a, dok Metoda 4 daje vrijednost koja je veća od očekivanog opsega $0 \leq a \leq 1.5$. Primjenom Metode 4 dobijena je preciznija vrijednost struje I_0 u odnosu na ostale tri metode. Takođe, može se zaključiti da sve metode daju dovoljno precizne vrijednosti struje strujnog izvora I_{pv}.

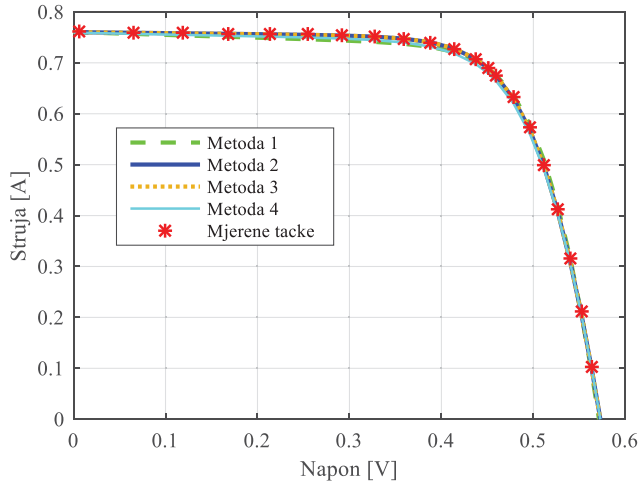
Estimacijom parametara Metodama 1 i 4 dobijene su vrijednosti serijske otpornosti bliske vrijednostima dobijenim primjenom HISA. Međutim, ove metode imaju manju preciznost pri određivanju vrijednosti paralelne otpornosti. Paralelna otpornost je dobro određena primjenom Metoda 2 i 3.

Na Sl. 2 predstavljene su $I - V$ karakteristike dobijene primjenom četiri opisane metode. Ove krive su upoređene sa grafikom dobijenim eksperimentalnim mjerenjima na fotonaponskoj ćeliji RTC France [11]. Sl. 2 prikazuje da najbolje poklapanje sa eksperimentalnom karakteristikom imaju $I - V$ krive dobijene primjenom Metoda 2 i 3.

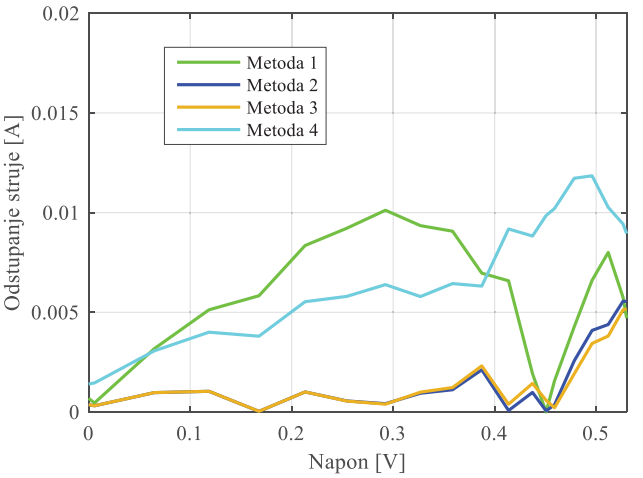
Na Sl. 3 grafički su prikazana odstupanja rezultata strujno naponskih karakteristika analitičkih metoda od eksperimentalnih rezultata. Uočava se da Metode 1 i 4 imaju veća odstupanja u prvom dijelu grafika. Kako parametar R_p utiče na ovaj dio $I - V$ karakteristike, iz Tabele I jasno se može zaključiti da je to glavni razlog odstupanja.

Na Sl. 4 prikazano je grafičko poređenje snaga napon karakteristika. Može se uočiti da Metode 2 i 3 najpreciznije prate tačku maksimuma snage. Ovo se može povezati i sa Sl 3. Naime, prema eksperimentalnim mjerenjima napon tačke maksimalne snage je 0.4057 V. Na Sl 3. može se uočiti da proračunate vrijednosti struja primjenom Metoda 1, 2 i 3, pri pomenutom naponu, nemaju značajnih odstupanja od struja

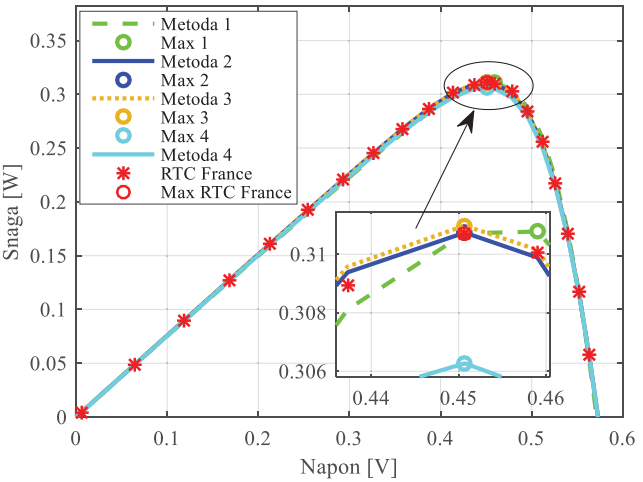
dobijenih eksperimentalno. Primjenom Metode 4. javlja se znatno veće odstupanje



Slika 2. Poređenje struja – napon karakteristika



Slika 3. Grafičko poređenje ostupanja struje primjenom svakog od korišćenih metoda u odnosu na mjerene vrijednosti



Slika 4. Poređenje snaga - napon karakteristika

V. ZAKLJUČAK

U ovom radu izvršeno je poređenje četiri analitičke metode za estimaciju parametara solrnih ćelija. Analizirajući dobijene rezulate može se zaključiti da metode 2 i 3 omogućavaju estimaciju parametara koje daju najbolje poklapanje $I - V$ krivih sa eksperimentalnom krivom. Pokazano je da je prva metoda precizna za praćenje tačke maksimuma snage, dok druga i treća metoda u poređenju sa ostalima daju najpreciznije vrijednosti R_p. Takođe, je prikazano da je druga metoda najpreciznija za određivanje faktora idealnosti diode, dok četvrta i prva daju najpreciznije vrijednosti R_s.

Analitičke metode su veoma moćan alat za estimaciju parametara solarnih ćelija u realnom okruženju i praćenje njihovog ponašanja pod različitim uslovima sredine. Detaljne analize i poređenja podataka dobijenih korišćenjem analitičkih metoda stvaraju podlogu za izradu kombinovanih metoda koje će služiti za još precizniju estimaciju parametara u budućim istraživanjima.

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Pregled savremenih softverskih arhitektura za distribuirana okruženja

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***Sadržaj*—Ovaj rad se bavi istraživanjem i pregledom softverskih arhitektura koje su nastale kao rezultat napredovanja informaciono-komunikacione arhitekture i kompleksnosti sistema koji probijaju granice otkrivanja i zadovoljavanja potreba korisnika u raznim poslovnim domenima. Sagledavaju se karakteristike savremenih softverskih arhitektura: *serverless,* mikroservisna i *cloud-native*. Na osnovu prednosti i mana svake od njih, u radu se donose zaključci koji mogu biti od ključnog značaja prilikom odabira podobne softverske arhitekture. Na taj način se formira temelj sistema koji je sposoban da zadovolji potrebe korisnika sa jedne strane, i da bude lako održiv i proširiv, sa druge strane.**

I. UVOD

U današnje vreme, činjenica koja softverske arhitekte konstantno podseća na značaj adekvatno osmišljene arhitekture jeste da je ona jedan od glavnih faktora za uspešno funkcionisanje celokupnog softverskog rešenja. Pored potrebe da softverski sistem zadovolji potrebe krajnjih korisnika, u kojim god intervalima i intenzitetima one nastajale, sistem mora da bude podoban za lako održavanje, proširivanje i konstantno unapređivanje i kreiranje novih funkcionalnosti koje će kreirati dodatnu vrednost za sve interesne strane. Jednom osmišljena arhitektura zahteva konstantno praćenje i modifikacije u skladu sa promenama potreba, sa napredovanjem tehnologije, kako bi se sprečilo zastarevanje i strukturno propadanje softverskog sistema. [1]

U ovom radu je fokus usmeren na pregled nekoliko softverskih arhitektura savremenog doba koje su nastale kao rezultat potrebe za rešavanjem problema održavanja, proširivanja, skalabilnosti, dostupnosti itd. Pored opisa glavnih karakteristika narednih arhitektura:

- *Serverless* arhitektura,
- Mikroservisna arhitektura i
- *Cloud-native* arhitektura,

rad sagledava njihove prednosti i daje pregled karakeristika softverskih sistema koje bi imale koristi od njihove upotrebe. Takođe, rad se bavi kompleksnošću pitanja: "Koja softverska arhitektura najviše odgovara našem informacionom sistemu?", kao i da li je odgovor na to pitanje uvek jednoobrazan ili ipak treba posmatrati svaki sistem kao nadogradivu i živu stvar, koja ima svoje karakteristike koje ga čine jedinstvenim, i samim tim joj treba na jedinstven način i prići.

II. *SERVERLESS* ARHITEKTURA

Poput svih modernih trendova u svetu informacionih sistema i tehnologija, ne postoji jedna, opšteprihvaćena definicija, već više pokušaja da se pojam opiše. Jedna od definicija naglašava da *serverless* („bez prisustva servera") predstavlja kvalifikator koji označava bilo koji softver ili uslugu koja se koristi kao naplativa usluga koja iziskuje troškove samo kada se koristi. [2] Ova definicija opisuje na jednostavan način ovaj pojam, ali u svojoj biti čuva detaljna objašnjenja koja predstavljaju postojanje servera (nasuprot nazivu arhitekture), ali je njegova konfiguracija i održavanje u potpunosti pod okriljem pružaoca te usluge. Ova činjenica omogućava programerima da sve svoje napore preusmere u razvijanje glavnih funkcionalnosti aplikacije i da ih samim tim razvijaju i isporučuju mnogo agilnije. Deo definicije koji se odnosi na troškove samo u slučaju korišćenja predstavlja da se samo isporučivanje funkcionalnosti na server pružaoca usluge ne naplaćuje, dok se naplaćuje u slučaju njihovog korišćenja, što jasno odvaja *serverless* od ostalih naplativih servisa i usluga koji su postojali pre ove arhitekture.

Serverless arhitektura ima dva pojavna oblika koja će biti opisana u nastavku:

- *BaaS* (*Backend as a Service*) i
- *FaaS* (*Functions as a Service*).

Kada je reč o *BaaS,* on predstavlja prvobitni oblik ove arhitekture i podrazumeva kreiranje aplikacija koje u potpunosti koriste serversku logiku od strane pružaoca usluga. To su aplikacije čiji se razvoj najviše fokusira na klijentski deo („*rich-client"* aplikacije), koje za upravljanje podacima najčešće koriste sisteme za upravljanje bazama podataka koji su dostupni na oblaku (*cloud*), kao što su *Parse* i *Firebase*, a za sisteme za autentifikaciju koriste *AuthO* i *AWS Cognito*. Sa druge strane, *FaaS* predstavlja aplikacije prilikom čijeg razvoja programeri ipak moraju da se bave razvojem serverske logike za svaku od funkcionalnosti. Za razliku od tradicionalne klijent-server arhitekture, ova serverska logika se izvršava na serveru koji je u potpunosti održavan od strane pružaoca usluga, bez stanja je, i njeno izvršavanje može biti jednokratno. Jednokratno izvršavanje predstavlja pozivanje funkcije da obradi zahtev samo onda kada se pojavi potreba za tim, a takođe je moguće i da ceo server bude u potpunosti ugašen i da se u jako kratkom vremenskom roku pokrene, izvrši funkciju koju je programer napisao, nakon čega se opet ugasi. [3]

Po samoj organizaciji procesa, *serverless* arhitektura omogućava programerima da budu znatno produktivniji i

samim tim brže razvijaju i isporučuju funkcionalnosti. Pisanjem manje koda, zbog pokrivenosti dobrog dela ili serverske strane u celosti od strane pružaoca usluga, programeri mogu da preusmere svoj fokus na razvijanje funkcionalnosti na što efikasniji način jer su, zbog prirode njihovog izvršavanja, direktno povezani sa troškovima koji nastaju prema pružaocima. S obzirom da se funkcionalnosti na serverima pokreću i rade samo onda kada za njima postoji potreba, a bivaju naplaćeni resursi samo za njihovo korišćenje, nedovoljno performantno i mudro osmišljene i napisane funkcionalnosti se istog trenutka oslikavaju na veće troškove koji ukazuju na potencijalni problem.

Pored toga što se sva konfiguracija i briga o serverima prepušta pružaocu usluga, *serverless* arhitekturom se i znatno smanjuje kompleksnost programskog koda izbacivanjem onog koda koji se odnosi na orkestraciju svih servera, njihovo rutiranje, itd.

Ovaj tip arhitekture u većini slučajeva izuzetno povoljno utiče na troškove kompanije (70–90% niži troškovi u odnosu na zakupljivanje ili posedovanje celokupnih servera)[1] jer se serveri u većini vremena nalaze u stanju čekanja. Iako se stiče utisak da se ova arhitektura vezuje samo za benefit uštede troškova, ona nije u svim slučajevima povoljnija od tradicionalnih arhitektura, pogotovo ne kada je reč o softverskim sistemima koji konstantno imaju veliku opterećenost zahtevima klijenata, te je potrebno dobro proceniti da li se ova arhitektura uklapa u potrebe i planove kompanije.

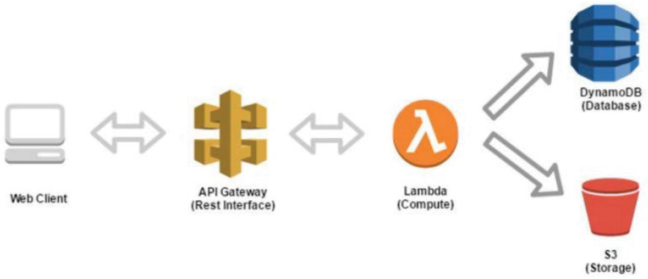
Takođe, u slučaju da se radi o specifičnim potrebama kada je reč o serverima i njihovoj organizaciji, ili je pak zahtev klijenta ograničavajući na potpuno *in-house* rešenje (bez oslanjanja na usluge pružaoca), *serverless* arhitektura nije odgovarajući izbor.

Serverless arhitektura nije pojam koji je prisutan decenijama, a čak ni godinama, stoga je izuzetno teško kompanijama vendorima da pronađu adekvatnu radnu snagu koje je upoznata sa svim konceptima i najčešće im je najprijatnije i najkomfornije da rade u tom okruženju. Takođe, negativna strana kompanijama predstavlja slabiji monitoring funkcija na serveru pružaoca usluga, što umnogome utiče na to da kompanije nemaju celokupnu sliku rada svog softvera.

Ograničenje koje će nekim kompanijama biti neprimetno, a nekim ključno, da ne izaberu ovu arhitekturu jeste skup programskih jezika koji su raspoloživi za korišćenje na serverima najvećih pružaoca usluga: *AWS Lambda* i *Azure Functions*. Korišćeni programski jezici u slučaju pomenutih pružaoca usluga jesu u širokoj upotrebi, a to su u slučaju *AWS*-a su: *Java, JavaScript, Go, Ruby, Python, C#* i *PowerShell*[2], dok *Azure functions* omogućava implementaciju u jezicima:*Java, Javascript, TypeScript, C#, Python, PowerShell, Go, Rust*[3].

[1]https://www.a3logics.com/blog/how-does-serverless-architecture-slash-development-costs
[2]https://aws.amazon.com/lambda/faqs/
[3]https://learn.microsoft.com/en-us/azure/azure-functions/supported-languages?tabs=isolated-process%2Cv4&pivots=programming-language-csharp#languages-by-runtime-version

Primer *serverless* arhitekturu u radu sa *AWS* servisima se može videti na slici 1, gde se uočava komunikacija između programerski napisanih *lambda* funkcija i drugih *AWS* servisa za čuvanje podataka i datoteka.



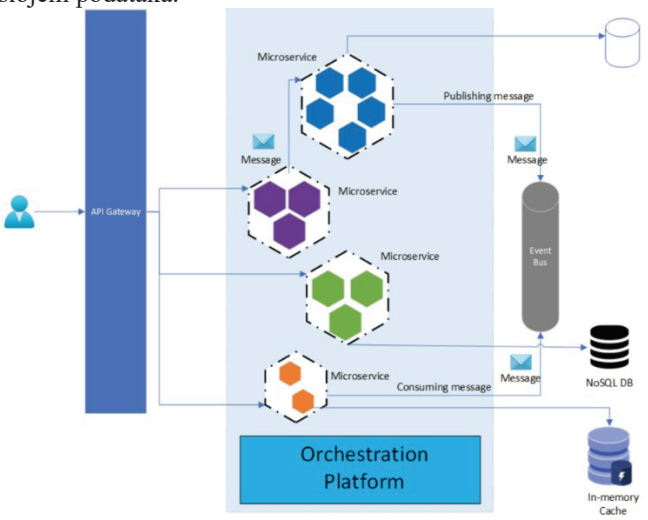
Slika 1. Serverless arhitektura u radu sa *AWS* servisima [4]

Još jedna negativna strana koja se nameće jeste potencijalno preterana zavisnost i uvezanost sa pružaocem usluga, u kontekstu rešenja i podrške, jer se, počevši od samih servera i njihove organizacije, stvaraju potrebe i za drugim uslugama koje se najbolje uklapaju u rešenje, ako se angažuje isti pružalac usluga.[5]

III. Mikroservisna arhitektura

Mikroservisna arhitektura, kao što deo ove složenice nalaže, predstavlja arhitekturu koja se zasniva na mikroservisima i nastala je kao unapređena verzija servisno orjentisane arhitekture (*SOA*). *SOA* je nastala sa idejom deljenja celokupnih sistema na logičke celine, gde jedna celina predstavlja servis za sebe i u potpunosti je autonomna. Mikroservisna arhitektura, sa druge strane, predstavlja skup servisa od kojih svaki obavlja samo jedan zadatak (odatle i prefiks mikro) koji je deo neke poslovne celine.[3]

Uprošćeni prikaz mikroservisne arhitekture se može videti na slici 2, gde srž celog sistema čini skup mikroservisa. Oni između sebe komuniciraju ili direktno ili preko *event-bus*-a i svaki servis ima svoju odgovornost i radi sa odgovarajućem slojem podataka.



Slika 2. Mikroservisna arhitektura [6]

Kada je reč o autonomnosti mikroservisa, ona označava da je svaki mikroservis izložen kao poseban entitet koji je

izolovan nekoj platformi, virtuelnoj mašini ili serveru kod pružaoca usluga. Sva komunikacija između mikroservisa se odvija putem mrežnih poziva, stoga je neophodno da svaki mikroservis ima otvoren i javno dostupan programski interfejs aplikacije (*Application Programing Interface - API*). [7]

Postavlja se pitanje do koje veličine treba smanjivati servise da bi bili u skladu ovom arhitekturom, odnosno, koliko „mikro" jedan servis treba da bude. Tačan odgovor, naravno, ne postoji, ali postoje generalne smernice zagovarača ove arhitekture koje ukazuju na to da je lako prepoznati kada je neki sistem previše kompleksan i zahtevan. Trenutak kada projektant ne uspeva da uoči da je neki servis previše kompleksan je pokazatelj da je najverovatnije zadovoljavajuće veličine. Još jedan pokazatelj da neki servis ipak nije dovoljno mali, jeste ukoliko manji tim programera, 3-7 ljudi, nije dovoljan za njegov razvoj. Sa druge strane, preterano rasparčavanje i usitnjavanje mikroservisa može dovesti do preterane operativne kompleksnosti i međusobne zavisnosti mikroservisa, čime se ugrožavaju osnovne prednosti ove arhitekture, a koji će biti navedeni u nastavku. [8]

Karakteristika autonomnosti mikroservisa omogućava njihov razvoj u različitim tehnologijama i programskim jezicima, što, sa jedne strane, omogućava rešavanje softverskih problema pravim alatom, a sa druge strane omogućava kompanijama zapošljavanje programera različitih profesionalnih renomea i stručnosti. Za razliku od tradicionalnih monolitnih arhitektura, gde se izbor tehnologije i programskih jezika svodi na izbor najmanjeg zajedničkog sadržaoca, tj. rešenja za sve probleme, glavni zadatak u mikroservisnoj arhitekturi jeste da se izaberu najefikasniji protokoli za komunikaciju između mikroservisa. [9]

Još jedna od prednosti koje oslikavaju mikroservisnu arhitekturu jeste otpornost celokupnog sistema na greške.

Za razliku od tradicionalnih monolitnih aplikacija, gde jedna greška može da prouzrokuje pad cele aplikacije, u mikroservisnoj arhitekturi je reč o grešci koju je mnogo lakše izolovati jer se desila u okviru jednog mikroservisa i time je lokalizovati da ostatak sistema nastavi da radi nesmetano. Dodatno, tip grešaka koje mogu da nastanu u mikroservisnoj arhitekturi i koje projektanti moraju da imaju stalno na umu predstavljaju greške usled rada mreže u komunikaciji servisa, kao i greške otkaza mašina na kojima se nalaze mikroservisi, stoga je potrebno imati dodatnu programsku logiku koja će umanjiti negativne efekte ovih situacija. Na primer, ukoliko dođe do otkaza servera, postojanje logike koja preusmerava rad na drugi server može značajno sniziti procenat posledica.

Kada govorimo o performansama, u slučaju tradicionalnih sistema je neophodni skalirati celokupan sistem, iako je samo neka komponenta u okviru njega usko grlo i zahteva bolje performanse, dok u mikroservisnoj arhitekturi možemo da skaliramo sam mikroservis koji je opterećeniji i zahteva bolje i brže usluživanje zahteva.

Testiranje, isporučivanje i rad sa bazama podataka pod transakcijom i prebacivanje odgovornosti iz jednog u drugi mikroservis predstavljaju još neke od glavnih tema koje programerima i projektantima predstavljaju izazovne teme u ovoj arhitekturi. [10]

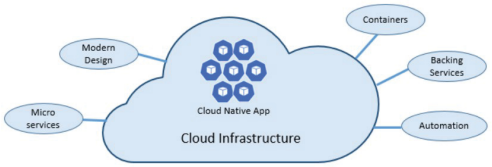
IV. *CLOUD-NATIVE* ARHITEKTURA

Zvanična definicija *cloud-native* glasi:
Cloud-native je skup tehnologija koje podstiču i osnažuju organizacije da kreiraju i pokreću skalabilne aplikacije u modernim i dinamičkim okruženjima kao što su javni, privatni i hibridni oblaci.[4]

Nju je dala organizacija *Cloud Native Computing Foundation (CNCF)* koja je deo neprofitne *Linux* fondacije i bavi se spajanjem svih interesnih strana *cloud-computing*-a, kao i održavanjem internacionalnih konferencija koje se bave gorućim temama ove oblasti.[5]

Kao što se može videti na slici 1, postoji 5 stubova koji definišu *cloud-native:*

- savremena arhitektura,
- automatizacija,
- servisi podrške,
- mikroservisi i
- kontejneri.



Slika 3. 5 stubova *cloud-native* [11]

Kada je reč o savremenoj arhitekturi, podrazumeva se softver koji se isporučuje kao servis, a metodologija koja olakšava razvoj takvih, *SaaS* (*Software as a Service*) rešenja je dvanaestofaktorska metodologija. U ovom radu se neće prolaziti kroz svih 12 faktora koji utiču na razvoj aplikacije savremene arhitekture, ali se glavne smernice mogu videti u nastavku:

- koristiti deklarativan format prilikom postavke automatizacije, što će olakšati priključivanje novih programera projektu i uticati na smanjenje troškova,
- oformiti jasnu vezu sa potpornim operativnim sistemom što će uticati na visok stepen portabilnosti softverskog rešenja,
- osposobiti aplikaciju čije će se isporučivanje vršiti na savremenim oblak rešenjima, time smanjujući potrebu za serverskim održavanjem i administracijom,
- smanjiti razliku između razvojnog i produkcionog okruženja čime se omogućava kontinualno isporučivanje zarad maksimalne agilnosti i
- omogućiti skaliranje aplikacije bez prevelikih promena na alate, arhitekturu i programski kod.[6]

Automatizacija je neizostavan činilac ove potpore. Sama ideja *cloud-native* arhitekture ne uspeva da dođe do izražaja

[4] https://github.com/cncf/toc/blob/main/DEFINITION.md
[5] https://www.cncf.io/about/who-we-are/
[6] https://12factor.net/

ukoliko sama automatizacija nije analizirana i sprovedena u delo do najsitnijih detalja, čime se omogućava kontinualna integracija i kontinualno isporučivanje – *CI/CD (Continuous Integration – Continuous Delivery)*.

Taj proces se sastoji od sledećih koraka:

- programer radi na razvoju neke funkcionalnosti, proverava je (eng. *debugging*) i testira je,
- po završetku prijavljuje (eng. *pushing*) svoje izmene na repozitorijum za verzionisanje koda,
- prijavljene izmene pokreću automatski *build* programskog koda, nakon čega sledi testiranje koda; implementirano pomoću *CI,*
- sledi faza kreiranja verzije gde se *build*-ovani kod pakuje u verziju sa odgovarajućom jedinstvenom oznakom uz podešavanja okruženja na koje su prijavljene promene; implementirano pomoću *CD* i
- poslednja faza u kojoj se funkcionalnost nalazi u okviru neizmenjive verzije u odgovarajućem okruženju.

Cloud-native arhitektura zavisi od mnoštva servisa koji se zovu servisi podrške i mogu biti implementirani od strane same kompanije koja kreira rešenje u ovoj arhitekturi, a mogu i biti iskorišćeni iz široke ponude samog pružaoca usluga. Ti servisi mogu biti: relacione baze podataka, dokument baze podataka, analitike, *message broker*-i, monitoring, *streaming* servisi itd.

Mikroservisi su opisani u prethodnom odeljku, a njihov razvoj je neizostavan u okviru *cloud-native* arhitekture zbog benefita koji su navedeni, a podržavaju ciljeve i *cloud-native* arhitekture.

Kontejnerizacija predstavlja koncept koji se u *cloud-native* kontekstu koristi za mikroservise. Celokupan kod, zavisnosti i izvršno okruženje se pakuju u *container image*.

Nakon pokretanja tog *image*-a nastaje instanca kontejnera i takvih instanci može biti onoliko koliko je potrebno i to omogućava lako skaliranje servisa. [12]

V. Zaključak

Izbor softverske arhitekture koja će zadovoljiti sve definisane slučajeve korišćenja od strane krajnjih korisnika i omogućiti lako tehničko održavanje, proširivanje i funkcionalno unapređivanje predstavlja najčešći predmet odlučivanja kompanija koje kreiraju rešenje i direktno utiču na uspeh sistema i same kompanije vendora.

Odgovornost koje softverske arhitekte i projektanti imaju u kompaniji je krucijalna, jer efikasnost, a zatim i sama monetizacija softverskog rešenja, ne zavise samo od toga koliko će programeri i razvojni tim dobro odraditi svoj deo posla, već da li njihov odrađeni posao u celini, uz arhitekturu, može da da performantne izlaze, zadovolji krajnje korisnike u rešavanju svakodnevnih aktivnosti, i omogući likvidnost kompaniji kreatoru rešenja. Glavni faktori su kako će same komponente sistema biti raspoređene, kako će komunicirati i koji će se protokoli koristiti za njihovu komunikaciju. Stoga, softverske arhitekte treba da analiziraju same potrebe, a i da predvide korišćenje i buduće karakteristike i probleme sa kojima se sistem može susresti.

Još jedno važno zapažanje koje proizilazi iz ovog rada jeste da prilikom projektovanja arhitekture ne treba nužno iskoristiti samo jedan tip arhitekture, već iskoristiti kombinaciju tipova i time iskoristiti benefite svakog tipa, a u skladu sa osnovnim ciljem rešenja koje se kreira. Analogno već opisanom problemu monolitne arhitekture u kojoj se bira programski jezik koji će biti najmanji sadržalac, tj. rešenje za sve probleme, softverska arhitektura ne treba da bude sadržalac uopšte, već kombinacija više tipova kako bi se zaobišli svi izazovi koji mogu nastati. Pristup ovoj problematici se može preslikati iz sveta mikroservisa, gde se svaka tehnologija i programski jezik koristi za ono za šta je najbolja/i, što podrazumeva da se u rešenju može iskoristiti više softverskih arhitektura. Tako nastaje tzv. hibridna arhitektura, koja ima obeležja više tipova arhitektura i specifično je skrojena za softver koji, kao što je navedeno u uvodu, treba posmatrati kao živu stvar.

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Prilog analizi uticaja Flyweight paterna na efikasnost softverskog sistema

Ana Korunović, Miloš Milić, Siniša Vlajić

***Sadržaj*—U ovom radu dat je prilog analize uticaja Flyweight paterna na efikasnost softverskog sistema. Objašnjen je koncept paterna projektovanja, opšta struktura Flyweight paterna i njegov uticaj na efikasnost korišćenja memorijskog prostora i vremena. U našem studijskom primeru izvršena je analiza performansi softverskog sistema dela biblioteke, pre i nakon što je primenjen Flyweight patern. Cilj istraživanja je bio usmeren na poboljšanje efikasnosti navedenog softverskog sistema koji vodi evidenciju o knjigama, autorima i izdavačima u biblioteci. Navedeno istraživanje je sprovedeno kako bi se pružio praktičan primer primene Flyweight paterna u sistemu koji kreira veliki broj istih objekata. U radu je pokazano da se primenom Flyweight paterna poboljšava efikasnost softverskog sistema u kontekstu korišćenja navedenih metrika.**

I. Uvod

U eri stalnih inovacija i kompleksnijih softverskih sistema, preduslov za uspešan razvoj softvera jeste optimizacija performansi. Sa zahtevima poput brzog odgovora sistema i efikasnije upotrebe resursa, programeri se susreću sa izazovom prilagođavanja svojih softverskih rešenja zahtevima korisnika. Efikasnost je prepoznata kao jedan od osnovnih atributa kvaliteta softvera (na primer, u standardu ISO/IEC 25010:2011 [1]). Efikasnost se može definisati kao sposobnost softverskog sistema da iskoristi onu količinu resursa (memorija, CPU vreme) koja je neophodna da bi se izvršio zadatak [2]. Prema ISO/IEC 25010:2011, efikasnost je određena vremenom ponašanja (stepen u kojem vreme odziva, vreme procesiranja i propusnost sistema ispunjavaju zahteve), upotrebom resursa (stepen u kojem količina i vrste resursa korišćenih od strane sistema ispunjavaju zahteve) i kapacitetom (stepen do kojeg maksimalni limiti parametra sistema ispunjavaju zahteve) [1].

Predmet ovog rada je istraživanje načina za povećanje efikasnosti softverskog sistema, kroz poboljšanje upotrebe resursa i smanjenja vremena neophodnim za generisanje odgovora na korisničke zahteve. Koncept koji je iskorišćen za optimizaciju performansi softverskog rešenja jeste Flyweight patern projektovanja. U radu je predstavljena komparativna analiza efikasnosti softverskog sistema koji je razvijen korišćenjem objektno-orijentisane paradigme i istog softverskog sistema koji je poboljšan uvođenjem Flyweight paterna. Analizom je potrebno utvditi da li primena Flyweight paterna ima pozitivne uticaje na smanjenje utroška memorije i vremena izvršavanja programa. Komparativna analiza softverskih sistema je urađena, kako bi se studentima Fakulteta organizacionih nauka (studijski program, Informacioni sistemi i tehnologije), Univerzitet u Beogradu, na izbornom predmetu Softverski paterni (4. godina studija), objasnila primena Flyweight paterna u poboljšanju efikasnosti softverskog sistema.

Rad je organizovan u šest poglavlja. Nakon uvoda u predmet istraživanja ovog rada, sledi objašnjenje koncepta paterna i uticaj paterna projektovanja na efikasnost softverskih sistema. U trećem poglavlju data je opšta definicija i objašnjenje Flyweight paterna. U četvrtom poglavlju objašnjena su dva softverska sistema, a u poglavlju pet data je komparativna analiza njihove efikasnosti. Šesto poglavlje sadrži zaključna razmatranja rada i pravce daljeg istraživanja.

II. Paterni projektovanja i efikasnost

Paterni projektovanja predstavljaju pouzdana rešenja koja se mogu primeniti na skup sličnih problema, koji se ponavljaju u različitim fazama razvoja softvera. Najpoznatiji paterni projektovanja su 23 paterna projektovanja, koji su objavljeni u knjizi „*Design Patterns: Elements of Reusable Object-Oriented Software*“, 1994 godine [3]. Paterni projektovanja su podeljeni u tri grupe: kreacioni paterni, stukturni paterni i paterni ponašanja. Kategorizacija paterna je određena na osnovu situacija u kojima se mogu primeniti rešenja paterna, tako da najefikasnije reše određeni problem.

Paterni projektovanja oblikuju strukturu aplikacije i pomažu da se sistem podeli u više manjih celina, kako bi se rešio problem snažne povezanosti (*tight coupling*) između objekata. Učaurivanjem specifičnih funkcionalnosti sistema unutar jasno definisanih celina olakšava se njihova ponovna upotreba u različitim kontekstima aplikacije. Podelom sistema na module, kreiraju se skalabilna i prilagodljiva rešenja, koja doprinose boljoj organizaciji softverskog sistema.

Paterni projektovanja mogu doprineti i smanjenju resursa koje aplikacije koriste za kreiranje novih objekata, tako što slični objekti koriste deljeni memorijski prostor. Na primer, Flyweight patern dozvoljava da objekti budu deljeni, dok Proxy patern omogućava odlaganje inicijalizacije stvarnog objekta koji može biti resursno zahtevan (u literaturi poznat kao Virtual Proxy [3]) [4]. Efikasnim upravljanjem memorijskim prostorom, paterni omogućavaju efikasnije

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izvršavanje korisničkih zahteva, posebno kod aplikacija koje zahtevaju velike resurse.

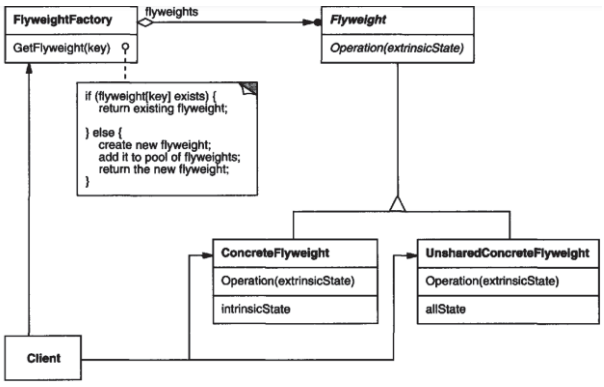
U nastavku rada opisan je Flyweight patern, koji je iskorišćen za analizu uticaja paterna projektovanja na efikasnost softvera.

III. FLYWEIGHT PATERN

U softverskom inženjerstvu, optimizacija performansi i smanjenje zauzetosti resursa su ključni za postizanje efikasnih i skalabilnih rešenja. Patern projektovanja koji bi mogao da odgovori na ove zahteve jeste Flyweight patern. Definicija Flyweight paterna glasi „Koristi deljenje da efikasno podrži veliki broj sitnih objekata“ [3]. Drugim rečima, Flyweight patern doprinosi smanjenju broja objekata koji se kreiraju, tako što koristi prethodno kreirane objekte čije se stanje može deliti.

Flyweight patern često se koristi u situacijama kada aplikacija kreira veliki broj istih objekata, pri čemu svaki od njih ima osobine koje se mogu deliti. U knjizi *Design Patterns: Elements of Reusable Object-Oriented Software* prikazan je način optimizacije upotrebe resursa prilikom uređivanja velikih tekstualnih dokumenata, korišćenjem Flyweight paterna [3]. Svaki karakter u dokumentu predstavlja deljeni objekat (*Flyweight*) koji sadrži nedeljena stanja (boja i pozicija karaktera u dokumentu). Ovaj pristup eliminiše nepotrebnu potrošnju resursa tako što omogućava pojavljivanje istog objekta (karaktera) u različitim kontekstima dokumenta.

Opštu strukturu Flyweight paterna čini interfejs *Flyweight*, preko koga Flyweight objekti mogu da prihvate i deluju na spoljašnje stanje, prosleđeno kroz metode (*extrinsic*) [5]. *FlyweightFactory* je odgovoran da kreira novi Flyweight objekat, ukoliko isti ne postoji ili da vrati postojeći. *ConcreteFlyweight* je deljeni objekat koji sadrži unutrašnje stanje (intrinsicState) koje ne zavisi od konteksta u kojem se poziva. *UnsheredConcreteFlyweight* je klasa koja nije deljiva, ali sadrži *ConcreteFlyweight* objekte kao svoju decu [3]. Na Slici 1. data je opšta struktura Flyweight paterna.



Slika 1. Opšta struktura Flyweight paterna [1]

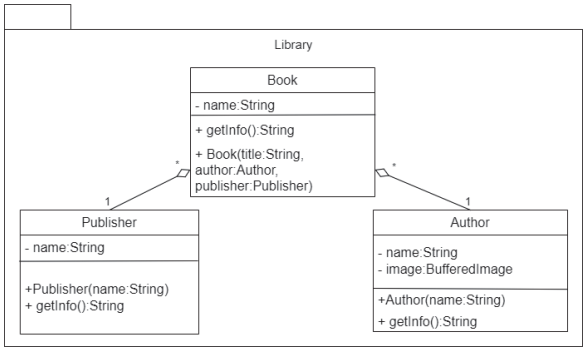
Bitno je napomenuti da Flyweight patern nije uvek efikasan i da program postaje kompleksniji njegovom primenom. Aplikacije u kojima se primećuju prednosti njegove upotrebe su one kod kojih postoji potreba za smanjenjem potrošnje resursa, a da pritom njihova struktura omogućava efikasno deljenje zajedničkih stanja (isti objekti se koriste u različitim kontekstima).

IV. STUDIJSKI PRIMER

Za potrebe objašnjenja uticaja Flyweight paterna na efikasnost softverskog sistema, razvijen je jednostavni sistem evidencije knjiga u biblioteci. Inicijalno rešenje implementirano je korišćenjem osnovnih koncepata objektno-orijentisanog programiranja i Java programskog jezika. Naknadno je isti softverski sistem unapređen primenom Flyweight paterna projektovanja. Efikasnosti jednostavnijeg i poboljšanog rešenja su izmerene korišćenjem Apache NetBeans profajlera [6] i biće prikazane u nastavku rada. Softverski sistem koji je razvijen kreira biblioteku u kojoj se čuva evidencija od 10000 knjiga, pri čemu postoji više kopija jedne knjige. Za svaku knjigu se pamti naziv, autor i izdavač.

A. Softversko rešenje bez primene Flyweight paterna

Kao što je prikazano na Slici 2., struktura dela bibliotečnog sistema čine 3 klase. Jedna knjiga (klasa *Book*) sadrži jednog autora (klasa *Author*) i jednog izdavača (klasa *Publisher*). Jedan autor može napisati više knjiga, a jedan izdavač može objaviti više knjiga. Naziv knjige, ime izdavača i autora se generišu na slučajan način iz kolekcija koje sadrže, redom, 1000, 50 i 100 različitih vrednosti (Slika 3.). Dakle, biblioteka može sadržati 1000 različitih naslova knjiga, 50 različitih izdavača i 100 različitih autora. Da bismo simulirali velike količine podataka koje se obrađuju u stvarnim sistemima, korišćena je klasa *BufferedImage*. Naime, slika simulira veliki objekat koji se učitava prilikom kreiranja klase *Author*, kako bi se dodatno zauzelo procesorsko vreme i memorijski prostor.



Slika 2: UML Dijagram klasa jednostavnijeg rešenja

Tokom izvršavanja programa, u biblioteci se ukupno kreira 10000 pojavljivanja klase *Book* (10000 iteracija). Tokom svake iteracije ciklusa, pored objekta klase *Book,* kreiraju se i objekti klasa *Publisher* i *Author* (po 10000 pojavljivanja svake klase). S obzirom da veliki broj knjiga u biblioteci imaju isti naslov, isto ime autora, pa čak i istog izdavača, dolazi do preopterećenja memorije objektima sa istim podacima. U našem primeru, tokom 10000 iteracija, kreira se 30000 objekata domenskih klasa (*Book, Author* i *Publisher*).

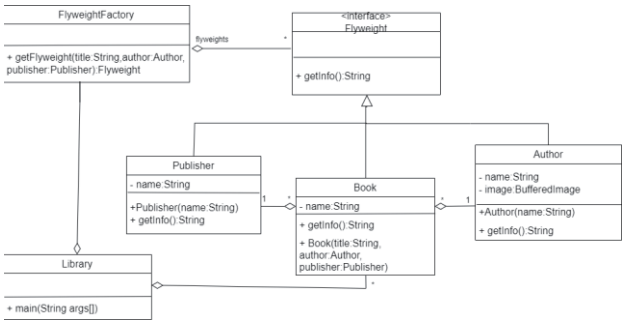
```
public static void main(String[] args) {

    for (int i = 0; i < 10000; i++) {
        String randomAuthor = getRandomAuthorName();
        String randomPublisher = getRandomPublisherName();
        String bookName = getRandomBookName();

        Author author = new Author(randomAuthor);
        Publisher publisher = new Publisher(randomPublisher);
        Book book = new Book(bookName, author, publisher);
        System.out.println(book.getInfo());
    }
}
```

Slika 3: Main metoda klase *Library*

B. Softversko rešenje sa primenom Flyweight paterna

U gore navedenoj strukturi softverskog sistema primećeno je da se u toku izvršavanja ciklusa kreiraju isti objekti klasa *Auhor*, *Publisher* i *Book* (objekti sa istim vrednostima atributa). Ovo prouzrokuje da vreme generisanja slogova (objekata) bude dugo. Kao rešenje uočenog problema, uveden je Flyweight patern, koji koristi deljeni memorijski prostor za veliki broj sličnih/istih objekata. Uvođenjem interfejsa *Flyweight,* objekti klasa *Book, Author* i *Publisher* kreiraće se samo ukoliko ne postoji objekat u kolekciji sa istim podacima. Ukoliko objekat postoji, nova knjiga (autor ili izdavač) dobija referencu na postojeći objekat iz kolekcije (ne zauzima se dodatni memorijski prostor). Ova činjenica je veoma bitna prilikom kreiranja objekta klase *Author,* tj. učitavanja slike iz datoteke (jednom se učitava slika za jednog autora).

UML Dijagam klasa poboljšanog softverskog sistema prikazan je na Slici 4.



Slika 4: UML Dijagram klasa unapređenog rešenja

Primenom Flyweight paterna, dijagramu klasa sa Slike 2. dodata je klasa *FlyweightFactory* i interfejs *Flyweight*. Interfejs *Flyweight* definiše deljene objekte i analogan je istoimenom interfejsu opšte strukture Flyweight paterna. Implementacije klasa *Book, Author* i *Publisher* su iste kao i u prethodnom softverskom rešenju. Klasa *Library* (klijent) nema odgovornost kreiranja domenskih klasa, već je za to odgovorna klasa *FlyweightFactory* (Slika 5.).

```
public static void main(String[] args) {
    for (int i = 0; i < 10000; i++) {
        String randomAuthor = getRandomAuthor();
        String randomPublisher = getRandomPublisher();
        String randomBookName = getRandomBookName();
        Book book = (Book) FlyweightFactory.getFlyweight(randomBookName,
                randomAuthor, randomPublisher);
        System.out.println(book.getInfo());
    }
}
```

Slika 5: Main metoda klase Library – Flyweight patern

Klasa *FlyweightFactory* sadrži HashMap-u, u kojoj se čuvaju deljeni objekti interfejsa *Flyweight*, sa odgovarajućim ključevima. Kada se pozove metoda *getFlyweight()* (Slika 6.), prvo se proverava da li je već kreiran autor, izdavač i knjiga sa prosleđenim ključem. Samo u situaciji kada prosleđeni ključ ne postoji u kolekciji *Flyweight* objekata, novi objekat se kreira i dodaje u kolekciju.

```
public class FlyweightFactory {

    private static Map<String, Flyweight> flyweights = new HashMap<>();

    public static flyweight.Flyweight getFlyweight(String b, String a, String p) {
        if (!flyweights.containsKey(a)) {
            String[] au = a.split("-");
            flyweights.put(a, new Author(au[0], au[1]));
        }
        if (!flyweights.containsKey(p)) {
            flyweights.put(p, new Publisher(p));
        }
        String bookKey = b + a;
        if (!flyweights.containsKey(bookKey)) {
            flyweights.put(bookKey, new Book(b, (Author) flyweights.get(a),
                    (Publisher) flyweights.get(p)));
        }
        return flyweights.get(bookKey);
    }
}
```

Slika 6: FlyweightFactory klasa

V. KOMPARATIVNA ANALIZA EFIKASNOSTI SOFTVERSKIH SISTEMA PRE I NAKON UPOTREBE FLYWEIGHT PATERNA

Efikasnost softverskih sistema može se razmatrati u kontekstu vremena izvršavanja i količine utrošene memorije za obavljanje zadataka. Softverski sistem je efikasniji ukoliko je vreme izvršavanja kraće i ukoliko je zauzeto manje memorijskog prostora. Cilj unapređenja softverskog sistema jeste smanjenje vremena izvršavanja i utroška resursa.

Za potrebe testiranja efikasnosti opisanih softverskih sistema korišćen je Apache NetBeans profajler [6]. Prilikom pokretanja NetBeans profajlera, grafički se prikazuje zauzetost memorije, upravljanje nitima, CPU vreme, kao i relativno vreme koje koristi Sakupljač smeća (*Garbage collector*) u svakoj fazi rada programa. Aplikacije su testirane na računaru sa operativnim sistemom Windows 10 Pro (verzija 22H2) na 64-bitnoj arhitekturi. Računar ima Intel Core i5-5200U procesor, sa 8GB RAM-a i SSD (*Solid-state drive*) disk kapaciteta 179GB.

A. Analiza efikasnosti softverskog sistema bez primene Flyweight paterna

U softverskom sistemu (Slika 2.) u kojem nije primenjen Flyweight patern, ukupno vreme između početka i kraja generisanja slogova je 1 minut i 49 sekundi. Veličina memorije koja je bila neophodna da bi se izvršio program jeste 130MB, a najveća zauzetost dinamičke (*heap*) memorije iznosila je 80.587.744 B.

B. Analiza efikasnosti softverskog sistema u kojem je primenjen Flyweight paterna

Nakon što je u inicijalni softverski sistem primenjen Flyweight patern dobijena je struktura softverskog sistema sa Slike 4. Ukupno vreme generisanja objekata kod unapređenog softverskog sistema je 16 sekundi. U trenutku testiranja najveća zauzetost dinamičke (*heap*) memorije iznosila je 61.172.016 B, a veličina memorije koja je dodeljena programu je 130MB.

Na osnovu izvršenog monitoringa aplikacija možemo doneti sledeće zaključke:

1. Primenom Flyweight paterna, softverski sistem postaje kompleksniji dodavanjem novih apstrakcija.
2. Primenom Flyweight paterna, vreme izvršavanja programa je kraće. U našem primeru, unapređen program se izvršava 1 minut i 33 sekunde kraće u odnosu na prvobitan sistem.
3. Primenom Flyweight paterna smanjena je zauzetost memorije. Koristeći deljene objekte, program ne kreira duplikate, već prosleđuje adresu postojećih objekata. Maksimalna iskorišćenost memorije je smanjena za 21MB.
4. Korišćenje deljenih objekata smanjuje vreme koje koristi Sakupljač smeća (*Garbage collector*). Kod unapređenog rešenja, objekti se ne uklanjaju jer na njih postoji bar jedna referenca.

C. Uticaj promene raspoloživog broja autora i broja iteracija na efikasnost softverskih sistema

S obzirom da kreiranje objekta klase *Autor* zahteva najviše procesorskog vremena, nameće se sledeće pitanje:„Na koji način promena ukupnog broja knjiga (broj iteracija) i broja različitih autora u biblioteci utiče na efikasnost opisanih sistema?“.

U Tabeli 1. dati su rezultati merenja efikasnosti softverskog sistema u kojem nije primenjen Flyweight patern i softverskog sistema u kojem je primenjen Flyweight patern. Prilikom analize efikasnosti razmatrane su sledeće situacije:

1. Promena broja raspoloživih autora u kolekciji autora (broj različitih autora), pri čemu je broj iteracija konstantan (10000). Razmatrane su situacije sa jednim autorom, 100 i 500 različitih autora.
2. Promena broja knjiga u biblioteci (broj iteracija ciklusa u klijentskoj klasi), pri čemu je broj različitih autora konstantan (100). Razmatrane su situacije sa 100, 1000 i 10000 iteracija.

TABELA I

KOMPARATIVNA ANALIZA EFIKSNOSTI SOFTVERSKIH SISTEMA

		Softverski sistem bez upotrebe Flyweight paterna			Softverski sistem sa upotrebom Flyweight paterna		
		Vreme generisanja slogova	*Zauzetost heap-a*	*Maksimalna upotreba heap-a*	*Vreme generisanja slogova*	*Zauzetost heap-a*	*Maksimalna upotreba heap-a*
Broj autora u kolekciji (10000 iteracija)	1	100s	130MB	81MB	13s	130MB	16MB
	100	109s	130MB	81MB	16s	130MB	61MB
	500	107s	130MB	81MB	19s	359MB	270MB
Broj iteracija ciklusa (100 različitih autora)	100	3s	130MB	11MB	2s	130MB	8MB
	1000	12s	130MB	76MB	4s	130MB	56MB
	10000	109s	130MB	81MB	16s	130MB	61MB

Na osnovu dobijenih rezultata možemo zaključiti da kod prvog softverskog sistema vreme generisanja slogova i maksimalna upotreba *heap* memorije zavisi od broja iteracija ciklusa. Broj autora ne utiče značajno na efikasnost, jer se u svakoj iteraciji uvek kreira jedno pojavljivanje klase *Author*.

Na efikasnost drugog softverskog sistema utiče i promena broja autora i promena broja iteracija. Povećanjem broja iteracija i autora, povećava se i vreme generisanja slogova i maksimalna upotreba dinamičke memorije. Najveće zauzeće memorije nastaje u situaciji kada je broj raspoloživih autora 500. Uočeno je da je broj preživelih generacija (*Surviving generations*) 16, što je posledica kreiranja referenci na objekte koji sadrže iste atribute. Broj preživelih generacija ukazuje na to koliko puta objekti u memoriji preživljavaju cikluse sakupljanja smeća pre nego što budu dealocirani. S obzirom da se ovaj broj povećava sa rastom broja različitih autora, zauzetost dinamičke memorije je veće.

VI. ZAKLJUČAK

Sa porastom broja deljenih objekata povećava se i količina memorijskog prostora koja se može uštedeti primenom Flyweight paterna [3]. Upravo ova tvrdnja je pokazana na primeru dela softverskog sistema biblioteke. Kao rezultat komparativne analize dva softverska sistema, zaključili smo da Flyweight patern dovodi do povećanja efikasnosti programa, smanjujući količinu zauzetosti resursa i vreme izvršavanja programa.

Pravci daljeg istraživanja biće usmereni na analizu uticaja drugih paterna projektovanja na promene veličine dinamičke memorije i vremena delovanja Sakupljača smeća na efikasnost opisanih softverskih sistama.

ZAHVALNICA

Autori se zahvaljuju Univerzitetu u Beogradu - Fakultetu organizacionih nauka, koji je finansijski podržao ovo istraživanje.

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Prednosti primene integrisane tehnologije veštačke inteligencije i Interneta stvari u maloprodaji

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***Sadržaj*—Maloprodajni sektor, sa jedne strane radno intenzivan i podrazumeva visok stepen komunikacije sa potrošačima, sa druge dinamičan i nepredvidiv, ne može da se isključi iz tehnološke evolucije vođene brzom digitalizacijom i prisustvom pametnih telefona i uređaja. Krajnji kupci više nisu isti jer su postali više informisani stalnim korišćenjem pametnih uređaja koja imaju uticaj na navike u kupovini i stil kupovine. Kombinacijom veštačke inteligaanije i Interneta stvari AI+IoT (AIoT) može da se pruži transformisano iskustvo u maloprodajnim objektima. Glavni cilj objedinjene tehnologije AIoT je da proširi prednosti Interneta stvari i veštačke inteligencije. U današnjem brzom maloprodajnom okruženju, ostati konkurentan i zadovoljiti zahteve potrošača može biti veliki izazov. Inovativne tehnologije su omogućile maloprodavcima da pojednostave poslovanje, unaprede svoj lanac snabdevanja, snize troškove, poboljšaju korisničko iskustvo, bolje komuniciraju sa potrošačima i donose odluke zasnovane na podacima.**

I. Uvod

Integrisana tehnologija veštačke inteligencije i Interneta stvari (AIoT) omogućava sistemima u kojima se primenjuju da se samoispravljaju, prilagođavaju kontekstu i kontinuirano se poboljšavaju. Kombinacijom obe tehnologije mogu se razviti inteligentna rešenja za pametne gradove, industrijalizaciju, zdravstveni sektor, transport, kao i maloprodaju. Tehnologija veštačke inteligencije (AI) se danas koristi u svim oblastima, i postaće sve prisutnija u našem svakodnevnom životu. Potencijalne primene veštačke inteligencije su skoro neograničene, a tehnologija već utiče na širok spektar sektora. Jedna od sektora na koju je veštačka inteligencija već značajno uticala je maloprodaja, sa revolucionarnim promenama u iskustvu kupovine. IoT uređaji objedinjuju i upravljaju velikom količinom podataka i, stoga, da bi se iskoristile i interpretirale informacije, potrebno je primeniti mašinsko učenje (ML). Globalno tržište veštačke inteligencije (AI) u maloprodaji bilo je procenjeno na oko 4,84 milijarde američkih dolara u 2021. godini, procenjuje se da će tokom narednog perioda tržište veštačke inteligencije u maloprodaji kontinuirano rasti i dostići 31,18 milijardi američkih dolara do 2028. godine [1]. Iako optimistične brojke, kapacitet da implementiraju tehnologiju i imaju stvarne benefite od nje imaće retki maloprodavci. IHL Grupa je objavila sveobuhvatne prognoze koja naglašavaju ogroman uticaj veštačke inteligencije (AI), tačnije generativne veštačke inteligencije na maloprodaju, gde se predviđa da će prednosti generativne AI proizaći iz tri osnovne oblasti [2]: povećanje prodaje (51%), povećanje bruto marža (20%) i smanjenje troškova prodaje i administracije (29%). Maloprodavci mogu očekivati da će postići između 5-100 puta veću efikasnost korišćenjem generativnih AI tehnologija, posebno u poslovima prodaje i opštih administrativnih poslova. Zadaci za koje su tradicionalno bili potrebni sati ili čak dani da se završe sada se mogu obaviti za nekoliko minuta, omogućavajući maloprodavcima da pojednostave svoje operacije, povećaju produktivnost i pruže vrhunsku uslugu potrošačima.

II. Prednosti AIoT u maloprodajnom lancu snabdevanja

Efikasnost u maloprodajnom sektoru je u velikoj meri zasnovana na modernizovanom lancu snabdevanja. Integracijom Interneta stvari (IoT) pojačava se uticaj algoritmima veštačke inteligancije (AI) na efikasnost lanca snabdevanja. Oblast upravljanja lancem snabdevanja se intenzivno transformiše, sa algoritmima vođenim veštačkom inteligencijom koji imaju potencijal da izmene čitav maloprodajni lanac snabdevanja. Uspešno implementiranje upravljanja lancem snabdevanja zasnovano na veštačkoj inteligenciji omogućilo je inovatorima u ovoj oblasti da smanje troškove logistike za 15%, nivoe zaliha za 35% i nivoe usluga za 65%, u poređenju sa konkurentima koji zaostaju u implementaciji [3].

Analizom ogromne količine podataka i uočavanjem obrazaca, AI algoritmi mogu da identifikuju specifične oblasti u kojima proces lanca snabdevanja može naići na prepreke ili usporavanja. Proaktivna identifikacija omogućava blagovremene intervencije i strateška prilagođavanja, obezbeđujući nesmetan tok operacija i olakšavajući operacije i pružajući konkurentsku prednost, donoseći efikasnost i preciznost.

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Štaviše, AI ima sposobnost da optimizuje rute isporuke, sugerišući najefikasnije i najneefikasnije puteve za isporuku proizvoda. DHL koristi veštačku inteligenciju da optimizuje rute vozila i smanji potrošnju goriva, što rezultira nižim emisijama i poboljšanom održivošću. Uzimajući u obzir mnoštvo varijabli, uključujući uslove saobraćaja, vremenske prognoze i istorijske podatke o isporuci, algoritmi optimizuju rute isporuke, minimizirajući vreme, potrošnju goriva i povezane troškove.

AI ne samo da doprinosi smanjenju logističkih troškova, već imajući u vidu i održivost, smanjuje emisiju ugljen-monoksida povezanog sa transportom. IoT tehnologija pruža priliku za povećanje produktivnosti kroz zelenu energiju i obnovljivu energiju, u realnom vremenu prikuplja podatke o energetskim resursima, olakšava očuvanje resursa sa više informacija i prikuplja podatke na jednostavan način kako bi se postigli obrasci saobraćaja i dostupnost parkinga, smanjila potrošnja goriva [4]. Još jedan značajan primer je upotreba AIoT-a su autonomnim vozilima. Tehnologija povezuje računar, kamere i druge elemente, tako da donosi autonomne odluke u realnom vremenu, uzimajući u obzir uslove na putu, bezbednost na putu i režim vožnje. Sistemi zasnovani na AIoT-u su autonomni, pa korisnici ne moraju da troše vreme na proveru uređaja, što štedi resurse i vreme, pomažući kompanijama da postanu održivije. Amazon je kupio Kiva Sistems 2012. godine, sa promenom imena u Amazon Robotics danas ima 200.000 robota koji koriste AI u skladištima, u 26 od 175 Amazonovih distributivnih centara, koji pomažu u biranju, sortiranju, transportu i skladištenju paketa [5].

Najzanimljivija upotreba IoT-a i veštačke inteligencije AI je ugradnja inteligentnih senzora u pakovanje proizvoda i analiza njihovih podataka kako bi se omogućilo praćenje proizvoda kroz lanac snabdevanja do završne faze isporuke [6]. IoT senzori povezani sa proizvodima pružaju neprocenjive podatke u realnom vremenu o stanju proizvoda, uključujući faktore kao što su temperatura, vlažnost i uslovi rukovanja. AI algoritmi analiziraju ove informacije, omogućavajući proaktivne mere kako bi se osiguralo da se proizvodi isporučuju u najboljem mogućem stanju. Na primer, u slučaju proizvoda osetljivih na temperaturu, ako postoji rizik od izlaganja nepovoljnim temperaturama, mogu se preduzeti odgovarajuće mere za ublažavanje potencijalne štete.

IoT uređaji, koji obuhvataju senzore i radio-frekventnu identifikaciju proizvoda (RFID), igraju značajnu ulogu nudeći uvid u realnom vremenu u lanac snabdevanja. Maloprodavci mogu precizno da prate kretanje proizvoda—od proizvodnje do stanja na policama u prodajnom objektu. Povećani nivo transparentnosti ne samo da pomaže u smanjenju rizika od krađe, kvarenja ili izgubljene pošiljke, već i olakšava bolje predviđanje i planiranje tražnje.

III. Promene maloprodajnog poslovanja pod uticajem AIoT

Integracija uređaja Interneta stvari (IoT) drastično menja konvencionalno iskustvo kupovine. Savremeni trend u maloprodaji je transformacija tradicionalnih prodajnih objekata do inteligentnog maloprodajnog prostora poznatog kao „pametne prodavnice“. Pametne prodavnice se zasnivaju na pametnim policama, koje stalno prate nivoe proizvoda na zalihama i komuniciraju u realnom vremenu o potrebama za obnavljanjem zaliha, što na kraju povećava operativnu efikasnost.

Maloprodavci se suočavaju sa stalnim izazovom u održavanju optimalnog nivoa zaliha kako bi zadovoljili tražnju potrošača i smanjili operativne troškove. Efikasno upravljanje zalihama je najvažnije u maloprodaji, a tehnološki napredak nudi održiva rešenja za ovaj stalni problem. Značaj predviđanja tražnje se može videti na primeru Nike, koji je kupio AI start-up pod nazivom Celect za 110 miliona dolara 2019. godine kako bi mu pomogao da bolje razume tražnju potrošača i prati zalihe u realnom vremenu [7].

Uključivanje uređaja Interneta stvari (IoT), korišćenjem senzorima u maloprodajnom objektu pokazalo se kao efikasan način za praćenje nivoa zaliha. Kada se kombinuju sa algoritmima veštačke inteligencije (AI) i mašinskog učenja (ML), IoT uređaji omogućavaju maloprodavcima da precizno predvide obrasce tražnje, optimizuju nivoe zaliha i efikasno ublažavaju situacije preteranih ili manjih zaliha. Walmart, na primer, koristi kamere na mašinama za pranje podova, koje beleže nivoe zaliha na policama i šalju informacije u data centar sa AI koji pomaže kompaniji da donese bolje odluke o zalihama. Dnevno se snimi više od 20 miliona fotografija proizvoda na policama. Algoritmi veštačke inteligencije primaju slike i određuju pojedinačne brendove na policama i nivoe zaliha sa više od 95% preciznosti [7]. Posledične uštede troškova i osiguranje dostupnosti proizvoda povećavaju zadovoljstvo potrošača.

Moguće je koristiti algoritme koji prate istorijske podatke, tržišne trendove i eksterne varijable da bi generisali veoma precizne prognoze tražnje. Maloprodavci mogu ne samo da efikasno planiraju svoje zalihe, već i da pojednostave svoje operacije u lancu snabdevanja, čime se povećava ukupna operativna efikasnost. H&M koristi rešenja veštačke inteligencije za maloprodaju da analizira povrate i račune u prodavnicama kako bi procenio kupovine po lokaciji, a zatim i stanje zaliha na osnovu ovih uvida. Proaktivni pristup omogućava maloprodavcima da optimizuju nivoe zaliha i minimiziraju troškove povezane sa prevelikim i nedovoljnim zalihama.

U dinamičnom okruženju maloprodajnog sektora, efikasno upravljanje energijom predstavlja ključan problem i za snižavanje troškova i ekološku odgovornost. Veštačka inteligencija igra glavnu ulogu u pametnoj automatizaciji upravljanja energijom, sastoji se od više inteligentnih algoritama koji omogućavaju predviđanje energije, planiranje energije, odgovor na potražnju i trgovanje energijom [8]. Korišćenje potencijala IoT uređaja može se unaprediti način na koji se energija nadgleda i kontroliše u maloprodajnim objektima. IoT uređaji nadziru, pažljivo upravljajući i regulišući potrošnju energije u maloprodajnim objektima. Inteligentnim upravljanjem sistemom osvetljenja, grejanja i hlađenja na osnovu potreba u realnom vremenu, IoT uređaji obezbeđuju da se energija troši razumno, što dovodi do značajnog smanjenja potrošnje energije. Primena

IoT tehnologije u ovom kontekstu ne samo da označava finansijsku opravdanost, već i ekološku svesnost.

U brzom svetu maloprodaje, gde strategije određivanja cena predstavlja ključ konkurentnosti, određivanje cena vođeno veštačkom inteligencijom može da se preoblikuje okruženje maloprodajnog preduzeća. Ne radi se samo o ceni kao postavljanju broja; radi se o navigaciji više varijabli od cena konkurenata, stalno promenljivih obrazaca tražnje i stalnim promenama tržišnih uslova. AI može da izvrši analizu cena konkurenata, trendove tražnje i fluktuaciju tržišta u realnom vremenu. Algoritam za određivanje cena je dinamično, agilno i stalno razvijajuće rešenje koje obezbeđuje da cene ostanu konkurentne i istovremeno profitabilne. Na taj način se osigurava da trgovci na malo mogu maksimizirati profitne marže dok ostaju konkurentni na tržištu koje se brzo menja. Maloprodavci mogu da prilagođavaju cene u hodu kako bi maksimizirali profit, a da pritom ostanu konkurentni. Veliki trgovci na malo kao što je Walmart koriste AI za prilagođavanje cena u realnom vremenu na osnovu faktora kao što su nivo zaliha i tražnja.

Bezbednost ostaje najvažniji prioritet za maloprodavce, zbog čega su neophodna napredna tehnološka rešenja. Kroz integraciju algoritama, AIoT omogućava maloprodavcima da analiziraju snimke sigurnosnih kamera i podatke IoT senzora u realnom vremenu. Takvim pristupom omogućava se blagovremeno otkrivanje neobičnih aktivnosti ili potencijalne krađe. Budući da je proaktivan u rešavanju bezbedonosnih problema, značajno doprinosi minimiziranju gubitaka, štiteći interese potrošača i zaposlenih. Ali kontroverze oko IoT tehnologije rastu, pokazalo se da je Amazon početkom 2019. godine otkrio da je hiljade njegovih radnika slušalo razgovore koje su snimili Echo pametni zvučnici, Amazon je analizirao ove transkripte bez znanja ili saglasnosti svojih potrošača [9].

Za trgovce na malo, zaštita od svih oblika prevare je imperativ za održavanje finansijskog integriteta i poverenja potrošača. U tu svrhu se koriste algoritmi koji su pažljivo dizajnirani za ispitivanje podataka o transakcijama. Maloprodavci su suočeni sa nizom rizika od prevare, bilo da potiču iz digitalnog domena prevara u plaćanju na mreži ili opipljivog domena krađe u prodavnicama. Ovo brzo otkrivanje omogućava maloprodavcima da spreče pokušaje prevare u realnom vremenu, efektivno minimizirajući finansijske gubitke i održavajući ključnu osnovu poverenja sa svojom bazom potrošača. Amazon sa svojom tehnologijom „Just Walk Out“, zasnovanoj na veštačkoj inteligenciji, prati šta potrošači uzimaju sa polica sa kamera na policama, a zatim ih naplaćuje kada izađu iz Amazon Go prodavnica bez potrebe da se zaustave i plate [7]. Potrošači jednostavno skeniraju aplikaciju kada uđu, izađu sa proizvodima koje žele i automatski se vrši naplaćivanje. Ali Amazon je nedavno zatvorio osam svojih Go prodavnica, što je znak da tehnologija možda neće biti tako revolucionalna i u operativnom smislu kako se pretpostavljalo.

Jedna od ključnih primena AIoT tehnologije je prediktivno održavanje opreme u prodajnim objektima. IoT senzori su raspoređeni da budno prate stanje opreme i mašina u maloprodajnim objektima. Prikupljeni podaci se zatim podvrgavaju rigoroznoj analizi korišćenjem AI i algoritama mašinskog učenja (ML). Analitičko praćenje omogućava maloprodavcima da precizno predvide potrebe za održavanjem, značajno smanjujući vreme zastoja i sprečavajući neočekivane kvarove. Prednosti integracije prediktivnog održavanja opreme u maloprodajnim objektima su višestruke. Tradicionalni sistem detekcije ne samo da je povećao cenu detekcije, već je imao i nisku bezbednost, a nakon testiranja i analize, prednosti novog sistema za detekciju su poboljšanje sigurnosti detekcije, ušteda mnogo troškova i povećanje efikasnosti [10]. Pored očiglednih poboljšanja efikasnosti i dugovečnosti opreme, primena pojednostavljuje rad izbegavajući skupe smetnje usled nepredviđenih kvarova. Maloprodavci mogu strateški planirati rasporede održavanja, optimizujući resurse i na kraju poboljšajući ukupnu produktivnost.

IV. Savremeni potrošač vođen AIoT tehnologijom

U današnjem maloprodajnom okruženju, ispunjavanje očekivanja modernih potrošača prevazilazi samo pružanje transakcijskog iskustva. Potrošači sada traže personalizovane interakcije koje su neprimetno usklađene sa njihovim preferencijama i ponašanjem. Postizanje ovog nivoa personalizacije omogućeno je algoritmima veštačke inteligencije (AI) i mašinskog učenja (ML). Napredni algoritmi imaju sposobnost obrade i tumačenja ogromnih količina podataka o potrošačima. Analizom istorije kupovine i ponašanja na mreži, maloprodavci mogu da kreiraju prilagođene preporuke proizvoda, promotivne ponude i ekskluzivne popuste za svakog pojedinačnog potrošača. Rezultat toga je eksponencijalno poboljšanje zadovoljstva potrošača koje se na kraju prevodi u povećanu prodaju i lojalnost potrošača.

Uz pomoć algoritama AI i ML, maloprodavci mogu da analiziraju istoriju kupovine potrošača i ponašanje na mreži kako bi predložili proizvode koji odgovaraju njihovim željama i zahtevima. Na primer, pri kupovini na Amazonu, elektronski prodavac će predložiti druge proizvode za kupovinu, a preporuke su zasnovane na istoriji prethodnih porudžbina, korisničkom profilu i drugim detaljima koje AI algoritmi obrađuju i kombinuju da bi dali najbolji odgovor. Algoritmi efikasno segmentiraju potrošače na osnovu njihovih jedinstvenih sklonosti, dajući maloprodavcima informacije za marketinške strategije usmerene na specifične segmente potrošača. Ovaj nivo personalizacije ostavlja potrošače potpuno zadovoljnim, što kulminira u značajnom povećanju prodaje.

Uticaj veštačke inteligencije i ML u sferi maloprodaje prevazilazi personalizovana iskustva. Pažljivim ispitivanjem ponašanja potrošača i uviđanjem tržišnih trendova, trgovci na malo mogu da donesu odluke da prilagode svoje strategije, uvedu nove proizvode ili na vreme izađu sa neefikasnih tržišta. S obzirom na složenost i potencijalnu dvosmislenost tehnologije veštačke inteligencije iz perspektive potrošača, dobijanje njihovog poverenja predstavlja veliki izazov u uslugama koje podržavaju veštačku inteligenciju; rezultati istraživanja ukazuju na pozitivan odnos između poverenja, pogodnosti i kvaliteta usluge [11]. Poverenje u brend, tehnologiju i proces koji koriste, kao i svrhu za koju prikupljaju i analiziraju podatke

o potrošačima raste kada je usluga pogodnija u smislu vremena i lokacije, nudeći bolji kvalitet usluge uz bezbednost, dizajn interfejsa, pouzdanost i korisničku podršku.

Jedna od oblasti u kojoj je tehnologija napravila veliki uticaj je korisnička podrška. Chatbotovi i virtuelni asistenti koje pokreće AI postali su nezamenljivi alati za maloprodavce. Oni igraju ključnu ulogu u obradi upita potrošača, pružanju podrške i obradi porudžbina 24 sata dnevno. Automatizacija ne samo da poboljšava operativnu efikasnost, već oslobađa ljudske resurse koji mogu da se fokusiraju na složenije zadatke. Chatbotovi i virtuelni asistenti sa veštačkom inteligencijom imaju mogućnost da ponude 24/7 korisničku podršku, efikasno rešavajući uobičajene upite i nedoumice. Chatbotovi su dovoljno dobri za obavljanje opštih zadataka, iako imaju ograničenu sposobnost u pogledu obrade i tumačenja prirodnog jezika, takođe pružaju menije za rešavanje najčešćih problema sa kojima se susreću potrošači dok rade po nižim operativnim troškovima [12].

Virtuelni asistenti sa AI mogu brzo da odgovore na uobičajene upite, ponude preporuke za proizvode i vode potrošače kroz proces kupovine. Poboljšana korisnička usluga dovodi do većeg zadovoljstva potrošača. Chatbotovi mogu da prikupljaju i analiziraju podatke o potrošačima, pružajući maloprodavcima dragocene uvide u preferencije potrošača. Ovim informacijama, maloprodavci mogu da podese svoje marketinške strategije, prilagode ponudu proizvoda i isporuče ciljane promocije, a sve to igra ključnu ulogu u poboljšanju njihove vidljivosti na mreži. Odlični su u pružanju personalizovane pomoći, odgovaranju na pitanja u vezi sa proizvodima i vođenju potrošača kroz proces kupovine. Rezultat je povišen nivo zadovoljstva potrošača i povećano zadržavanje potrošača.

AR i VR tehnologije su transformisale način na koji potrošači komuniciraju sa proizvodima, posebno u sektoru mode i lepote. Virtuelna iskustva isprobavanja omogućavaju kupcima da zamisle kako će odeća, dodaci ili šminka izgledati na njima pre kupovine, što smanjuje nesigurnost i oklevanje i dovodi do povećanja stope konverzije. Sephora koristi Color IQ skener lica kupca i daje personalizovane preporuke za nijanse pudera i korektora, dok Lip IQ čini isto kako bi pomogao u pronalaženju savršene nijanse karmina [7]. Nove tehnologije, IoT, AR/VR/MR, virtuelni asistenti, chatbotovi i roboti, imaće ogroman uticaj na korisničko iskustvo; pored ovih tehnologija, blockchain će značajno poboljšati transparentnost u celom lancu vrednosti kompanije, a 3D štampa ima moć da dramatično smanji vreme između kupovine i isporuke [13].

Sa rasprostranjenošću pametnih telefona, trgovci na malo imaju priliku da iskoriste mobilnu tehnologiju u svoju korist. Mobilne aplikacije mogu da služe kao digitalne kartice lojalnosti, nude ekskluzivne popuste i pružaju ažuriranja u realnom vremenu o promocijama. Zahvaljujući Internetu, moguće je efikasnije pratiti informacije potrošača kroz program lojalnosti prateći njihove kupovne navike i preferencije [14]. Integracija mobilne tehnologije sa iskustvom u prodajnom objektu povećava angažovanje potrošača i podstiče ponovne posete.

V. ZAKLJUČAK

Transformativni uticaj AIoT u lancu snabdevanja je dalekosežan. Osim smanjenja troškova, garantuje tačne isporuke proizvoda i optimalno stanje po dolasku. Ovo se odražava na povećano zadovoljstvo i lojalnost potrošača, stvarajući na taj način efikasniji i konkurentniji ekosistem lanca snabdevanja. Efikasnost u maloprodajnom sektoru je u velikoj meri zasnovana na modernizovanom lancu snabdevanja. Međutim, bilo kakvi poremećaji duž ovog vitalnog lanca mogu dovesti do neefikasnosti i velikih operativnih troškova. Prepoznajući ključnu ulogu dobro orkestriranog lanca snabdevanja, maloprodavci se sve više okreću inovativnim tehnološkim rešenjima. U dinamičnom okruženju maloprodajnog sektora, efikasno upravljanje energijom predstavlja ključnu brigu. Korišćenje potencijala AIoT može se revolucionisati način na koji se energija nadgleda i kontroliše u maloprodajnim objektima. Maloprodajna preduzeća moraju da prihvate ove nove tehnologije kako bi poboljšala angažovanje kupaca, obezbedila besprekorno iskustvo kupovine i optimizovala svoje poslovanje. Koristeći moć veštačke inteligencije AI, interneta stvari IoT, AR/VR i chatbot-ova, maloprodavci mogu da ostave svoju konkurenciju iza sebe i da se postave na čelo digitalne maloprodajne revolucije.

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Procjena osnovnih komponenti Sunčeve iradijacije na osnovu proizvodnje fotonaponske elektrane

Vasilisa Vlahović, Vladan Durković

***Sadržaj*—Prilikom projektovanja fotonaponskih elektrana jedan od najznačajnih koraka je procjena solarnog potencijala lokacije na kojoj je planirana fotonaponska elektrana. Tačnost i preciznost ulaznih meteoroloških podataka, a prije svega solarne insolacije, za manje fotonaponske elektrane predstavlja jedan od najbitnijih ulaznih podataka prilikom procjene tehno-ekonomskih indikatora ovakvih elektrana. Imajući u vidu da se prilikom projektovanja fotonaponskih elektrana u EPCG koriste komercijalni softveri čiji su ulazni podaci, uopšteno rečeno, satelitski ili rezultat numeričke ekstrapolacije, od značaja je utvrditi tačnost ovih dostupnih podataka u ovakvim softverima. U ovom radu je na primjeru jedne izvedene manje fotonaponske elektrane izvršena procjena osnovnih meteo podataka na osnovu satne proizvodnje elektrane koji su upoređeni sa podacima koji se dobijaju iz komercijalnih softvera. Urađena je i komparativna analiza koja pokazuje kako se ponašaju pojedine komponente Sunčevog zračenja u zavisnosti od izbora metode koja se koristi u proračunu. Predloženi metod je analitičkog tipa i izveden je pomoću osnovnih matematičkih operacija.**

I. Uvod

Sve veća potreba za energijom koja je nastala kao rezultat porasta broja stanovnika na Zemlji, životnog standarda i mobilnosti ljudske populacije, kao i konstantni porast cijene energenata doveli su do ubrzanog razvoja tehnologija obnovljivih izvora energije. Standardi savremenog društva, odgovornost prema društvu i čovjeku, ali i prema tehnološkom napretku civilizacije definisali su moderne izvore električne energije. Oni treba da ispunjavaju sledeće kriterijume: obnovljivost primarnog energenta, dostupnost, pouzdanost, ekološka prihvatljivost, rasprostranjenost, vrsta tehnologije, estetika, način rada, potencijal njegovog korišćenja i konkurentnost u cijeni [1]. S tim u vezi fotonaponske (FN) elektrane se mogu definisati kao najsavremeniji elektroenergetski izvor pa se poslednjih godina najbrži razvoj bilježi upravo na području solarne energije. Shodno svjetskim trendovima, u Crnoj Gori se od 2020. godine bilježi značajan porast upotrebe solarne energije u cilju dobijanja električne energije

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U zavisnosti od godišnjeg doba i atmosferskog stanja, intenzitet Sunčevog zračenja u Crnoj Gori u popodnevnim časovima varira od 200 W/m^2 do 1000 W/m^2. Crna Gora ima od 1500 do 2500 sunčanih sati godišnje, dok su južni i centralni dio države klimatski pogodni za aktivno korišćenje Sunčeve energije. Energija koja dospijeva na horizontalnu površinu od 1 m^2 se kreće od 1500 kWh/god do 1750kWh/god [2]. Vrijednost maksimalne solarne iradijacije na području Crne Gore iznosi 4.39 kWh/m^2/dan u oblasti oko Ulcinja, a najmanje 3.60 kWh/m^2/dan na sjeveru [3].

Strategija razvoja energetike u Crnoj Gori predviđa korišćenje obnovljivih izvora energije minimum u iznosu od 20% od ukupne potrošnje primarne energije u periodu od 2020. do 2025. godine [4].

Elektroprivreda Crne Gore energetsku tranziciju u sopstvenoj režiji zvanično pokreće otvaranjem projekta Solari 3000+ i 500+ koji predviđaju postavljanje FN elektrana na više od 3000 objekata u Crnoj ukupne instalisane snage oko 30 MWp. Ciljevi projekta su da korisnici u potpunosti ili djelimično zadovolje svoje potrebe za energijom kako bi rasteretili mrežu i u nekom momentu postali u velikom dijelu energetski nezavisni, ali i očuvanje životne sredine smanjivanjem emisija ugljen – dioksida. Projekat je pokrenut 2021. godine i podrazumijeva postavljanje FN elektrana na krovove individualnih objekata za stanovanje (snage do 10 kW) i poslovne objekte i javne ustanove (snage preko 10 kW) [5].

Ono što ovaj projekat donosi korisnicima jeste da oni dobijaju status kupca – proizvođača (engl. *prosumer*) koji potrebe za energijom podmiruju iz sopstvenog izvora, dok eventualni višak distribuiraju u mrežu, a manjak preuzimaju iz mreže. U slučaju da korisnici u posmatranom vremenskom trenutku troše električnu energiju u približno jednakoj količini koliko je i trenutna proizvodnja FN elektrane posledično se umanjuju i tehnički gubici u prenosnoj i distributivnoj mreži. Pored malih planira se izgradnja velikih FN elektrana na zemlji, u čijoj realizaciji značajnu prepreku predstavlja cijena zemljišta. Zbog toga se poseže izgradnji elektrana na pasivnim površinama kao što su krovovi, u našem slučaju, a intenzivno se sprovode analize proizvodnje plutajućih fotonaponskih elektrana na površinama kao što su rezervoari, vještačka jezera što može doprinijeti i smanjenju isparavanja vode [3].

U okviru projekta Solari 3000+ i 500+ do januara 2024.

instalirano je 3222 sistema, instalisane snage 34866.4 kWp. Stavljeno je u pogon 3091 sistema (25940 kW), dok je više od polovine instaliranih sistema otpočelo obračun razmjene energije u oba smjera. Planira se ugradnja sličnih sistema ukupne snage 70 MW u okviru projekta Solari 5000+. U radu je sprovedena analiza proizvodnje elektrane snage 8.8 kW (9kWp) koja je instalirana na jednoj lokaciji u Nikšiću u okviru projekta Solari 3000+.

Koristeći dostupne podatke za razmatranu elektranu, autori ovoga rada predlažu metod za procjenu komponenti Sunčevog zračenja. Na ovaj način dobijaju se poređenja Sunčeve iradijacije (na satnom nivou) i baza podataka koje koriste savremeni softveri za projektovanje FN elektrana. Na osnovu dobijenih podataka o Sunčevoj iradijaciji, projektovanje budućih FN elektrana bi moglo biti preciznije jer bi se pored baza podataka o Sunčevoj iradijaciji koju koriste komercijalni softveri, vršila korekcija sa stvarnim Sunčevim potencijalom dobijenim na osnovu proizvodnje postojećih FN elektrana. Bitno je istaći, da bi dodatnu korist imao i distributivni operator, a u bliskoj budućnosti i operator prenosnog sistema jer bi se moglo vršiti preciznije upravljanje i adekvatnije planiranje elektroenergetskog sistema.

II. Modelovanje FN elektrane i proračun meteo podataka

Nagibni i azimutni ugao FN modula u značajnoj mjeri utiču na proizvodnju električne energije dobijene iz FN elektrane. Karakteristika krovnih FN elektrana, koje pripadaju klasi fiksnih FN elektrana, je da su nagibni i azimutni ugao određeni samom konstrukcijom krova i položajem objekata na kojem se postavljaju FN moduli. Naime, pošto se FN moduli montiraju tako da su zanemarljivo odignuti od krova, smatra se da je nagibni ugao FN modula u odnosu na horizontalnu površinu jednak nagibnom uglu krova objekta, a azimutni ugao odgovara položaju dijela krova na kojem se postavljaju FN moduli.

Sunčevo zračenje koje dospijeva na površinu FN modula se sastoji od direktne, difuzione i reflektovane komponente. Direktno zračenje dospijeva pravolinjski od Sunca, dok difuziono zračenje, kao posledica oblaka dolazi iz raznih pravaca. Reflektovano zračenje, kako samo ime kazuje, dospijeva na FN modul kao posledica odbijanja prethodna dva navedena zračenja od površine zemlje ili drugih okolnih objekata. Sa aspekta modelovanja navedenih komponenti zračenja, direktno zračenje što zbog svoje fizičke karakterstike (pravolinijski dospijeva na FN modul) što zbog duboko utemeljene teorije o kretanju i položaju Sunca u odnosi na Zemlju je, sa aspekta preciznosti i tačnosti proračuna, najlakše modelovati. U [6] se može naći detaljan model direktne komponente Sunčevog zračenja. Za potrebe ovoga rada, ovdje su prikazane relacije koje su korišćene pri samom proračunu direktne komponente. Imajući u vidu da proizvodnja električne energije kao posledica direktnog Sunčevog zračenja zavisi od ugla pod kojim zračenje dolazi na površinu FN modula, u literaturi [6] je definisan incidentni ugao zračenja. Direktno Sunčevo zračenje koje pada na FN modul se može izračunati na sledeći način:

$$I_{BC} = I_B \cdot \cos\theta \tag{1}$$

gdje je I_{BC} direktno Sunčevo zračenje koje dospijeva na površinu FN modula, I_B je direktno Sunčevo zračenje na površini Zemlje i θ je incidentni ugao direktnog Sunčevog zračenja na FN modul.

Incidentni ugao čija vrijednost zavisi od položaja Sunca i položaja FN modula je data sledećom relacijom:

$$\theta = \arccos\left(\cos\beta \cdot \cos\left(\phi_{FN} - \phi_S\right)\sin\Sigma + \sin\beta \cdot \cos\Sigma\right) \tag{2}$$

gdje je β ugao visine Sunca, ϕ_s je azimutni ugao Sunca, ϕ_{FN} je azimutni ugao FN modula i Σ nagibni ugao FN modula. [6]

Na kraju, direktna horizontalna komponenta Sunčevog zračenja se može izračunati na sledeći način:

$$I_{BH} = I_{BC} \cdot \sin\beta \tag{3}$$

gdje je I_{BH} direktno Sunčevo zračenje koje dospijeva na horizontalnu površinu.

Postoji nekoliko modela proračuna difuzionog Sunčevog zračenja koji se mogu podijeliti na dvije klase, a to su: izotropski i anizotroski modeli. Izotropski modeli pretpostavljaju da Sunčevo zračenje dolazi jednakim intenzitetom iz svih pravaca, dok anizotropski modeli pretpostavlja da postoji neravnomjerna raspodjela Sunčevog zračenja na nebeskoj polusferi [7]. Postoji veliki broj radova na temu analize i poređenja ove dvije vrste Sunčevog zračenja. Ipak, imajući u vidu zastupljenost kao i njegov jednostavan matematički model, autori ovoga rada su prilikom procjene difuzione horizontalne komponente Sunčevog zračenja koristili izotropski model koji je opisan jednačinom (4).

$$I_{DH} = \left(0.095 + 0.04 \cdot \sin\left(\frac{360}{365}(n - 100)\right)\right) \cdot I_B \tag{4}$$

gdje je n redni broj dana u godini.

U zavisnosti od toga da li se koristi cilindrični ili sferni model za proračun difuzionog zračenja, veze između difuzione komponente Sunčevog zračenja koja pada na FN modul i difuzione horizontalne komponente su prikazane sledećim relacijama:

$$I_{DC} = I_{DH} \cdot \frac{1 + \cos\Sigma}{2} \tag{5}$$

$$I_{DC} = I_{DH} \cdot \frac{3 + \cos 2\Sigma}{4} \tag{6}$$

gdje je I_{DC} difuziono zračenje koje pada na FN modul, I_{DH} difuziona horizontalna komponenta Sunčevog zračenja.

Jednačina (5) se odnosi na cilindirčni model, dok se jednačina (6) odnosi na sferni model difuzionog zračenja [6].

Reflektovana komponenta Sunčeve iradijacije zavisi od mnoštva faktora kao što su: refleksione karakteristke podloge od koje se odbija Sunčevo zračenje, udaljenost i položaj okolnih objekata, karakterstike zemljane površine u okolini objekata [6]. U zavisnosti od navedenih parametara, reflektovana komponenta može uticati na proizvodnju FN elektrane velikih snaga i do 15%, dok kod FN elektrana manjih snaga, prema iskustvu autora, reflektovana komponenta ima zanemarljiv uticaj.

Imajući u vidu činjenicu da za proračun reflektovane komponente postoji široko prihvaćeni obrazac u slučaju sfernog modela difuzionog zračenja važi jednačina:

$$I_{RC} = \rho \cdot \left(I_{BH} + I_{DH} \right) \cdot \frac{1 - \cos 2\Sigma}{4} \tag{7}$$

gdje je I_{RC} reflektovana komponenta Sunčevog zračenja koja dospijeva na FN modul, a ρ je koeficijent refleksije površine.

Ukupno reflektovano zračenje koje pada na FN modul od površine tla kod cilindričnog modela difuzionog zračenja je prikazano formulom (8).

$$I_{RC} = \rho \cdot \left(I_{BH} + I_{DH} \right) \cdot \frac{1 - \cos \Sigma}{2} \tag{8}$$

Ukupna iradijacija kojom je ozračen FN modul predstavlja zbir direktne, difuzione i reflektovane komponente.

Nakon osnovnih matematičkih operacija i kombinovanjem prethodnih jednačina, na osnovu kvadratne jednačine (9) se može proračunati Sunčevo zračenje koje pada na FN modul na osnovu proizvodnje FN elektrane:

$$\alpha_p \cdot \frac{NOCT - 20}{0.8} \cdot I_c^{\,2} + \left(1 + \alpha_p \left(T_{amb} - 25°\right)\right) \cdot I_c - \frac{P_{AC}}{P_{DC} \cdot \eta_n \cdot \eta_z \cdot \eta_{inv}} = 0 \tag{9}$$

gdje je α_p koeficijent koji uvažava smanjenje snage FN modula zbog povećanja temperature modula u odnosu na 25 °C, *NOCT* je nominalna radna temperatura, P_{AC} je naizmjenična snaga FN elektrane, P_{DC} je nominalna jednosmjerna snaga FN elektrane, η_n koeficijent koji definiše smanjenje efikasnosti usled neuparenosti FN modula, η_z je koeficijent koji definiše smanjenje efikasnosti usled zaprljanja FN modula i η_{inv} je koeficijent koji definiše efikasnost invertora.

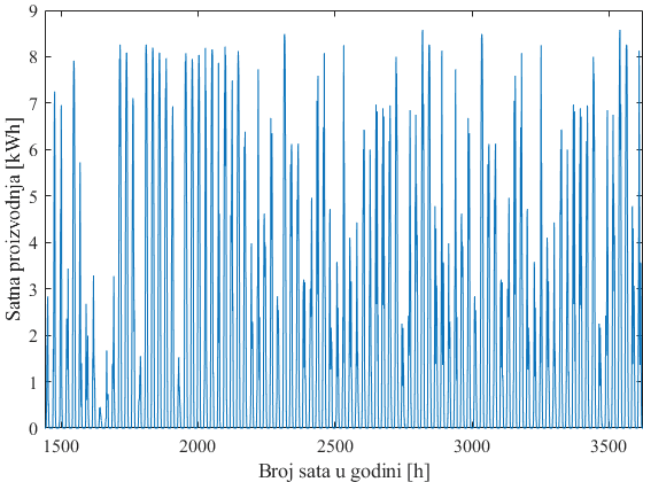
Ograničenja predloženog metoda za proračun iradijacije, koja dospijeva na FN module, poznata autorima, se odnose na starenje FN modula, lokalne temperaturne efekte, efekte zasjenčenja usled okolnih objekata i gubitke u DC i AC razvodu energije. Takođe, jasno je da bi uvažavanje krive efiksnosti invertora poboljšalo preciznost rezultata. Ipak, autori smatraju da navedeni efekti ne mogu bitno uticati na procijenjenu vrijednost iradijacije, a sa druge strane zahtijevali bi relativno dosta vremena u cilju tačne procjene njihovog uticaja na dati metod.

Nakon odabiranja korektnog rešenja kvadratne jednačine a imajući u vidu nazivnu efikasnost modula i koristeći jednačine (3) i (4) moguće je dobiti vrijednost za direktnu horizontalnu i difuzionu horizontalnu komponentu, a koje predstavljaju osnovne meteo podatke za proračun proizvodnje FN elektrane.

III. Rezultati i diskusija

U ovom poglavlju je, na osnovu jednačina (1) - (9) data procjena iradijacije koja pada na FN modul za konkretnu krovnu elektranu. Na jednoj lokaciji u opštini Nikšić geografske dužine 18°57'47.6"E i širine 42°46'45.7"N instalisana je FN elektrana DC snage 9 kWp koja se sastoji od 20 FN modula marke HC - Chaser maksimalne izlazne snage pri standardnim testnim uslovima (*STC – Standard Test Conditions*) po 450 Wp. Razmatrana elektrana je orijentisana južno sa azimutnim uglom od 0° (prema jugu) i nagibom od 30° u odnosu na horizontalnu površinu. Površina koju zauzima elektrana je 44.1 m^2. Korišćen je trofazni invertor marke Sofar Solar maksimalne izlazne snage na AC strani 8.8 kW sa jedničnim faktorom snage, a njegova nominalna efikasnost je 98.5 %.

FN ćelije od kojih su napravljeni moduli su monokristalne i korišćena je half–cell tehnologija za izradu istih. Temperatura FN modula je za 1.6°C niža od konvencionalnih modula što rezultira manjim gubicima snage. Nominalna radna temperatura (*NOCT – Nominal Operating Cell Temperature*) je 45°C, a temperaturni koeficijent za maksimalnu snagu FN modula je -0.36 %/°C. Kao izvor podataka za analizu korišćena je aplikacija SOLARMAN Business koja na osnovu veze između invertora i smart meter brojila daje informacije o proizvodnji elektrane, potrošnji objekta, kao i temperaturi ambijenta. Podaci se prikazuju u određenim vremenskim intervalima (najčešće 5 minuta), a za proizvodnju po satu uzeta je prosječna vrijednost vrijednosti koje registruje smart meter brojilo u toku jednog sata.



Slika 1. Satna proizvodnja razmatrane FN elektrane u toku marta, aprila i maja.

S obzirom na to da su autorima ovoga rada dostupni

podaci o proizvodnji FN elektrane za tri mjeseca (mart, april i maj) na slici 1 prikazana je proizvodnja razmatrane FN elektrane na osnovu kojih su dobijeni podaci o Sunčevom zračenju na datoj lokaciji.

Takođe, autorima rada su dostupna i satna mjerenja temperature koja zbog ograničenosti prostora nisu prikazana.

U cilju poređenja izvedenih mjerenja, u tabeli I su prikazani mjesečni podaci o iradijaciji koja dospijeva na FN module na osnovu prikazane metodologije i podaci o iradijaciji na osnovu PVGIS meteo baze [8]. Važno je napomenuti da je mjesečna iradijacija, predloženom metodologijom, dobijena na satnom nivou, ali u cilju što sažetijeg prikaza u radu su prikazani samo mjesečni podaci.

TABELA I

KOMPARATIVNO POREĐENJE PREDLOŽENOG MODELA ZA PRORAČUN IRADAIJACIJE I PVGIS-METEO BAZE

Mjesec	Predloženi model za procjenu iradijacije cilindirčni model [kWh/m^2]	Iradijacija prema PVGIS meteo baza [kWh/m^2]
Mart	128.699	122.982
April	133.175	149.218
Maj	156.780	165.512

Na osnovu tabele I se može zaključiti da je Sunčevo zračenje u toku mjeseca aprila i maja u 2023-oj godini bilo manje nego osunčanost koju procenjuje PVGIS-meteo baza, dok za mjesec mart važi obrnuta zakonitost. Razlog za odstupanje leži u činjenici da što je manji vremenski interval analiziran to je za očekivati veće odstupanje u procjeni iradijacije. Najveće odstupanje je bilo za mjesec april i to u iznosu od 12.05%

Drugim riječima, godišnja iradijacija koja bi se dobila predloženim metodom bi bila bliža iradijaciji koja se može naći u PVGIS i ostalim meteo bazama.

U tabeli II date su procijenjene vrijednosti direktne i difuzione horizontalne komponentne u slučaju cilindričnog modela, a u tabeli III za slučaj sfernog modela.

TABELA II

DIREKTNA I DIFUZIONA HORIZONTALNA IRADIJACIJA-CILINDRIČNI MODEL

Mjesec	Direktna horizontalna iradijacija [kWh/m^2]	Difuziona horizontalna iradijacija [kWh/m^2]
Mart	90.567	16.008
April	93.062	15.118
Maj	115.516	21.562

TABELA III

DIREKTNA I DIFUZIONA HORIZONTALNA IRADIJACIJA-SFERNI MODEL.

Mjesec	Direktna horizontalna iradijacija [kWh/m^2]	Difuziona horizontalna iradijacija [kWh/m^2]
Mart	91.058	16.023
April	93.641	15.244
Maj	116.333	22.266

Na osnovu tabela II i III može se zaključiti da sferni model daje nešto veće procjene za direktno i difuziono Sunčevo zračenje koje dospijeva na horizontalnu podlogu. Najveće odstupanje između dva modela je u toku mjeseca maja i to za difuzionu komponentu u iznosu od 3.26%. Takođe, na osnovu tabela II i III se jasno zaključuje da za razmatrane mjesece sferni model daje nešto veće vrijednosti analiziranih horizontalnih komponenti Sunčevog zračenja.

IV. ZAKLJUČAK

U radu je predložena metoda za procjenu osnovnih meteo podataka na osnovu satne proizvodnje FN elektrane. Predloženi metod je analitičkog tipa i izveden je pomoću osnovnih matematičkih operacija. Shodno tome, metod se dalje može unapređivati i samim time omogućava obuhvatanje fizičkih fenomena vezanih za proizvodnju električne energije iz FN elektrane, a koji nisu prikazani u ovome radu. U radu je pokazano da u procjeni horizontalnih komponenti direktnog i difuzionog Sunčevog zračenja ne utiče značajno, za razmatrane mjesece, da li se koristi sferni ili cilindrični model za proračun Sunčevog zračenja. Dalje unapređenje predloženog modela će biti zasnovano na detaljnijoj verifikaciji predloženog modela, a koristeći veći broj mjerenja dobijene električne energije iz FN elektrana instalisanih na različitim lokacijama.

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Softverski sistem rezervacije sala razvijen primenom State paterna

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Sadržaj—Ovaj rad se bavi primenom State paterna u razvoju softverskog sistema za rezervaciju sala. Rad je podeljen u tri dela. U prvom delu dato je teorijsko razmatranje softverskih paterna. U drugom delu je data analiza State paterna i mogućnosti njegove primene u razvoju softverskih sistema. U poslednjem delu je dat studijski primer razvoja softverskog sistema rezervacije sala primenom State paterna, kroz osvrt na arhitekturu sistema i njegove funkcionalnosti.

I. Uvod

Izazov sa kojim se savremeni softverski inženjeri susreću jeste pronalaženje balansa između toga da rešenje problema bude dovoljno specifično, a u isto vreme i dovoljno generičko kako bi se primenjivalo na slične probleme. *Softverski paterni* javili su se kao koncept koji omogućava projektovanje softverskih sistema na ispravan način. Ovaj pojam ne odnosi se samo na rešenje problema u programiranju, već istovremeno predstavlja i ideju i apstraktni koncept koji korisnici mogu da primene na način specifičan za odgovarajući problem[10]. Prednost softverskih paterna kao koncepta jeste što predstavljaju rešenje na takav način da se može primeniti nebrojeno njegovih varijacija, a da se među njima nikada ne nađu dva ista [1].

Glavni zahtev savremenih korisnika softverskih sistema je velika kompleksnost sistema, uz istovremenu mogućnost obrade velikog broja korisničkih zahteva u realnom vremenu. Za softverske inženjere to podrazumeva razvoj softverskog sistema koji je istovremeno *fleksibilan*, *pouzdan* i *održiv*. Jedan od glavnih pokazatelja kvaliteta softverskog sistema je njegova održivost. Održivost predstavlja karakteristiku sistema da funkcioniše i nakon nastanka greške u sistemu i ova osobina je direktno povezana sa troškovima nadogradnje i održavanja sistema [7]. Softverski paterni i održivost softverskih sistema rezultovali su rastom i razvojem softvera bez značajnih promena strukture i ponašanja, a istovremenim dodavanjem novih funckionalnosti [6].

Jedna od glavnih karakteristika koja narušava održivost softverskih sistema je rigidnost. Rigidnost predstavlja osobinu softverskog sistema koja podrazumeva da je sistem teško promeniti, čak i na jednostavne načine. U ovom slučaju svaka promena sistema dovodi do eksponencijalnog rasta budućih promena. Usled ovakvog ponašanja sistema softverski inženjeri izbegavaju promene sistema i dodavanje novih funkcionalnosti, a samim tim se rast i razvoj softverskog sistema usporava [8].

Nastavak naučno-istraživačkog rada organizovan je kroz sledeća poglavlja. Drugo poglavlje predstavlja teorijski osvrt na koncept softverskih paterna. U okviru ovog poglavlja date su neke od ključnih definicija paterna, kao i prikaz GOF paterna projektovanja. Treće poglavlje detaljno se bavi analizom jednog od paterna ponašanja - State paternom. U četvrtom poglavlju prikazan je korisnički zahtev i njegovo rešenje primenom State paterna u okviru koga je kreiran softverski sistem rezervacije sala za ispite. Poslednje poglavlje predstavlja zaključak ovog naučno-istraživačkog rada i razmatra buduće pravce istraživanja.

II. Primena State paterna u praksi

State patern predstavlja koncept koji je usko povezan i nadopunjuje se sa pojmom konačnih automata. Konačan automat predstavlja računarsku mašinu koja je u tačno jednom stanju u bilo kom trenutku i koja definiše promenu stanja u odnosu na neki određeni ulaz (uglavnom događaj). S obzirom da State patern sam po sebi enkapsulira ponašanje aplikacije u zavisnosti od njenog stanja, iz ugla softverskih sistema konačni automati zaduženi su za definisanje načina tranzicije između stanja, dok State patern pruža specifikaciju ponašanja u odnosu na to u kom stanju se softverski sistem nalazi. [12]

Veliku primenu State patern pronalazi u razvoju video igara. Video igre same po sebi obuhvataju veliki broj stanja u kojima igrač može da se nađe. Zadatak State patern u njihovoj razvoju jeste povezivanje svakog od stanja igrača sa određenom animacijom ili ponašanjem na takav način da se kod ne usložnjava u većoj meri nego što je potrebno. [13]

III. Softverski paterni

Koncept softverskog paterna može se istovremeno vezati i za problem, ali i za rešenje [11]. Ne postoji jedinstvena definicija paterna, već mnoštvo njih. Svaka definicija pojam paterna objašnjava iz drugačijeg ugla, i za svaku se može reći da je u potpunosti tačna.

Aleksander Kristofer je za paterne rekao: „Svaki patern je

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trodelno pravilo koje uspostavlja relaciju između nekog problema, njegovog rešenja i njihovog konteksta. Patern je u isto vreme i stvar, koja se dešava u stvarnosti, i pravilo koje govori kada i kako se kreira navedena stvar.“ [2]

Gabriel je ovu definiciju paterna upotpunio na sledeći način: „Svaki patern je trodelno pravilo, koje uspostavlja relaciju između nekog konteksta, nekog sistema sila koji se ponavljaju u tom kontekstu (problem) i softverske konfiguracije koja omogućava tim silama da uspostave odgovarajuće odnose (rešenje).“ [5]

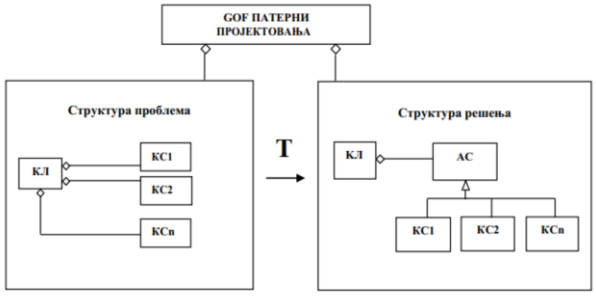
Osvrćući se na to da paterni zapravo proističu iz određenih rešenja konkretnog problema, koje zatim generalizujemo kako bi ih opet koristili, na ovo se nadovezuje definicija Rihla i Culigovena: „Patern predstavlja apstrakciju konkretnog oblika koja se može ponovo koristiti u specifičnim kontekstima.“ [9]

Kako bi dočarao svestranost i sveobuhvatnost pojma paterna, kao i razne aspekte njegove primene, Koplin patern definiše na sledeći način: „Patern je pravilo za građenje stvari, ali je ono istovremeno i sama stvar.“ [11]

Ideja paterna jeste olakšavanje rešavanja problema, gde bi se pojavom sličnih problema proces njihovog rešavanja značajno ubrzao. Sa ove tačke gledišta, uloga paterna prilikom kreiranja i održavanja softvera jeste upravo to – prevazilaženje problema i ubrzavanje i pojednostavljivanje rada programa. Primena softverskih paterna usložnjava sam proces njihove implementacije i kreira višu logiku sistema, ali rezultati i logika izvršavanja programa postaju mnogo bolji. Uloga paterna jeste da sva mesta u programu gde može doći do nepotrebnog nagomilavanja koda usled pristizanja novih klijentskih zahteva („bifurkacione tačke“) njihovom primenom uvedu odgovarajuću apstrakciju i na taj način odvoje implementacije. [11]

S obzirom da softverski sistemi predstavljaju modele realnih sistema, u okviru primene paterna za smanjivanje složenosti može se osvrnuti i na određene prirodne pojave. Ako se posmatra usložnjavanje sistema zbog pristizanja velikog broja novih korisničkih zahteva, ova situacija može dovesti do stvaranja „špageti koda“ i kolapsa samog programa, što se može poistovetiti sa apsolutnim haosom u realnom svetu. Takođe, ukoliko bi program bio previše jednostavan i nezavisan od korisničkih zahteva, u tom slučaju teško da bi zadovoljavao potrebe samih korisnika i da bi verodostojno preslikavao realni sistem. Ta monotonost i nezavisnost od problema mogla bi se predstaviti pojmom apsolutnog reda. Svaki čovek i realni sistem teže tome da se konstantno kreću između ova dva pojma – apsolutnog reda i apsolutnog haosa. U određenim momentima preovlađuje težnja ka haosu, a zatim se teži uspostavljanju reda, i obrnuto. Ova teorija se analogno može primeniti i na softverske sisteme, a ovo egzistiranje između reda i haosa omogućeno je upravo primenom softverskih paterna. [11]

Osnivači koncepta softverskih paterna otkrili su 23 paterna projektovanja softvera koji se na osnovu tipa problema koji rešavaju grupišu u tri celine: kreacioni paterni, strukturni paterni i paterni ponašanja. Uočeno je da se kod 20, od tih 23 paterna, može primeniti jedna struktura koja postoji kod svakog od tih paterna. Ta struktura u potpunosti opisuje patern ili neki njegov deo i predstavlja ključni mehanizam GOF paterna projektovanja. Na slici ispod prikazan je **opšti oblik GOF paterna projektovanja.**



Slika 1. Opšti oblik GOF paterna projektovanja

Strukturu problema čini uređena dvojka (*Klijent, Konkretni server*) koja je definisana na sledeći način: [11]

1. *Klijent* – element strukture koji koristi funkcionalnosti konkretnog servera kako bi mogao da obavi sopstvenu funkcionalnost
2. *Konkretni server* – element strukture paterna koji klijentu daje konkretnu funkcionalnost

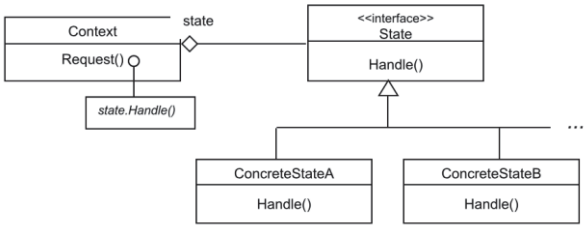
Strukturu rešenja čini uređena trojka *(Klijent, Apstraktni server, Konkretni server*) definisana na sledeći način: [11]

1. *Klijent* – element strukture paterna koji koristi funkcionalnosti apstraktnog i konkretnog servera kako bi obavio sopstvenu funkcionalnost
2. *Konkretni server* – element strukture paterna koji klijentu obezbeđuje konkretnu funkcionalnost
3. *Apstraktni server* – element strukture paterna koji obezbeđuje apstraktnu funkcionalnost

Transformacijom strukture problema u strukturu rešenja dobijamo softverski sistem koji je stabilan, održiv i imun na promene.

IV. STATE PATERN

Po definiciji, ***State patern*** dopušta objektu da promeni ponašanje kada se menja njegovo interno stanje [4]. Osnovna ideja je da program u svakom trenutku može biti u ograničenom broju stanja. U svakom od tih jedinstvenih stanja, program se ponaša na specifičan način, a prelazak iz jednog stanja u drugo može se odviti momentalno. Ipak, u zavisnosti od trenutnog stanja, program može ili ne mora preći u određena druga stanja. Pravila ovih prelazaka (tranzicije) su takođe ograničena i unapred definisana [3].



Slika 2. Struktura State paterna

U okviru dijagrama klasa strukture State paterna uočavamo sledeće učesnike: *Context*, *State* i *ConcreteState,* kojih može biti više u zavisnosti od broja stanja. Context ima referencu na interfejs State, koji dalje definiše trenutno stanje objekta Context. Ovo omogućava dinamičku promenu ponašanja programa u skladu sa stanjem. Sa druge strane, State predstavlja interfejs koji definiše ponašanje objekta Context, a koje se menja u zavisnosti od stanja objekta. Ovaj deo paterna omogućava apstrakciju specifičnosti pojedinih stanja, čime se olakšava proširivanje sistema novim stanjima. ConcreteState potklase implementiraju State interfejs i daju rešenja za konkretna ponašanja, prilagođena određenim stanjima objekta Context. [11]

V. PRIMENA STATE PATERNA U RAZVOJU SOFTVERSKOG SISTEMA ZA REZERVACIJU SALA

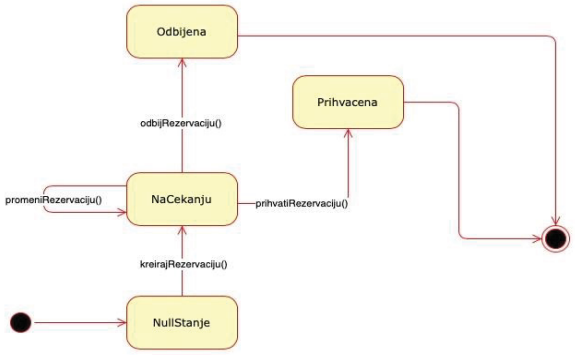
A. *Opis softverskog sistema*

Praktični aspekt ovog naučno-istraživačkog rada odnosi se na razvoj softverskog sistema za upravljanje rezervacijama sala za ispite, razvijen u Java programskom jeziku. Funkcionalnosti sistema su jednostavne i fokusiraju se na manipulaciju stanjima rezervacija. Cilj je da se prikaže primena State paterna u praksi, odnosno na konkretnom korisničkom zahtevu.

B. *Korisnički zahtev*

Omogućiti da rezervacija sale (ukoliko postoji) bude u tri moguća stanja: Prihvaćena, Odbijena i Na čekanju. Ukoliko je rezervacija na čekanju ona se može promeniti, prihvatiti i odbiti. Ukoliko je rezervacija prihvaćena ona se ne može promeniti, vratiti u stanje čekanja niti se odbiti. Ukoliko je rezervacija odbijena ona se ne može promeniti, vratiti u stanje čekanja niti se prihvatiti. Ukoliko rezervacija ne postoji, ona se nalazi u Null stanju. Null stanje onemogućava da se izvode operacije prihvati, odbij i stavi na čekanje nad nepostojećom rezervacijom. Zahtev uraditi korišćenjem State paterna.

S obzirom da se State patern bavi manipulacijom stanja objekta, u nastavku je prikazan je dijagram prelaza stanja za navedeni korisnički zahtev.



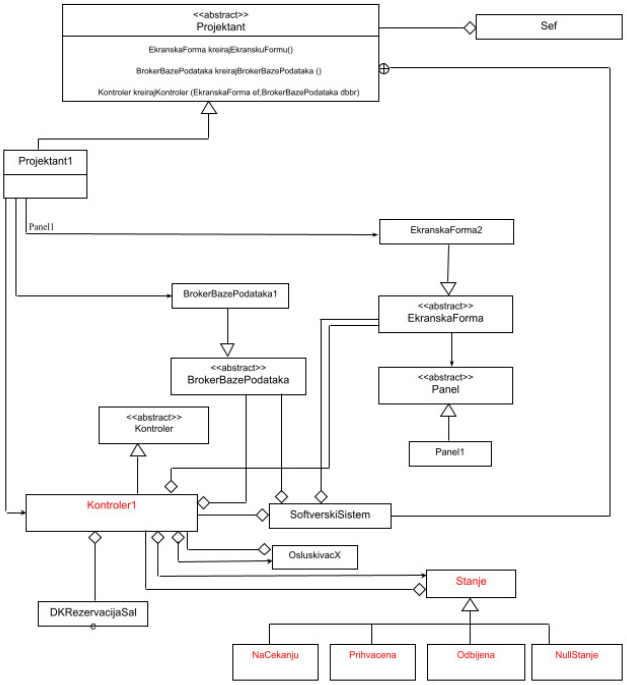
Slika 3. Dijagram prelaska stanja softverskog sistema

Na prikazanom dijagramu prelaska stanja može se, pored stanja navedenih u korisničkom zahtevu, uočiti i niz operacija primenjenih na stanja kako bi se izvršili prelasci.

Date operacije koje se mogu uočiti su sledeće:

1. kreirajRezervaciju() - prevodi rezervaciju sale iz Null stanja u stanje NaCekanju
2. prihvatiRezervaciju() - prevodi rezervaciju sale iz stanja NaCekanju u stanje Prihvacena
3. odbijRezervaciju() - prevodi rezervaciju iz stanja NaCekanju u stanje Odbijena
4. promeniRezervaciju() - dozvoljava izmenu rezervacije ukoliko je njeno stanje NaCekanju

Svako od navedenih stanja koja su opisana ima logiku gorenavedenih operacija, međutim u projektovanju softverskog sistema željeno ponašanje se postiže uz pomoć jedinstvenog interfejsa i metode, koja će implementirati različito ponašanje u zavisnosti od trenutnog stanja rezervacije sale.



Slika 4. Struktura softverskog sistema rezervacije sala

Na dijagramu klasa za navedeni korisnički zahtev fokusiraćemo se na deo gde je primenjen State patern. U nastavku je prikazana veza između elemenata strukture rešenja State paterna i specifičnih potreba našeg korisničkog zahteva.

Klasa Kontroler1 predstavlja Context unutar State paterna. Ona je ključna za integraciju komponenti sistema, jer omogućava povezivanje dugmadi na ekranskim formama sa

odgovarajućim osluškivačima događaja, kao i određivanje trenutnog stanja rezervacije sale.

Centralnu ulogu u ovom obrascu ima apstraktna klasa Stanje, koja predstavlja State. Ova apstraktna klasa definiše osnovne metode koje se moraju implementirati u konkretnim stanjima.

Klase Prihvacena, Odbijena, NaCekanju i NullStanje su ConcreteState. Svaka od ovih klasa nasleđuje apstraktnu klasu Stanje i implementira njene metode na specifičan način, prilagođen svakom pojedinačnom stanju.

Ukoliko bi se ovaj problem rešavao na tradicionalan način, bez primene State paterna, dijagram strukture rešenja ovog problema ne bi raspoznavao Stanje. Kontroler bi u tom slučaju bio jedini nosilac logike promene stanja koja bi morala da bude obrađena kroz neku od struktura grananja (if-else ili switch metoda). Na taj način bi pojava novih stanja vodila do eksponencijalnog usložnjavanja koda, čime bi se stvorio „špageti kod“. State patern izbegava ovaj problem uvođenjem novih klasa za svako od stanja, dok se kod unutar kontrolera ponaša uniformno bez obzira na broj postojećih stanja.

Ovako strukturiran dijagram klasa uz primenu paterna efikasno prikazuje kako se State patern može primeniti u realnim scenarijima, pružajući fleksibilnost u upravljanju različitim stanjima unutar sistema.

VI. Zaključak

Softverski paterni predstavljaju oblast iz koje neprestano mogu da se crpe nova znanja. Koliko god softverske tehnologije konstantno i brzo napredovale, softverski paterni predstavljaju osnovu koja se može koristiti nezavisno od programskog jezika ili dinamike razvoja softverskih tehnologija. Primena paterna i kreiranje odgovarajuće strukture softverskog sistema predstavlja umetnost i daje određeni nivo slobode softverskom inženjeru da odluči koji patern i na koji način će primeniti.

State patern predstavlja elegantan i održiv način za postizanje varijabilnosti u ponašanju samih komponenti sistema u zavisnosti od toga u kom stanju se nalaze. Primena ovog paterna omogućava povećanje održivosti o kojoj je bilo govora u uvodnom poglavlju, a takođe i olakšava dodavanje novih funkcionalnosti u razvijeni softverski sistem, ukoliko za to bude potrebe u budućnosti.

Budući pravci daljeg naučno-istraživačkog rada u ovoj oblasti na kojima će biti fokus jesu istraživanje primene State paterna u drugim programskim jezicima, zatim istraživanje primene ostalih softverskih paterna u razvoju softverskih sistema u Java programskom jeziku, a zatim i komparativna analiza kako bi se došlo do zaključaka kada i u kojim situacijama u aktuelnim problemima projektovanja softverskih sistema treba iskoristiti koji patern.

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Standardi i standardizacija u oblasti vještačke inteligencije

Ivana Vlahović, Zoran Glomazić

***Sadržaj*— Ovoj rad prikazuje kratku analizu i pregled stanja standardizacije u oblasti vještačke inteligencije, koja je pokrenula veliki broj izazova, ne samo tehničkih, pa i oblasti stadarda i standardizacije. U radu će biti prikazan presjek standarda i standardizacije iz ove oblasti tj. biće predstavljena stručna tijela na međuarodnom i evropskom nivou koja su sa svojim ekspertima koji ih čine učestvovala u izradi međunarodnih kao i evropskih standarda. Takođe, predstaviće se pravci razvoja standardizacije na nacionalnom nivou koja će pratiti evropsku i međunarodnu standardizaciju tj. standardi na nacionalnom nivou će se publikovati preuzimanjem referentnih evropskih/međunarodnih standarda koje su prethodno publikovale evropske/međunarodne organizacije za standardizaciju (CEN i CENELEC na evropskom kao i ISO i IEC na međuarodnom nivou.**

I. UVOD

Standardizacija je skup koordiniranih aktivnosti na donošenju standarda i srodnih dokumenata. Standard je tehnička specifikacija koju je donijelo priznato tijelo za standardizaciju za višekratnu ili stalnu upotrebu sa kojom usaglašenost proizvoda, procesa i usluga nije obavezna.Standardizacija se razvija u svim pravcima kroz publikovanje standarda na evropskom i međunarodnom nivou. Jedna od oblasti koja će biti obrađena u ovom radu je oblast vještačke inteligencije.

Rad je koncipiran tako da ima 4 poglavlja. Nakon uvoda slijedi predstavljanje stručnih tijela i standarda iz oblasti vještačke inteligencije na međunarodnom nivou koje su osnovale IEC – Međunarodna elektrotehnička komisija i ISO - Međunarodna organizacija za standardizaciju (to je zajedničko stručno tijelo ISO/IEC JTC 1/SC 42), zatim standarda u čijoj su izradi učestvovali eksperti koji čine stručno tijelo CEN/CLC/JTC 21 koje su osnovale evropske organizacije za standardizaciju i to Evropski komitet za standardizaciju (CEN) i Evropski komitet za standardizaciju u oblasti elektrotehnike (CENELEC). Eksperti su učestvovali u izradi ovih standarda u svim fazama razvoja kao i u završnoj fazi tj. fazi publikovanja standarda. Nakon objavljivanja standarda na međunarodnom i evropskom nivou slijedi i preuzimanje evropskih standarda na nacionalnom nivou shodno internim pravilima o standardizaciji.

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II. STANDARDIZACIJA U OBLASTI VJEŠTAČKE INTELIGENCIJE NA MEĐUNARODNOM NIVOU

Tehnički komitet za standardizaciju veštačke inteligencije nastao je u okviru zajedničke inicijative međunarodnih organizacija za standardizaciju IEC i ISO - ISO/IEC JTC 1/SC 42. ISO i IEC zajednički komitieti pokrivaju širok spektar oblasti za standardizaciju. Tehnički komitet JTC 1 radi na izradi standarda u oblasti informacionih tehnologija, dok se potkomitet ISO/IEC JTC 1/SC 42 (subcommittee 42) bavi isključivo radom na izradi i publikovanju standarda iz oblasti vještačke inteligencije. Predmet i područje rada ovod stručnog tijela je publikovanje međunarodnih standarda u oblasti veštačke inteligencije. Fokus rada ovog stručnog tijela jeste u predlaganju plana i prograa rada standardizacije stručnom tijelu ISO/IEC/JTC 1 za oblast veštačke inteligencije.Takođe, i pružanje uputstava ekspertima ISO/IEC/JTC 1 kao i IEC i ISO komitetima koji razvijaju aplikacije za vještačku inteligenciju je područje rada stručnog tijela ISO/IEC JTC 1/SC 42.

Program rada i broj zainteresovanih strana ovog stručnog tijela je u porastu. Kad su u pitanju tekući projekti , njihov broj je oko 31 aktivan, sa 22 objavljena IEC standarda. Ukupan broj zemalja koje prate ovo stručno tijelo i učestvuju u u izradi međunarodnih standarda iz oblasti vještačke inteligencije je oko 56 sa tendencijom stalnog porasta, kao i sa oko 250 delegata koji su prisutni na plenarnim zasijedanjima.

Tehnički komitet za standardizaciju veštačke inteligencije je struktiuran na sljedeći način:

- Osnovni standardi
- Podaci
- Pouzdanost
- Slučajevi korišćenja i aplikacije
- Računski pristupi i računski karakteristike AI sistema
- Testiranje sistema koji rade na bazi na AI
- Zdravstvena informatika koja radi na bazi AI
- Veza sa SC 27

U sljedećoj tabeli dat je prikaz standarda u čijoj su izradi učestvovali eksperti iz stručnog tijela ISO/IEC JTC 1/SC 42:

TABELA I - SPISAK ISO/IEC PUBLIKACIJA IZ AI

Referentna oznaka međunarodnog IEC standarda	Naslov međunarodnog standarda na crnogorskom jeziku - predlog
ISO/IEC TS 4213:2022	Informacione tehnologije – Vještačka inteligencija (AI) – Ocjenjivanje performansi klasifikacije mašinskog učenja
ISO/IEC 5338:2023	Informacione tehnologije – Vještačka inteligencija (AI) – Procesi životnog ciklusa sistema veštačke inteligencije
ISO/IEC 8183:2023	Informacione tehnologije – Vještačka inteligencija – Okvir životnog ciklusa podataka
ISO/IEC 20546:2019	Informacione tehnologije – Veliki podaci – Pregled i rječnik
ISO/IEC TR 20547-1:2020	Informacione tehnologije – Referentna arhitektura velikih podataka – Dio 1: Okvir i proces primjene
ISO/IEC TR 20547-2:2018	Informacione tehnologije – Referentna arhitektura velikih podataka – Dio 2: Slučajevi korišćenja i izvedeni zahtjevi
ISO/IEC 20547-3:2020	Informacione tehnologije – Referentna arhitektura velikih podataka – Dio 3: Referentna arhitektura
ISO/IEC TR 20547-5:2018	Informacione tehnologije – Referentna arhitektura velikih podataka – Dio 5: Mapa puta standarda
ISO/IEC 22989:2022	Informacione tehnologije – Vještačka inteligencija – Koncepti i terminologija vještačke inteligencije
ISO/IEC 23053:2022	Okvir za sisteme vještačke inteligencije (AI) koji koriste mašinsko učenje (ML)
ISO/IEC 23894:2023	Informacione tehnologije – Vještačka inteligencija – Uputstvo za menadžment rizikom
ISO/IEC TR 24027:2021	Informacione tehnologije – Vještačka inteligencija (AI) – Pristrasnost u sistemima AI i donošenje odluka pomognuto AI-jem
ISO/IEC TR 24028:2020	Informacione tehnologije – Vještačka inteligencija (AI) – Pregled pouzdanosti u vještačkoj inteligenciji
ISO/IEC TR 24029-1:2021	Vještačka inteligencija (AI) – Ocjenjivanje robusnosti neuronskih mreža – Dio 1: Pregled
ISO/IEC 24029-2:2023	Vještačka inteligencija (AI) – Procjena robusnosti neuronskih mreža - Dio 2: Metodologija za korišćenje formalnih metoda
ISO/IEC TR 24030:2021	Informacione tehnologije – Vještačka inteligencija (AI) – Slučajevi korišćenja
ISO/IEC TR 24368:2022	Informacione tehnologije – Vještačka inteligencija – Pregled etičkih i društvenih problema
ISO/IEC TR 24372:2021	Informacione tehnologije – Vještačka inteligencija (AI) – Pregled računskih pristupa za sisteme AI
ISO/IEC 24668:2022	Informacione tehnologije – Vještačka inteligencija – Okvir upravljanja procesima za analitiku velikih podataka
ISO/IEC 25059:2023	Softverski inženjering – Zahtjevi i evaluacija kvaliteta sistema i softvera (SKuaRE) – Model kvaliteta za sisteme vještačke inteligencije
ISO/IEC 38507:2022	Informacione tehnologije – Upravljanje IT – Implikacije korišćenja vještačke inteligencije na upravljanje organizacija
ISO/IEC 42001:2023	Informacione tehnologije - Vještačka inteligencija - Sistem upravljanja

Sistemi vještačke inteligencije kao što su mašinsko učenje, obrada prirodnog jezika, prepoznavanje govora i pronalaženje informacija koriste kombinaciju tradicionalnih softverskih elemenata kao što su kod i baze podataka, kao i onih specifičnih za AI. U mašinskom učenju, na primjer, dio sistema se definiše obučavanjem na podacima za razliku od direktnog unosa koda. Podaci se takođe mijenjaju tokom vremena tako da će možda biti potrebna ponovna obuka na sistemu.

Međunarodni IEC standardi za ove procese mogu da obezbijede snažnu platformu na kojoj programeri i korisnici mogu da komuniciraju, čime se poboljšava razumijevanje i performanse i smanjuju troškovi.

Jedan od veoma važnih standarda u tom kontekstu, u čijoj izradi su učestvovali eksperti iz pomenutog stručnog tijela za standardizaciju u oblasti vještačke inteligencije, je standard ISO/IEC 5338. ISO/IEC 5338 je međunarodni standard u kome se opisuje životni ciklus sistema veštačke inteligencije koji uzima u obzir specifične karakteristike vještačke inteligencije. To će pomoći da se poboljša razumijevanje funkcija i performansi AI sistema tokom razvoja i promoviše međusobno razumijevanje između programera i korisnika AI sistema.

Standard ISO/IEC 5338 definiše skup procesa i odgovarajuću terminologiju za opisivanje životnog ciklusa AI sistema. ISO/IEC 5388 pokriva sve, od ključnih koncepata do upravljanja rizikom, potrebu zainteresovanih strana, verifikaciju, održavanja i kao takav se ističe kao jedan od najbitnijih standarda iz oblasti standardizacije AI.

Ovaj standard uključuje zapažanja procesa zasnovanih na slučajevima upotrebe koji se nalaze u IEC tehničkom izvještaju ISO/IEC TR 24030 kako bi se identifikovali aspekti specifični za AI.

Važnost standarda ISO/IEC 5338 je suštinski u tome što se proširuje na trenutno uspostavljene i široko korišćene procese životnog ciklusa za tradicionalni softver tako da sistemi veštačke inteligencije takođe mogu imati koristi. Ovaj standard omogućava programerima da se neprestano poboljšavaju, što rezultira sve efikasnijim i efikasnijim proizvodima vještačke inteligencije i uliva veće povjerenje korisnicima.

ISO/IEC 5338 standard uspostavlja procese životnog ciklusa AI sistema, a imati zajednički jezik i okvir je ključ za obezbjeđivanje odgovornog dizajna, razvoja i usvajanja AI." Međunarodno stručno tijelo ISO/IEC/JTC 1/SC 42, kao što je već napomenuto, razvija međunarodne standarde za AI, sagledavajući tehnološke sposobnosti i netehničke zahjteve, kao što su poslovni, regulatorni i politički zahtjevi, potrebe domena aplikacije i etička i društvena pitanja.

Ovo međunarodno stručno tijelo organizuje redovne radionice o vještačkoj inteligenciji na kojima se raspravlja o novim trendovima, tehnologiji, zahtjevima i primjenama, kao i ulozi standarda. Oni okupljaju inovatore na granici razvoja veštačke inteligencije sa različitih lokacija i sektora.

U nastavku ovog dijela biće navedeni još neki značajni IEC standardi koji su nastali kao rezultat rada stručnog tijela

ISO/IEC/JTC 1/SC 42. ISO/IEC 23894:2023 pruža smjernice o tome kako organizacije koje razvijaju, proizvode, primjenjuju ili koriste proizvode, sistemi i usluge koji koriste vještačku inteligenciju (AI) mogu upravljati rizikom koji je posebno povezan sa AI. Smjernice takođe imaju za cilj da pomognu organizacijama da integrišu upravljanje rizikom u svoje aktivnosti vezane za vještačku inteligenciju i funkcije. Suštinski, ovaj standard opisuje procese za efikasni menadžment implementacijom i integracijom rizika vještačke inteligencije.

Zatim standard ISO/IEC TS 4213:2022 specificira metodologije za mjerenje performansi klasifikacije mašinskog učenja modela, sistema i algoritama, dok međunarodni tehnički izvještaj ISO/IEC TR 24368:2022 pruža informacije u vezi sa principima, procesima i metodama u AI oblasti i namijenjen je tehnolozima, regulatorima, interesnim grupama i društvu u cjelini, a nije namijenjen zagovaranju bilo kakvog specifičnog skupa vrijednosti (sistema vrijednosti).

ISO/IEC 22989:2022 uspostavlja terminologiju za AI i opisuje koncepte u oblasti AI. Ovaj standard može koristiti u razvoju drugih standarda i kao podršku komunikacijama među različitim zainteresovanim stranama. Ovaj dokument je primjenljiv na sve vrste organizacija (npr. komercijalna preduzeća, vladine agencije, neprofitne organizacije.

ISO/IEC 23053:2022 uspostavlja okvir za vještačku inteligenciju (AI) i mašinsko učenje (ML) opisujući generički sistem vještačke inteligencije koji koristi ML tehnologiju. Okvir opisuje komponente sistema i njihove funkcije u ekosistemu vještačke inteligencije. Ovaj dokument je primjenljiv na sve tipove i veličine organizacija, uključujući javna i privatna preduzeća, vladine subjekte i neprofitne organizacije, tj. implementiranje ili korišćenje AI sistema.

Još jedan u nizu važnih standarda koji se bavi problematikom AI je ISO/IEC 38507:2022. Ovaj standard pruža smjernice članovima upravnog tijela organizacije da omoguće i upravljaju korišćenje veštačke inteligencije (AI), kako bi se obezbijedila njena efikasna i prihvatljiva upotreba u okviru organizacija. Ovaj dokument takođe pruža smjernice široj zajednici, uključujući menadžere, eksterne poslovne ili tehničke stručnjake, kao što su pravni ili računovodstveni stručnjaci, maloprodajna ili industrijska udruženja, odnosno stručna tiela(javne vlasti i kreatori politike, interni i eksterni pružaoci usluga (uključujući konsultante) kao i procjenitelji i revizori.Ovaj standard je primjenljiv na bilo koju organizaciju, uključujući javna i privatna preduzeća, vladine subjekte i neprofitne organizacije kao i na organizaciju bilo koje veličine, bez obzira na njenu zavisnost od podataka ili informacionih tehnologija.

Tehnički izvještaj ISO/IEC TR 24372:2021 pruža pregled stanja tehnike računarskih pristupa za AI sisteme, opisujući: a) glavne računarske karakteristike AI sistema; b) glavne algoritme i pristupe koji se koriste u sistemima vještačke inteligencije, pozivajući se na slučajeve upotrebe sadržane u ISO/IEC TR 24030.

ISO/IEC TR 24027:2021 se bavi sklonostima u vezi sa sistemima vještačke inteligencije, posebno u pogledu donošenja odluka uz pomoć vještačke inteligencije. Sve faze životnog ciklusa AI sistema su opisane, uključujući, ali ne ograničavajući se na prikupljanje podataka, obuku, kontinuirano učenje, dizajn, testiranje, evaluaciju i upotrebu. ISO/IEC TR 24030:2021 pruža kolekciju reprezentativnih slučajeva upotrebe AI aplikacija u različitim domenima.

Zatim ISO/IEC TR 24029-1:2021 pruža pozadinu o postojećim metodama za procjenu robusnosti neuronskih mreža. Sledeći važni IEC dokument povezan sa područjem AI je ISO/IEC TR 24028:2020. Ovaj dokument istražuje teme vezane za pouzdanost u sistemima vještačke inteligencije, uključujući sljedeće: pristupe uspostavljanju povjerenja u sisteme vještačke inteligencije kroz transparentnost, mogućnost kontrole, itd., inženjerske zamke i tipične povezane prijetnje i rizike za AI sisteme, zajedno sa mogućim tehnikama i metodama ublažavanja, kao i i pristupe za procjenu i postizanje dostupnosti, otpornosti, pouzdanosti, tačnosti, bezbjednosti i privatnost AI sistema. Specifikacija nivoa pouzdanosti za AI sisteme je van opsega ovog dokumenta.

ISO/IEC 24668:2022, isto tako jedan od važnih međunarodnih standarda iz oblasti AI pruža okvir za razvoj procesa za efikasno korišćenje analitike velikih podataka u cijeloj organizaciji, bez obzira na industriju ili sektor. Ovaj dokument specificira upravljanje procesima za analitiku velikih podataka sa različitim kategorijama procesa uzetih u obzir uz njihovu međusobnu povezanost. Ove kategorije procesa su organizacija procesa zainteresovanih strana, procesi razvoja kompetencija, procesi upravljanja podacima, procesi analitike razvoja i procesi integracije tehnologije. Ovaj dokument opisuje procese za sticanje, opisivanje, čuvanje i obrađivanje podataka na nivou organizacije koji obezbjeđuje usluge analize velikog broja podataka.

ISO/IEC 20547-1:2020 - Serija ovih standarda je namijenjena da korisnicima pruži standardizovan pristup razvoju i implementaciji arhitekture velikih podataka i da pruži reference za pristupe. Ovaj dokument opisuje okvir referentne arhitekture velikih podataka i proces kako da korisnik dokumenta može da ga primjeni na svoj određeni problemski domen.

ISO/IEC 20547-3:2020 opisuje referentnu arhitekturu u smislu korisničkog i funkcionalnog pogleda. Referentna arhitektura predstavljena u ovom dokumentu pruža okvir arhitekture za opisivanje komponente, procesa i sistema velikog broja podataka za uspostavljanje zajedničkog jezika za različite zainteresovane strane imenovane kao referentna arhitektura velikog broja podataka (BDRA).

Takođe je važan IEC tehnički izvještaj ISO/IEC TR 20547-2:2018 koji daje primjere slučajeva korišćenja velikog broja podataka sa domenima aplikacija i tehničkim razmatranjima koja proizilaze iz slučajeva korišćenja. Napominjemo da su naslovi međunarodnih IEC standarda samo predlozi naslova standarda koji će u narednom periodu da se usvoje na nacionalnom nivou.

III. STANDARDIZACIJA U OBLASTI VJEŠTAČKE INTELIGENCIJE NA EVROPSKOM NIVOU I NACIONALNOM NIVOU

Kada je u pitanju standardizacija vještačke inteligencije na evropskom i nacionalnom nivou treba istaći da je broj dokumenata koje su objavile evropske organizanizacije za standardizaciju CEN i CENELEC mnogo manji u odnosu na broj koji su objavile međunarodne organizanizacije za standardizaciju ISO i IEC.

TABELA II - SPISAK EN PUBLIKACIJA IZ AI

Referentna oznaka evrpskog standarda	***Naslov evropskog standarda na engleskom jeziku***
CEN/CLC ISO/IEC/TR 24027:2023	Information technology - Artificial intelligence (AI) - Bias in AI systems and AI aided decision making (ISO/IEC TR 24027:2021)
CEN/CLC ISO/IEC/TR 24029-1:2023	Artificial Intelligence (AI) - Assessment of the robustness of neural networks - Part 1: Overview (ISO/IEC TR 24029-1:2021)
EN ISO/IEC 22989:2023	Information technology - Artificial intelligence - Artificial intelligence concepts and terminology (ISO/IEC 22989:2022)
EN ISO/IEC 23053:2023	Framework for Artificial Intelligence (AI) Systems Using Machine Learning (ML) (ISO/IEC 23053:2022)

U prethodnoj tabeli dat je prikaz evropskih standarda iz oblasti AI na kojima su radili eksperti koji su članovi stručnog tijela CEN/CENELEC/JTC 21, u svim fazama razvoja, od početne faze do faze publikovanja (60.60 – stage code za fazu publikovanja):

Kao što je već istaknuto, stručno tijelo CEN/CENELEC/JTC 21 predstavlja udruženo tijelo evropskih organizanizacija za standardizaciju CEN i CENELEC sa ciljem standardizacije u oblasti vještačke inteligencije na evropskom nivou. Ovo tijelo je pandan stručnom tijelu ISO/IEC/JTC 1/SC 42 koje su osnovale međunarodne organizanizacije za standardizaciju ISO i IEC takođe u cilju standardizacije područja vještačke inteligencije. CEN/CENELEC/JTC 21 se dakle bavi publikovanjem dokumenata u oblasti veštačke inteligencije (AI) na evropskom nivou, a u području rada takođe se navodi da će davati smjernice drugim tehničkim komitetima koji se bave veštačkom inteligencijom.

Ovo stručno tijelo će takođe razmotriti usvajanje relevantnih međunarodnih standarda i standarda od drugih relevantnih organizacija, kao što je ISO/IEC JTC 1 i njegovih podkomiteta, kao što je je ISO/IEC JTC 1/SC 42 koji se bavi oblašću vještačke inteligencije.

Što se tiče standardizacije na nacionalnom nivou, ISME će u narednom periodu da uzme u obzir i preuzimanje evropskih standarda i dokumenata na nacionalnom nivou koje je publikovalo stručno tijelo CEN/CENELEC/JTC 21 uz pomoć svojih eksperata. Usvajanje evropskih standarda na nacionalnom nivou ima prioritet gdje ta dokumenta u početku imaju status radnog nacrta(stage code 30.99), zatim se za njih organizuje javna rasprava za nacrte dokumenata (stage code 40.20) u trajanju od 60 dana. Po isteku javne rasprave nacrti prelaze u konačne nacte dokumenata, nakon čega dolazi do njihovog publikovanja (stage code 60.60) tj. dolazi do publikovanje crnogorskog standarda sa oznakom MEST.

Napominjemo da se proces usvajanja standarda na evropskom nivou od strane evropskih institucija za standardizaciju CEN i CENELEC vrši u najvećem dijelu preuzimanjem identičnih međunarodnih standarda koje su publikovale međunarodne organizacije za standardizaciju ISO i IEC. Konačni cilj rada ovog stručnog tijela u dijelu publikovanja evropskih standarda iz oblasti AI jeste zadovoljenje potreba evropskog tržišta i društva i prvenstveno podupiranja zakonodavstva, politike, principa i vrijednosti EU.

IV. ZAKLJUČAK

Ovaj rad je dao prikaz trenutnog stanja standarda i standardizacije na međunarodnom i evropskom nivou sa posebnim naglaskom na pravce razvoja standardizacije na nacionalnom nivou u cilju publikovanja i promovisanja važnosti standarda na nacionalnom nivou iz oblasti vještačke inteligencije kao relativno nove i vrlo značajne oblasti za budućnost. Aplikacije AI su nove i stalno se razvijaju, tako da je važno imati jasno razumijevanje konteksta, mogućnosti, procesa i uticaja koji imaju kako bi se efikasno i odgovorno razvijale, a u tome veliku ulogu igraju međunarodni, evropski i konačno nacionalni standardi. Što se daljeg razvoja ove oblasti tiče, u kontekstu standardizacije, vizija bi bila primjena budućih nacionalnih standarda iz oblasti AI od strane zainteresovanih strana nakon publikovanja istih na nacionalnom nivou.

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Uticaj SVC i SCC uređaja na tranzijentu stabilnost jednomašinskog sistema

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Sažetak- **Poremećaj tranzijentne stabilnosti je jedan od glavnih faktora koji može izazvati velike havarije elektroenergetskih sistema (EES). Samim tim, kako u nauci tako i u praksi izuzetno je važno procijeniti granice tranzijentne stabilnosti EES. Ovaj rad najprije predstavlja osnovne metode za procjenu tranzijentne stabilnosti EES, sa fokusom na metod za direktnu analizu - metod jednakih površina i metod za indirektnu analizu u koji spada metod numeričke integracije diferencijalnih jednačina kretanja rotora. Navedene metode za procjenu tranzijentne stabilnosti primijenjene su kod jednomašinskog sistema (JMS). Štaviše, testiran je i uticaj fleksibilnih sistema za prenos naizmjenične struje (FACTS), konkretno statičkih VAr kompezatora (SVC) i serijskih kapacitivnih kompezatora (SCC), na tranzijentnu stabilnost. Rezultati proračuna pokazali su da primjena navedenih FACTS komponenti može značajno doprinijeti poboljšanju tranzijentne stabilnosti EES.**

Ključne riječi - **SCC, SVC, tranzijentna stabilnost, metod jednakih površina, metod numeričke integracije**

I. Uvod

Stabilnost elektroenergetskog sistema je sposobnost sistema da ostane u uravnoteženom stanju tokom normalnog rada sistema i da vrati uravnotežene uslove rada u minimalnom mogućem vremenu nakon pojave poremećaja. Razlikuju se: stabilnost ugla rotora - sposobnost sinhronih mašina u EES da ostanu u sinhronizmu pod normalnim radnim uslovima i da povrate sinhronizam nakon što su izložene malom ili velikom poremećaju (ukoliko EES, podvrgnut velikim iznenadnim poremećajima uspije da održi sinhronizam kaže se da je sistem tranzijentno stabilan), naponsku stabilnost - odražava sposobnost EES-a da održi prihvatljive vrijednosti napona u svim čvorovima sistema, stabilnost frekvencije - sposobnost EES da održava frekvenciju u dozvoljenom opsegu nakon ozbiljnog poremećaja sistema koji rezultira značajnom neravnotežom između proizvodnje i opterećenja, stabilnost rezonance - rezonanca, uopšteno, nastaje kada se periodično odvija razmjena energije na oscilatoran način, ukoliko se ove oscilacije povećavaju u slučaju nedovoljnog rasipanja energije na putu protoka to se manifestuje povećanjem magnituda napona/struje/momenta (kada ove magnituda premaše određene pragove, kaže se da je došlo do nestabilnosti rezonance), stabilnost vođena pretvaračem - nova kategorija stabilnosti koja je uvedena da pokrije brze elektromagnetne tipove fenomena uzrokovane reakcijom energetske elektronike u EES na dinamičke fenomene i njihove povezane šeme upravljanja [1]. Ovaj rad se bavi tranzijentnom stabilnošću EES.

Prilikom velikih poremećaja u EES mogu se desiti velika njihanja rotora sinhrone mašine, kao i gubitak sinhronizma. Gubitak sinhronizma se razvija za nekoliko sekundi nakon početka poremećaja [2]. Uzroci potencijalnog narušavanja tranzijentne stabilnosti elektroenergetskog sistema uključuju kratki spoj, kao najčešći slučaj, ili iznenadno isključenje vodova ili generatora, itd.

Nelinearni karakter tranzijentne stabilnosti, njen uticaj na rad EES i na snadbijevanje potrošača električnom energijom govore o izuzetnom značaju proučavanja iste. Zbog svega prethodno navedenog problematika tranzijente stabilnosti i brza procjena iste predmet je analize u mnogim radovima [2], [4]. Uopšteno, metode za procjenu tranzijentne stabilnosti mogu se podijeliti na direktne: metod jednakih površina [5], i metod Ljapunova [6] i na indirektne: metod numeričke integracije koji se bazira na numeričkom rješavanju diferencijalne jednačine kretanja rotora. Prethodno pomenute metode - metod jednakih površina i metod numeričke integracije biće upotrijebljene za procjenu tranzijente stabilnosti jednomašinskog sistema u ovom radu.

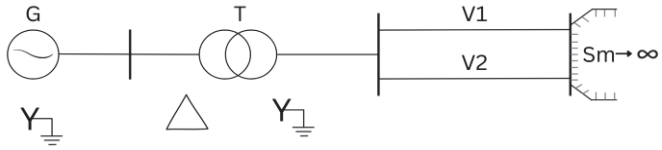
Primjena fleksibilnih AC sistemskih kontrolera je u poslednje vrijeme dobila značajno interesovanje kao sredstvo za poboljšanje dinamičkih performansi sistema [7], [8]. Postoje brojne klase kako paralelnih tako i serijskih FACTS kontrolera. Od paralelnih FACTS kontrolera najveću primjenu u praksi imaju SVC uređaji (*eng. Static VAr Compensator*) [9], dok od serijskih se najviše koristi SCC (*eng. Series Capacitive Compensation*) [10]. U ovom radu opisaće se primjena oba pomenuta FACTS kontrolera za ispitivanje tranzijentne stabilnosti EES.

Ovaj rad sastoji se od pet poglavlja. Nakon uvoda, u drugom i trećem poglavlju dat je opis metoda jednakih površina i metoda numeričke integracije za analizu tranzijentne stabilnosti jednomašinskog sistema respektivno. U četvrtom poglavlju opisan je uticaj SVC i SCC uređaja na tranzijentnu stabilnost EES. Rezultati implementacije prikazani su u petom poglavlju. Na kraju rada dat je zaključak sa smjernicama budućih istraživanja.

II. METOD JEDNAKIH POVRŠINA

Metod jednakih površina je metod koji se bazira na grafičkoj interpretaciji kinetičke energije obrtnih masa generatora i pogonske mašine na dijagramu zavisnosti aktivne snage koju generator isporučuje mreži P_e u funkciji ugla rotora sinhrone mašine δ.

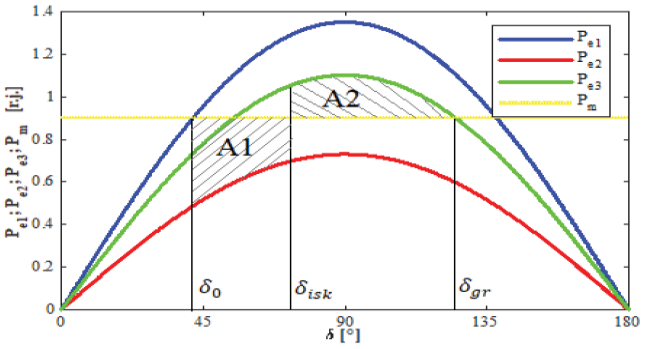
U nauci i literaturi koja se bavi ispitivanjem tranzijentne stabilnosti dominantno se koristi šema jednomašinskog sistema EES koja je prikazana na Sl. 1. Kod analize tranzijentne stabilnosti posmatraju se režimi prije, tokom i nakon eliminacije poremećaja. Pri tome se uvodi pretpostavka da su elektromotorna sila generatora E'_G i napon jake mreže U_m konstantni, kao i da u mreži nema aktivnih gubitaka. Uslov da generator ostane tranzijentno stabilan jeste da je površina ubrzanja A_1 manja ili jednaka površini usporenja A_2 (Sl. 2).



Slika 1. Jednopolna šema jednomašinskog sistema

Na ovoj slici krive $P_{e1}(\delta)$, $P_{e2}(\delta)$ i $P_{e3}(\delta)$ predstavljaju aktivne snage koju generator isporučuje mreži prije, tokom i nakon eliminacije kratkog spoja, respektivno, sa upotrebom odgovarajućih vrijednosti parametra reaktanse mreže *x,* dok prava P_m prestavlja mehaničku snagu na vratilu turbine. Ugao δ_0 je ugao opterećenja prije poremećaja, dok ugao δ_{gr} predstavlja granični ugao isključenja kvara. Prethodne krive se crtaju polazeći od sljedeće jednačine:

$$P_e = \frac{E'_G\, U_m}{x} sin\delta \tag{1}$$



Slika 2. Metod jednakih površina

Na Sl. 2. δ_{isk} predstavlja kritični ugao isključenja kvara dobijen iz graničnog uslova stabilnosti $A_1 = A_2$. Ovo je maksimalni ugao opterećenja pri kome se vrši isključenje kvara, a da se pri tome ne naruši tranzijentna stabilnost generatora. Odavde je moguće izraziti i kritično vrijeme isključenja kratkog spoja t_{isk}:

$$cos\delta_{isk} = \frac{P_m(\delta_{gr} - \delta_0) + P_{e3}cos\delta_{gr} - P_{e2}cos\delta_0}{P_{e3max} - P_{e2max}} \tag{2}$$

$$t_{isk} = \sqrt{\frac{(\delta_{gr} - \delta_0)\cdot 2TS_n}{\omega_s P_m}} \tag{3}$$

gdje je T - inerciona konstanta sihronog generatora [s], ω_s - sinhrona brzina generatora [rad/s], S_n - nominalna snaga sinhronog generatora [r.j.].

III. METOD NUMERIČKE INTEGRACIJE

Metod numeričke integracije zasniva se na rješavanju diferencijalne jednačine kretanja rotora:

$$\frac{T}{\omega_s}\frac{d^2\delta}{dt^2} = P_m - P_e = P_a \quad [r.j.] \tag{4}$$

Ova diferencijalna jednačina drugog reda može se zapisati kao sistem dvije diferencijalne jednačine prvog reda:

$$\frac{d\delta}{dt} = \omega - \omega_s = \frac{\omega - \omega_s}{\omega_s}\omega_s = \omega_s \cdot \Delta\omega \tag{5}$$

$$\frac{d\Delta\omega}{dt} = \frac{1}{T}(P_m - P_e) \tag{6}$$

nakon čega se iste rješavaju koristeći jednu od numeričkih metoda za rješavanje diferencijalnih jednačina. Konkretno, u ovom radu korišćen je eksplicitni Runge-Kuta metod. Periodična promjena ugla opterećenja u vremenu $\delta = f(t)$ znači da je sistem, tj. generator tranzijentno stabilan, dok aperiodična promjena znači gubitak sinhronizma.

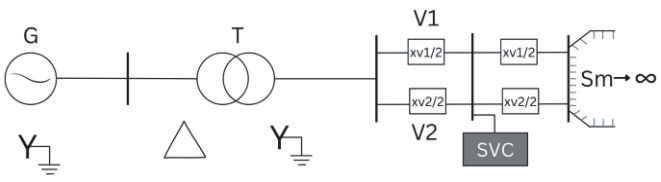
IV. UTICAJ FACTS UREĐAJA NA TRANZIJENTNU STABILNOST

FACTS sistemi su savremeni sistemi energetske elektronike koji se sve više koriste u EES za rješavanje različitih problema. Najviše se koriste za poboljšavanje naponskih prilika, ali i za poboljšanje upravljanja EES.

A. Uticaj SVC uređaja

SVC predstavljaju paralelne FACTS uređaje čija je dominantna primjena u poboljšanju profila napona. Cilj ove kompenzacije je da se podigne napon u tački priključenja injektiranjem reaktivne snage. Priključenjem *n*-1 SVC uređaja na vod, tj. dijeljenjem voda na *n* sekcija, prenosni kapacitet voda se povećava *n* puta pa je sada maksimalna vrijednost snage koja se prenosi sa jednog kraja voda na drugi primjenom SVC kompezacije povećana *n* puta.

Na Sl 3. prikazan je JMS sa ugrađenim SVC uređajem.



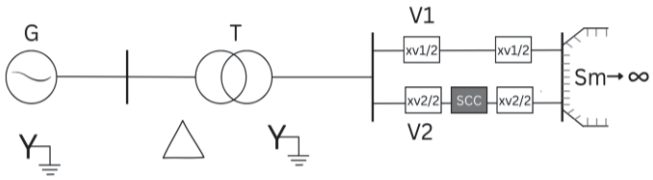
Slika 3. JMS sa ugrađenim SVC uređajem na sredini dva voda

U slučaju kratkog spoja na jednom od vodova jasno je da dolazi do promjene naponskih prilika u mreži, kao i na mjestu priključenja SVC uređaja. U tom slučaju SVC uređaj može značajno da doprinese povećanju stabilnosti sistema jer isti daje veću mogućnost za prenos snage kroz sistem u odnosu na nekompezovan sistem.

B. Uticaj SCC uređaja

Metoda serijske kapacitivne kompenzacije je veoma poznata i široko se primjenjuje u prenosnim mrežama. Osnovni princip je sprovođenje kapacitivne kompenzacija dijela induktivne reaktanse električnog prenosa, što rezultira povećanom sposobnošću prenosa snage kompenzovanog prenosnog voda. Serijska kompenzacija može da obezbijedi povećan kapacitet prenosa, poboljšan naponski profil mreže, poboljšanu ugaonu stabilnost energetskog koridora, prigušivanje oscilacija snage i optimizaciju podjele energije između paralelnih vodova.

Primjer SCC ugrađenog u JMS prikazan je na Sl. 4.



Slika 4. JMS sa ugrađenim SCC uređajem u vodu 2

Uključivanje SCC uređaja kapacitivnosti C u induktivni vod dovodi do smanjenja reaktanse voda i povećanje prenosa snage cjelokupnog sistema. Naime, u ovom slučaju je vrijednost reaktanse voda:

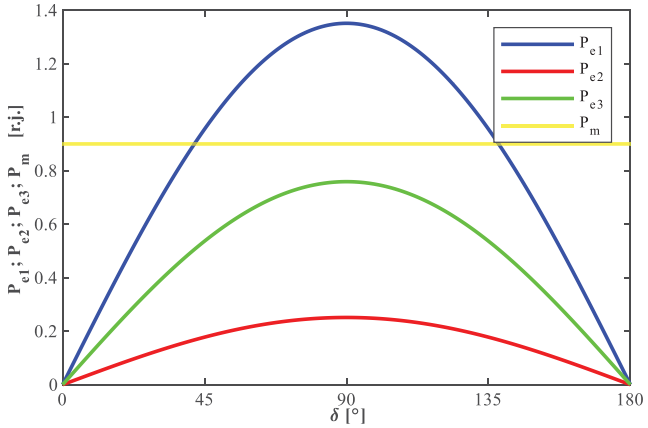
$$x_{komp} = x_V - x_C = x_V\left(1 - \frac{x_C}{x_V}\right) = x_V(1-k) \qquad (7)$$

gdje je $0 \leq k \leq 1$. U slučaju SCC kompezovanog sistema dolazi do povećanja krive $P_e(\delta)$, te do povećanja površine usporenja A_2 i rezerve tranzijentne stabilnosti.

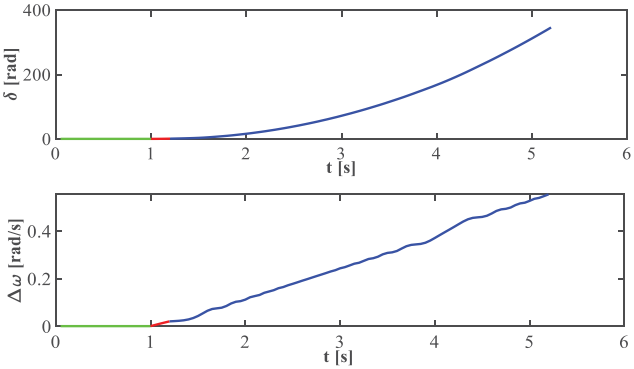
V. Uticaj FACTS Uređaja na Tranzijentnu Stabilnost - Implementacija

U cilju analize tranzijentne stabilnosti EES, pretpostavljeno je da se tropolni kratki spoj (3ks) desio na vodu 1, na razdaljini $a = 0.3 \cdot l_v$ od početka voda. Vrijeme trajanja kvara je uzeto da je 0.06s.

Na Sl 5. prikazane su ugaone krive koje opisuju navedeni slučaj. Kao što je moguće uočiti sa Sl 5. električne snage tokom i nakon otklanjanja kratkog spoja P_{e2} i P_{e3} su manje od mehaničke snage P_m na čitavom intervalu zbog čega dolazi do ubrzavanja rotora i generator nije u stanju da održi sinhronizam. Ovaj zaključak moguće je potvrditi i primjenom numeričke analize gdje se sa Sl 6. vidi da ugao rotora eksponencijalno raste u vremenu.



Slika 5. Metod jednakih površina -3ks, *v*1, *a* = 0.3

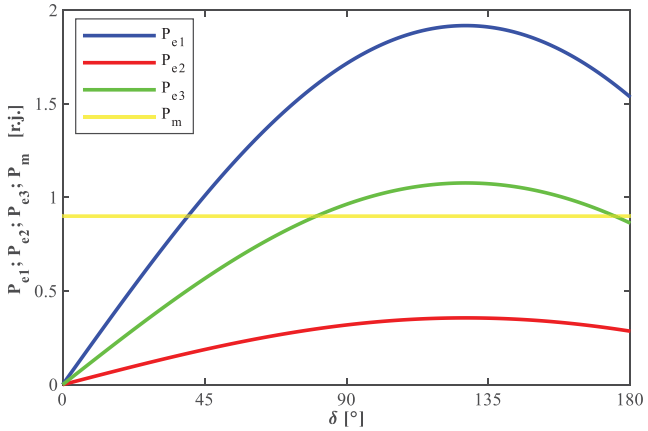


Slika 6. Metod numeričke integracije - 3ks, *v*1, *a* = 0.3

U ovom slučaju inicijalni sistem je nestabilan što je potvrdjeno primjenom oba prethodno opisana metoda.

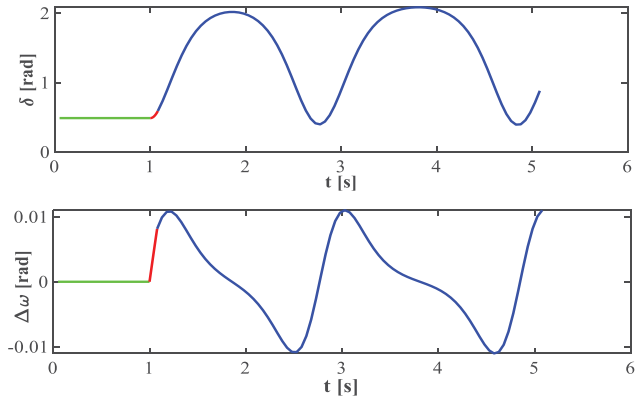
○ *SVC uređaj*

U ovom radu posmatran je uticaj jednog SVC uređaja na poboljšanje tranzijentne stabilnosti. Primjenom metoda jednakih površina za uslov $A_1 = A_2$ određen je ugao isključenja δ_{isk}. Primjenom jednačina (2) i (3) proračunata je vrijednost potrebnog vremena isključenja kvara koja iznosi 0.09s. Ugaone krive za posmatrani slučaj prikazane su na Sl 7.



Slika 7. Metod jednakih površina nakon priključenja SVC uređaja 3ks, *v*1, *a* = 0.3

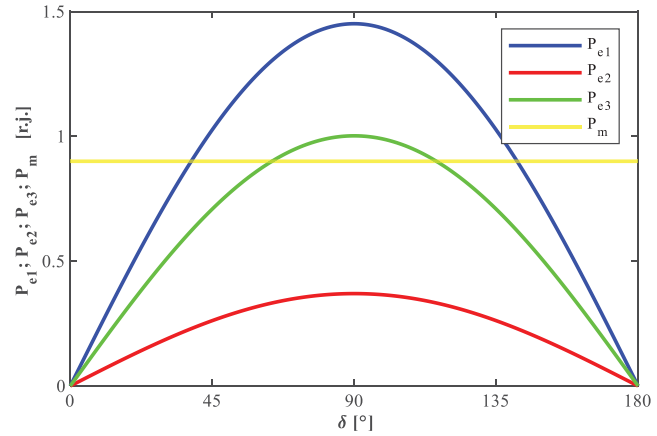
Prethodni rezultat moguće je potvrditi korišćenjem metoda numeričke analize (Sl. 8), koristeći jednačine (4) – (6). S obzirom da je promjena ugla opterećenja i ugla brzine generatora periodična, to znači da je generator očuvao sinhronizam.



Slika 8. Metod numeričke integracija nakon priključenja SVC uređaja 3ks, *v*1, *a* = 0.3

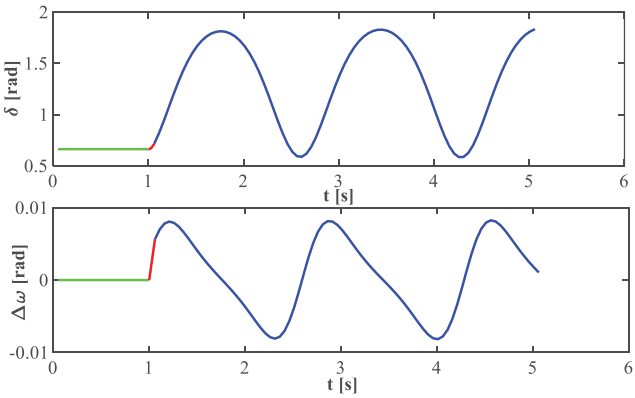
- *SCC uređaj*

Rednu kompezaciju je moguće ugraditi u vod pogođen kvarom, vod koji nije pogođen kvarom ili u oba voda. Posmatraće se slučaj priključenja SCC uređaja u vod koji nije pogođen kvarom. Da bi se zadovoljio uslov tranzijentne stabilnosti jednomašinskog sistema koeficijen *k* ovog uređa je potrebno da bude 0.39. U ovom slučaju kvar se isključuje za 0.06s i sistem je u stanju da očuva sinhronizam (Sl 9).



Slika 9. Metod jednakih površina nakon priključenja SCC uređaja 3ks, *v*1, *a* = 0.3

Prilikom provjere stabilnosti numeričkim putem dolazi se do rezultata sa Sl. 10. Zapaža se da je promjena ugla opterećenja i ugla brzine generatora periodična, odnosno tranzijentna stabilnost je očuvana. Pri tome je potrebno naglasiti da je ova promjena dobijena za vrlo malo vrijeme isključenja kvara, te da bi sa povećanjem vrijednosti koeficijenta *k* posmatrano vrijeme moglo biti značajno veće.



Slika 10. Metod numeričke integracija nakon priključenja SCC uređaja 3ks, *v*1, *a* = 0.3

VI. ZAKLJUČAK

U ovom radu dat je pregled metoda koji su korišćeni za procjenu tranzijentne stabilnosti jednomašinskog ESS. Prikazana su dva široko zastupljena metoda te njihova implentacija na konkretnom primjeru. Takođe, analizirani su uticaji SVC i SCC uređaja na tranzijentnu stabilnost JMS, odnosno dati su rezultati proračuna sa i bez ugrađenih FACTS uređaja. Rezultati pokazuju da je došlo do poboljšanja tranzijentne stabilnosti, odnosno da je nakon ugradnje ovih uređaja vjerovatnoća za očuvanjem iste povećana.

U narednim istraživanjima na ovu temu fokus će biti stavljen na efekat SVC i SCC uređaja na tranzijentnu stabilnosti složenijih sistema proračunom relativnih kretanja rotora generatora sistema.

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Утицај употребе апстрактних типова података језика PL/SQL на перформансе апликације

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***Садржај*—У овом раду приказан је развој софтвера употребом апстрактних типова података у програмском језику PL/SQL. Такође, представљени су Oracle база података и систем за претраживање, измену и складиштење података. Дат је генерални опис апстрактних типова података, након чега је описан PL/SQL. У централном делу рада је реализовано пројектовање, имплементација, а потом и тестирање перформанси објектног релационог модела и класичног релационог модела. Након тога је спроведена и представљена компаративна анализа резултата тестирања перформанси наведена два модела.**

I. Увод

Циљ у развоју софтверских решења приликом коришћења апстрактних типова података је да се у вишим програмским језицима обезбеде апстракције које би омогућиле редукцију комплексности проблема. На тај начин се остварује и поузданост софтвера, као и обезбеђивање потребних функционалности. Свакако, програмеру је тешко да унапред изабере апстракције које би у развоју софтвера могле бити потребне, па може довести до тога да неке апстракције нису довољне за решавање проблема. Такође, постоји могућност да апстракције имплементиране у софтверу немају употребну вредност. Циљ овог истраживања је да се омогући разумевање могућности и предности употребе апстрактних типова података у развоју софтвера у PL/SQL програмском језику. PL/SQL је програмски језик који додаје процедуралну екстензију Oracle верзији SQL-а и служи као програмски језик унутар алата Oracle developer. Језик PL/SQL је у језгру већине Oracle-овог софтвера [8]. Кроз детаљну анализу, истраживање ће приказати механизме, методологије и изазове који се јављају при развоју софтверских решења са апстрактним типовима података. Као резултат истраживања, очекује се да буду реализоване анализе перформанси које имплицирају даље препоруке и наставак даљег развоја и унапређења ових модела.

У развоју софтверских решења, употреба апстрактних типова података представља изузетно значајан концепт. Софтверски инжењери се често сусрећу са потребом изражавања апстракција у њиховим програмима. То даје могућност скривања детаља имплементације и фокус на битне концепте и функционалности. PL/SQL програмски језик пружа могућност коришћења кориснички дефинисаних типова података, што доноси предности у изражавању апстракције. Уместо рада са конкретним типовима података, могуће је креирати сопствене типове који се најбоље уклапају у специфичне потребе софтверских решења. Ово даје могућност енкапсулације података и функционалности, што повећава модуларност и умањује дуплирање кода. Осим тога, кориснички типови података дају могућност креирања модела и представљања концепта из домена одређеног софтверског проблема на разумљивији начин, што доприноси јасноћи и читљивости кода. Коришћењем апстрактних типова података у PL/SQL програмском језику, инжењери имају моћан алат за развој комплексних софтверских система који су лако разумљиви, прошириви и одрживи. Ови типови могу бити дефинисани као објекти, табеле или рекорди. Сваки од типова који нам служе да креирамо модел, могу садржати атрибуте, методе и релације.

Већина организација аутоматизује своје информационе системе користећи базе података. Главна функција базе података је прикупљање, складиштење и преузимање релевантних података како би апликације базе података могле да их користе. Систем за управљање базом података (Database Management Systems - DBMS) је софтвер који контролише складиштење, организацију и преузимање података [6].

Систем за управљање базама података се састоји од колекције међусобно повезаних података и сета програма за приступ тим истим подацима. То је софтвер који служи за креирање, коришћење и одржавање базе података.[1]

Основна карактеристика система за управљање базама података је да, поред тога што има базу података, има и комплетну дефиницију структуре базе података као и ограничења. Дефиниција структуре базе података се

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налази у њеном каталогу. Каталог садржи информације о структури сваке датотеке, формату и типу података као и о врстама ограничења који су над подацима. Информације које су сачуване у каталогу се зову метаподаци [1].

II. Студијски пример

Истраживање је спроведено на софтверском систему за заказивање активности у клиници, која пружа различите медицинске услуге својим пацијентима. Запослени у клиници имају различите улоге и задатке које обављају. Они су распоређени по одељењима у којима раде. Лекари имају своје специјализације и пружају услуге у складу са тим. Медицинске сестре пружају подршку лекару и обављају различите активности у складу са задужењима на којима су распоређене. Основни подаци о пацијентима, као што су крвна група и пол, користе се за планирање и пружање адекватне медицинске неге. У зависности од потреба, за пацијенте се заказује одговарајућа активност у дефинисаном термину. На клиници се води евиденција о активностима, пацијентима и медицинском особљу. Осим тога, свака активност има своју категорију (тип активности) која је дефинисана медицинским протоколом. На основу датог вербалног описа дефинисани су релациони и објектно-релациони модел.

Релациони модел чине следеће табеле:
Grad(grad_id,postanskiBroj,ime_grada),
Odeljenje(odeljenje_id,naziv),
Pacijent(pacijent_id,ime,prezime,krvnaGrupa,pol),
Adresa(adresa_id,ulica,broj,grad_id),
Zaposleni(zaposleni_id,ime,prezime,JMBG,nadredjeni_id, *odeljenje_id*),
Lekar(zaposleni_id,specijalizacija),
MedicinskaSestra(zaposleni_id,strucna_sprema),
Zaposleni_Adresa(zaposleni_id,*adresa_id*),
Vrsta_aktivnosti(vrsta_id,naziv),
Aktivnost(aktivnost_id,termin,*zaposleni_id*,*pacijent_id*, *vrsta_id*)

Да би се дефинисао објектно-релациони модел, односно табеле које су у овом случају објектне, неопходно је дефинисати апстрактне типове – објекте:
Adresa_t(adresa_id,ulica,broj),
Grad_t(grad_id,postanskiBroj,ime_grada),
Odeljenje_t(odeljenje_id,naziv),
Zaposleni_t(zaposleni_id, ime, prezime, JMBG, naredjeni_id, grad,adrese,odeljenje),
Lekar_t(Zaposleni_t(zaposleni_id,ime,prezime,JMBG, naredjeni_id,grad,adrese,odeljenje),specijalizacija),
MedicinskaSestra_t(Zaposleni_t(zaposleni_id,ime,prezime, JMBG,naredjeni_id,grad,adrese,odeljenje),strucna_sprema),
Pacijent_t(pacijent_id,ime,prezime,krvnaGrupa,pol),
TipAktivnosti_t(tip_aktivnosti_id,vrsta),
Aktivnost_t(aktivnost_id,termin,zaposleni,pacijent, tipAktivnosti)

Користећи објекте као корисничке дефинисане типове у PL/SQL-у креирају се објектне табеле, где је сваки ред табеле, инстанца објекта (за успоредбу, у Јави би се дефинисао као објекат класе) [7].

Табеле:
Grad_ot(grad_id,Grad_t(grad_id,postanskiBroj,ime_grada)),
Odeljenje_ot(odeljenje_id,Odeljenje_t(odeljenje_id,naziv)),
Zaposleni_ot(zaposleni_id,Lekar_t(zaposleni_id,ime,prezime ,JMBG,naredjeni_id,grad(Grad_ot()),
odeljenje(Odeljenje_ot())),
MedicinskaSestra_t(zaposleni_id,ime,prezime,JMBG,
naredjeni_id,grad(Grad_ot()),odeljenje(Odeljenje_ot())),
Pacijent_ot(pacijent_id,Pacijent_t(pacijent_id,ime,prezime,krvnaGrupa,pol)),
TipAktivnosti_ot(tip_aktivnosti_id,
TipAktivnosti_t(tip_aktivnosti_id,vrsta)),
Aktivnost_ot(aktivnost_id,Aktivnost_t(aktivnost_id,termin,
zaposleni(Zaposleni_t()),pacijent(Pacijent_t()),
tipAktivnosti(tipAktivnosti_t())))

III. Мерење и анализа перформанси

Након креирања модела, потребно је да се обезбеди ефикасно и брзо извршавање упита, трансакција и операција над базом података. Добре перформансе омогућавају да апликације раде брже и да се омогући квалитетнији кориснички рад. Имајући у виду главни фокус истраживања, а то је утицај употребе апстрактних типова података на перформансе и рад са подацима у објектном релационом моделу и класичном релационом моделу, реализовано је тестирање и мерење перформанси у различитим условима. Тестирање перформанси ова два модела је реализовано на следећи начин:

1. Планирање и организација тестирања: Дефинисани су циљеви и захтеви тестирања, а то су: тестирање перформанси које укључује извршавање упита, додавање, измену података и комплексне операције над више табела.

2. Дефинисан је скуп података који је коришћен у тестовима. Подаци су генерисани аутоматизовано, тако да се свака табела попуњава са одређеним бројем записа. Тестирање је реализовано са 4 групе записа: 100 записа, 1.000 записа, 10.000 записа и 100.000 записа. Количина података је прилагођена према перформансама хардверског и софтверског окружења на којем су реализовани тестови.

3. Имплементација тестова: Имплементирано је 11 тестова у језику PL/SQL над оба модела. У складу са планом, заступљене су све важније операције за следеће тестове: Унос запослених, Унос нових врста активности, Унос нових пацијента, Заказивање активности (над више табела), Измена заказаних активности, Измена података о запосленима, Претраживање запослених, Претраживање пацијената, Претраживање заказаних активности (над више табела), Брисање запослених (над више табела) и Брисање заказаних активности. Имплементација је реализована у програмском језику PL/SQL у оквиру Oracle-овог окружења за развој (Oracle

SQL developer).

4. Извршавање скрипти (тестова) за планиране операције омогућавају мерење времена извршавања. У овим тестовима су симулирани услови слични реалном окружењу и мерене перформансе у условима наведених количина података.

5. Приказ и анализа података: Након извршавања тестова, реализовано је прикупљање, обрада и анализа података о времену извршавања (брзини) на ресурсима који су коришћени, са различитом количином података. У анализи је реализовано упоређивање перформанси два модела и идентификација предности и недостатака.

6. Оптимизација (подешавање параметара прформанси): На основу резултата анализе, примењена је оптимизација (одабране су две технике оптимизације) ради побољшања пеформанси. Коришћене су технике: индексирање B-TREE и примењено је BULK COLLECT решење за Oracle. Да би анализа оптимизације била релевантна, коришћени су идентични подаци, услови и операције за тестирање. Тестирање је такође реализовано са четири групе записа: 100 записа, 1.000 записа, 10.000 записа и 100.000 записа. Коришћени су функционално идентични тестови над оба модела. Након добијених резултата, реализована је компаративна анализа са резултатима без и са оптимизацијом [14],[15].

У Табели 1 (бројеви ван заграда) је приказан компаративни приказ резултата мерења времена (у милисекундама) обраде података на моделима, где Модел1 представља релациони модел, а Модел2 објектно-релациони модел. Називи спроведених тестова су следећи:

1. Унос (додавање) запослених
2. Унос (додавање) нових врста активности
3. Унос (додавање) нових пацијента
4. Заказивање активности (додавање над више табела)
5. Измена заказаних активности
6. Измена података о запосленима
7. Претраживање запослених
8. Претраживање пацијената
9. Претраживање заказаних активности (над више табела)
10. Брисање запослених (над више табела)
11. Брисање заказаних активности

На основу приказане анализе, може се закључити да Модел1 (релациони модел) има краће време извршавања свих тестираних операција над једном табелом у односу на Модел2 (објектни релациони модел). Када је у питању извршавање операција над једном табелом, Модел2 дуже извршава операције због трајања извршавања активности над објектном табелом. Међутим, када је реч о великој количини записа и операцијама над више табела истовремено, Модел2 има предност у односу на Модел1.

IV. Оптимизација

Оптимизација базе података обухвата различите технике којима се желе побољшати перформансе. Постоји више техника оптимизације. У овом раду је коришћено индексирање, конкретно B-TREE и BULK COLLECT техника за Oracle базе података.

B-TREE функционише тако што се формира сортирана листа вредности подељена у опсеге. Индекс додељује кључ сваком реду или опсегу редова. Састоје се од заглавља, дужине кључа, вредности кључа и ROWID-ја [14]. Основни недостатак индексирања је да нарушава перформансе операција убацивања и избацивања записа. На основу резултата тестирања и анализе приказаних у Табели 1 (бројеви у заградама), потврђује се недостатак индексирања приликом операција убацивања и избацивања записа. Међутим, у овом случају Модел2 показује предност у односу на Модел1, односно има краће време извршавања свих тестираних операција над једном табелом. Када је реч о великој количини записа и операцијама над више табела истовремено, Модел2 има предност у односу на Модел1. Друга техника која је коришћена за отимизацију база података је специфично развијена за Oracle, назива се BULK COLLECT, односно ускладиштена процедура која се користи у PL/SQL језику. Ова техника се користи искључиво над PL/SQL реченицама које врше операције над више табела (не користи се на само једној табели). Коришћен је исти скуп записа који је коришћен приликом тестирања без оптимизације и са индексирањем. На основу резултата тестирања приказаних у Табели 2, може се закључити да Модел2 има значајно краће време извршавања претраживања података над више табела у односу на резултате са индексирањем и без оптимизације (укључујући оба модела).

Табела 1

Компаративни приказ резултата мерења времена обраде података на моделима

Тест	100 записа		1.000 записа		10.000 записа		100.000 записа	
	Модел1	*Модел2*	*Модел1*	*Модел2*	*Модел1*	*Модел2*	*Модел1*	*Модел2*
1.	*4 (5)*	*30 (40)*	*27 (24)*	*270 (250)*	*238 (227)*	*2340 (2320)*	*2325 (2331)*	*23330 (23330)*
2.	*2 (2)*	*10 (35)*	*30 (30)*	*102 (120)*	*230 (202)*	*1024 (1024)*	*2278 (2100)*	*10316 (10316)*
3.	*6 (6)*	*16 (41)*	*59 (59)*	*156 (170)*	*583 (235)*	*1521 (2450)*	*2698 (2698)*	*17435 (25322)*
4.	*24 (19)*	*14 (13)*	*192 (169)*	*116 (107)*	*1926(1709)*	*1242 (1052)*	*18018 (18274)*	*14611 (10589)*
5.	*5 (6)*	*1 (1)*	*64 (65)*	*2 (2)*	*630(638)*	*10 (11)*	*6259 (2937)*	*512 (438)*
6.	*2 (2)*	*1 (1)*	*19 (19)*	*5 (2)*	*172(172)*	*4 (3)*	*1702 (1702)*	*302 (320)*
7.	*7 (7)*	*8 (30)*	*10 (10)*	*12 (450)*	*40(40)*	*39 (1020)*	*291 (291)*	*270 (10400)*
8.	*1 (1)*	*2 (15)*	*3 (3)*	*5 (113)*	*28(28)*	*28 (1106)*	*281 (285)*	*273 (10385)*
9.	*2 (4)*	*14 (2)*	*8 (25)*	*15 (3)*	*75(90)*	*28 (15)*	*762 (808)*	*168 (141)*
10	*12 (12)*	*1970 (30)*	*122 (110)*	*19270 (210)*	*2792(2664)*	*188150 (5210)*	*302564 (285421)*	*1850786 (401210)*
11.	*1 (2)*	*1 (2)*	*7 (10)*	*4 (9)*	*65(70)*	*33 (83)*	*598 (843)*	*332 (1025)*

ТАБЕЛА 2
КОМПАРАТИВНИ ПРИКАЗ РЕЗУЛТАТА МЕРЕЊА ВРЕМЕНА ОБРАДЕ ПОДАТАКА НА МОДЕЛИМА

Тест	100 записа		1000 записа		10000 записа		100000 записа	
	Модел1	*Моде2*	*Модел1*	*Модел2*	*Модел1*	*Модел2*	*Модел1*	*Модел2*
4.	*4*	*8*	*25*	*79*	*225*	*862*	*2437*	*8275*
9.	*1*	*1*	*3*	*2*	*22*	*4*	*237*	*45*
10.	*9*	*10*	*108*	*170*	*2259*	*8390*	*201910*	*506120*

V. ЗАКЉУЧАК

На основу резултата истраживања долази се до одређених закључака који могу бити препоруке и упутства за боље коришћење апстрактних типова података и употребу објектног релационог модела у развоју софтвера у PL/SQL програмском језику. Резултати тестирања перформанси, са и без примене оптимизације, потврђују да постоје значајне предности примене апстрактних типова података у објектном релационом моделу за обраду и претраживање велике количине података. Такође, може се констатовати да је испуњен циљ, а то је практичан приказ могућности у развоју софтвера приликом коришћења апстрактних типова података. У вишим програмским језицима, апстракције омогућавају решавање проблема комплексности у креирању финалног софтверског решења. На крају, може се закључити да је апстракција значајна за квалитетан дизајн, као и да је кроз реализоване експерименте потврђена препорука за њену примену. У евентуалном наставку рада на овом истраживању, могуће је проширити опсег тестирања, мерења и оптимизације на сложенијим моделима и типовима података, као и са већом количином података у условима комплекснијих тестних захтева, што захтева веће перформансе тестне опреме.

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Development of traffic monitoring tools using Apache Spark and Apache Kafka tools

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***Abstract*— The developed solution aims to provide users with a traffic monitoring tool that combines Kafka and Spark Streaming technologies. The system enables efficient data collection, real-time processing, traffic flow prediction and change detection, which helps drivers, traffic system managers and other relevant actors to make better decisions and improve traffic efficiency and safety. A traffic monitoring solution is being developed that uses a combination of Kafka and Spark Streaming technologies.**

I. Introduction

In today's digital age, an increasing number of organizations and cities rely on technology to collect, process and visualize traffic data to make informed decisions. The integration of Apache Spark and Apache Kafka tools opens up possibilities for efficient collection, processing and visualization of this data through a unique user interface.

In the first research [1], the focus is on using Apache Spark for real-time traffic monitoring using data from sensors and cameras. The goal is to effectively solve the problem of overloaded city traffic through accurate prediction of traffic flows through machine learning algorithms, which is confirmed by the high performance of the system.

In paper [2], city traffic flow is analyzed through sensor data, applying machine learning techniques for congestion prediction. This paper is also part of a European project that investigates the correlation between traffic and air pollution, further emphasizing the importance of sustainability of urban traffic.

Research [3] presents an innovative system for real-time traffic analysis using short-term memory networks in Apache Spark. The system successfully predicts traffic flow, identifies congestion and tracks accidents using data from sensors and cameras.

Kuhl et al. [4] propose an innovative system for real-time vehicle detection through microservices with Apache Kafka streams. The system efficiently analyzes traffic data, highlighting details such as vehicle type, color and speed.

Paper [5] presents an advanced web platform for managing road survey and maintenance information, providing detailed insight into road condition and maintenance requirements. This platform has the potential to revolutionize road infrastructure management and help create smarter road maintenance systems.

In this paper, research focuses on the application of Apache Spark for real-time traffic monitoring through the use of data from sensors and cameras. These projects aim to solve the challenge of congested traffic in urban areas. The results of the experiments clearly confirm the high efficiency of the system in real time.

There are several key reasons why researching the development of traffic monitoring tools using Apache Spark and Apache Kafka tools is important:

1. More effective urban mobility planning by collecting a large amount of real-time traffic data and analysing it to get useful insights about traffic conditions. This data can be used to improve the planning and organization of sustainable mobility, which could lead to more efficient and sustainable transport in urban areas.

2. Improving traffic safety: The analysis of traffic data enables the identification of places with a high risk of accidents and congestion, and the planning and organization of traffic in these places can improve traffic safety. In addition, public transport route optimization and the use of smart traffic lights could reduce congestion and reduce the risk of accidents.

3. Increasing the quality of life in cities: Improving traffic efficiency and safety in urban areas, as well as optimizing urban transportation, could significantly improve the quality of life of city dwellers.

4. Combination of tools: This paper aims to show how these tools can be combined together, and how the results of that combination can be used to support decision making in planning and improving sustainable mobility.

All these reasons make the development of traffic monitoring tools using Apache Spark and Apache Kafka relevant and significant for research community.

There are several reasons for developing a web platform for traffic monitoring using Apache Spark and Apache Kafka tools:

1. Increasing the efficiency and sustainability of traffic: Fast and sustainable transport is crucial for the development of urban areas and improving the quality of life of residents. With the help of the web platform, it is possible to extract useful information about congestion and delays, optimize traffic lights and public transport routes, reduce pollution and transport costs, and improve the efficiency and sustainability of traffic in urban areas.

2. The need for advanced data processing tools: In today's

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979-8-3503-6961-8/24/$31.00 ©2024 IEEE

world of big data, using Apache Spark and Apache Kafka tools, it is possible to efficiently collect, analyze and process large amounts of data in real time, which is crucial for decision support in sustainable mobility planning.

3. Potential applications in cities: The developed tool can be applied in cities in order to improve the efficiency and sustainability of traffic, reduce costs, and improve the quality of life of residents. This tool has the potential to bring significant benefits to cities, and research focuses on simulating its application in real urban environments.

The objectives of the research are as follows:

1. Collection of traffic data from various sources, including sensors, GPS devices and other available data sources.

2. Processing, combining and analyzing the collected data using appropriate tools and integration of big data, in order to obtain relevant results and a comprehensive picture of the traffic situation.

3. Providing better visualization of traffic data through maps, graphs, tables and other visual displays that allow users to process information more easily.

All these goals are aimed at the development and application of a traffic monitoring tool that uses Apache Spark and Apache Kafka tools.

II. ANALYSIS OF TECHNOLOGIES AND TOOLS

In the following, the overall architecture of the web platform development, which has a unique design for traffic monitoring, is presented, with a detailed explanation of all the tools used (Figure 1).

The developed platform is an IoT data monitoring platform powered by Spark Streaming. Here, data of the connected vehicles are sent in real time in order to monitor traffic. The tool itself is divided into three modules and an additional display module using the Google Maps API (Figure 2). These modules are stand-alone Maven modules written in the Java programming language in the Spring Boot framework.

IoT Data Producer is the first module which simulate connected vehicles. Connected vehicles will generate IoT messages that are collected by the message broker and the traffic monitoring platform. The IoT Data Producer itself serves for simulation and use Apache Kafka to generate IoT events.

The IoT Data Processor accept and process the data received from multiple vehicles to obtain useful traffic data. Basically the IoT Data Processor first collect all the information about the number of different vehicles on different roads and forward it to the Cassandra database. This is done within 5 minutes time interval where all the information are placed back into the Cassandra database. Based on this data, data on vehicles of interest for a certain distance can be downloaded.

IoT Data DashBoard is a Spring Boot platform that retrieves data from a database built in Cassandra and send it to a web page. The platform use web sockets (to establish a good two-way TCP connection) and jQuery to send data to the web page at certain intervals. DashBoard present data through tables and graphs. Also, by using Bootstrap, we get a page that changes interactively depending on the query and the selection of certain options (graphics and tables).

The last module includes the display of the Google Map API with marked paths and the ability to select new paths.

As can be noted, although there are four functional parts that represent the platform, the platform as a whole is closely connected through its parts. Data producer deals with data generation, Data processor with their processing, and DashBoard more with data display via Bootstrap, jQuery and Spring Boot.

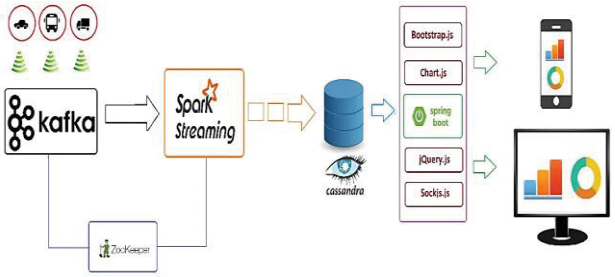

Figure 1: Architecture of traffic monitoring tools.

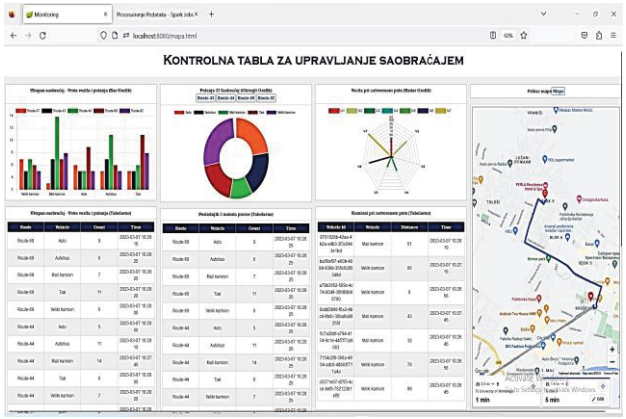

Figure 2: Traffic tracking platform layout view.

III. RESULTS AND ANALYSIS

Our platform consists of two main parts: the database server and the visual part.

The database server is used to collect and store traffic data, including information about vehicles, routes and travel times.

This data is continuously updated to ensure the accuracy and reliability of the data.

The visual part of the platform uses this data to display traffic information in a clear and understandable way. Users are allowed to view traffic information at different locations and routes, using an interactive map and graphical displays. It also provides windows for filtering data and analyzing traffic flows, enabling decision makers to make better and more informed decisions.

The combination of the database server and the visual part of the platform provides a comprehensive solution for traffic management, which is flexible and adaptable to different user needs.

A. Platform architecture:

IoT sensors: IoT sensors are placed along roads and used to collect traffic data. They can measure vehicle speed, number of vehicles on the road, traffic density and other parameters. Data is collected in real time and sent further for processing. In order to collect data, pre-generated data was used, due to insufficiently available sources.

Kafka: The data collected by the IoT sensors is sent to the Kafka topic, which functions as the entry point of the system. Kafka enables fast and reliable data flow between different system components.

Spark Streaming: The data received on the Kafka topic is downloaded by Spark Streaming and further processed for the needs of the traffic monitoring system. Spark Streaming provides real-time data processing, enabling data analysis, aggregation and transformation.

Database: Processed data are stored in a database for further analysis and display. The database enables long-term storage of traffic data and allows users to access historical data and analyze traffic trends.

User interface: The web platform has an intuitive user interface consisting of graphs, tables and maps, which allow visualizing traffic data.

The interface displays various traffic information, including total traffic, vehicle types, routes, and vehicle travel times.

B. Platform functionality

View Total Traffic: Users can view the total traffic in the selected area. This view can be useful for decision makers in traffic planning and management.

Display of vehicle types: Users can see what types of vehicles are present on the roads, such as cars, trucks, buses, etc. This information can help in analyzing traffic and planning traffic decisions.

Viewing paths: Users can see the paths that vehicles take on the map. This can help identify major traffic routes and potential congestion zones.

View vehicle movement times: Users can see how long it takes vehicles to move between specific points. This information can be useful for travel planning and avoiding traffic jams.

Also, the platform will allow a detailed overview of individual routes with the possibility of switching to other routes, as well as an overview of traffic in the last few minutes. This allows decision makers to respond to traffic congestion and speed up travel times.

The platform will also provide information on the vehicle's distance from points of interest, routes that are interrupted or impassable. This information allows decision makers to react quickly and efficiently to obstacles on the road and ensure smooth transport.

Through all these functionalities, the traffic monitoring web platform provides users with a tool for planning trips and promoting sustainable mobility. The platform will be easily accessible to decision makers, with an intuitive and simple user interface that enables easy access and analysis of relevant traffic information.

The modules and their functionalities are described in more details below (Figure 3):

Total Traffic Module: This module displays information about total traffic, types of vehicles, vehicle paths, and vehicle travel times. It provides a deeper understanding of traffic flows and helps in planning more efficient transport.

Module for a detailed view of paths: This module allows a detailed view of individual paths with the possibility of switching to other paths. It also provides an overview of traffic in the last 5 minutes. This module is a valuable tool for decision makers who want to quickly react to traffic congestion and reduce travel time between two points.

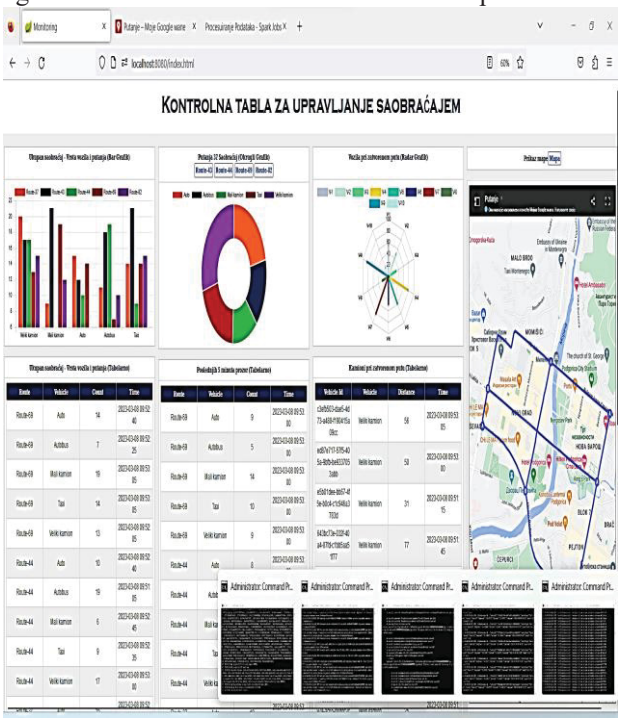

Figure 3: Platform view with backend tools open

Road Obstacle Module: This module focuses on the distance of the vehicle from the point of interest and displays paths that are interrupted or impassable. This information enables decision makers to react quickly and efficiently to obstacles on the road and ensure smooth transport (Figure 4).

Module for Google Maps API: The platform also contains a module that displays the Google Maps API with the ability to select routes and display the time required to travel from point A to point B. This module allows users to plan a trip in the most efficient way, providing detailed information about the duration of the trip on different routes.

Total traffic: vehicle types and routes: The dashboard displays a table showing the total traffic on different routes and vehicle types. Each route and type of vehicle is presented in the form of a row and a column in the table.

This view allows users to get an overview of how many vehicles are passing through a certain route and what types of

vehicles are most prevalent. In this way, users can identify traffic nodes and areas with a higher load.

Number of vehicles and time: The table also shows the number of vehicles passing through certain routes and time stamps. This information allows users to track changes in the number of vehicles over time. Also, timestamps can be useful for analyzing traffic jams and planning trips accordingly.

Last five minutes window: In addition to the total traffic view, the platform also has a window that shows the traffic of the last five minutes. This window allows users to see the current traffic situation and quickly react to any changes or congestion. In this way, users can make real-time decisions to optimize their journey or manage traffic.

Closed road window: This window shows the distance of a certain type of vehicle to the closed road. When there is a closed path or obstacle in the way, users can see how far they are from that closed path. This information helps decision makers to quickly identify route alternatives and adjust their routes to avoid obstacles and congestion.

These functionalities allow users to have a detailed overview of traffic and make informed decisions. Additionally, users can use the option to select routes and display travel times from point A to point B using the Google Maps API. This module allows users to plan their trip in the most efficient way.

In Figure 3 is shown a simulation of our platform that is applied in the city of Podgorica. We have chosen five different routes which are marked as Route 37, Route 82, Route 43, Route 44 and Route 69. Route 37 goes from the roundabout near the Children's Park in Kruševac to Sava Kovačević Bulevar, Route 82 from the Children's Park in Kruševac to 71 Marka Miljanova, Route 43 from 71 Marko Miljanova to 151 Bulevar Sava Kovačevića, Route 44 from 26 Marka Miljanova to Bulevar George Washington, and Route 69 from 13 July to 6 John Jackson.

Our platform allows an individual overview of each route, as well as an overview of all important points on those routes. Also, the simulation in Figure 3 shows how our platform actually works, providing decision makers and planners with the information they need for effective route planning and travel time optimization.

IV. Conclusion

Our platform aims to increase the efficiency and effectiveness of traffic management. Using state-of-the-art technologies and tools for collecting, analyzing and visualizing traffic data, users are enabled to receive real-time traffic information and adjust their routes according to the latest data.

This allows for faster and more efficient travel, reducing travel time and reducing the stress of traffic jams. In addition, our platform represents a good support for decision makers in planning sustainable mobility, which contributes to the reduction of harmful gas emissions and the creation of a cleaner and healthier environment.

Our platform provides several key benefits and contributions:

1. Traffic data visualization through an interactive user interface enables users to easily access and analyze relevant information.

2. Traffic information offered on the platform enables decision makers to make traffic decisions quickly and efficiently.

3. The efficiency and scalability of the platform enable the handling of a large amount of data that is collected and processed.

This platform is a tool for planning trips and promoting sustainable mobility, providing easily accessible information and an intuitive user interface.

There are a number of possible suggestions for future research. Some of the possibilities include:

Integration of other types of data: Although this research involves the integration of different types of traffic data, there is the possibility of integrating other types of data, such as meteorological data, air quality data, public transport congestion data, etc. Integrating this additional data can enable more accurate traffic forecasting and provide more useful information to decision makers.

Development of new technologies for collecting traffic data: There is a possibility of developing new technologies for collecting data, such as new sensors, chips for the automotive industry, etc. The integration of these new technologies can enable better traffic data collection and the provision of more useful information.

Analysis of the impact of changes in traffic: Future research can focus on the analysis of the impact of changes in traffic, such as the construction of new roads or the introduction of new vehicles into traffic. This analysis can provide useful information about the effects of traffic changes and help plan future changes.

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Protection System Against Slowloris DDoS attack at application level

Boban Banjević, *Student*, Nikola Žarić Mentor

***Abstract*— Detection and prevention on application level, the most upper level of the open systems interconnection (OSI) model, from different types of cyber security threats can be a huge obstacle and a challenge. The goal of this research, was to showcase that even while using older systems, and/or older technologies, it is still possible to find a way to detect and to prevent one of these types of security threats, of course with a little bit of creativity and knowledge on different types of security threats. In the practical example of this research, the type of security threat that is being conducted is the Distributed Denial of Service (DDoS) attack, or to be precise "Slowloris" DDoS attack. Results of the practical example proved that it is possible to secure a web server and prevent an application from being timed out, using a different combination of open-source tools, while keeping the solution simple and cost free, which could be especially helpful for start-ups and small companies, that want to try to be competitive.**

I. Introduction

Cisco's annual internet report has assessed that in 2023 the number of DDoS attacks would skyrocket to 15.4 million attacks per year [1]. The development of different detection and prevention techniques and tools is in a way a never-ending circle, as new types of DDoS attacks also develop all the time. Additionally, the growth of system and network is based on anonymity of data, which makes catching attackers a lot harder, especially with the number of protocols and applications as well as complexity of the system [2]. Considering that the biggest number of threats is caused by a number of weaknesses and errors written by developers [3]. one of the biggest questions asked is whether it is worth investing in trying to discover and solve vulnerabilities in the system. If it is then solving certain vulnerabilities will be a step to solving them all, otherwise it is a well without bottom [4].

The idea behind this research is to try to think of a practical way to detect and prevent Slowloris DDoS attack by combining different tools with few scripts that complete the whole detection-prevention system against this type of DDoS attack. But before that, it would be necessary to first get to know more about this type of security threat, what it targets and how it works. We will also show the challenges we had to solve to make the detection and prevention work as well as how modularity of the system allows future changes, upgrades and fixes in a way that will not affect other components.

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II. Slowloris distributed denial of service attack

DDoS attack is a type of security threat where the attacker tries to take down a server using computers belonging to other people. The attacker creates a back door for himself by baiting a user to install a virus on its computer. That will allow it to access this user's computer and commit an attack by ordering it to send requests on a server hosting a web application or a web site. Now by doing this to multiple users will make something that is called a botnet that is a huge network made of multiple controllable users (zombies). When the attacker establishes a communication with Command and Control (C&C) server, it allows it to send one command to all bots attacker controls, which will at the established time massively send request to a web application or a web server and try to take it down.

Slowloris DDoS attack functions in a similar way, but at level seven of OSI model, it targets the application itself, trying to prevent it from presenting content to end-users. It sends partial HTTP requests which keep the connection open for as long as it's needed for the application to be slowed down and web server taken down. It doesn't need a big amount of bandwidth to keep the connection open, and that's why we can say it is a low-bandwidth attack. It is very slow and methodical, and it sends "infinite" requests which never complete. Its goal is to occupy and take down all ports, one by one, which are used for connection with the web server. After accumulating huge number of requests on ports and taking them all down (time out), and simultaneously the web server, and in the process stopping any actual request from going through, that's when we can say the attack was successfully executed. It is very persistent, and it won't stop even after taking down one port, it will keep trying to establish communication until the web server is completely taken down, and that is why we call it "persistent DDoS". To make things even harder, at least from the aspect of detection and prevention, it can also send different headers, as well as disable any notification sent to the administrators, and preventing itself from being detected. It is safe to say that traditional systems used for detection are not very successful in detecting this type of security threat [5].

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III. TESTING ENVIRONMENT SETUP

In order to enable practical testing, we had to make a basic environment simulating one used by different companies to host their applications and web sites. Test environment looks like the one used in real life, but it will never be the same as those since this is a sandbox, and the environment is controlled and limited. However, it is still enough to present the whole picture and show that it is possible to think of a solution despite any hurdle or obstacle thrown at you.

For this example, we used "VMWare Work Station 17 Player", a software for cloud computation and virtualization, on which we boot up three different Virtual machines with two different operating systems (OS), that is two "Windows 7 32-bit" and one "Debian Kali Linux". For easier reference we will call base Windows 7 a host, second Windows 7 a client and Kali Linux an attacker. One of the main reasons why we went with the older version of OS is to show that it is possible to find a solution and prevent an attack no matter how your system is set up and no matter what it uses.

Next on the host we installed "XAMPP version 3.2.1." and set up an "Apache version 2.4" web server, which we will use to host our simple application. We must mention that for creation of the application, Hypertext Preprocessor (PHP) and Hyper Text Markup Language (HTML) were used, and they basically send a GET HTTP request that in a response sends a table filled with random data from a MySQL database. For a client to be able to access the website hosted on a local host with port 81, which we configured through the Apache configuration file to enable direct access, we had to start Apache and MySQL modules. But for a web server to be secure, it is not good for it to be publicly accessible, and that means we should not let anyone outside the network to directly be able to contact it.

The next step in the chain that should be fulfilled is installing software called "NGINX", which is configured to work as a reverse proxy. Reverse proxy is a server that is found in front of a web server and forwards requests sent by a client to a web server. In other words, it can listen to anything sent and write it down in its log files, which will be used by us, and at the same time it helps the web server by offloading the busy proxy and speeding up communication [6]. But before that we must set it to work as reverse proxy, so to do that we have to change the configuration file of NGINX. Firstly, we must find the "http" block inside and add a server tag with the open curly braces. There we can set few properties which will allow NGINX to listen HTTP requests on port 80, set its name to a localhost, set a location tag inside with additional properties which will additionally allow NGINX to send request further to Apache on the IP address 192.168.206.128 and port 81, as well as the header which will contain the IP address of a client sending that request. This will tell the web server what the IP address of a client is, in other words, who the client is (Fig. 1).

```
#limit_req_zone $binary_remote_addr zone=limit_req_zone:10m rate=1r/s;
    server {
        listen 80;
        server_name localhost;
        location / {
            proxy_pass http://192.168.206.128:81;
            proxy_set_header Host $host;
            proxy_set_header X-Real-IP $remote_addr;
        }
    }
```

Figure 1: NGINX configuration file

The following issue we have to tacke is, how to block any request being sent directly to the web server on a port 81. And for this to be possible, we can use a built-in Windows firewall „Windows Firewall with Advanced Security". There we set two different inbound rules. The first rule allows NGINX to communicate with a web server, and a second rule blocks all incoming traffic that is not coming from port 80 (Fig. 2).

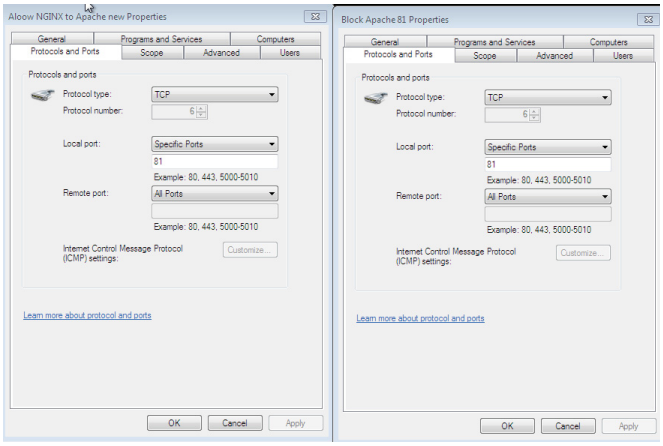


Figure 2: Windows firewall rules

In the following section we will explain how we set up our detection system and briefly mention how we executed Slowloris DDoS attack, but as for the base set up, this is how our environment will function. The last thing we must say is NGINX functions as a service, which means once it is started it will be active for as long as the machine is working.

IV. PRACTICAL EXAMPLE – ATTACK AND DETECTION

After setting up the base environment, the next issue that had to be tackled was how to execute the Slowloris DDoS attack. Instead of creating the script, we used a finished script that sends a huge number of HTTP requests, and you can change the code, so the number of the requests is higher and time between them is shorter [7]. The script was trying to generate 1000 connections every 100 seconds. It was occupying all sockets and in addition prevented any additional request from going through. If any user wanted to try to visit the web application, it would get the error that says that this page is unreachable.

First, we tried to visit the web application from the client machine, to check if we could visit the page we wanted to, and it was working as intended by typing the IP address and port 80 of NGINX in a browser. After it, we booted up the attacker machine and placed the script with the name "slowloris.pl" on a desktop and opened a terminal. We positioned ourselves where the file was (Fig.3) and executed the script with the IP

address and port 80 (Fig. 4). This would send multiple incomplete requests from the same IP address, which we will mark as the IP address of the attacker. This IP address is 192.168.206.131, and we will need to remember it as we will talk about detection next.

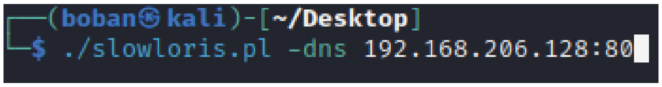


Figure 3: Positioning and execution - Slowloris script

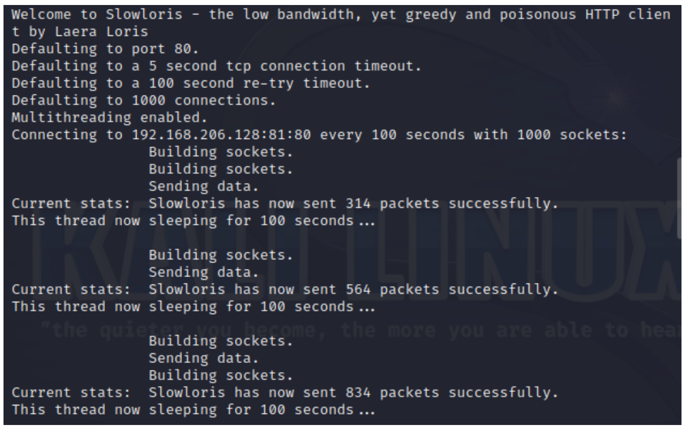


Figure 4: Slowloris post script execution

After executing the Slowloris script, we tried accessing the web application from the client machine and as expected the page we visited was down, meaning that the attack was successfully executed.

Successful attack execution meant we could take the first step of securing the web server and the application, by detecting the attack. The first step was using “access.log”, the NGINX log file, to read all requests that were going through the reverse proxy. But this alone would not help us much, that is why we combined it with the NXLog tool. Inside the NXLog configuration file we set a few rules that will allow us to filter all data needed to proceed with detection (Fig. 5). First thing we set was “ONLY_HTTP” rule, that will allow us to read only rows from NGINX log file which have “GET /HTTP/ 1.1.” pattern. For the input file we set attribute Module to “im_file”, which will allow it to read log files. Of course, we could set it to “im_tcp” for log files through TCP, “pm_grok” for log manipulation, or any other property depending on the need. Next, we set attribute File to the path of the NGINX log file, and attribute Exec to the rule we set in the beginning, which will execute it. For the output file, we had to set the attribute Module to “om_file”, meaning a log file that will be used for writing in data, and File attribute set to a path of a newly created log file named “http_list.log” (Fig. 5). In the last section named “Route 2” we set the direction, meaning input file to be read and a file to be written into, in our case from NGINX log file to newly created http_acess.log file (Fig. 6). NXLog is also started as a service, the same way NGINX is, and every time NGINX gets new data into its log file, NXLog will also write it down in the new log file, with all filters applied.

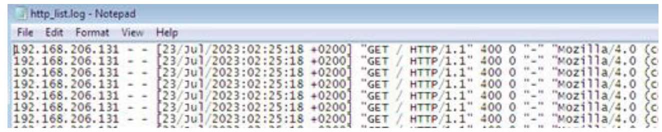


Figure 5: Http_list.log file

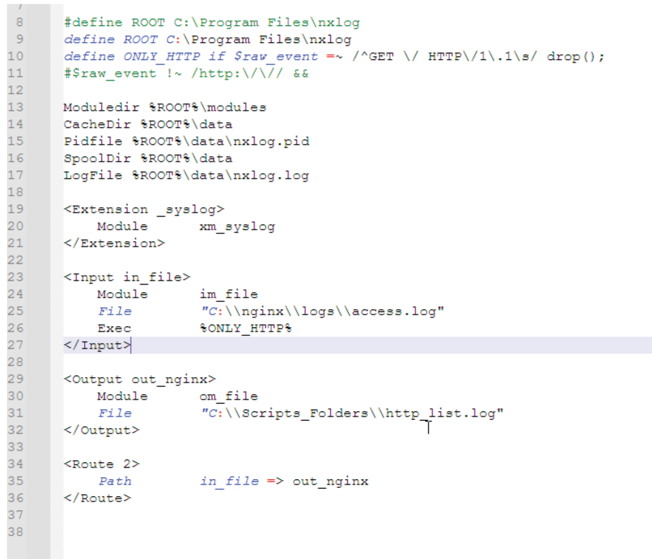


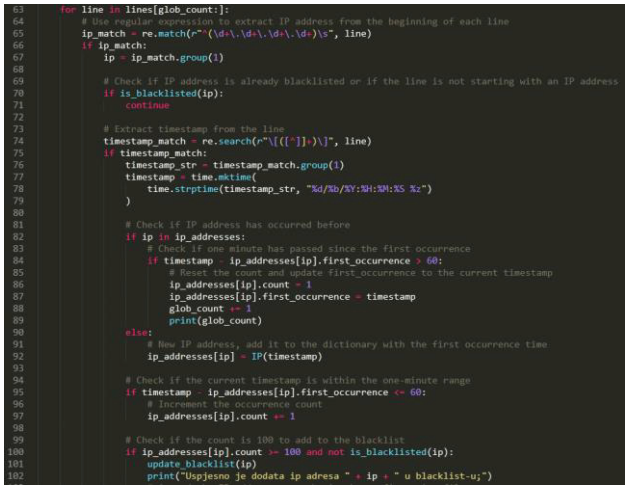
Figure 6: NXLog configuration file

Upon data being written down in http_access.log file, we needed to find a way to read it and get only data we will use to recognize that the attack is happening and to eventually prevent the attacker from further performing Slowloris DDoS attack. We wrote a script that will allow us to read data from http_access.log file using “Python 3.7” programming language and “Sublime text” integrated development environment (IDE). This script does both detection and prevention, so in the next section we will explain the rest of the script related to prevention.

The first problem that we had to solve is how to read the log file and detect attackers. Reading the log file was easy, we just used the built-in functions “open” and “readlines”. But to solve detection, we needed to think of a couple different rules that we would base our detection of Slowloris DDoS attack on. The first rule was how many HTTP requests are needed by a single IP address, so we could decide that this is considered as a DDoS attack. The second rule is how much time is needed to pass between HTTP requests. The final rule is how do we memorize the number of requests, a system that we could follow. The number of requests per a single IP address we decided to set to a hundred. This means that only a hundred requests can be sent by a single client. For the second rule, we decided that a maximum of a hundred requests can be sent every sixty seconds, or one minute. And lastly, we decided to use dictionaries as the system that will allow us to memorize the number of requests per minute. It consisted of “first_occurrence”, which memorized the timestamp of the first time the IP address occurred and “count” which memorizes the number of occurrences. Detection worked in a way, which would make an additional dictionary in which we

would memorize every appearance of the IP addresses in a row, and when the timestamp of the last appearance would be within a minute of the first appearance, it would increment the count by one. If the appearance is more than a minute, it would decrement the count by one, and set the next appearance of the IP address as the first appearance (Fig. 7). This is highly memory dependent, and not the best solution, but it is a way to show that it is possible to think of a way to detect a security threat. Following the time passed between requests is possible because of timestamps being written in http_access.log next to the IP addresses. Also, to further speed up the process of counting IP addresses and hopefully go a little bit easy on the memory usage, we made a condition that will check if the IP address is already in blacklist.txt file and skip adding it in the dictionary.

One way detection could be further improved is setting an alert being sent to an email address or something similar, that will notify administrators that the DDoS or high level of requests per IP address were being sent to their web server, which would additionally help keep it safe.



```
for line in lines[glob_count:]:
    # Use regular expression to extract IP address from the beginning of each line
    ip_match = re.match(r"^(\d+\.\d+\.\d+\.\d+)\s", line)
    if ip_match:
        ip = ip_match.group(1)

        # Check if IP address is already blacklisted or if the line is not starting with an IP address
        if is_blacklisted(ip):
            continue

        # Extract timestamp from the line
        timestamp_match = re.search(r"\[([^]]+)\]", line)
        if timestamp_match:
            timestamp_str = timestamp_match.group(1)
            timestamp = time.mktime(
                time.strptime(timestamp_str, "%d/%b/%Y:%H:%M:%S %z")
            )

            # Check if IP address has occurred before
            if ip in ip_addresses:
                # Check if one minute has passed since the first occurrence
                if timestamp - ip_addresses[ip].first_occurrence > 60:
                    # Reset the count and update first_occurrence to the current timestamp
                    ip_addresses[ip].count = 1
                    ip_addresses[ip].first_occurrence = timestamp
                    glob_count += 1
                    print(glob_count)
            else:
                # New IP address, add it to the dictionary with the first occurrence time
                ip_addresses[ip] = IP(timestamp)

            # Check if the current timestamp is within the one-minute range
            if timestamp - ip_addresses[ip].first_occurrence <= 60:
                # Increment the occurrence count
                ip_addresses[ip].count += 1

            # Check if the count is 100 to add to the blacklist
            if ip_addresses[ip].count >= 100 and not is_blacklisted(ip):
                update_blacklist(ip)
                print("Uspjesno je dodata ip adresa " + ip + " u blacklist-u;")
```

Figure 7: Part of the script in charge of requests per minute

V. PRACTICAL EXAMPLE - PREVENTION

Once the detection has been set up and working, the following step is using the data we collect to prevent any suspicious activity going on. So, the idea is to blacklist all IP addresses that break the rules we set up in the previous section. For that to be possible, we had to create a textual file named "blacklist.txt", in which we will write down all IP addresses to be blacklisted. After the counter for number of requests has reached a hundred in a minute, it would automatically write down the IP address in a row inside of the blacklist.txt file. The only issue with this is, because of the built-in "write" function everything you write in the file will automatically delete everything that is already written inside. So to solve this issue, we could read everything currently inside the file and copy it to some temporary textual file, and then concatenate newly found IP address together with all we copied in the new textual file and write it all together in blacklist.txt file. In this way no IP address will be gone from the blacklist.txt file.

After we added IP addresses to the blacklist.txt file, the next thing in order is to block their access to the reverse proxy and ultimately to the web server. By reading all IP addresses from the blacklist.txt file and writing them inside NGINX configuration file with a keyword "deny" in front of it, we managed to deny any request sent to our NGINX server. But as before with writing data inside blacklist.txt file, we had the same issue of everything being deleted from the file upon new data being written. This issue was solved by separating configuration into two textual files, exactly split where the data should be written, and then upon writing data into configuration file we would write it by doing concatenation of first part of configuration file, deny keyword with IP addresses to be blocked and in the end second part of the configuration file (Fig. 8). In this way configuration would always stay the same in the base outlay. This is no a solution we would recommend to anyone trying to protect their web server, but it shows that is possible to solve issues of this type with a little bit of creative thinking.

To make the script work as a service we used an infinite loop with "while" condition, which is always true. And one more function which will check the last modified date and time of the http_list.log file, which will tell us if the file was changed, and based on the timestamp inside we would be able to continue checking IP addresses based on the last row that was added.

In the end after trying to visit the page on the site from the attacker machine, we would get "Forbidden" message, and while trying to visit from the client machine, all data was loaded as intended.

```
server {
    listen 80;
    server_name localhost;

    location / {
        deny 192.168.206.131;
        proxy_pass http://192.168.206.128:81;
        proxy_set_header Host $host;
        proxy_set_header X-Real-IP $remote_addr;
    }
```

Figure 8: NGINX deny IP address

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Chat with PDFs: Chat with multiple PDF files, powered by OpenAI

Sario Al Mustafa

Abstract— **The „Chat with PDFs" paper presents a solution to document interaction through conversational AI (Artificial Intelligence). Searching for a specific information from a PDF file or from multiple PDF files can be daunting task as users had to use the PDF tool find and by entering a keyword or perhaps a short sentence in hope that it will match exactly as it is in the PDF documents and then scrolling through all the results and reading them. This process can be time consuming and not efficient at all. This paper presents a solution to the tedious work of finding information through PDF documents by utilizing a range of technologies and libraries to achieve the user-friendly experience while "talking" with the PDF documents. The paper presents how AI and UI (User Interface) technologies may be combined to change typical document handling into an engaging dialogue system.**

Key words — **Artificial Intelligence, AI, PDF, OpenAI, chat.**

I. Introduction

When it comes to digital documentation, PDF files are one of the most popular formats used for sharing and archiving information in a number of industries. However, searching through large PDF files for a particular piece of information can be a difficult task, it frequently calls for scanning pages by hand or using crude keyword search functions that are devoid of semantic awareness and context sensitivity. This old-fashioned method of document searching is time consuming and occasionally ineffectual.

In order to address this problem, the "Chat with PDFs" paper makes use of a chat-based interface that is driven by OpenAI's Large Language Models (LLMs) to enable natural language interactions with the system. This enables the users to easily perform conversational queries and obtain information from multiple PDF files. The application can comprehend and analyze complex queries thanks to the integration of OpenAI's LLMs, and it can provide precise and contextually relevant information from the PDF documents. This method improves the user experience by making information finding from PDF documents as easy and natural as having a conversation, while simultaneously increasing the efficiency of the search process.

There are several papers dealing with similar issues [1–5]. In [1] paper the solution is presented as a Language Chatbot that is powered by OpenAI and Google's speech recognition which is developed as a WeChat mini-program. The chatbot offers three learning levels to enhance language skills. The challenges that the chatbot is facing are phonetic recognition and dataset limitations. The paper demonstrates the potential of AI in education while highlighting the need for improvement in answer accuracy and diversity. While in the [2] paper the solution is presented using frequent subgraph mining, Maximal gSpan offers a novel method for Multi-Document Summarization (MDS) that allows for the extraction of important information from several texts. This method focuses on mining maximal frequent subgraphs with different words to improve document coverage and decrease redundancy in summaries, in contrast to deep learning methods that require large amounts of data. This method performs better than conventional unsupervised techniques like TextRank, proving its efficacy and efficiency in producing clear and thorough summaries. The [3] paper explores how ChatGPT from OpenAI might be used to provide literature reviews for the healthcare industry with a particular emphasis on Digital Twin technology. The abstracts from studies (2020–2022) that they discovered via a Google Scholar keyword search for "Digital Twin in Healthcare" were paraphrased using ChatGPT. The iThenticate tool's plagiarism checks found significant matches in the paraphrased sections, indicating a lack of originality, even though the results show potential in speeding up knowledge accumulation and expression with little human work. The study highlights the nascent phase of artificial intelligence's involvement in scholarly publishing, implying that forthcoming developments may alleviate the academic burden, so enabling scholars to focus more intently on their research. In [4] paper the evaluation of ChatGPT, an AI-powered chatbot, in relation to writing English essays is discussed. It is clear that the chatbot can write well-structured essays with appropriate voice, syntax, tenses, and grammar on a range of subjects. The findings demonstrate that ChatGPT can provide students with comprehensive and contextually appropriate support with their English assignments in an effective manner. However, the study suggests that the papers generated by ChatGPT might require closer attention to grammatical accuracy. This study demonstrates the potential of ChatGPT as a teaching tool that can support students learning, especially with regard to language-related assignments. The [5] paper talks about ChatGPT, an AI conversational bot created by OpenAI that uses the GPT-3 language model to interact with users in a natural way. Similar to a human, ChatGPT can accurately

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reply to a broad variety of cues. Because of its thorough training on numerous datasets. Because of its potential uses in customer service, translation and content creation, this technology has attracted a lot of attention. Despite its potential, ChatGPT has drawbacks such as a limited capacity to comprehend complicated ideas and the potential for biases in its training set.

While each paper [1–5] showcases a number of AI applications while identifying particular difficulties and areas for improvement, "Chat with PDFs" offers one potential way that AI may be used in a person's everyday life.

In the second section, the use of technologies and libraries are explained. The Third section presents the design and logic of the application "Chat with PDFs". The fourth section presents the use case of the application and its results, while concluding remarks are given in the fifth section.

II. Technologies and Libraries

Using a variety of technologies and libraries [6–12], the solution presented in this paper "Chat with PDFs" application creates an interactive chat interface that allows users to query information from PDF documents. An extensive rundown of the different libraries and technologies used:

• Pyenv - is a tool that allows for the management of multiple Python versions on a single system. It enables users to switch between different versions of Python easily, making it highly useful for developers who work on multiple projects that may require different Python versions.

• Streamlit – is open-source Python library that simplifies the process of creating web applications for machine learning and data science. In this paper, Streamlit is used to build the interactive web interface, allowing users to upload PDFs, ask questions, and view responses.

• Python-dotenv (dotenv) is a Python library for reading key-value pairs from a .env file and setting them as environment variables. It is used to manage configuration and sensitive information securely.

• PyPDF2 is a Python library built as a PDF toolkit. It is capable of extracting document information, splitting documents page by page, merging documents, cropping pages, and more. In this apper, PyPDF2 is used to read and extract text from uploaded PDF files.

• LangChain is a framework designed to build applications with language models. It includes components for text splitting, embeddings, vector stores, chat models, memory management, and more. The application presented in this paper uses several LangChain modules:

o Text Splitter (CharacterTextSplitter): Splits text into manageable chunks or segments based on characters, useful for processing large texts.

o Embeddings (OpenAIEmbeddings): Converts text into numerical representations (embeddings) using models from OpenAI, enabling semantic text analysis.

o Vector Stores (FAISS): Utilizes the FAISS library for efficient similarity search and clustering of dense vectors. In this paper it is used to store and retrieve text embeddings.

o Chat Models (ChatOpenAI): Facilitates the integration of OpenAI's GPT models for generating conversational responses.

o Memory (ConversationBufferMemory): Manages the state and history of conversations.

o Chains (ConversationalRetrievalChain): Combines language models, retrievers, and memory to create a conversational interface.

• FAISS (Facebook AI Similarity Search) is a library for efficient similarity search and clustering of dense vectors. It's particularly useful for tasks that involve searching for the nearest neighbors of vectors in high-dimensional spaces.

• HTML Templates (css, bot_template, user_template): Custom HTML and CSS templates for styling the chat interface in the Streamlit application, enhancing the user experience.

In summary, the "Chat with PDFs" application combines multiple technologies and libraries, each chosen for its role in developing a practical and efficient platform for conversational document retrieval.

III. Design and Logic

The "Chat with PDFs" application is designed to be an easy-to-use platform that connects document browsing (including search and retrieval functions) with conversational user interfaces. Its main goal is to give the users a easy way of retrieving PDF content (which can often be a difficult process) by allowing users to engage with and extract information from PDF documents via natural language conversations.

The front-end interface is designed to be minimalist yet functional. It is developed with Streamlit, a Pyhon library that is known for its efficiency in building machine learning and data science applications. The applications interface is split into two main components (Figure 1 and Figure 2): a conversational section where the user can “talk” with the PDF files and the side bar that contains the upload field for PDF files, as well as button for processing the PDF files and details of the PDF files such as number of pages per PDF file and their size in KB/MB.

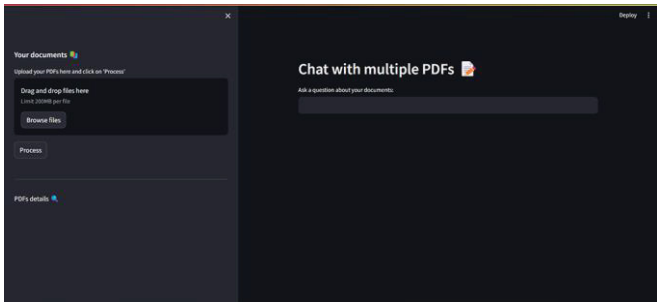

Figure 1. Interface design before the question is asked

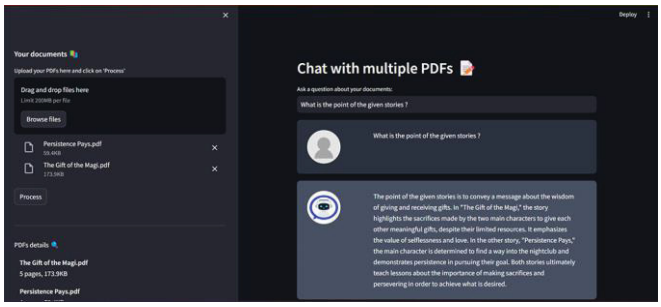

Figure 2. Interface design after the question is asked

The templates that are developed aims to give the users a feeling of natural conversation, as if they are talking to a person. The templates represent the user who is asking the questions and the bot that is replaying with an answer. Templates are developed using HTML and CSS. The templates have placeholders that are populated with the user questions and bot replies/answers.

The "Chat with PDFs" application is developed with a robust back-end (Figure 3) to simulate a smooth conversational experience through document parsing, text processing, and effective information retrieval.

The process starts with the application using PyPDF2 library to extract text from uploaded PDF documents, parsing through each page to construct a detailed textual representation.

After which the CharacterTextSplitter from LangChain comes into play, segmenting the extensive text into smaller, more manageable pieces. This segmentation is important for improving processing efficiency of the next steps. The application then uses OpenAIEmbeddings to convert these text chunks into semantic vector embeddings. These embeddings are indexed within a FAISS vector store. This method is important to the applications ability to understand user queries/questions and retrieve the most relevant information.

The ConversationalRetrievalChain is the application's interactive functionality. This component combines the semantic richness of the vector store, the contextual awareness offered by a conversation memory buffer (ConversationBufferMemory), and the nuanced capabilities of a language model (ChatOpenAI). This combination allows the application to provide accurate and contextually relevant responses from the indexed text while also preserving the conversational context and memory of previous exchanges.

When the user submits a question, the application does a semantic analysis to identify the most relevant text segments. Based on these segments, the language model then generates informative responses delivering them through the chat interface. By using the content of the PDF files, this dynamic response generating mechanism turns user questions/questions into dialogue exchanges resulting in accurate and meaningful information.

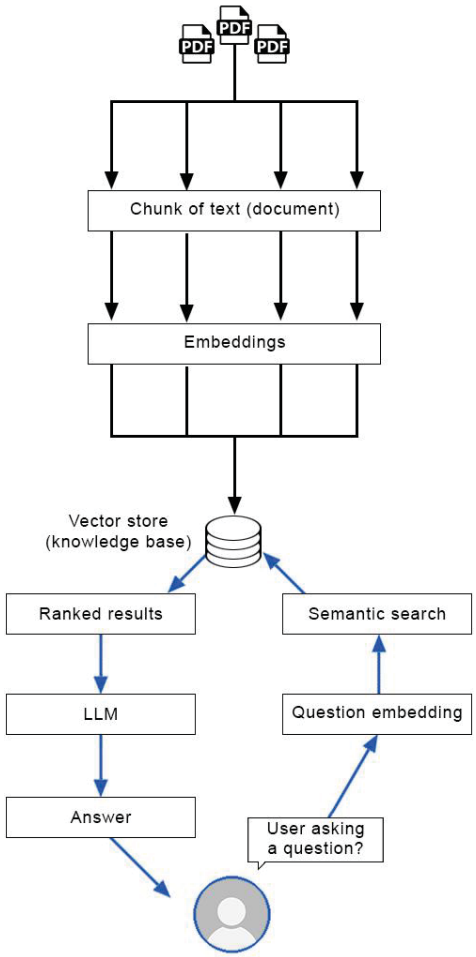

Figure 3. Back-end logic

The "Chat with PDFs" application redefines how users interact with and extract information from PDF files by combining a thorough back-end design with an easy-to-use front-end interface. This makes the process feel as natural as having a conversation with a person.

The applications interaction flow is made for simple, uncomplicated user involvement. By asking questions using the chat interface, users start a conversation. The application uses its conversational processes to answer these queries. With its skill at semantic comprehension, the application processes searches through indexed text from uploaded PDF files to find the content that most closely fits the user's question.

The application simulates a normal conversation by dynamically crafting and presenting responses within the chat when it finds pertinent content. This methodology not only guarantees precision but also enhances the user experience by simulating conversational and straightforward information retrieval.

The application uses visual signals like progress bars to notify users while processing, particularly for complex searches that may take longer. Throughout the use of the application by the users, these components aid in managing expectations and preserving a smooth and interesting engagement.

The goal of the "Chat with PDFs" application is to change how people engage with PDF documents by using conversational AI to make information retrieval not only effective but also entertaining. This design concept captures this goal.

IV. Results

The "Chat with PDFs" application was tested for its ability to help with efficient information retrieval from PDF documents in a practical evaluation involving a focus group of 10 participants. Through the usage of the application chat interface, participants were able to review the applications accuracy and user experience by requesting specific details from a set of provided PDF files. The application received positive feed backs for its user-friendly interface and shown impressive effectiveness in text parsing and providing relevant responses. Participants used various PDF files ranging from stories like „The adventures of Tom Sawyer“, „The Gift of Magi“ to legal documents such as „The Constitution of the United States“. Some of the results are shown in Figure 4.

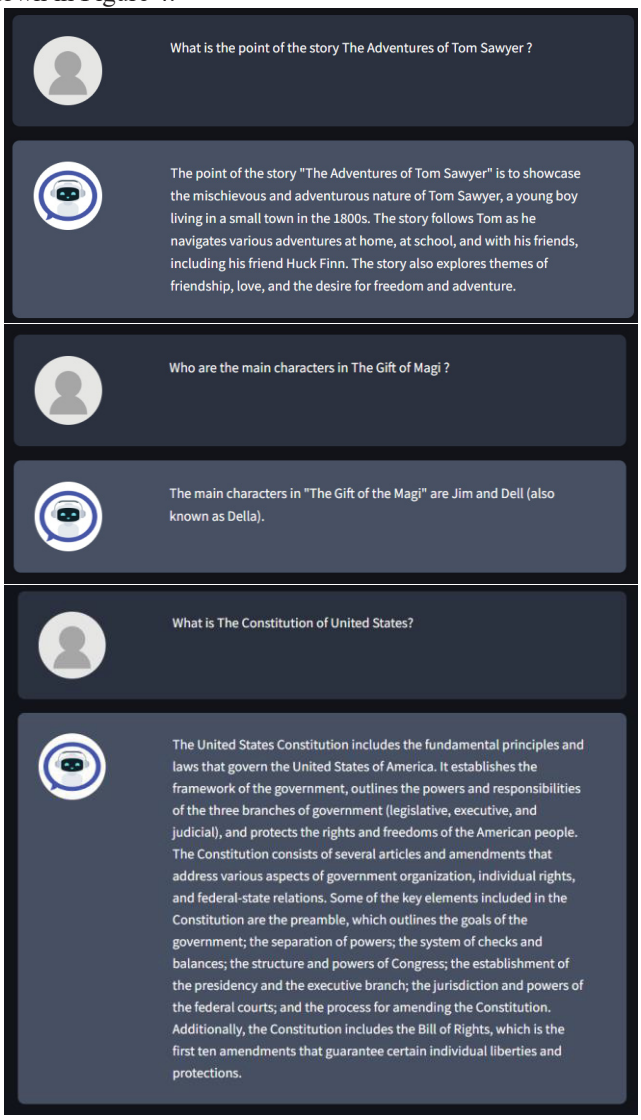

Figure 4. Results (questions and answers)

Participants liked how easy it was to interact with the PDF files and how much less work it took to search for particular information from PDF files. Even though the application answered questions quickly and accurately, there were sometimes delays when they were difficult, which pointed out areas that could be optimized. Participants feedback suggest enhancements such as key word highlighting, references from the PDF documents that the answer is based on and broader document format support, pointing toward opportunities for further development. The focus groups overall experience highlighted the applications value in expediting the retrieval of information from PDF documents, while also suggesting areas for further development.

V. Conclusion

The "Chat with PDFs" application is a big step in reinventing how people engage with PDF documents. The application improves the user experience by enabling conversations between users and their papers (PDF documents). This makes information retrieval easier. The focus group feedback highlights how much less time and work it may save compared to the conventional method of searching through PDF documents. Although there is room for improvement, especially in terms of processing sophisticated queries more quickly, the application lays a strong basis for upcoming advancements in document management and interaction. It has the potential to develop into an essential tool in the field of digital documentation as it moves forward.

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Utilizing Digital Twins for the Decarbonization of the Maritime Traffic in Boka Bay

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***Abstract*— This paper aims to emphasize the potential application of digital twins (DTs) in the maritime sector. The primary objective is to assess how DT technology facilitates the reduction of carbon emissions in maritime traffic. In the maritime industry, implementing DT can provide valuable insights into vessel performance, operational efficiency, and environmental impact. Using the example of a tourist boat cruising in Boka Bay, the benefits of creating an appropriate DT for this vessel are highlighted, with a specific focus on reducing harmful gas emissions. Future research directions in this crucial area are also outlined.**

I. Introduction

Maritime transport carries over 80% of global cargo and plays a crucial role in the world economy [1]. Due to the use of fossil fuels, this mode of transportation causes significant emissions of harmful gases. These emissions, including CO_2 and methane, contribute to climate change, accounting for 2-3% of total greenhouse gas (GHG) emissions, according to an International Maritime Organization (IMO) study from 2020. It is projected that emissions of harmful gases in the maritime sector could increase by up to 50% by 2050. In the European Union (EU), maritime transport has accounted for 13% of GHG emissions in the transportation sector since 2015. Continuous efforts are being made in the maritime sector to enhance safety and environmental protection, with the particular challenge of achieving decarbonization. Digitalization plays a crucial role in addressing safety and environmental concerns. European Union (EU), focusing on decarbonization and digitalization, utilizes digital tools for information exchange, presenting the potential to reduce carbon impact in the maritime transportation sector [2], [3], [4].

In the process of digitalization, the DT plays a crucial role, already emerging as a promising concept for improving various processes, including reducing emissions of harmful gases and enhancing operational efficiency in the maritime sector. The DT provides a system that enables monitoring, sharing, and planning operations for all participants in the supply chain. Through the efficient use of data, digital twins significantly contribute to improving operational efficiency in ports, reducing waiting times for ships near ports, and optimizing overall operations [5], [6], [7], [8]. The digital twin, including hardware and software for data acquisition, processing, and management, surpasses traditional models and simulations by utilizing digital data streams, connecting a physical entity with its virtual representation [9], [10].

The paper is structured into five chapters. The concept of the DT and its potential applications are presented in the second chapter. The development of the DT in the maritime sector is outlined in the third chapter, while the fourth chapter highlights the role of the DT in the decarbonization process. The conclusion and a list of references used are provided at the end of the paper.

II. About Digital Twins and Their Use in Maritime Sector

A digital model is a virtual representation of a physical system or object, while a digital shadow is an enhanced digital model with an automated one-way flow of data from the physical system. Going a step further, a DT is an advanced model that enables a two-way flow of data between the model and the physical object or system. This interaction allows engineers to proactively manage assets, reducing potential issues in real-time [11].

DTs are devices or computer models, either physical or virtual, that imitate, mimic, or "twin" a real entity such as an object, process, person, or human characteristic. Each DT is connected to its physical twin through a unique key, enabling clear linkage between them. These twins are not just simple models or simulations; they represent a living, intelligent, and evolving virtual copy of the real entity or process. They track the life cycle of their physical twin to monitor, control, and optimize its processes and functions. Continuously predicting future states, such as defects, damages, or failures, they enable simulation and testing of new settings for preventive maintenance operations. The twinning process is achieved

*Research supported by Ministry of Education, Science and Innovations, Republic of Montenegro.

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through continuous interaction, communication, and synchronization (closed-loop optimization) between the DT, its physical twin, and the environment in which it operates [12]. Physical and digital twins must have network equipment for continuous connectivity and data exchange, either through direct physical communication or via the cloud. Thanks to this uninterrupted connection, the DT constantly receives dynamic data about the status of the physical twin and the environment, changing throughout the life cycle. It also actively sends predictions and recommendations for system maintenance and optimization functions to its physical twin, field experts, and other DTs in the environment [13], [14].

DTs have diverse applications in manufacturing, construction, automotive, aviation, maritime, healthcare, etc. In manufacturing, they aid in product and process design, supply chain management, and preventive maintenance. The construction sector leverages the benefits of DTs for project control and safety. The automotive and aviation industries use them for product innovation. Healthcare applications include drug discovery, personalized medicine, and facility design [15], [16], [17], [18].

These diverse applications highlight the versatility of DT technology across various sectors. In many industries, including maritime, opportunities arise for digital modeling and simulation before key decision-making moments. The use of DT technology in port operations is centered on digitization and integrated management, simulating construction and operations to achieve the virtualization of port infrastructure [8]. In the maritime sector, the DT becomes crucial for strategic decision-making in shipping companies serving multiple clients, analyzing business transactions. Customized for fleet optimization, it enhances operational decisions, especially in unpredictable situations, allowing for quick and thorough option evaluations and contributing to more efficient operational strategies [9], [19].

The use of DTs is also significant in assessing travel performance, which is crucial for both the safety of transoceanic vessels and the reduction of GHG emissions [20]. The ship's DT enables an assessment of speed loss due to hull fouling, using information from relevant sensors on the ship. The application of DT in this case allows for the analysis of reduced fuel consumption due to the mentioned cause, contributing to more efficient travel planning [21]. The use of DT is also of great significance for the development of Autonomous Maritime Surface Vehicles (AMSV) as it enables improved navigation and enhances the safety of these vessels [22].

III. DIGITAL TWIN OF A SHIP

The DT model essentially involves connecting (knowledge construction) various types of ship models that are populated with data corresponding to the ship's design, operational data, and even data from the ship's environment. During the operational phase of the ship, this data is collected through Internet of Things (IoT) sensors installed on the vessel [23].

Ship models, enriched with collected data, are used to analyze, predict, and control the vessel's behavior through a combination of simulations and machine learning (ML) techniques. These models rely on a multitude of input parameters to compute corresponding output parameters. The input parameters encompass a diverse array of variables sourced from both external and onboard sources. External data sources include AIS data and information from meteorological stations, providing crucial contextual information. Additionally, onboard sensors play a pivotal role by monitoring engine performance indicators such as pressure, temperature, RPM, fuel consumption, and vibration. Furthermore, real-time data on electrical power consumption by various onboard systems, ranging from propulsion to auxiliary systems like lighting, air conditioning, refrigeration, navigation, and communication, is integral for accurate analysis. The ultimate goal is to optimize the ship's operational parameters to reduce its environmental impact.

Optimization possibilities encompass various aspects, including navigation, ship route selection, as well as maintaining the vessel in optimal operational condition with the aim of reducing fuel consumption, utilizing preventive maintenance [5], [24]. DT management requires specific features such as comprehensive integration of virtual and real, data-driven decision-making, fusion of all elements in the scene, comprehensive optimization, and continuous upgrading [22] .

DTs simulate complex ship operations, offering cost-effective testing for scenarios unfeasible on actual ships, applied from financing to decommissioning to mitigate human error. By integrating diverse ship models and enriching them with real data, DTs create virtual replicas of ships for comprehensive analysis throughout their life cycles. [5], [23].

The basic DT model compiles normalized ship data from various sources, serving as a reference for ML predictions and simulations. It provides a foundational framework for verifying predictions and comparing more intricate data models [10], [12], [24], [25].

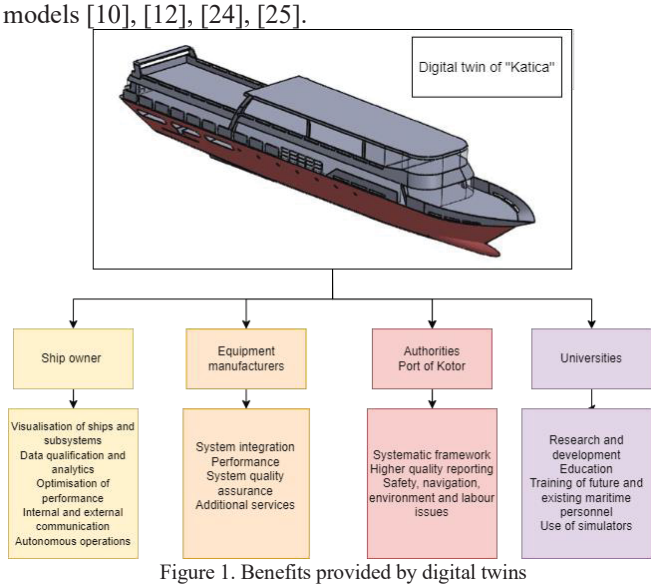

Figure 1. Benefits provided by digital twins

By introducing various variables into these models, scenarios can be shaped to offer adaptable solutions, especially in compliance with changing regulations [26]. For instance, these models are used to test compliance with various emission regulations, ensuring that ships meet environmental standards. This approach enables proactive measures and compliance to address evolving regulatory requirements in the maritime industry.

The use of DTs in the maritime industry promises significant benefits through systematic alignment of digitization efforts. These DTs provide valuable information for ship owners, equipment manufacturers, authorities, universities, and maritime colleges and academies. For ship owners, they enable visualization, analysis of operational data, performance optimization, and improved communication.

Equipment manufacturers are provided with tools for system integration and demonstration of technological performance. Authorities benefit from a systematic framework for collecting information from each ship, enhancing reporting. Universities and maritime academies experience increased system understanding and facilitate knowledge exchange, supporting research and education, as shown in Figure 1 [27].

IV. Decarbonisation Solutions: Assessing Energy Savings and Building the Digital Twin

Before constructing a DT model, it is crucial to establish the framework within which that model will be built and applied, as shown in Figure 2. DT models consist of interdependent and real-time interacting physical components and their digital representations. For simulation platforms, a substantial amount of data is required to optimize the operational environment, whether it involves shipbuilding or maritime operations. To imitate real activities as accurately as possible, a well-defined DT framework is essential [5], [10], [12], [28].

The assessment of the effectiveness of decarbonization solutions involves several key steps. Initially, a performance-black-box model is established, trained using pre-twin data, capturing the vessel's behavior before the application of decarbonization solutions. Subsequently, this trained model is utilized to predict energy consumption and harmful gas emission production, employing input data from post-twin(s), enabling comparisons under similar conditions. The final step involves the analysis and comparison of the predicted energy consumption and generated harmful gas emissions with actual post-application data, thereby providing a precise assessment of the observed processes [5].

Creating a DT for the vessel "Katica" cruising the Boka Bay enables precise monitoring of its performance, including fuel consumption and other key data, which can aid in improving efficiency and sustainability of its operations. Integrating the DT of "Katica" with the DT Framework will provide a detailed view of the actual state of the ship and enable simulations to optimize routes, navigation management, and reduce environmental impact.

Real-time vessel performance management becomes crucial with digital twins, enabling continuous monitoring through embedded sensors and connected equipment. This technology allows for instant recognition of the need for optimization, improving responsiveness to changes in navigation conditions or the availability of renewable energy sources (RES). By analyzing vessel data, weather conditions, and solar resource availability, digital twins contribute to route and speed optimization. The integration of this information enables recommendations for the most efficient routes and appropriate speeds, significantly reducing fuel consumption and increasing the utilization of RES, directly contributing to decarbonization goals. Additionally, through the analysis of driving behavior, system maintenance, and the use of RES, digital twins identify operational aspects influencing the energy efficiency of the vessel. Implementing recommendations derived from this analysis can achieve long-term improvements in energy efficiency operational indicators. This approach allows for continuous enhancement of vessel performance with a focus on emission reduction and optimizing the use of renewable energy sources.

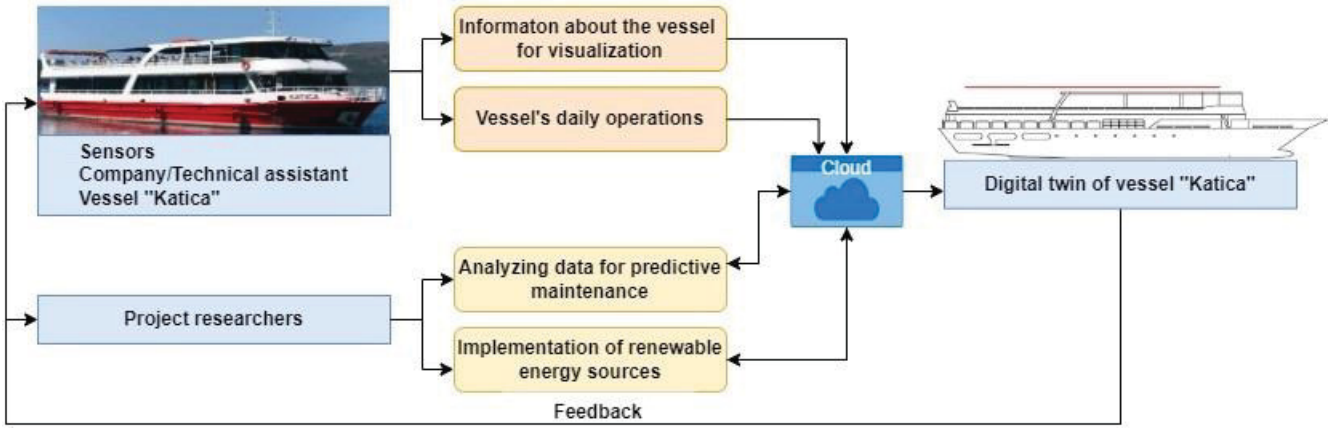

Figure 2. Processes required for the development of the digital twin of the vessel 'Katica'

V. Conclusion

Based on the review of research on the application of digital twins in the maritime sector, it can be concluded that this technology has significant potential to enhance maritime safety and contribute to the reduction of harmful emissions from ships. The aim of this paper is to outline the steps and highlight the possibility and significance of creating a DT for the vessel "Katica" that sails in the Boka Bay. Future research will focus on collecting data from the vessel "Katica" and working on developing its DT model. A particular challenge is the method of collecting, storing, and integrating the relevant data necessary for the development of the digital twin. Considering the large amount of expected diverse data to be collected in different navigation modes, future work plans to utilize advanced artificial intelligence techniques for their processing and analysis.

Acknowledgment

This paper is a result of the research carried out under the national research project "Decarbonization of the Maritime Sector - Green Boka Bay - DeMS-GBB" (No. 0402-082/23-1106/1).

Funding: The research was funded by the Ministry of Education, Science, and Innovations, Republic of Montenegro.

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Proposal for Standardization of the Application of Digital Twins in the Maritime Sector

Maja Krčum, Jelena Žanić Mikuličić, Vera Kapetanović, Jelena Nikčević

***Abstract* —** *Standardization has found its application in digital technologies through the concept of digital twins in the maritime sector. Understanding and knowing existing standards is particularly important for better and correct implementation and use of digital twins in the marine sector. There are standard-setting initiatives to facilitate the application of digital twins by creating common frameworks, guidelines, and protocols in the maritime sector. In this paper, on the example of the vessel that sails Boke Bey (Montenegro), an overview of part of the norms that provide guidelines for the creation, use, maintenance, and management of digital ship twins is given, as well as a proposal on how to manage documentation in the context of standardization. It is precisely in this example that the importance and establishment of a standardized normative framework that can be used and exchanged by shipbuilders, designers, shipyards, vessel owners, the academic community as well as other users whose common goal is to create a unique database based on the concept of digital twins and to contribute, per example, to sustainable development.*

I. INTRODUCTION

The maritime industry is transforming, leveraging cutting-edge technologies to enhance operational efficiency, safety, and sustainability. Digital twins (DTs) have emerged as game changers among these technological advancements. DTs are virtual replicas of physical objects, systems, or processes, enabling real-time monitoring, analysis, and optimization. They facilitate predictive maintenance by monitoring the condition of critical components in real time and decision-making by digitally testing different scenarios without real risks [1].

Digital twins are reshaping how vessels, ports, and supply chains operate in the maritime sector. When discussing DT applications in the maritime industry, they are used for vessel performance optimization, predictive maintenance, port and terminal management, supply chain visibility, environmental monitoring, and compliance [2]. DTs allow for the creation of virtual models of entire vessels, replicating their structure and systems. This enables continuous monitoring of performance metrics such as fuel consumption, engine efficiency, and overall health of onboard equipment. Machine learning algorithms integrated with digital twins can predict potential issues based on historical data, enabling crews to take preventive measures before a failure occurs. Ports and terminals are complex ecosystems involving numerous processes and entities. DTs provide a holistic view of port operations, allowing stakeholders to optimize resource allocation, streamline cargo handling, and improve overall efficiency [3]. Real-time tracking of cargo movements, predictive analytics, and simulation capabilities empower port authorities to handle increasing traffic and enhance security. Furthermore, they extend beyond individual vessels and ports, encompassing the entire maritime supply chain. This includes cargo tracking, inventory management, and coordination between different modes of transport. Enhanced visibility into the supply chain ensures timely deliveries, minimizes disruptions, and improves overall logistics efficiency [4]. DT's role is crucial in environmental sustainability by monitoring vessel emissions, fuel consumption, and compliance with environmental regulations. By analyzing data from digital twins, the maritime industry can proactively address environmental concerns, reduce its ecological footprint, and align with global sustainability goals [5, 6].

II. IMPORTANCE OF DIGITAL TWINS IN THE MARINE INDUSTRY

The DT concept differs due to the nature of the information for each area in terms of the specific needs, protocols, methods, and technologies themselves. However, it is important to point out that a general framework for DT architecture has its own real and virtual worlds interconnected, as illustrated in Figure 1 using the DT of a ship as an example.

Each element integrates different components, such as sensors from the real world (boat speed, emissions, etc.) and twins that process data and databases using machine learning or artificial intelligence. The communication elements are interconnected (internet, satellite, etc.), and this architecture enables constant monitoring and visualization. In this paper, we would like to highlight the maritime sector with all its specificities precisely because it is becoming increasingly important to assess the environmental footprint, social aspects, and economic value of the use of renewable energy sources (hydrogen, photovoltaics, wind power...) in shipping across the entire value chain.

Research supported by the Ministry of Education, Science and Innovations, Republic of Montenegro U ovom radu se upravo želi istaknuti domena pomorstva sa svim svojim specifičnostima upravo iz razloga što je sve je veća

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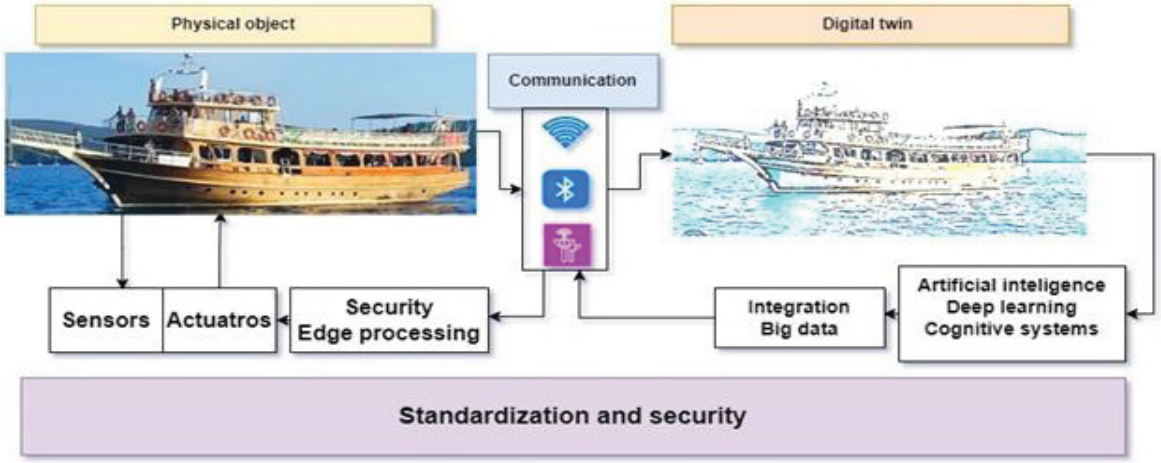

Figure 1. General princpe of DT architecture

Digital twin technology has been increasingly used in the shipping industry over the last 4-5 years. Many companies have digital twin solutions, but they are different and fragmented. For Industry 4.0, data, information, and services in the digital twin must be consistently interoperable and available for exchange in the value and supply chain in a standardized way. This cannot be achieved if every company in the industry develops its own digital language and its own company-specific APIs/interfaces for accessing and using the digital twin. Interoperability is so important that it is one of the three pillars of Vision 2030 defined by the Industry 4.0 platform. The lack of interoperability in the shipping industry is currently a reality. Many endpoints/interface dictionaries are key to achieving interoperability in Industry 4.0. The digital twin systems used for decision support should be based on a monitoring system that oversees the improvement of documentation, information flow, and regulatory standards in the industry, leading to continuous optimization throughout the entire life cycle value chain. Therefore, work should be done on the development of an interoperable digital twin platform based on Industry 4.0 standards, on the development of data and information models in the value chain from production and distribution to refueling and storage to distribution and energy conversion in the ship, and to combine these elements in a fully documented, accessible and reliable platform for innovation. Standardization is, as can be seen from Figure 1, the basis on which the entire development rests.

The work aimed to create a concept of a database where data is collected in one place, from different sources, in different forms (paper, digital), and the ways of using that database are agreed upon for all users who are within a certain group (it can be a project team ...). The purpose is to use this method to reduce costs, speed up, and facilitate work on documentation. (Figure 2):

- One or more documents belong to a standardization system, and several documents can belong to a standardization system
- The project coordinator issues one or more documents that belong to a group within the standardization system, and the standardization system itself may have one or more documents.
- A standardization system requires one or more services from institutions dealing with standardization (IMO, IEEE...), and an institution provides several services required by such a system.
- Several institutions send one or more data to the Project team system, which belongs to a standardization system, and the project team may have one or more data for a specific standardization group.
- One document has several notes.
- A ship can have multiple notes.

III. STANDARDIZATION

The maritime industry is embracing DTs as a powerful tool for optimizing operations, enhancing safety, and improving overall efficiency. As DTs adoption accelerates, standardization becomes paramount to ensure seamless integration, interoperability, and widespread industry adoption [7].

This paper explores the importance of standardization in the realm of digital twins within the maritime sector and the steps being taken to establish a common framework. Therefore, standardization is needed due to interoperability, data consistency and quality, regulatory compliance, and cost efficiency. Standardization fosters interoperability among these entities' various systems and platforms. A standardized approach ensures that DTs from different manufacturers or service providers can communicate, share data, and work together seamlessly, promoting a more integrated maritime ecosystem [8]. Standardized data formats and structures ensure consistency and quality across digital twin implementations. Common standards facilitate the exchange of information between different components of the maritime ecosystem, promoting a more transparent and collaborative industry. The maritime industry is subject to numerous international and regional regulations governing safety, security, and environmental sustainability. Standardization helps ensure that digital twins comply with

these regulations, providing a reliable framework for regulatory authorities to assess and monitor compliance.

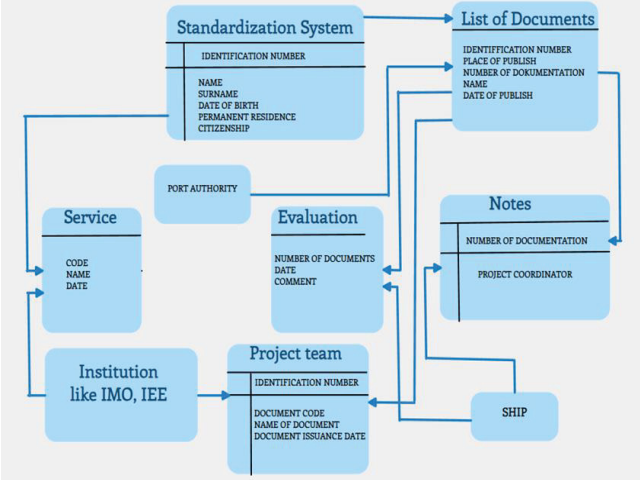

Figure 2. Database concept – Standardisation system

It can lead to cost efficiencies by reducing the complexity associated with integrating diverse systems [9]. Current initiatives in standardization are:

ISO 9001- an international standard that specifies the requirements for a quality management system (QMS). The standard places a strong emphasis on performance evaluation, requiring organizations to monitor, measure, analyze, and evaluate the performance of the QMS. This includes the use of key performance indicators (KPIs) to assess the effectiveness of processes [10].

ISO 23247 - the International Organization for Standardization (ISO) has initiated work on ISO 23247, a standard specific to the maritime industry for the exchange of digital information between ship and shore. This standard aims to enhance communication, data exchange, and interoperability in the maritime ecosystem. The standard has four parts: (1) overview and general principles, (2) reference architecture, (3) digital representation, and (4) information exchange. These four parts provide guidelines and procedures for defining scope and objectives, analyzing, modelling requirements, promoting and implementing common terminology usage [11].

ISO/IEC 27032 as guidance on the establishment of a framework for coordinating and managing cybersecurity [12].

ISO 19030 - set of standards related to the measurement of changes in ship hull and propeller performance. It specifically provides guidelines and methodologies for the assessment of the performance of a ship through the monitoring and analysis of data. It is aimed at helping ship operators, owners, and other stakeholders in the maritime industry to assess and optimize the performance of their vessels [13].

IACS Unified Requirements (UR) S104 - the International Association of Classification Societies (IACS) has developed UR S104, a unified requirement providing guidelines for the use of digital technologies, including digital twins, in the design, construction, and operation of ships. This contributes to a standardized approach across different societies [14].

Collaborative Industry Efforts - industry consortia, collaborative initiatives, and partnerships are emerging to address standardization challenges collectively. These efforts involve key stakeholders working together to define common standards, share best practices, and accelerate the adoption of digital twins in the maritime sector.

IV. LEGAL IMPLICATIONS OF DIGITAL SHIPS TWIN

The discovery of digital twins also has legal implications. The complex nature of digital twins raises numerous legal issues that require clarification, such as ownership or possession, issues related to data and liability, intellectual property related to digital twins, and the like [15,16]. The first question that arises is the question of ownership, i.e. "who owns the digital twin?" Furthermore, the digital twin as an information repository contains a lot of data from the ship, the physical twin, and its quality depends precisely on the data that goes into it [17]. For example, data describing how the ship was designed and built, its design, its construction, data about its functioning, its wear and tear (how it "ages") and many others, depending on the purpose of the digital twin. To avoid unforeseen situations, it is necessary to shed light on the ownership of the data, data sharing/transmission, its confidentiality, accuracy, unauthorized modification and the like. In connection with the data, you should keep in mind the EU regulations, which apparently can also be applied to the data contained in digital ship twins. These are Directive (EU) 2016/943 on the protection of undisclosed know-how, experience and business information (trade secrets) against their unlawful acquisition, use and disclosure [18], Regulation (EU) 2018/1724 of 2. October 2018 on the establishment of a single digital gateway for access to information, procedures, assistance, and problem-solving services and amending Regulation (EU) No 1024/2012 [19, 20] and Regulation (EU) 2022/868 on European data management and amending Regulation (EU) 2018/1724 (Data Management Act) [21]. Of course, this is binding for the EU area, but also for countries that intend to become EU members.

The responsibility that can arise from implementing a digital ship twin is one of the issues that needs to be defined. Legally, in order to hold someone liable for any form of damage, you must be able to prove that the responsible party breached their duty, resulting in the loss or injury for which they are responsible. In this case, however, it is difficult to prove such responsibility because digital twins are networks of interconnected systems. Changes in one system therefore propagate and affect the entire model. As there are multiple users and data sources, it is difficult to detect and monitor errors or responsibilities [22].

The legal implications of digital twins are related to intellectual property. The applicability of intellectual property rights to the concept of digital twins remains unclear.

The above issues need to be clarified, resolved or specified in a legally relevant contract, as this is the only way to ensure that all parties involved in the use of digital twins are adequately legally protected. Despite the above legal implications, the list is not exhaustive, as we should bear in mind that the range of potential legal issues will undoubtedly expand as the use of digital twins develops.

IV.CONCLUSION

The ship and the maritime industry are challenging due to the complex technologies required to manage the ship's operating system. DTs are introduced in the engine room and navigation. They can improve safety, reliability, the number of photovoltaic panels, and a more energy-efficient installation under maritime regulations, as well as other regulations closely related to design. This paper aims to draw attention to the fact that standardization in digital twins is considered inevitable. Although there are currently initiatives to introduce certain general, international, and specific standards (related to digital twins), it is expected that in the near future, the way will be paved for their actual application. It is not excluded that standardization in the field of digital twins will also gain its legal significance through the formulation of provisions in a legal act towards a reference to a specific standard. Future research should include other documents that are important for this topic, integrate them, and make them available to users.

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Empowering Industry with Advanced Computing: A guide to Strategy and Best practices in Stakeholder Engagement

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Abstract— **In the digital era of large-scale multi-modal AI, HPC at exascale, Big Data analytics, Digital Twins and in-silico material/process design, integrating advanced computing in industry is becoming a necessity. The European Commission has invested in this endeavor through several vehicles such as the Network of National Competence Centres in HPC (EuroCC2), the European Digital Innovation Hubs and EIT Digital. At the heart of this mission is industrial and more generally stakeholder engagement. Expert personnel, such as Industrial Engagement Managers, are poised to act as the conduit through which advanced computing technologies are translated into tangible business value, driving innovation and collaboration across industry boundaries. This article aims to serve as a guide in this endeavour, laying out a strategic framework for this mission, including internal mapping, strategic thinking and sectorial landscaping as well as describing tools and tactics for effective engagement such as the art of pitching, leveraging events and networking strategies.**

I. Introduction

Our digital era is characterized by unprecedented advancements in technology, marking a transformative period in how we interact with and harness digital tools for innovation and problem-solving. At the heart of this transformation is the emergence of advanced computing technologies such as large-scale multi-modal Artificial Intelligence (AI), High-Performance Computing (HPC) at the exascale, High-Performance Data analytics, Digital Twins, and in-silico material and industrial process design. HPC in particular, is a key enabling technology behind the greatest technological feats of the last decade. Supercomputing infrastructure has been instrumental in training Large Language Models (LLMs) powering ChatGPT, Bard, and Claude, which now play a mainstream role in our digital interactions. It has also facilitated the processing and analysis of vast amounts of genomic data, leading to the latest refinements in the human genome. Large-scale simulations powered by HPC have become crucial in developing Digital Twins for aircraft designs, designing advanced and sustainable materials, and discovering and screening new pharmaceutical compounds.

In this digital era where technological advancements rapidly redefine the boundaries of possibility, the strategic integration of advanced computing technologies into the industrial sector emerges as a critical catalyst for innovation and competitive edge. At the heart of this mission is industrial and more generally stakeholder engagement of Advanced Computing Research Centres, National Competence Centres in HPC within the EuroCC2 network [1], European Centres of Excellence (CoEs) for High Performance Computing (HPC) applications [2], and the European Digital Innovation Hubs (EDIHs) [3]. Stakeholder engagement in this context has distinct nuances setting it apart from typical Business Development.

The objective of this guide is to share best practices relevant to Engagement Managers such as industry scouts, termed Industry Champions within EuroCC2 or Account Managers as per the EDIH terminology, technically-oriented business development managers working on introducing advanced technologies to enterprises. The short-hand notation EM for Engagement Manager will henceforth be used to refer to all these professionals. This paper specifically addresses the topic of industrial engagement, however similar principles can be followed in engaging with a variety of stakeholders such as governmental departments.

The insights summarized in this paper arise from working experience at the Computation-based Science and Technology Research Centre serving industrial engagement as Industry Champion at the National Competence Centre in HPC within EuroCC2 [4], Account Manager within DiGiNN, the local European Digital Innovation Hub of Cyprus coordinated by the Cyprus Institute [5], and as Industry Scout for the SimEA ERA Chair project on Simulations and Modelling for Engineering Applications [6].

II. Strategic Framework for Industrial Engagement

A. Industrial Engagement as a Strategic Activity

Industrial engagement is a strategic activity primarily because it enhances an organization's growth, innovation capacity, as well as visibility and reputation. This engagement is not just about building business partnerships; it's a way to position the organization at the forefront of technological innovation. By actively engaging with industries, an organization demonstrates its expertise, commitment to progress, and willingness to be a part of the broader conversation in advanced computing. This visibility fosters a reputation of being a leader and innovator in the field, attracting further partnerships, funding, and talent. Additionally, it allows for the exchange of ideas and insights, which can spur new developments and applications of technology, further cementing the organization's role as a pivotal player in the tech community.

B. The profile of an Industrial Engagement Manager

The Industry Engagement Manager (henceforth EM) serves as a pivotal bridge connecting the technical and

business worlds, embodying a unique blend of skills that cater to both domains. This role is inherently application-driven, with a strong emphasis on problem-solving from a perspective that marries technological capabilities with business needs. Effective communication stands at the core of this position, enabling the translation of complex technical concepts into strategic business advantages that resonate with stakeholders across the spectrum.

An industry scout embodies a critical link between the forefront of computational technologies and their practical applications in various industries. This role demands a **solid foundation in technical expertise**, encompassing a deep understanding of advanced computing technologies such as High-Performance Computing (HPC), Artificial Intelligence (AI), High-Performance Data Analytics (HPDA) and Engineering Simulations such as Computational Fluid Dynamics (CFD), Finite Element Methods (FEM) and Molecular Dynamics (MD). The scout should be in place to explain what each of the technologies are, their relevance and applications in an industrial context and give examples to actors with various backgrounds and technological awareness levels. Technical knowledge enables the scout to recognize and articulate how advanced computing can address specific industry challenges, transforming technical capabilities into tangible business solutions. In an ever-evolving field like advanced computing and AI, adaptability and a commitment to continuous learning are indispensable, ensuring the scout remains at the cutting edge of technology and industry needs.

Beyond technical know-how, a successful EM must be equipped with robust business acumen and exceptional communication skills. An acute understanding of market trends, business strategies, and the economic landscape allows the scout to navigate business models and strategic planning effectively. Coupled with the ability to communicate complex technical concepts in a language that resonates with non-specialists, these skills ensure that potential industry partners grasp the value of integrating advanced computing into their operations. The EMs must be well-versed in business strategy concepts [7], enabling them to adjust their language and approach when engaging with executives. Training in innovation and entrepreneurship [8-11], alongside refined communication skills and marketing knowledge, further equips them to navigate and leverage the commercial landscape effectively. Networking abilities are at the core of the EM's role, facilitating the building of meaningful relationships within the industry and identifying potential collaboration opportunities. The role also encompasses project management, negotiation, and a keen awareness of legal and ethical considerations, including intellectual property rights and data handling practices. Together, these competencies enable an EM to effectively forge collaborations that drive innovation and solve real-world problems, making them an invaluable asset to any advanced computing centre.

C. Main Concepts in Business Strategy

Why and Overview: Given the importance of Industrial Engagement, an EM needs to proceed with care in choosing partners wisely. There are thousands of possible stakeholders that one could approach about introducing these advanced technologies, and given that EuroCC/EDIH projects offer free services, this greatly broadens the set of possible beneficiaries. As such, placing a strategic, methodical and targeted approach in industrial engagement is necessary. In order to establish such a comprehensive framework one can greatly benefit by adapting main Concepts in Business Strategy [7,10]. These include aligning with the Vision & Mission of the Centre or even the Country as a whole (especially given the National Leadership of NCCs), performing a SWOT Analysis, formulating the value proposition and analysing the Competitive Advantage that corporations would obtain from leveraging advanced computing, targeting specific sectors, actors and stakeholders in a Market Segmentation approach, keeping in mind Sustainability & Social Responsibility, ie ESG alignment.

Ultimately, the EM needs to formulate a value proposition to communicate the answer to the basic question: What value/benefit will the Centre's expertise bring to the stakeholder? This value proposition should highlight how the Centre's resources and expertise can solve specific industry problems or contribute to advancements in specific fields. This comes into two parts: A) What kind of expertise is the Centre providing, and B) how this is relevant to the specific stakeholder that the EM is interacting with. In the following sub-sections we will analyse the methodology that the EM can follow to address both of these concepts, and in this process the aforementioned Business Strategy concepts will naturally arise. Addressing item A involves undertaking an internal capacity mapping to understand areas of expertise, applications and what the Centre's vision and mission are. Addressing item B involves market segmentation and targeting, sectorial landscaping and strategic thinking. Designing bespoke strategies for market segmentation allows the scout to target specific industry actors effectively. This involves identifying and focusing efforts on segments where the Centre's capabilities are most needed and can make the most significant impact, ensuring that engagement efforts are both strategic and efficient. We will finish with proposing effective networking strategies and practical tools in delivering and communicating this value proposition to specific stakeholders in the next section.

D. Internal Mapping

Despite its extrovert character, the work of industrial scouting should begin with a thorough **internal mapping of capacity,** existing partnerships and areas of interest. Firstly, understanding the **vision and mission** of the Centre, its goals and objectives sets the foundation of any engagement activity. This ensures that all engagement efforts contribute meaningfully to the Centre's overarching goals, such as promoting innovation in HPC or advancing scientific research through technological solutions. A thorough **SWOT analysis** of the Centre helps the scout understand its strengths, cutting-edge research capabilities, as well as potential weaknesses such as missing expertise, opportunities in emerging tech markets and sectors. For a Centre in advanced computing this includes understanding the **technological areas of expertise**

as well as the **areas of applications** of its various research or thematic groups. For example, a group with expertise in HPDA might have strong track record in analysis of time series data and may be interested in fintech applications. Knowing past collaborations and **success stories** [12] provides the industry scout with directions as to what sectors and actors to engage with, and a pool of examples to draw from when discussing with potential partners. Finally, if the aforementioned SWOT analysis has identified technological trends and opportunities the expertise of which is missing or lacking at the Centre, then the scout can communicate such findings to the Technical Manager or Steering Committee.

Another important consideration is what know-how is **deployable** within a reasonable timeframe to provide meaningful consultation and implementation of proof-of-concept or pilot projects towards test-before-invest solutions. For example, if several companies and potential projects are lined-up for a specific expert group, then the EM should consider engaging with partners that would collaborate with other teams. This is particularly important as industry moves at a faster pace: attracting the interest of a company only to keep them waiting for months to start a collaboration would negatively affect the reputation of the Centre.

These last two considerations of the capabilities and resources of the Centre are aligned with the theory of "resource-based view of the firm" (RBV for short) which bases the competitive advantage of an organisation on its resources and capabilities. RBV has dominated business strategy, shifting away from market-based positioning view [13]. The RBV perspective argues that firms can achieve and sustain a competitive edge through the acquisition, development, and deployment of valuable, rare, inimitable, and non-substitutable (VRIN) resources and capabilities. The RBV suggests that by identifying and leveraging these unique resources and capabilities, organizations can create strategies that are difficult for competitors to replicate, thereby achieving superior performance and long-term success. This view contrasts with other strategic frameworks that focus on the firm's external environment, positing instead that internal factors are crucial in strategic planning and execution.

E. Strategic Thinking and Sectorial Landscaping/Mapping

Equipped with a consolidated understanding of the Centre's internal capacity, the scout will then begin to look outwards and start considering which sectors to target, how to prioritise these with the Strategic priorities, vision and mission of the Centre as well as the National Smart Specialisation strategy [14] and EU priorities [15]. Identifying synergies with EDIH, Digital Europe, Centres of Excellence, EIT sectors, specific partnerships and other JUs can be of great value.

Having identified the sectors to be targeted and prioritised, the scout will then take a deeper dive into sectorial mapping. This involves identifying sector-specific unions and associations (eg within the local Chamber of Commerce and Industry [16] or through the EEN network [17]), leveraging data analytics and potential reports. Access to such information provides an overview of the specific sector, identification of the main players/innovators in the field, as well as the main challenges faced and attempts to solution. Sourcing success stories from EuroCC/EDIH/FF4HPC [12, 18] that will give a pool of ideas when brainstorming with in-sector actors.

III. TOOLS AND TACTICS FOR EFFECTIVE ENGAGEMENT

A. Practical Tools

For an industry scout in advanced computing, practical tools like business cards, a well-crafted presentation deck with an accompanying pitch, and a comprehensive service portfolio are essential for effective engagement. A robust website serves as a digital front door, showcasing the center's capabilities and achievements. Flyers, easily designed with tools like Canva and enhanced with AI-generated content from ChatGPT, offer a quick, visually appealing way to communicate offerings. Additionally, maintaining a strong presence on professional networks like LinkedIn is crucial for networking, sharing achievements, and connecting with industry stakeholders.

Next we discuss in detail the topic of pitching to stakeholders and active listening, both of which are key ingredients in the success of these brief networking interactions.

B. The Art of Pitching and Active Listening

The main purpose of a pitch to a stakeholder is to concisely communicate the value proposition of the Centre's expertise offered via services or projects, demonstrating its benefits and relevance to the stakeholder's needs or challenges. It aims to engage the stakeholder's interest, stimulate a dialogue, and ultimately persuade them to collaborate on participate in a project. A successful pitch is tailored to the listener's context, highlighting alignment with their strategic priorities and how it offers solutions to their specific challenges. Being equipped with a well-structured pitch can empower the success of short networking interactions at events.

Outline A successful first interaction between an EM and a stakeholder during a networking session should start with a warm introduction, including handshakes, exchanging names, positions, institutions, and business cards. This sets a professional and friendly tone. Listening to the stakeholder's priorities, computational needs, and challenges is crucial for tailoring the discussion. Providing crisp information about the center's profile, expertise, and collaboration opportunities in the form of a pitch establishes a foundation for potential partnerships. Engaging in mini-brainstorming about synergies can spark interest in collaborative projects. Wrapping up with clear next steps ensures a path forward for both parties.

Adaptation is crucial in the successful delivery of the pitch and the overall interaction, with the industry scout's approach varying based on the audience. For conversations with CEOs and business-focused individuals, the emphasis is on the impact of technologies like AI and supercomputing within a business context, using accessible business terminology and carefully avoiding overly technical language. Conversely, interactions with CTOs and technical staff demand a display

of technical expertise, delving into the specifics of advanced computing capabilities to highlight the center's innovative potential and technical prowess.

Active listening with the stakeholder as the focal point and the goal of adding value to their organisation, offers valuable insights into the company's perspective, strategic priorities and computational challenges. Depending on the context, questions such as "Do you harness the value of your data?", "Have you incorporated AI in your workflows?", or for manufacturing companies, "Do you utilize in-silico design?" guide the discussion towards identifying areas where the scout's organization can offer impactful solutions and support.

Upon establishing this context, the industry scout can then highlight the Centre's exceptional proficiency in leveraging advanced digital technologies, such as High-Performance Computing, Artificial Intelligence, High-Performance Data Analytics, engineering simulations and computational modelling etc. The focus should be application-oriented and tailored to the listener. Examples of relevant applications drawing from the track record of the Centre or the pool of success stories from other NCCs within the EuroCC2 network, make these technologies more tangible and their impact better communicated. The industry scout must be able to communicate the importance of HPC to executives that may lack technical background. Adapting pitching techniques from entrepreneurial and business development contexts can be immensely powerful when preparing this short pitch [8-11]

Industry scouts should also spotlight the Centre's wide array of services and collaboration opportunities. This includes offering consultation services to identify and address specific industry needs using HPC and advanced computing, initiating pilot projects to demonstrate the practical application of advanced computing solutions, and providing bespoke training tailored to the unique requirements of different sectors. The Centre also engages in joint research projects, fostering partnerships between academia and industry. Additionally, distinguishing between services offered free of charge via European projects such as EuroCC2 or EDIH, pursuing joint research funding in national or Horizon Europe grants and those requiring contracts is crucial for setting clear expectations, ensuring that potential collaborators understand the scope and terms of engagement.

C. Leveraging Events and Networking Strategies

A multi-stakeholder approach as a networking strategy has had great success for the NCC Cyprus and local EDIH. Rather than approaching stakeholders in a 1-1 approach, the EMs can target a variety of networking events in which they can engage with multiple stakeholders per event and thus maximize engagement opportunities. This also gives the EM the opportunity to interact with executive team members with an established context already in place. For example, visiting a booth at an EXPO or meeting an executive after they have delivered a plenary talk at a conference, offers insights into the organization's priorities and activities, and thus the opportunity for the EM to better adapt accordingly.

There are several types of events that can facilitate direct connections with industry players, such as sectorial Conferences and Forums organised by the Chamber of Commerce & Industry, Industrialist Unions, Sectorial Associations and Unions, governmental departments or the local EEN or EIT offices. Such events are invaluable for strategic networking as they offer excellent networking opportunities and insights into industrial challenges, trends and innovation.

Preparation before networking events is crucial. Industry scouts should review the event's agenda, speakers, and booth list to identify key opportunities and plan their time effectively. This allows for a strategic approach to networking, ensuring that scouts target the most relevant sessions and stakeholders, such as CEOs and CTOs.

During the event, leveraging insights from plenaries can kickstart conversations, allowing scouts to adapt their language and pitch to the specific context of each stakeholder as analysed above. Networking breaks offer prime opportunities for informal interactions. Engaging in guided discussions helps in sourcing requirements and exploring potential synergies. It's vital to exchange business cards and connect on LinkedIn, with a clear plan for follow-up steps.

Post-event, consolidating notes and registering contacts is essential. Industry scouts should evaluate potential collaborations based on their alignment with the center's strategic priorities and the stakeholder's willingness to collaborate. Highlighting promising contacts and briefing the team allows for a focused approach in inviting companies for introductory meetings, maximizing the potential for fruitful partnerships.

I. Initiating and Nurturing Collaborations

Scheduling the initial meeting between the company and a guest organization requires careful planning and consideration of participants to ensure effective communication and outcomes. The delegation from the guest company or organization should ideally include key decision-makers and technical experts, such as the CEO, Head of IT, CTO, Technical Personnel, and Production Managers, depending on the size and type of the company. From the internal team, participants should include the Manager, EM, members of the Engineering team or Technical Specialists.

Prior to the meeting, it's essential to email the agenda and scope to all participants to ensure everyone is aligned on the purpose and objectives of the meeting. Sending a questionnaire in advance can help gather preliminary information, facilitating a more focused and productive discussion. A reminder should be sent a day before the meeting to confirm attendance and ensure all participants are prepared. Additionally, briefing the internal team on the background, expectations, and specific goals of the meeting is critical to present a unified and informed front during the engagement.

At the meeting, after introductions and extending hospitality, a brief presentation of the Centre (3-5 minutes) provides an overview of its capabilities, focusing on the interested gauged by the industry scout. The guest organisation should then be offered 10-20 minutes to present

an overview of mission, activities and challenges. This sets the foundation for a targeted discussion, where asking pointed questions becomes instrumental in uncovering the company's challenges, data handling capabilities, and the technical expertise of their ICT and Engineering personnel. This is a crucial interactive part of the meeting which involves brainstorming to identify 2-3 specific synergies, laying the groundwork for potential collaborative projects. By the end of the meeting, the team should aim to have decided on the topic of collaboration.

The meeting should conclude by establishing next steps, including the person responsible for follow-up and the main contact points, to maintain momentum and ensure the collaboration progresses smoothly. Shortly after the meeting, the team can draft a scope of work or roadmap to be finalized together with the stakeholder, ensuring both parties have a clear understanding of the collaboration's objectives. This can include the scope of collaboration and milestones to be achieved, the timeframe and resource allocation. Distinguishing between services offered free of charge via European projects such as EuroCC2 or EDIH, pursuing joint research funding in national or Horizon Europe grants and those requiring contracts is crucial for setting clear expectations from the very beginning, ensuring that potential collaborators understand the scope and terms of engagement.

In embarking on any collaboration, it is vital to address legal considerations meticulously. Ensuring that Non-Disclosure Agreements (NDAs) are in place protects sensitive information shared between parties. Intellectual Property (IP) protection is paramount, clearly defining the ownership of innovations and technologies developed during the collaboration. Legal liability issues must be addressed, outlining each party's responsibilities and liabilities. Due diligence is essential, not only in assessing the potential and capabilities of the collaboration partner but also in ensuring compliance with all relevant laws and regulations. These legal frameworks form the backbone of a secure and fruitful collaboration, safeguarding the interests of all involved parties. The EM should seek expert advice on such topics from specialised departments of the Centre, such as the Legal and Knowledge Transfer Departments.

IV. Conclusion

As we navigate the complexities and opportunities presented by the digital era, the significance of integrating advanced computing technologies across various industries cannot be overstated. These technologies, encompassing HPC, large AI, HPDA, digital twins, computational modeling and in-silico design simulations, are reshaping the competitive landscape, enabling unprecedented levels of innovation, efficiency, and product development. The ability of industries to harness these capabilities directly correlates with their potential to solve complex problems, accelerate research and development, and ultimately, lead in a rapidly evolving global market. This integration not only fosters the creation of new products and services but also enhances the sustainability and resilience of businesses facing the challenges of the 21st century.

Central to realizing the full potential of these advanced computing technologies is the role of effective stakeholder engagement. As the bridge between the technical possibilities offered by advanced computing and the practical applications within industries, stakeholder engagement is pivotal in driving innovation and growth. Engagement Managers, serving as conduits for this translation, play a crucial role in identifying opportunities for collaboration, aligning technological capabilities with business needs, and fostering environments where innovation can flourish. By prioritizing communication, collaboration, and strategic alignment, these professionals ensure that the benefits of advanced computing are fully leveraged, marking a path toward sustained economic growth and technological leadership.

Acknowledgment

The author would like to thank several colleagues the collaboration or interaction with which has helped shaped her views and outlook of Industrial Engagement: Prof Constantine Dovrolis, Prof Vangelis Harmandaris, Dr Christos Christodoulou, Dr Vassilis Tsakalos, Dr Nicos Rossides, Dr Konstantinos Kleovoulou, Dr Fabio Maria Montagnino, Dr Anixi Antonakoudi, Dr Kathy Christoforou, Dr Katerina Loizou, Mrs Natalie Kafantari and Mr Constantinos Kritiotis, all of which are colleagues at the Cyprus Institute, as well as Dr Phyllis Leah Speser.

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(https://ieeexplore.ieee.org/xpl/conhome/10475674/proceeding)

Factors that influence college students in the use of ChatGPT in Indonesia

R. Silvano and A. Gui

This research investigates the characteristics that influence Indonesian college students' use of ChatGPT, an AI-powered chatbot. Understanding students' opinions and usage patterns is critical as AI becomes more prevalent in education. This questionnaire data collection was distributed using Google form and filled in by college students who were undergoing their studies. It focuses on three essential factors: trust (TRU), performance (PE), and effort (EE). The students' trust in ChatGPT's data security, credibility, and information correctness is critical. Performance Expectancy assesses how ChatGPT helps with job completion and information quality. The ease of use and user-friendliness of ChatGPT are factors in Effort Expectancy. This questionnaire data processing was processed using the SmartPLS 4 application. The data show that trust has a considerable positive influence on ChatGPT usage, implying that higher trust levels correlate with increasing utilization. Students recognize ChatGPT's usefulness in academic settings, which has a positive impact on usage. The platform's intuitive design and user-friendly interface are crucial reasons in its acceptance, according to Effort Expectancy. The study sheds light on AI adoption in educational settings, emphasizing the importance of trust, performance, and effort anticipation in changing student views toward technology. These findings can be used to influence the development of AI tools in education, emphasizing the importance of safe, efficient, and accessible designs to improve the learning experience.

The Effect of E-Commerce Factors on Consumer Purchasing Behavior

William and A. Gui

As the digital landscape evolves, consumer confidence within social environments increasingly shapes their purchasing choices. This shift presents new opportunities for entrepreneurs leveraging social commerce to enhance sales. While previous research focused largely on digital trust elements, like the reliability of user reviews, exploring consumer behavior requires considering various influencing factors. This study seeks to create a dependable structure for internet-based enterprises. Through a Google form circulated across platforms like Telegram, Twitter, Instagram, WhatsApp, and Line between January 1st and January 8th, 2024, a group of 277 participants was collected. Among them, 256 met the eligibility criteria, while 21 did not, and the data collected was later analyzed using SmartPLS 4. The study's outcomes were not quite satisfactory, as 2 hypotheses were rejected on which social support and customers satisfaction have not had a positive impact towards purchasing behavior, while the other 5 have been accepted. Essentially, this study underscores the substantial influence of customer trust in e-commerce reviews and the significance of s-commerce in shaping customer satisfaction and loyalty within marketplaces.

Modeling of Motion of Autonomous Drone Swarms Based on Altitude Measurements from iOS Frameworks

Jacob Baytelman, Konstantin Yatsko

Determining altitude correctly is crucial for autonomous flights, yet errors in navigation are hard to predict or evaluate in the real time due to variety of reasons causing them. Achievement of the necessary level of sophistication in automatic control systems is possible via the use of AI, machine learning and neural networks, however it requires big data arrays for training. Such data can be generated by a simulation model, but the model should be aligned with realistic data patterns obtained during tests on physical devices. This study establishes an experimental environment for addressing the above-mentioned issues.

Implementing Lightweight, Dynamic Hierarchical Key Assignment Scheme For Cloud Computing

Ibrahim Celikbilek, Baris Celiktas, *Member, IEEE*, and Enver Ozdemir, *Senior Member, IEEE*

In this paper, we propose the implementation and adaptation of a hierarchical key assignment scheme (HKAS) previously developed in our research to improve access control in cloud computing environments. The secret keys generated and managed by this scheme can be utilized for various purposes within the cloud computing, including data encryption, integrity checks, secure communications, and accessing critical infrastructures or services. Our implementation performs dynamic update operations with minimal computational cost and storage demands, as users within the hierarchical structure do not store any key components. Through security analysis, the scheme demonstrates strong key indistinguishability security (S-KI-security), effectively safeguarding keys against various cryptographic attacks. The scheme's flexibility allows it to be tailored to specific organizational needs, whether for securing sensitive data, ensuring compliance with regulatory standards, or facilitating secure data sharing and collaboration in cloud environments. Thus, we advocate for the practical implementation of the HKAS in transitioning to cloud environments.

Hotel Chatbot Receptionist for Smart Hospitality

Sara Kovacevic, Tomo Popovic, Senior *Member, IEEE*, Ivan Jovovic, Stevan Cakic, Dejan Babic

The dynamic changes in the global business landscape are being driven by cutting-edge technologies such as artificial intelligence and machine learning, blockchain, and high-performance computing. Recognizing the pivotal role of digital transformation, particularly in the tourism sector, Montenegro has started embracing innovative solutions. The continuous evolution of technology has significantly influenced the tourism industry presenting an opportunity for digital transformation in the sector. The introduction of chatbots in Montenegrin hotels and resorts emerges as a potential gamechanger. This implementation aims not only to reduce waiting times at reception but also to elevate the overall user experience. By adopting hotel chatbots in different hotels, each establishment can have a dedicated knowledge base tailored to its specific policies and regulations. This approach ensures a seamless integration of technology that not only enhances operational efficiency, but also enriches the offerings within the tourism and hospitality sector in Montenegro.

Hand-drawn Electric Circuit Diagrams Recognition using Deep Learning

Ahmad AlMughrabi and Hazem Hiary

This paper tackles component identification in hand-drawn electrical circuit diagrams by employing Regionbased Convolutional Neural Networks (R-CNN). This paper introduces a new offline circuit recognition system for handdrawn diagrams, including a new annotated dataset. We surveyed 200 engineers who possess knowledge of electric diagrams with a three-page document to propose an annotated dataset containing 6273 symbols distributed for 12 classes and 728 diagrams distributed for three classes. Our proposed Faster RCNN model recognizes components with an accuracy of 75.9% mAP.

AI and Computer Vision in Cultural Heritage Preservation

Jovana Mitric, Igor Radulovic, Tomo Popovic, *Senior Member, IEEE*, Zoja Scekic, Sandra Tinaj

In the recent years, rapid advances in technology, especially in Artificial Intelligence (AI) and Machine Learning (ML), have impacted the way economy functions, as well as society at large. The integration of these technologies in tourism plays a significant role in cultural heritage preservation. This research explores the intersection of artificial intelligence, cultural heritage, and tourism, with a focus on Montenegro's efforts to leverage digital transformation for tourism development. Many monuments are not marked and there is no background information about their historical significance. With four UNESCO World Heritage sites, Montenegro is recognized as country with high touristic potential and rich cultural heritage, which implies that implementation of AI technologies can preserve forgotten monuments and give them a new life, as well as enhance the overall touristic experience and position Montenegro at the forefront of international touristic landscape. Using a well-known framework Flask, we developed web application that allows users to take images of a monument, upload it to our web application and after a few seconds, they get annotated image of a recognized monument, along with a text containing more information about the said monument.

Performance Analysis of Original Implementation of ResNet50-Mask-RCNN using Transfer Learning: A Benchmark Data for Backbone-Improved Based Future Comparative Studies

Lysa V. Comia and Enrique D. Festijo

In computer vision applications such as object recognition and instance segmentation, deep learning techniques—more specifically, the Mask-RCNN architecture based on ResNet50—have shown exceptional capabilities. This work makes use of transfer learning to provide a thorough analysis of the ResNet50-Mask-RCNN model's first implementation to understand its performance features and constraints on a range of datasets and situations. Additionally, the study presents benchmark data that will be used as a standard reference for the next comparative assessments that will concentrate on techniques with enhanced backbones. With significant convergence in validation loss values during training, validation results demonstrate the model's efficacy in object identification and classification tasks. As shown by the Precision- Recall curve data, the model also achieves an impressive average mAP of 0.8095 and shows resilience with high recall rates at various precision levels. The AUC-ROC value of 0.9399 highlights how well the model can distinguish between positive and negative instances. High detection rates for the target class were noted in the testing results, which support the model's effectiveness.

Implementing an IoT System for Sea to Fork Transparency and Consumer Engagement

Tomo Popović, *Senior Member, IEEE*, Dejan Drajić, *Senior Member, IEEE*, Nives Ogrinc,

Cathrine Terro, Vladimir Urošević

This paper describes an approach to implementing an IoT system for fish farmers, with open integration and support to the end-to-end sea to fork digital platform for transparency, seafood traceability and consumer engagement. The system is implemented as a Cloud SaaS solution providing digital tools for easier fish farm management, easily accessible via Internet using desktop/laptop or mobile devices. The paper discusses the overall sea to fork platform, and then focuses on the specifics related to the IoT sensors and systems requirements. A discussion on initial evaluation of the pilot system implemented according to the requirements is given at the end. The solution is open for adding different IoT sensors that can be installed in the other stages of the seafood value chain, such as transport, packing/processing facilities, and retail. The system is open to utilization of QR codes to uniquely identify items in different phases of the chain, e.g., trade units or final products, to allow interaction with different stakeholders and motivate seafood consumers to engage with the overall platform.

A New Approach to Detecting Free Parking Spaces Based on YOLOv6 and Keyframe Detection with Video Analytics

Merve Yilmazer[1], Mehmet Karakose[2] *Senior Member, IEEE,* Senem Tanberk[3], Samed Arslan[3]

With urbanization and population growth, automobile use has also increased. As a result of this, there is a need to expand parking management and inspection systems to ensure safe and efficient use of parking areas. A new deep learning-based method has been proposed as an alternative to traditional systems to control free spaces in parking areas monitored by CCTV security cameras. A large amount of video data needs to be processed for parking areas recorded with video cameras 24 hours a day, 365 days a year. Repeating frames in videos cause overlearning in deep learning models. It also increases memory and computation cost. For this reason, keyframe detection based on sampling was first performed on the sample video of the Dragon Lake Parking (DLP) dataset and a summary of the dataset was obtained. Then, empty parking areas were detected by YOLOv6 deep neural network. It has been observed that the model can detect empty parking areas at a rate of 96.6% mAP.

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Quantum Circuit Dataset Generator Approach for Deep Learning based Solutions

Niyazi Furkan Bar and Mehmet Karakose

Today, although there are studies for the active use of quantum computers, deep learning-based studies on quantum computing are few. Since the large amount of data needed by deep learning cannot be met from the literature, using deep learning in subjects such as quantum circuit optimization, and quantum circuit/algorithm generation challenges researchers. In this study, an approach is proposed to overcome the data and dataset deficiencies related to quantum circuits in the literature. The proposed approach generates datasets consisting of quantum circuits, truth tables of quantum circuits, unitary matrices, visuals, and pairs of these data. The circuits, data, and datasets produced with this approach have already been studied and are still being actively done. The performance of the proposed approach was evaluated as dependent on different variables and as elapsed time. With the proposed approach, circuits, data, and datasets with desired properties can be generated successfully. As a result, the contribution and performance of the proposed approach have been verified.

A Quantum Computing based Approach for Sentiment Analysis in Bilateral Conversations

Niyazi Furkan Bar, Musa Yenilmez, Sedef Aksu and Mehmet Karakose

Sentiment analysis finds widespread applications in health, marketing, finance, stock markets, media, and politics. To analyze attitudes and emotions in textual data, handling large datasets and significant computational power is essential. Traditional computing methods struggle with the growing data volume, prompting interest in quantum computing as a promising alternative with its inherent high-speed processing capacity. This study focuses on sentiment analysis applied to texts derived from bilateral conversation dialogues. The primary objective is to categorize emotions within the text as positive, neutral, or negative, while concurrently identifying the speaker. To achieve this, a novel quantum-classical hybrid approach is proposed. The quantum side of this approach includes the variational quantum circuit (VQC). On the classical side, preprocessing of the data set, feature extraction with a model containing LSTM, and optimizing the parameters of VQC are performed. The proposed approach was trained and tested using a data set containing bilateral conversations. As a result of the tests, the proposed approach achieved a higher accuracy rate compared to studies using the classical approach. Thus, the effectiveness of the proposed approach is confirmed.

Devices for improving voltage conditions in low-voltage electrical distribution networks

Nada Cincar, Marko Malović

The power quality is defined through the standard EN 50160. Consumer areas where the power quality of supplied falls outside the standard EN 50160 pose a problem, causing dissatisfaction among consumers and inefficiencies for distribution companies, leading to losses and system inefficiencies. The most vulnerable areas are primarily those farthest from the corresponding transformer station. Due to voltage drop along the lines, voltage values at the network's end points may fall below the recommended minimum. In such locations, the network is sensitive to voltage sags. In these cases, rehabilitation of voltage conditions is necessary to bring the power quality parameters within prescribed values. This paper presents new solutions for improving voltage conditions in low-voltage electrical distribution networks and outlines the advantages of these solutions compared to previously used ones.

Multi-link operation for performance improvement in Wi-Fi 7 networks

Ana Jeknić, Enis Kočan

The Wi-Fi 7 standard is in the final voting phase, and devices that support this standard are already accessible in the market. The seventh generation of Wi-Fi standards is primarily designed to enable extremely fast transmission speeds and minimize packet delays. Multi-link operation (MLO) plays a vital role in meeting these requirements. Using ns3 simulation tool, we examine MLO performance in the propagation scenario of a residential building, considering a various number of users. The obtained results demonstrate that, when comparing the same total occupied bandwidth, the two-link MLO mode exhibits slightly better performance than SLO mode. Furthermore, our findings indicate that MLO significantly reduces average packet delay, particularly in scenarios with many users.

Algorithmic Discrimination: Continuation of Human Bias or a Gateway to Equality?

Jovan Jablan, Luka Lakovic, Andrea Micanovic

In this paper, the question is posed whether Artificial Intelligence (AI) represent an extension of human biases or a path towards achieving equality. It systematically examines three pivotal aspects of algorithmic discrimination: the propensity of algorithms to inherit biases from pre-existing data, the ability of algorithm creators to mitigate this bias through internal rules, and the role of supranational management and regulation in curbing algorithmic bias. By exploring examples of biased models, the research identified instances of both good and bad practices. Additionally, it pointed towards the potential framework for ensuring an equal gateway, as exemplified in the latest international legal frameworks addressing AI non-discrimination principles. The focus of this work is a discussion on the legal regulation of decision-making by algorithms, aiming to prevent potential discrimination.

An Overview for Trustworthy and Explainable Artificial Intelligence in Healthcare

Kübra ARSLANOĞLU[1], Mehmet KARAKÖSE[2], Senior Member, IEEE

Recently, the increased use of artificial intelligence in healthcare has significantly changed the developments in the field of medicine. Medical centres have adopted AI applications and used it in many applications to predict disease diagnosis and reduce health risks in a predetermined way. In addition to Artificial Intelligence (AI) techniques for processing data and understanding the results of this data, Explainable Artificial Intelligence (XAI) techniques have also gained an important place in the healthcare sector. In this study, reliable and explainable artificial intelligence studies in the field of healthcare were investigated and the blockchain framework, one of the latest technologies in the field of reliability, was examined. Many researchers have used blockchain technology in the healthcare industry to exchange information between laboratories, hospitals, pharmacies, and doctors and to protect patient data. In our study, firstly, the studies whose keywords were XAI and Trustworthy Artificial Intelligence were examined, and then, among these studies, priority was given to current articles using Blockchain technology. Combining the existing methods and results of previous studies and organizing these studies, our study presented a general framework obtained from the reviewed articles. Obtaining this framework from current studies will be beneficial for future studies of both academics and scientists.

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Predicting Music Sentiment: A Comparative Analysis of Machine Learning Models Before and After Feature Selection

Kasim Suleyman Oner, Dželila Mehanović, Nedim Bandžović

Department of Information Technology, International Burch University

This study delves into the intersection of music and machine learning, examining the performance of five algorithms—Logistic Regression, Random Forest, Decision Tree, Support Vector Machine, and K-Nearest Neighbours—in sentiment analysis for music. The goal is to systematically evaluate their effectiveness in decoding and classifying the emotional content of musical compositions. The selected algorithms represent diverse computational approaches, contributing to the overarching objective of understanding the intricate emotional landscape of music. A crucial aspect of this comparative analysis involves assessing the accuracy of these machine learning models, both before and after applying feature selection techniques. This step proves critical in enhancing the predictive capabilities of the models. The observed accuracy levels exhibit a dynamic range from 57% to 67%, unveiling subtle yet noteworthy performance variations among the chosen algorithms.

Factors Affecting the Intention to Buy Customers in Live Streaming Shopping

Fredy Jingga and Jessica R. Santoso, *Member, IEEE*

In this digital era, the technology development is rapidly growing. The growth of digital technology also impacts the development of people's lifestyle in daily life. One thing affected is the lifestyle of shopping and selling. The COVID-19 pandemic has caused all people to isolate at home for about 2 years. This is also very influential with a drastic change in lifestyle activities must be conducted online at home. As a result, the process of doing business and shopping is also conducted at home and makes online shopping growing rapidly. The development of online shopping is also a factor that drives sellers to do live streaming shopping. This feature can help sellers in promoting products and helping customers to be able to shop more practically and interestingly. According to the development of live streaming shopping, it can be said that this feature is popular and demanded by many people in selling and shopping, especially on digital platforms because of its massive influence on both sellers and customers. This study aims to determine customer's purchase intention in using live streaming shopping. The research examines the relationship between Product Information Demonstration, Hedonic Value, Seller Reputation, Perceived Usefulness, Seller Interaction, and Product Promotion, on Purchase Intention. With 130 data from respondents collected from social media using Structural Equation Modeling (SEM) for processing data. In this study, we will see how the factors affect customer purchase intention in using live streaming shopping.

Design and Comparative Analysis of Shunt-Passive and Series-Passive for AC Drives-based Loads using Sequential Quadratic Programming

Shady H. E. Abdel Aleem, *Senior Member, IEEE*

This study uses Sequential Quadratic Programming (SQP) as an optimization technique. Shuntpassive and series-passive filters have been investigated to reduce the harmonic distortion associated with AC drive loads while accounting for utility source and load non-linearities. DC drives represented by their equivalent current source model are much more common in practice. On the opposite side, AC drives are also possible, and they are indicated by their corresponding voltage source model. The performance of the filters for these non-linear loads under different scenarios is compared. It was discovered that the type of non-linear load significantly limits the selection of a suitable compensator.

Proposal of Hiking Route Planning Optimization with Iterated Local Search and Modified Tourist Trip Design Problem

Yevheniia Kataieva, Lea Hianikova

Modeling situations concerning route planning belongs to the fundamental problems in computer science. The Tourist Trip Design Problem is one of the most used in tourist route planning involving visits to various points of interest. Multiple variations exist, focusing on specific needs in the planning of different types of trips, however, one of the favorite types of tourism has not been explored yet. Hiking trips, similar to trips in cities, involve planning a route through as many interesting places as possible, furthermore, the paths also provide additional interest value to the route. In this work, we will focus on different specifics of hiking trip planning, best ways of modeling and solving the problem based on similar existing studies and implementations. We also propose a design for a hiking route planning application.

Investigation of the separation zone for split-domain light field visualization

Kamran Javidi, Maria G. Martini and Peter A. Kara

Light field visualization commonly provides a single content over the entire field of view. However, the angularlyselective nature of the technology enables the simultaneous visualization of different contents at different viewing angles. Yet segmenting the valid viewing area comes with content interference as well in forms of separation zones, resulting invalid viewing domains. In this paper, we introduce a study on the separation zone of split-domain light field visualization. We created a static-content-based scenario in which we split the valid viewing area into two distinct domains, with a separation zone in between them. This was achieved by merging two light field contents in the middle with an instantaneous switch. The resulting visualization on a light field display was captured by a DSLR camera from two viewing distances, and it was compared to the crosstalk effect caused by insufficient angular resolution.

Improved LOS Guidance Law for Curved Path Following of Underactuated USV in Presence of Ocean Currents

Vladimir Ćetković, Luka Martinović, *Student Member, IEEE*, Žarko Zečević, *Member, IEEE*

This paper introduces a novel Kalman filter-based Line-of-Sight (LOS) guidance law for the curved path-following of unmanned surface vehicles in the presence of environmental disturbances. By using an extended Kalman filter and available measurements, the proposed method efficiently estimates the vehicle's sideslip angle and compensates for the sideslip effect on path-following performance. Through two simulation scenarios, it has been demonstrated that the proposed guidance law exhibits superior performance compared to the two available guidance methods.

Credit Card Fraud Detection Using Supervised Learning Algorithms

Danilo Planinić, *Member, IEEE* and Vesna Popović-Bugarin, *Member, IEEE*

Different machine learning techniques demonstrate exceptional performance in numerous banking challenges, with one of them addressing the ever-present issue of credit card fraud detection. This paper examines the performances of Logistic Regression, Random Forest, and CatBoost in the context of credit card fraud. The capability to handle imbalanced classes is evaluated for each algorithm, as well the impact of hyperparameter tuning on model performance. The findings reveal that algorithms based on decision trees effectively manage imbalances without need for additional data preprocessing. CatBoost outperforms other algorithms in all standard metrics, making it the most desirable choice for addressing this specific problem.

Proposal for Enhancing Legal Advisory Services in the Montenegrin Banking Sector with Artificial Intelligence

Ivan Bošković, Vladan Tabaš

This paper examines the integration of Large Language Models (LLMs) and Retrieval-Augmented Generation (RAG) in improving legal advisory services within the Montenegrin banking industry. It explores the vectorization of regulatory documents using ADA-2 embedding model, the storage and management of these vectorized forms in Chroma DB, and the utilization of GPT-4 for processing relevant documents to generate user responses, providing insights into the use of artificial intelligence (AI) for legal advisement and financial education.

A Comparative Analysis of Different Natural Exponent Inertia Weight Strategies for Particle Swarm Optimization in Multilevel Image Thresholding

Emir Turajlic, Member, IEEE

This paper presents a comparative analysis of two different natural exponent inertia weight strategies for particle swarm optimization in multilevel image thresholding. The considered multilevel image thresholding methods are based on Otsu's between class variance. The multilevel thresholding methods are evaluated on different test images and for varying numbers of thresholds. The experimental results have demonstrated that the particle swarm optimization algorithm with the natural exponent inertia weight can be successfully employed to obtain threshold levels for different test images.

Multi-swarm Particle Swarm Optimization with Chaotic Random Inertia Weight and Dynamic Learning Strategy for Multilevel Thresholding Image Segmentation

Emir Turajlic, Member, IEEE

This paper presents a multilevel thresholding method based on the multi-swarm particle swarm optimization with dynamic learning strategy and chaotic random inertia weight. This multilevel thresholding method is implemented using Kapur's entropy. The performance of the presented method is validated on a set of standard test images. For each image and each considered number of threshold levels, the mean and standard deviation of Kapur's entropy values are determined based on 30 independent applications of the thresholding method. The reported experimental results show that the presented method can be successfully applied across different images.

Adaptive System for Monitoring the Patient's Environment Using Telemetric Data

Carmen Ionela Rotună, Iustin Floroiu, Elena-Anca Paraschiv and Alexandru Radu Bostan

Currently, medical telemetry sensors data analysis in scientific research addresses patient monitoring, the digital recording, transmission and analysis of patient health information. This paper proposes an adaptive system for monitoring the patient's environment using telemetric data collected by sensors useful for optimal recovery conditions. The described system utilizes machine learning algorithms to analyze telemetric data, allowing it to identify patterns, adjust responses, and identify deviations from normal conditions. This adaptability enables the system to offer proactive and personalized patient care by providing information about potential health risks associated with room related parameters.

Digital Innovations Development: Causal factors and relations A Case Study of Montenegro

Ivana Ognjanović, Luka Laković, Ramo Šendelj, Laszlo Bokor, Peter A. Kara, Christoph Reich, Manav Madan, Milovan Roganović, Emmanouil Zouilas, John Mantas, Jevto Eraković, Tanja Radusinović, Nada Rakočević

In order for economies to expand and develop globally, innovation is essential. A popular statistic for evaluating innovation between countries is the Global Innovation Index (GII), which provides a thorough analysis of the state of innovation worldwide. In this context, this paper aims to contribute to the literature by examining the multi-factoral effects of the innovation ecosystem on innovation development (internal causal effects), and the impact of global trends and crises on the innovation ecosystem (external causal effects) in Montenegro. The resources provided in this paper offer valuable insights into the innovation landscape in Montenegro and the Western Balkans, as well as the impact of globalization, global trends, and crises on innovation in the region. The paper also discusses the function of innovation hubs such as the DigNest project, in promoting cooperation between academic institutions, government agencies and corporations, and supporting the exchange of knowledge and fresh concepts.

Optimization of voltage controller parameters considering the real model of the automatic voltage regulation system

Mihailo Micev, *Student Member, IEEE*, Martin Ćalasan, *Member, IEEE*, and Milovan Radulović,

Member, IEEE

This paper deals with the optimal tuning of a voltage controller for a real model of the automatic voltage regulation (AVR) system of a synchronous generator. The real simulation model of the automatic voltage regulation system is developed in MATLAB Simulink software and is based on the technical documentation of real generator in hydropower plant Perucica. Optimal parameters of the proportional-integral (PI) controller with anti-windup protection, which is used for voltage regulation of real generator, are estimated using equilibrium optimizer (EO) algorithm. The comparative analysis with parameters used for voltage controller in real hydropower plant is carried out.

Comparative Analysis of Degradation in Monocrystalline and Amorphous Silicon Solar Cells

Snežana Vujošević, Faculty of Electrical Engineering, University of Montenegro

The paper provides a detailed analysis of degradation in monocrystalline and amorphous silicon solar cells, essential technologies for harnessing solar energy. It delves into the mechanisms and factors that lead to degradation, and their impact on the characteristics of these solar cells. Through experimental field measurements and laboratory analysis, it identifies the primary causes of this degradation.

Assessing Compressive Sensing Methods for Impulsive Noise Reduction in Audio Signals

Svetozar Ivanović and Miloš Brajović, *Member, IEEE*

Impulsive noise often corrupts audio signals due to various factors, leading to a degradation in signal quality and clarity. In this paper, we analyze denoising techniques based on compressive sensing (CS) theory. CS-based methods leverage signal sparsity or high concentration in specific transformation domains. Audio signals exhibit high concentration in the discrete cosine transform (DCT) domain. CS-based denoising involves two main steps: (i) detecting corrupted samples and (ii) reconstructing samples at detected positions. The positions of the noisy samples identified in the first step are considered inaccessible, and we employ compressive sensing methods to reconstruct these values. We will evaluate the performance of two CS methods alongside a traditional denoising approach based on the median filter.

Random Walk Operator-Based Fourier Transform in Connected Directed Acyclic Graphs

Miloš Brajović, *Member, IEEE*, Isidora Stanković, *Member, IEEE*, Miloš Daković, *Member, IEEE*,

Ali Bagheri Bardi, Ljubiša Stanković, *Fellow, IEEE*

Spectral analysis of signals defined on Directed Acyclic Graphs (DAGs) poses significant challenges due to the presence of zero eigenvalues in the adjacency matrix and equivalent shift operators, such as the random walk matrix. This characteristic hinders the differentiation between spectral components of signals on such graphs, rendering conventional spectral analysis impossible. To mitigate this issue, a zeropadding technique for signals defined on DAGs was recently proposed. Given the similarity between the properties of the random walk matrix and the adjacency matrix, this paper explores the feasibility of Fourier analysis using the eigendecomposition basis of such matrices. The extension of the zero-padding concept to signals on DAGs described by the random walk matrix involves introducing additional nodes connected to the existing structure, with the signal values on these added nodes set to zero. The primary objective of this approach is to facilitate the computation of vertex-domain convolution, thereby enabling the output of graph filters without encountering aliasing issues.

Application Development From Monolithic to Microservice Architecture

Anja Kapikul, Dušan Savić, Miloš Milić, Ilija Antović

Classical application development typically involves a monolithic architecture, where the application is constructed as a single entity. However, modern software systems demand characteristics such as high concurrency, availability, scalability, cohesion, and low coupling. Microservices present an architectural approach in modern software development, wherein applications are viewed as a collection of loosely coupled, finegrained services that communicate via simple protocols. This paper outlines the process of migrating a Java application, used for organizing thesis defense commissions at a faculty, from a monolithic architecture to a microservices architecture.

Advancing Cultural Heritage Preservation through monument 3D reconstruction and multi-platform interaction-based applications

Foteini Rizou[1], Rigas Kougkolos[1], Dimitrios Kapetas[1], Charalampos Georgiadis[1], Georgios Patseas[2], Athanasios Tsakiris[1], Eleftheria Maria Pechlivani[1], Dimosthenis Ioannidis[1], Dimitrios Tzovaras[1]

The preservation and sharing of cultural heritage is a practice that not only connects us to our past but also enriches our present and future, fostering a deeper understanding and appreciation of the diverse narratives and histories that shape our world. Recent technological advancements have opened up new possibilities for this endeavor, allowing for preservation on a scale previously unimaginable. This study focuses on demonstrating the feasibility and effectiveness of these technologies by virtually recreating the Holy Monastery of Pantokrator, a significant heritage site in the monastic state of Mount Athos, Greece. The study involves the detailed 3D reconstruction with modern 3D image acquisition techniques such as photogrammetry and advanced 3D modeling. The interactive experience is facilitated through three modes: Desktop Mode (Screen, Keyboard, Mouse), Virtual Reality Headset Mode and 360° Video mode, catering to different user preferences and access to hardware. Our results indicate a high level of accuracy and detail in the virtual model, closely mirroring the actual site. This study contributes to the growing body of research exploring the application of VR in cultural heritage preservation and dissemination. The findings highlight the potential of VR to democratize access to cultural heritage assets, particularly those that may be difficult or impossible to visit in person.

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Artificial Intelligence Data Model Verification through Distributed Ledger Technology

Georgios Gkogkos, Nikolaos Giakoumoglou, Eleftheria Maria Pechlivani, Konstantinos Votis and Dimitrios Tzovaras

The integration of Artificial Intelligence (AI) and Distributed Ledger Technology (DLT) into Decision Support Systems (DSS) is revolutionizing agriculture, enabling data-driven decision-making and ensuring the integrity of AI model results for enhanced productivity. To ensure the reliability of AI-driven insights, a pioneering approach is proposed, which employs Distributed Ledger Technology (DLT). The proposed system combines advanced AI algorithms with the security and transparency of DLT. By leveraging digital signatures, cryptographic hashing, and timestamping, this solution guarantees the immutability of data recorded in the ledger. This innovation fosters stakeholder trust, enabling independent verification of AI model outputs by policymakers, researchers, and farmers. The system's accountability and transparency make it a valuable tool for promoting data interoperability and collaboration across diverse agricultural systems. This study outlines the system's architecture, testing, and assessment, highlighting its role in preserving data integrity and ensuring accurate AI model outputs. This technology has the potential to revolutionize decision-making in AI-driven agriculture, addressing critical concerns around data reliability and promoting more efficient and sustainable practices.

Preliminary Experiences of Using the Azure DevOps Platform in Software Development Automation

Željana Grujić, Miloš Milić, Ilija Antović

The goal of this research is to examine the principles offered by GitOps and their integration with the services offered by the Azure DevOps platform for automating software development. The paper discusses how the use of selected principles and services can help with Continuous Integration, Continuous Delivery and Automation of the development of a software solution designed for the retail clothing store. The observed advantages, disadvantages and limitations, as well as other possibilities offered by both solutions, will be analyzed side by side, and an overview will be given of how to implement them in a way to use the maximum potential they provide. Combining and implementing these solutions creates an opportunity to achieve excellence in software development and meet the growing needs of end users for complex software products.

Transformer Based Multimodal Summarization and Highlight Abstraction Approach for Texts and Speech Audios

Turan Goktug Altundogan, Mehmet Karakose and Senem Tanberk

Multimodal summarization is a kind of summarization application in which its inputs and/or outputs can be in different data types like text, video, and audio. In this study, a new approach based on fine tuning of different pre-trained transformers was developed for abstractive and extractive summarization of audio and text data. In the proposed method, abstractive and extractive summaries of text data are provided only as text, while extractive summaries of audio data are presented as both text and audio data. Abstractive summaries of the audio data are presented as text only. Transformers with text2text input-output relationship were used in both extractive and abstractive summarization processes of the proposed method. For the training and inference processes of audio this type of data to be handled in transformers, an ASR step was followed before the summarization step. The experimental results obtained were given in detail and compared with similar approaches in the literature. As a result of the comparison, it was seen that the proposed method achieved better performance than similar prior approaches.

Exploring and Analyzing Spam Messages: A Comprehensive Study Using Python, Natural Language Processing and Machine Learning Models

Nedim Bandžović, Ajdin Pašić, Dželila Mehanović, Adnan Dželihodžić

This paper concentrates on the analysis of spam messages as well as processing them by using machine learning models. The result of this research allows the reader to learn about the most important characteristics of spam messages in the form of the most common pattern used, which may assist in their detection as well as prevention of any kind of loss that may occur.

A New Efficient-Attention Based Disaster Classification for Emergency Monitoring

I. Aydin, Y. Karabulut

Natural disasters such as earthquakes, floods and storms have increased today due to climate change. Since infrastructure problems often occur in places where natural disasters occur, it is vital to reach the disaster area as quickly as possible. In such disaster situations, unmanned aerial vehicles can be used, which have significant advantages with their flexibility, low cost and mobility features. In this study, a low-weight deep learning approach that can work on UAV is presented to detect the disaster situation and perform emergency response. The proposed approach is based on the EfficentNetv2 model, which has offered significant advantages in recent years, especially in terms of speed and accuracy. By adding an attention mechanism to this model, its performance has been increased. Experimental results showed that the proposed approach achieved around 6% accuracy compared to the base EfficentNetv2S model.

Blockchain applications and cybersecurity threats: A review

Lindani H. Ntshangase, and Sanja Bauk

This paper provides a brief overview of the development of blockchain technology, with reference to Bitcoin as the main platform and the cryptocurrency of the same name that runs on top of it. A major part of the paper deals with some of numerous applications of blockchain technology in different areas of human life and work. Special attention is given to actual and prospective deployments of blockchain technology in maritime business and industry. The paper also provides an overview of the most common types of cyber-attacks on blockchain networks.

Machine Learning for Cybersecurity Frameworks in Smart Farming

Charis Eleftheriadis, Georgios Andronikidis, Konstantinos Kyranou, Eleftheria Maria Pechlivani, Ioannis Hadjigeorgiou and Zisis Batzos

In recent years, the rapid advancements in Artificial Intelligence (AI) have stimulated numerous breakthroughs and applications. With the advent of Industry 4.0, agriculture has become a primary subject of ongoing digitalization efforts. Modern agricultural applications prominently feature Decision Support Systems (DSS) characterized by practical User Interfaces (UI). While several applications align with these criteria, a noticeable gap exists in the domain of cybersecurity for smart farming. This paper addresses the identified gap by introducing an innovative solution: a robust tool designed to address critical security issues, including privacy, confidentiality, integrity, and availability. In this manner, the regular operation of the intelligent system is ensured, rendering it resilient against a diverse set of potential attack methods, including Denial of Service (DoS) attacks, replay attacks, and trojan horse attacks. Throughout this article, we articulate the systematic development of our framework, emphasizing its dependability and user-friendly attributes. By prioritizing cybersecurity, our framework contributes to establishing more resilient Information Technology infrastructures for the evolving landscape of modern agriculture.

Blockchain Technology's Effects on Big Data in Maritime Transportation

Zdravko Paladin, Sanja Bauk, Rasim Mujalović, Nexhat Kapidani, Žarko Lukšić

This paper reviews the most important cases of using Blockchain to support Big Data in maritime transport and supply chains and to make them secure and integrated. Contemporary global markets and trade produce a vast amount of Big Data that is collected from various sources and processed, structured, and categorized in order to provide important information to various users in the maritime sector. Also, Blockchain as a new disruptive technology could provide important benefits for handling, securing, and efficient management of Big Data within the maritime transportation supply chain. The paper presents some of the key platforms of Blockchain for maritime and logistics purposes, including smart contracts and other use cases.

Enhancing Electrical and Physical Properties of Epoxy Resin by Incorporating S_iO_2 Nano Filler

Eid J. Eid, Ahmed Hossam-Eldin, Loai S. Eldeen, and Hossam Kotb

This work investigates the effect of incorporating silicon dioxide (S_iO_2) nano filler on the electrical and physical characteristics of epoxy resin composites. The primary objective is to boost the dielectric strength and reduce the swelling effect of epoxy resin under various environmental conditions. Composites with different S_iO_2 nano filler lengths were prepared and subjected to a series of tests to evaluate their electrical and physical characteristics. The results demonstrated that the additive of S_iO_2 nano filler substantially enhanced the flashover voltage, dielectric constant, and reduced the swelling effect of epoxy resin. The results indicate that the incorporation of S_iO_2 nano filler successfully alters the microstructure and improves the overall performance of epoxy resin, demonstrating its potential as a viable material for high-voltage insulation applications.

Implementation of Chaotic DSSS Technique for Underwater Acoustic Communication System

Luka Lazović, Jeffrey Neasham, Benjamin Sherlock, Ana Jovanović and Vesna Rubežić

This paper proposes a novel modulation scheme for underwater acoustic communications based on chaotic signal. The proposed method is Chaotic Direct-sequence spread spectrum (DSSS). The conventional modulation techniques often encounter challenges related to spectral efficiency, robustness against noise, and security. In contrast, chaotic modulation harnesses the unique properties of chaotic signals to achieve improved performance in these aspects. In this study, the Logistic map is used as the spreading sequence code for BPSK signal for direct sequence spread spectrum communications.

In contrast to conventional methods employing chirp signals for synchronization, this approach utilizes a chaotic signal to achieve synchronization. Additionally, demodulator incorporates a Doppler shift compensator capable of addressing shifts of up to 10 m/s. This compensator operates on a bank of Doppler shifts.

To assess the impact of the underwater acoustic channel on our proposed acoustic signal, the simulations in MATLAB were conducted. The channel was characterized by the inclusion of white Gaussian noise, multipath propagation and the Doppler effect.

KF-based LOS Guidance Law for Path Following of USV: Experiments and Performance Evaluation

Žarko Zečević, Luka Martinović, Lazar Ašanin, Marco Bibuli, Roberta Ferretti, Angelo Odetti, Simona Aracri, Massimo Caccia

In this paper, we present the experimental results of the recently proposed Kalman filter-based line-of-sight (KF-based LOS) path-following algorithm tailored for Unmanned Surface Vehicles (USVs), addressing a known challenge where traditional LOS methods lack robustness against external disturbances leading to sideslip and tracking errors. A series of experiments focusing on straight-line following has been conducted, with all data systematically recorded for further analysis. The vehicle's performance is quantitatively assessed through well-known performance indices. The results demonstrate that the KF-based LOS method effectively compensates for sideslip, enabling a USV to accurately follow a straight line.

Formation Path Following of Multiple Underactuated Surface Vehicles in Presence of Unknown Environmental Forces

Mitar Otašević, Luka Martinović, *Student Member, IEEE,* Žarko Zečević, *Member, IEEE*

In this paper, we propose a cooperative guidance law for straight-line formation path-following of multiple USVs in the presence of ocean currents. In the proposed approach, the desired USV paths are synchronized using the distributed observer, while the KF-based LOS guidance laws and nonlinear velocity laws are used to minimize the path-following errors and compensate for the sideslip. The effectiveness of the proposed approach is verified by numerical simulations.

Simulation Analysis of the Impact of Underwater Channel Reliability on Machine Learning-Optimized Framed-Aloha MAC protocols

Aleksa Albijanic, Slavica Tomovic, *Member, IEEE*, Igor Radusinovic, *Member, IEEE*

In underwater acoustic sensor networks (UASNs), the unpredictable nature of the underwater acoustic channel presents significant challenges for reliable communication. Traditional medium access control (MAC) protocols, designed for more stable terrestrial environments, struggle to perform effectively in these circumstances. This paper evaluates the performance of UW-ALOHA-Q, a reinforcement learning (RL)-based MAC protocol designed for UASNs, focusing on its adaptability and performance in the face of the underwater channel's inherent unreliability—an aspect not thoroughly examined in prior evaluations. Utilizing the DESERT Underwater simulator, we investigate the impact of channel conditions on the effectiveness of UW-ALOHA-Q's learning mechanism. Our results show that UW-ALOHA-Q outperforms conventional protocols such as ALOHA-CS and TDMA in terms of channel utilization, but faces challenges in achieving convergence in highly unreliable channel conditions. Our study underscores the potential of RL-based MAC protocols in enhancing the robustness and efficiency of UASNs, while also identifying critical areas for further research in RL methodology to address the unique challenges of underwater environments.

An Approach to the Collision Detection of Non-SOLAS Vessels Using the Concept of e-Navigation

Igor Stanovčić, Milutin Radonjić *IEEE Member*, Enis Kočan *IEEE Member*, Božidar Škrbić, Božo Krstajić, *IEEE Member*

This paper presents a proposal for the approach to potential collision detection of non-SOLAS vessels using an e-navigation system based on modern IoT systems. Although there are significantly more non-SOLAS vessels than SOLAS vessels worldwide, the lack of basic navigation equipment excludes them from the navigation safety system. The implementation of the proposed innovative IoT concept and the described architecture, using available smart devices, would significantly increase the navigation safety of non-SOLAS vessels, and thus the overall safety at sea.

A Model Proposal for Monitoring Key Performance Indicators - a Case Study of the Faculty of Maritime Studies Kotor

Vera Kapetanović, Maja Krčum, Stevan Kordić, Igor Petrović, and Tatijana Dlabač *IEEE Member*

This paper presents a model proposal for monitoring Key Performance Indicators (KPI), based on the example of the Faculty of Maritime Studies Kotor (FMS), from the aspect of quality control. This is the way of measuring and monitoring the quality of work processes. The analysis of the self-evaluation process of the higher education institution was the starting point for the proposal of the model of an advanced information system that would help in monitoring key performance indicators. This case study can be applied not only to the educational process but also to all other activities that accompany the work of an educational institution.

Development and implementation of a facial recognition intrusion detection system

Nikola Živković, Nikola Žarić *Member, IEEE*

This paper deals with the problem and offers solutions in the area of developing a resource and energy-efficient, automated system for the adequate recognition of unknown and/or unwanted individuals in the surveillance area using facial recognition technology. It also deals with the development and implementation of a web-based control center for monitoring and controlling the aforementioned system from a remote location. By using the database as an intermediary in the communication between the raspberry-pi device and the web server, a resource-efficient control and monitoring center was successfully implemented in the form of a web application

Implementation and Performance Evaluation of Convolutional Neural Network models for Low-Power Microcontrollers with Constrained Resources

Bogdan Krivokapic, Slavica Tomovic, *Member, IEEE*, Igor Radusinovic, *Member, IEEE*, Ana Jovanovic, *Member, IEEE*

Recent advancements in machine learning have given rise to TinyML, a field focused on developing efficient, miniature models capable of operating on devices with severe power and computational limitations. In this paper, we evaluate the performance of TensorFlow Lite Micro Convolutional Neural Network (CNN) models, which are prime examples of TinyML. Our research centers on image classification tasks, with a strong emphasis on enabling execution on sensor node devices equipped with ARM Cortex M4 microcontrollers. With a specific focus on the application of TinyML in underwater sensor networks, where resource limitations are paramount, our study serves as a benchmark, assessing the capabilities of these lightweight CNN models across low-power sensor nodes characterized by diverse computational and memory constraints. Our findings convincingly demonstrate the practicality and adaptability of TinyML models on low-power devices based on ARM Cortex M4 microcontrollers. The overarching goal of this research is to contribute to a broader understanding of the potential of TinyML in critical real-world applications, where energy and bandwidth resources are scarce, and the need for immediate data processing is imperative.

Tartini Tones on the Copy of Antonius Stradivarius Violin

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In the first part of the paper, Tartini tone is defined. Tartini tone, despite the fact that it is not present in the acoustic audio signal, is experienced as an audio sensation in the human consciousness, which is a consequence of the nonlinearity of the hearing system. In addition, some musical instruments, due to acoustic-mechanical nonlinearity, can reproduce Tartini tones when playing dyads. After that, as a measure of the intensity of Tartini tones, the Quadratic distortion coefficient C_2 is defined. In the second part of the paper, an experiment is described. In the experiment, the results of the analysis of Tartini tones on the copy of Antonius Stradivarius violin, are shown. A Base of test signal was formed, which was created from the dyads played on the tested violin (dyads from tones A4-E5 to A4 - G6#). Analysis of Tartini tones from the Base, in the spectral domain, was performed. The results of the analysis (Quadratic distortion coefficient C_2) are shown using graphics and tables. As an overall measure of the intensity of the Tartini tones, for the entire range of the violin (tones G3 – E6), the Mean quadratic distortion coefficient is defined. Finally, the results of the comparative analysis of Tartini tones on the tested violin and acoustic guitar CG 510 are presented.