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Uvodna reč

„Kvalitetno obrazovanje je osnova napretka i uspeha kako pojedinca, tako i društva u celini."

Valentin Kuleto

Poštovani profesori, nastavnici, saradnici, naučni istraživači i stručnjaci,

Želim da sa vama podelim svoja razmišljanja u vezi sa vitalnim sektorom u kome svi radimo, obrazovnim sektorom, i time kako da unapredimo iskustvo nastave i učenja tako da ne ugrozimo beneficije nijedne zainteresovane strane. Pred nama je važan zadatak: da oblikujemo obrazovanje u skladu sa potrebama naše dece, budućim očekivanjima na tržištu rada i razvojnim tendencijama u društvu. Naš ključni saveznik na ovom putu je informaciona tehnologija. Istraživanje i razvoj ključnih tehnologija od strane tehnoloških kompanija i instituta omogućili su široku primenu najsavremenijih tehnologija u obrazovanju. Zbog toga se svakodnevno suočavamo sa važnim prilikama i izazovima na našem putu ka boljem obrazovanju i boljem svetu.

Neosporno je da je od samog početka digitalnog doba razvoj tehnologije doveo do neprekidnog unapređenja obrazovanja. Široka primena kolaborativnih računarskih mreža krajem 80-ih i početkom 90-ih godina 20. veka utrla je put onlajn-učenju. U današnjim obrazovnim institucijama postoji rastuća potražnja za izuzetnim iskustvima učenja i tehnološki potpomognutom nastavom na svim nivoima obrazovanja, kako bi se zadovoljile potrebe sve raznovrsnije studentske populacije. Neki od ovih problema mogu se rešiti korišćenjem AI-ja, ML-a, XR-a, IoT-a i slično, koji su se postepeno odomaćili u obrazovnom okruženju. Prilike i izazovi povezani sa korišćenjem IT i IKT tehnologija od strane učenika i nastavnika pominju se u mnogim naučnim člancima, istraživačkim studijama i primerima evaluacionih mogućnosti.

Ove skrivene motive, koji mogu značajno da izmene način na koji posmatramo sebe, vreme i slobodnu volju, treba dodatno istražiti, budući da se modeli nastave i učenja neprestano testiraju tokom obrazovnog putovanja.

Institut za moderno obrazovanje, izdavač časopisa „EdTech", deo je LINK obrazovne alijanse (LEA). Kao kompanija koja je po svojoj prirodi i načinu rada usmerena na obrazovne tehnologije (EdTech), mi smo lider na polju informacionih tehnologija i obrazovanja. Zahvaljujući transferu tehnologije, LEA svoje modele i platforme razvijene u laboratorijama prenosi u tradicionalnu i onlajn učionicu, deleći ih sa ostatkom sveta duže od 20 godina. Zahvaljujući najnovijim tehnološkim dostignućima, ali i analizi tuđih iskustava, naš sektor za istraživanje i razvoj, koji čine timovi naučnika i stručnjaka, razvija nove proizvode, usluge i procese i unapređuje postojeće, osluškujući potrebe obrazovne industrije, privrede i društva.

Časopis pred vama je garancija da će samo najbolje prakse biti uzete u razmatranje, ali i da ćemo doći do najboljih rešenja. On je poziv na dijalog i zajedničku saradnju koja će proizvesti zdravije, zadovoljnije i obrazovanije mlade ljude koji će izrasti u profesionalce na koje ćemo svi biti ponosni.

Glavni i odgovorni urednik

dr Valentin Kuleto

Introductory

"Quality education is the basis of progress and success of individuals and society."

Valentin Kuleto

Distinguished professors, teachers, associates, scientific researchers and professionals,

I want to share with you some of my thoughts regarding the vital sector in which all of us are gathered: the education sector and how to enhance the teaching and learning experience while maintaining benefits for various shareholders. We all have an important task ahead of us: to shape education according to our children, future expectations of the labour market and development tendencies in society. We have a crucial collaborator on this path: information technology. Thanks to the research and development of essential technology companies and institutes, cutting-edge technologies can be introduced broadly in education. Therefore, we face significant opportunities and challenges every day in our journey for better education and a better world.

Throughout the digital era, technology has unquestionably improved education. The widespread use of collaborative computer networks in the late 1980s and early 1990s paved the way for online learning. In today's education institutions at every educational level, there is a growing demand for exceptional learning experiences and technology-enhanced teaching to meet the needs of an increasingly diverse student population. Some of these issues can be addressed by using AI, ML, XR, IoT and the like, which has gained traction in educational settings. The opportunities and challenges that arise when students and teachers use IT and ICT tools can be found in many scientific articles, research studies, and examples of evaluation opportunities.

These ulterior motives, which can significantly alter our perceptions of ourselves, time, and free will, should be further examined as teaching and learning models are constantly tested during the educational path.

The Institute for Contemporary Education, publisher of the EdTech Journal, is part of the LINK group Education Alliance (LEA). As an EdTech company in its nature and basis, it is a leader in information technology and education. Through the transfer of technology, LEA has been transferring its platforms and models developed in laboratories to its traditional classrooms and online classrooms, and has been sharing all this with the world for more than 20 years. In our research and development sector, based on the latest technological achievements but through the analysis of the experience of others, teams of scientists and experts develop new products, services and processes and improve existing ones by listening to the needs of the education industry, the economy and society.

The journal in front of you ensures that we all discuss best practices and find the best solutions. This is an invitation to dialogue and joint work that will result in healthier, more satisfied, and well-educated young people who will grow into great professionals in whom we will take great pride.

Dr Valentin Kuleto

Editor in Chief

Valentin Kuleto
Editor in Chief

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Problemi u vezi sa procenom pouzdanosti podataka na kojima počiva Internet stvari

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Apstrakt: U poslednje vreme beleži se povećano interesovanje za proučavanje Interneta stvari (IoT – Internet of Things). Otkriveni su novi koncepti, a stari su unapređeni ili ispravljeni zahvaljujući inovativnim istraživačkim studijama i razvoju IoT tehnologija u različitim sektorima. Pored toga, fokus je i na bezbednosti i standardima Interneta stvari. IoT aplikacije koje se primenjuju u drugim granama industrije, poput pametnog življenja, Industrije 4.0 i E-zdravlja su i dalje relevantne. Cilj ovog rada jeste da pokaže da se Internet stvari (IoT) mora smatrati pouzdanim, naročito kada se radi o Internetu stvari zasnovanom na podacima. Pouzdanost takvog Interneta stvari je kompleksan problem koji nije lako rešiti, jer podrazumeva hardver, softver, ljudski faktor, podatke, a u današnje vreme i veštačku inteligenciju. Moguće je izračunati pouzdanost IoT sistema pomoću proste jednačine koja će biti predstavljena u ovom radu. Ali osnovni problem jeste kako izračunati pouzdanost podsistema u ovoj jednačini. Pored toga, pouzdanost ima veze sa dostupnošću i pogodnošću održavanja. Sadržaj ovog rada se uglavnom oslanja na dve nedavno objavljene publikacije autora.

Ključne reči: pouzdanost, dostupnost, pogodnost održavanja, Internet stvari, zasnovanost na podacima, podaci.

1. Uvod

Internet stvari (IoT – Internet of Things) ili internet pametnih uređaja nastao je krajem XX veka, dok je teorija i praksa pouzdanosti počela da se javlja 50-ih godina prošlog veka. Međutim, Internet stvari je veoma kompleksan i međuzavisan sistem, zbog čega su obrazovanje i istraživanje pouzdanosti svakodnevno suočeni sa novim zahtevima u vezi sa IoT-om.

Kod Interneta stvari uređaji su međusobno povezani i mogu da komuniciraju između sebe, često bez ikakvog uplitanja ljudi. Budući da Internet stvari počiva na ljudskom faktoru, hardveru i softveru, on mora posedovati visoku pouzdanost, zbog čega je neophodna šira diskusija o ovoj temi.

IoT sistem zasnovan na podacima je kompleksniji od običnog, budući da su podaci sastavni deo ovog sistema. Iz tog razloga, neophodno je razmotriti pouzdanost tih podataka. U [1] primenjena je klasična metoda procene pouzdanosti da bi se istražilo pitanje dostupnosti i pouzdanosti IoT-a. Fokus ovog rada je pouzdanost Interneta stvari zasnovanog na podacima.

2. Internet stvari

Internet stvari će transformisati ljudsko društvo, čineći ga inovativnijim, pristupačnijim i efikasnijim, a tu je i ogroman potencijal za ekonomski i ekološki razvoj. Međutim, jedno od neodložnih pitanja koje se mora rešiti, ukoliko želimo da do ove revolucionarne transformacije dođe, jeste njegova pouzdanost [2].

Internet stvari je trenutno jedna od najpopularnijih tema. Elektronske komponente postaju sve manje i sve jeftinije, a bežične komunikacije sve rasprostranjenije. Upravo ova tri faktora imaju najveći uticaj na Internet stvari.

Internet stvari će transformisati aplikacije poput elektronskog zdravstva, kućne automatizacije i senzora za praćenje parametara životne sredine. Čak je i ekonomija deo ove rasprave. Aktuelni razvoj internet veza i pametnih računara je Internet stvari, njegove aplikacije i prateće hardverske platforme učinio glavnom temom u akademskoj i stručnoj javnosti. IoT sistemi se mogu primeniti u najrazličitijim scenarijima, od malih prenosivih uređaja, pa sve do infrastrukture čitavih gradova [3, 1].

Internet stvari je neosporno vrlo složen koncept. IoT sistemi podrazumevaju hardverske i softverske komponente, ali povremeno i ljudski faktor [1]. Upravo zato što Internet stvari počiva na hardveru, softveru i ljudskom faktoru, na njegovu pouzdanost utiču sva tri. Dostupnost i pogodnost održavanja takođe imaju veze sa pouzdanošću. Prvi korak u ovoj diskusiji biće definisanje pouzdanosti, dostupnosti i pogodnosti održavanja.

3. Pouzdanost, dostupnost i pogodnost održavanja

Oblast teorije i prakse pouzdanosti počela je da se razvija tek 50-ih godina prošlog veka. Ukoliko se od predmeta/koncepta/stavke očekuje da ispuni određene standarde učinka i da proizvede željene rezultate u određenom vremenskom periodu, onda se govori o njegovoj/njenoj pouzdanosti.

Pouzdanost komponenti i održavanje sistema su dva faktora koja određuju dostupnost računarskog sistema. Međutim, različiti ljudi različito definišu i izračunavaju dostupnost.

Na primer, trenutna dostupnost (takođe poznata i kao dostupnost) definiše se kao verovatnoća da će sistem (ili komponenta) biti u funkciji u određenom trenutku.

U slučaju neispravne komponente ili sistema, pouzdanost i dostupnost su jednake, međutim dostupnost je značajnija od pouzdanosti kada govorimo o ispravnim komponentama i sistemima [4].

I pouzdanost i dostupnost imaju veze sa održavanjem. Stoga, da bi troškovi IoT-a bili što niži, faza projektovanja IoT-a mora da uključi analizu i procenu održavanja.

Pogodnost održavanja podrazumeva da se pametni sistem može lako isključiti, popraviti i prepraviti bez značajnog ugrožavanja normalnog funkcionisanja sistema ili njegovih funkcija. Da bi se osiguralo da se IoT sistem može lako popraviti ili zameniti u slučaju kvara, potrebno je da on sadrži komponente koje se lako menjaju. Lako održivi IoT sistem se može opisati kao sistem koji efikasno i delotvorno izvršava operacije održavanja [5, 1].

Kako izračunati dostupnost sistema ili komponente, može se pronaći u [4].

Zamena IoT uređaja može da smanji njegovu dostupnost ako se od IoT sistema očekuje da radi i tokom zamene baterije, na primer. Zbog toga se IoT sistemi zasnovani na podacima strože i detaljnije kontrolišu, sa fokusom na njihovu pouzdanost u pogledu hardvera, softvera, ljudskog faktora i podataka.

4. Internet stvari je sistem zasnovan na podacima

Izraz „zasnovan na podacima" (data-driven) odnosi se na sve odluke i procese koji zavise od dostupnih informacija. Ovo se najbolje može videti na primeru velikih podataka [6]. Zasnovanost na podacima ima veze sa naukom o podacima, rudarenjem podataka i drugim srodnim oblastima. Mnoga polja, uključujući polje kome pripada Internet stvari, koriste izraz „zasnovan na podacima" da opišu svoje polje delovanja.

Da bi organizacija bila kvalifikovana kao „zasnovana na podacima", ona mora da se bavi prikupljanjem i analizom podataka. Da bi se to postiglo, neophodan je neki oblik komunikacije. Mi danas koristimo različite uređaje, mreže, softver i Internet stvari da to postignemo, a svaki od ovih elemenata može da se pokvari. Međutim, mi želimo da oni funkcionišu i popravljamo ih kada se pokvare, a upravo to je svrha pouzdanosti. Dok budemo govorili o pouzdanosti, kratko ćemo se osvrnuti na Internet stvari.

Heterogenost „end-to-end" IoT sistema donosi određene izazove u vezi sa pouzdanošću. Mnogo veća pažnja se mora posvetiti interfejsima između podsistema kako bi se osigurala kompatibilnost, a to može da utiče na pouzdanost. Najkritičnija tačka IoT-a jeste fizički sistem kod koga može da dođe do nepredviđenih kvarova. Inženjeri i matematičari su dugo analizirali ove sisteme kao element hardverske pouzdanosti kako bi smanjili učestalost kvarova i sačuvali ljudske živote [7].

5. Elementi IoT sistema zasnovanog na podacima

Netačne glasine o praćenju podataka, dugim zastojima, pa čak i gubitku podataka mogu da smanje interesovanje za IoT komunikacije, ali i poverenje u podatke. Internet stvari zahteva visok nivo pouzdanosti kako bi mogao da održi korak sa sopstvenim ubrzanim razvojem [8].

Zbog toga, pouzdanost sistema zasnovanih na IoT-u zavisi od samih komponenti (elemenata) IoT-a i podataka koji čine sistem.

5.1. Pouzdanost IoT hardvera

MIL-HDBK-217 se koristi za utvrđivanje pouzdanosti elektronskih uređaja još od 60-ih godina prošlog veka. Prvobitna verzija ovog proizvoda razvijena je 1961. godine (verzija A). I pored svih njenih nedostataka, više od 80% inženjera i dalje koriste MIL-HDBK-217 za utvrđivanje pouzdanosti. Industrijski i komercijalni sektor, naravno, imaju sopstvene standarde za izračunavanje pouzdanosti. Međutim, RIAC's 217PlusTM metodologija i softverski alat zamenili su MIL-HDBK-217, koji se više ne može besplatno koristiti. Pored toga, novi MIL-HDBK-217 je značajno teži za razumevanje od prethodne verzije [9].

I pored toga što imamo MIL-HDBK-217 na raspolaganju, teško je utvrditi pouzdanost hardvera. Zbog toga što ne postoji standardizovana metoda za predviđanje pouzdanosti hardvera, rezultati mogu drastično da variraju u pogledu metodološke strogosti, kvaliteta podataka i mere u kojoj se analiza i neodređenost uzimaju u obzir [10]. Pored toga, dešava se da nisu svi procesi predviđanja zabeleženi. IEEE standard 1413 je utvrđen 2009. kao odgovor na to (Standard Framework for Hardware Reliability Prediction – Skup standarda za predviđanje pouzdanosti hardvera). Internet stvari obuhvata širok spektar hardverskih komponenti različitog kvaliteta i stepena pouzdanosti. Da bi se precizno izračunala pouzdanost komercijalnog hardvera, neophodno je utvrditi pouzdanost i stopu kvarova, prosečno vreme do kvara (MTTF) ili prosečno vreme između kvarova (MTBF), a takvih podataka nema.

5.2. Pouzdanost IoT softvera

Važan kriterijum koji treba razmotriti jeste kvalitet softvera kao gotovog proizvoda. Postoje različiti modeli za procenu pouzdanosti softvera, ali nijedan nije univerzalno prihvaćen [11, 9]. Uglavnom je teško definisati zahteve koji moraju biti ispunjeni da bi se softver mogao smatrati pouzdanim. Ovo naročito važi za Internet stvari. Pošto se softver suštinski razlikuje od hardvera, problem samim tim postaje još teži. Iako je pouzdanost softvera probabilistička, ona nije i vremenski zavisna funkcija. Važno je napomenuti i da ne postoje standardizovane prakse za predviđanje pouzdanosti softvera. Stručnjaci za pouzdanost i softver moraju se postarati da softver bude uključen u studije slučaja pouzdanosti sistema.

Kada dođe do kvara ključnog elementa/komponente, tada nastaje pravi problem sa softverskom pouzdanošću. „Otporan na kvarove" nije isto što i „nikada se ne kvari". Softverska bezbednost i pouzdanost idu jedno s drugim zato što je njihova zajednička svrha kreiranje bezbednog i pouzdanog softvera. Softverski inženjeri i inženjeri za pouzdanost moraju ponovo da udruže snage. Uprkos tome, mali broj obrazovnih institucija i profesionalaca iz ove industrije se uopšte

trudi da druge nauči osnovama softverske pouzdanosti i bezbednosti [4].

Veliki je izazov unaprediti pouzdanost pomoću redundantnog softvera, jer u svakoj kopiji postoji greška [4].

5.3. Ljudska pouzdanost u IoT-u

Kao što je navedeno u uvodu ovog rada, i ljudi mogu biti deo IoT sistema. Zbog toga je Internet stvari podložan ljudskoj grešci.

Ljudska pouzdanost se može povećati sprečavanjem akcidenata i minimiziranjem štete. Pored rada sa hardverom i softverom, do ovih problema može doći isključivo kod uskladištenih podataka. Ljudski postupci utiču na tehnološke sisteme. Postoji mnogo primera gde su odluke ili postupci jedne ili više osobe tokom korišćenja, održavanja ili popravke tehnološkog sistema izazvale katastrofe ili pad čitavog sistema. Inženjeri za pouzdanost mogu značajno da utiču na ovakve ishode kroz saradnju sa drugima, na primer menadžerima rizika, ekolozima ili inženjerima za bezbednost i zdravlje na radu. Posledice ljudske greške u rukovanju podacima mogu biti prilično ozbiljne. Ljudskoj pouzdanosti se može pristupiti na različite načine i pomoću različitih modela [9]. Procedure, pravila, kodeksi, standardi i zakoni ne mogu da spreče sve kvarove na sistemu, ali mogu da smanje njihovu verovatnoću i učestalost.

Za autora ovog rada pouzdanost, uključujući i ljudsku, oduvek je bila važna tema, zbog čega se pominje u svim njegovim udžbenicima.

5.4. Pouzdanost podataka u IoT-u

Neophodno je da podacu budu pouzdani, a to znači potpuni i tačni, jer se tako gradi poverenje u njih. Iz tog razloga, da bi se održala sigurnost i kvalitet podataka, kao i njihova usklađenost sa propisima, osnovni cilj inicijativa posvećenih integritetu podataka jeste da osiguraju pouzdanost podataka [12].

Kako bi donosili ispravne odluke, biznis liderima su potrebne tačne informacije. Zbog toga je pouzdanost podataka jedan od najvažnijih faktora u organizacijama koje rade sa podacima. Međutim, validnost i pouzdanost podataka nisu ista stvar. Pouzdanost skupa podataka zavisi od validnosti, potpunosti i jedinstvenosti tog skupa podataka. Zbog nepouzdanosti Interneta stvari, neki podaci mogu nedostajati, biti oštećeni ili nepotpuni.

Nažalost, ne postoji adekvatna teorija niti praksa koja nam pomaže da konceptu pouzdanosti podataka pristupimo na pravi način.

5.5. Pouzdanost veštačke inteligencije Interneta stvari

Internet stvari zasnovan na podacima nije izuzetak kada se radi o trendu korišćenja veštačke inteligencije (AI – Artificial Intelligence). Mašinsko učenje (MU) i veštačka inteligencija transformišu različite aspekte ekonomije, obrazovanja i ljudskih života uopšte. Mašinsko učenje postaje sve značajnije u ključnoj oblasti otkrivanja sajbernapada na Internetu stvari. Mašinsko učenje takođe može da otkrije sofisticirane napade pomoću strategija zasnovanih na znanju. Međutim, nedostatak javno dostupnih i redovno ažuriranih skupova podataka predstavlja najozbiljniji problem u vezi sa bezbednošću IoT-a [13].

Veštačka inteligencija je evoluirala od mašinskog učenja, preko dubokog učenja, pa sve do praktičnog AI-ja. AI mašinama omogućava da uče iz sopstvenog iskustva, da se prilagođavaju novim okolnostima i podacima i da izvode određene zadatke bez učešća ljudi. Prepoznavanje lica, glasa i pobede u šahu su već moguće. Trenutno se najviše primenjuje kod IoT podataka, brzog interneta i superračunara i njihovog neprekidnog rasta. Statističke i računarske tehnike se trenutno primenjuju za istraživanje veštačke inteligencije [14].

AI prepoznaje obrasce i abnormalnosti u podacima zahvaljujući pametnim senzorima i uređajima, a pritom mu nisu potrebne nikakve instrukcije, npr. gde da ih traži. Pored toga, algoritmi mašinskog učenja „uče" kako da s vremenom generišu sve tačnije rezultate. Zbog toga je MU nadmašilo tradicionalne alate poslovne inteligencije u pogledu brzine i tačnosti. Duboko učenje, računarski vid, obrada prirodnih jezika i primena MU za proveru optimizacije i predviđanja su AI tehnologije koje upotpunjuju Internet stvari [15].

Čak i veštačka inteligencija može da otkaže, i to na isti način kao ljudsko rasuđivanje, ako pokuša da mašinsku inteligenciju zameni ljudskom. Zbog čega onda ljudi donose pogrešne zaključke (odluke)? Da li postoji način da rešimo problem pouzdanosti AI-ja ili da izbegnemo kvarove?

S obzirom na značaj ovog pitanja, ISO/IEC je odlučio da se pozabavi njime. Takozvana pouzdanost AI sistema ispitana je u [16], uključujući sledeće: poverenje u AI sisteme može se uspostaviti kroz transparentnost, upravljivost i druge mehanizme; (2) inženjerske zamke i povezane pretnje i rizici po AI sisteme, zajedno sa mogućim tehnikama i metodama za ublažavanje njihovih posledica; (3) metoda za postizanje dostupnosti, otpornosti, pouzdanosti, tačnosti, bezbednosti i privatnosti AI sistema. Postoji mnogo karakteristika koje nešto čine pouzdanim, uključujući pouzdanost, dostupnost, otpornost, bezbednost, odgovornost, integritet, autentičnost, kvalitet i upotrebljivost. Svi ovi atributi uključeni su u ovu definiciju pouzdanosti. Kao i bilo koji drugi proizvod, AI se mora održavati kako bi i dalje bio upotrebljiv i snažan.

Jedan od faktora za utvrđivanje pouzdanosti IoT-a jeste stopa kvarova hardvera i softvera. Pored nje, tu su i drugi faktori, poput protokola, energetske efikasnosti (zelene energije), standardizacije i drugih uticaja, kao na primer bezbednosti. Kada govorimo o protokolima, pouzdan protokol obaveštava pošiljaoca da li su podaci uspešno isporučeni naznačenom primaocu na mreži [17].

Tip korisnika određuje pouzdanost proizvoda koji koristi. Pouzdanost i dostupnost servisa umnogome zavise od onoga ko ga koristi. To znači da će dizajn IoT sistema zavisiti od tipa korisnika kome je namenjen. Internet stvari je takođe zasnovan na podacima i zavisi od njih.

Ciljevi u vezi sa dostupnošću Gugl servisa uglavnom zavise od njihove funkcije i tržišne pozicije. Međutim, potrebno je uzeti u obzir nekoliko faktora [18]. Ako je pitanje šta kupci mogu da očekuju od kompanije u pogledu korisničke

usluge, onda se na umu moraju imati sledeće stavke: da li kupovina ove usluge od strane korisnika direktno utiče na prihod kompanije; da li je ova uslugakomercijalna; ako na tržištu postoji konkurencija, kakav je njihov nivo usluge; da li ova usluga služi pojedincima ili kompanijama; pouzdanost IoT sistema vođenih podacima je tek na petom mestu.

6. Pouzdanost IoT sistema

IoT sistem zasnovan na podacima je kompleksniji od običnog IoT sistema, koji podrazumeva hardver, softver i ponekad ljudsku i veštačku inteligenciju, koje se mogu smatrati podsistemima IoT sistema, stoga preporučujemo promenu jednačine u [1, 19],

$$R_S(t) = R_{HW}(t)R_{SF}(t)R_H(t)R_D R_{AI} \tag{1}$$

gde R_{HW}, R_{SF}, R_H, R_D i R_{AI} predstavljaju pouzdanost podsistema hardvera, softvera, ljudskog faktora, podataka i veštačke inteligencije, tim redosledom.

Iako prethodna formula deluje jednostavno, ona je validna jedino ako su kvarovi na podsistemu hardvera, softvera i podataka međusobno isključivi. Na blok dijagramu pouzdanosti ovo predstavlja serijski model. Izračunavanje pouzdanosti ovih podsistema predstavlja poseban problem koji zavisi od vrste podsistema.

U jednačini iznad pouzdanost je jednaka verovatnoći. Dakle, ako smatramo da je podsistem pouzdan, onda ćemo u formuli napisati da je verovatnoća za taj podsistem jednaka 1.

Kao što je ranije pomenuto, postoji čitava teorija i praksa u vezi sa izračunavanjem pouzdanosti hardvera i softvera, koja je daleko od jednostavne, naročito ako hardver sadrži veliki broj komponenti (elemenata). Izračunavanje pouzdanosti softvera je poseban problem, a ne postoji ni adekvatna teorija niti praksa u vezi sa izračunavanjem pouzdanosti ljudskog faktora, podataka i AI-ja.

Ne postoji jednostavan način da se izračuna pouzdanost Interneta stvari zbog njegove prividne složenosti. Upravo zbog kompleksnosti IoT-a, preporučujemo da se njegova pouzdanost testira pomoću simulacije. Pokorni i Janković [20] i Pokorni i saradnici [21] izvršili su simulaciju kompleksnih sistema, čiji su rezultati doveli do novih saznanja. Slično drugim podsistemima, i veštačka inteligencija se može tretirati kao podsistem u IoT sistemu zasnovanom na podacima i uključiti u jednačinu (1).

7. Pet pravaca istraživanja pouzdanosti IoT-a

Pouzdanost Interneta stvari zasnovanog na podacima je oblast pogodna za istraživanje. Postoji čitav niz radova posvećenih ovoj temi. Na primer, [22] izdvaja sledećih pet ključnih karakteristika sistema za upravljanje pouzdanošću IoT-a:

1. Merenje po vertikalnoj i vremenskoj osi
   Ukoliko je IoT sistem dizajniran za upravljanje kritičnom infrastrukturom, poput sistema bezbednosti i saobraćaja, neophodno je izmeriti otpornost sistema u realnom vremenu ili približno realnom vremenu. Neophodno je obratiti posebnu pažnju na aplikacije koje upravljaju servisima za hitne slučajeve i koje zahtevaju hitar i pouzdan odgovor. Pored toga, kriterijumi za određivanje pouzdanosti svakog pojedinačnog domena se moraju definisati. Na primer, rešenja instalirana u pametnoj zgradi mogu da tolerišu nekoliko sekundi kašnjenja, dok sa druge strane, proizvodni proces može da toleriše zakašnjenje od nekoliko mikrosekundi. Iz tog razloga, istraživanje je ključno za kategorizaciju ovih potreba i izgradnju odgovarajućih rešenja za svaki vertikalni domen.
2. Svi uređaji, svi protokoli
   Veliki broj protokola se povezuje na servise Interneta stvari i koristi ih. Veliki broj istraživačkih grupa radi na dizajniranju laganijih i efikasnijih komunikacionih protokola. Svakog dana, novi IoT uređaji i hardver se pojavljuju na potrošačkom tržištu, zbog čega pouzdana rešenja moraju biti nezavisna od hardvera, softvera i komunikacionih protkola.
3. „Full-stack" svest
   Pregled literature otkrio je da, iako su neki istraživači rešili određeni problem ili grupu problema u vezi sa istraživanjem IoT-a, nijedno istraživanje se nije bavilo „end-to-end" pouzdanošću. Imajući u vidu raspon i kompleksnost IoT implementacija, to ne znači da istraživači treba da kreiraju „univerzalnu" metodu za postizanje pouzdanosti, jer bi to bilo u direktnoj suprotnosti sa prvim istraživačkim ciljem navedenim iznad. Umesto toga, potrebno je predlagati prilagođena rešenja za svaku pojedinačnu IoT vertikalu. Povećanje pouzdanosti IoT-a predstavljalo bi dragocen i inovativan rezultat istraživanja koji bi bio od ogromne koristi za krajnje korisnike IoT-a.
4. Korišćenje anomalija za dobijanje podataka o pouzdanosti
   Anomalije u IoT servisima su česta pojava. Iako je ovaj rad važan i neophodan, on ne mora nužno da poboljša pouzdanost. Anomalija ne upozorava korisnika da je IoT sistem manje pouzdan nego ranije, zbog čega je neophodno sintetisati informacije o pojavi abnormalnosti u IoT sistemima i pretvoriti ih u podatke o pouzdanosti. Na primer, ako senzor u pametnoj kući koji kontroliše parametre okruženja zakaže, to neće dovesti do situacije opasne po život. Međutim, kvar na senzorima za kontrolu temperature u fabrici može da dovede do pregrevanja i opasnih kvarova na zupčanicima.
5. Predviđanje i upravljanje kvarovima
   Ovaj rad se opširno bavi pouzdanošću. Međutim, ukoliko istraživanje ode dalje od toga, moguće je razmotriti prediktivno održavanje. Na primer, da li je moguće odrediti tačan datum održavanja pomoću merljivih parametara pouzdanosti sistema? Da li se ovo može klasifikovati kao dinamički proces zasnovan na pouzdanosti podataka u realnom vremenu umesto kao istorija pređašnjih kvarova pomoću kojih ćemo predvideti buduće? Rešavanje

ovog istraživačkog izazova predstavljalo bi suštinsku prekretnicu u istraživanju pouzdanosti IoT-a.

8. Zaključak

Tradicionalne kompanije koje nisu prisutne na internetu mogle bi da se transformišu u digitalne kompanije zahvaljujući novim industrijama i tehnologijama, poput računarstva u oblaku, veštačke inteligencije i Interneta stvari. Međutim, ovo zahteva reviziju modela poslovanja, ali je i neophodno za kompanije koje žele da opstanu na sve kompetitivnijem tržištu. Elementi Interneta stvari i procena pouzdanosti sistema zahtevaju znanje iz različitih tehničkih i netehničkih oblasti, kao i timski rad.

Internet stvari zasnovan na podacima je višedimenzionalni sistem koji uključuje hardver, softver, ljudski faktor i podatke. Neophodno je razmotriti pouzdanost svakog od ovih podsistema, što je otežano nedostatkom adekvatne teorije i prakse za neke od njih. Otpornost veštačke inteligencije kao potencijalnog podsistema mora biti testirana.

Pouzdanost nije uvek glavni prioritet kada se govori o Internetu stvari zasnovanom na podacima. Međutim, znanje o tome šta treba da tražimo i kako donošenje odluka pomoću nepotpunih ili neispravnih podataka može dovesti do niza negativnih posledica može nam pomoći u slučaju kvara.

Došlo je do dramatične promene u načinu na koji komuniciramo i koristimo tehnologiju zahvaljujući Internetu stvari. Jeftini uređaji mogu da se međusobno povežu na fleksibilniji i pouzdaniji način nego ranije, a ta karakteristika se danas koristi u kritičnim aplikacijama poput saobraćajne infrastrukture, zdravstva i bezbednosti u domu. Mogućnost merenja pouzdanosti ovih IoT uređaja pomoću ograničenih resursa jedna je od njihovih vitalnih funkcija. Nakon detaljne analize trenutnog stanja u merenju pouzdanosti IoT-a, ovo istraživanje se bavi različitim problemima u vezi sa tim poduhvatom. Ključni pravci u istraživanju pouzdanosti IoT-a utvrđeni su nakon detaljnog ispitivanja i analize.

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Problems of Reliability Assessment in Data-Driven Internet of Things

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Abstract: There has been an increase in interest in the Internet of Things (IoT) research endeavour. New concepts were discovered or existing ones were improved or fixed due to many novel research studies and IoT technologies in various sectors. There was also a focus on IoT security and standards for the Internet of Things. IoT applications that serve other industries, such as smart-living, industry 4.0, and e-health, are still relevant today. This paper aims to demonstrate that the Internet of Things (IoT) must be considered reliable, especially if it is data-driven IoT. Reliability of data-driven IoT is a complicated issue to solve because it involves hardware, software, people, and data, and today artificial intelligence. It is possible to calculate the reliability of an IoT system using a simple equation proposed in this paper. But the main problem is how to calculate the reliability of subsystems in this equation. Additionally, reliability is linked to availability and maintenance. The author of this paper primarily relies on two of his recent publications for the bulk of this paper's content.

Keywords: reliability, availability, maintainability, Internet of Things, data-driven, data

1. Introduction

The Internet of Things (IoT) was first introduced at the end of the twentieth century, and reliability theories and practices began to emerge in the 1950s. However, the Internet of Things (IoT) is a very complex and interdependent system, and as a result, new demands are placed on reliability research and education.

In the Internet of Things, all devices are interconnected and can communicate with each other often without the intervention of a human being. Since the Internet of Things relies on people, hardware, and software, it must have high reliability. A discussion of these relationships is warranted.

A data-driven IoT system is more complex since data are an important, integral part of this system. As a result, the reliability of data must be considered. In [1], the traditional reliability assessment method is used to examine the issue of IoT availability and reliability. This paper will focus on the reliability of data-driven IoT.

2. The Internet of Things

Human society will be transformed by the Internet of Things, thus becoming more innovative, more accessible and efficient with potentially enormous economic and environmental advantages. However, one of the most pressing issues is reliability, which must be addressed for this revolutionary transformation to occur [2].

There is much hype around the Internet of Things. Electronic components are getting smaller and more expensive, and wireless communications are becoming more commonplace. These three factors are driving the Internet of Things.

Applications such as electronic health care, home automation, and environmental sensors will be transformed by the IoT. Even the economy is a part of this discussion. Recent advances in Internet connectivity and intelligent personal computers have made the Internet Things and its applications and supporting hardware platforms a hot topic among academic and professional communities. It is possible to deploy IoT systems in many different scenarios, from personal wearables to city-wide infrastructures [3,1].

The Internet of Things is undeniably complex. IoT systems include hardware and software as well as humans at times [1]. Because IoT relies on more than just hardware, software, and humans, its reliability is affected by all three factors. Availability and maintainability are also linked to reliability. Defining reliability, availability and maintainability is the first step in this discussion.

3. Reliability, availability, and maintainability

As recently as the 1950s, the field of reliability theory and practice began to emerge. If an item is expected to meet a certain standard of performance and deliver the desired results within a specific time frame, it is considered reliable.

Component reliability and system upkeep are two factors determining a computer system's availability. However, availability is defined and calculated in various ways by different people.

For example, immediate availability can be defined as the probability that a system (or a component) will be operational at a given time (also known as availability).

Reliability and availability are equal for an unrepaired component or system, but availability is more significant than reliability for a repaired component or system [4].

Both reliability and availability are linked to maintainability. Therefore, to keep the IoT's cost as low as possible, the design phase of the IoT must include consideration for maintainability.

Being maintainable means that an intelligent system can be easily uncoupled, fixed, and modified without affecting the system's normal operations or functions in any significant way. To ensure the IoT system can be easily repaired or replaced in case of a malfunction, look for easily replaceable components. A highly maintainable IoT system can only be described as one that can effectively and efficiently complete maintenance tasks [5,1].

Information on how to calculate a system's or component's availability can be found in [4].

IoT device replacements, for example, can reduce availability if the IoT system is supposed to function while the battery is being replaced. As a result, data-driven IoT systems will be scrutinised in greater detail now, focusing on the system's dependability across hardware, software, people, and data.

4. The Internet of Things is a data-driven system

The term "data-driven" refers to all the decisions and processes based on the available information. This is most apparent when it comes to big data [6]. It has ties to data science, data mining, and other related fields. Many fields, including the Internet of Things, use the term "data-driven" to describe their work.

In order to be a data-driven organisation, you must first collect and analyse data. As a result, some form of communication must be employed. We use various devices, networks, software, and the Internet of Things to achieve this, but any of these can fail. We want to keep things working and fix them when they go wrong, and that is the job of reliability. While discussing reliability, we will briefly explain the Internet of Things.

The heterogeneity of an end-to-end IoT system presents reliability challenges. Much attention must be paid to the interface between subsystems to ensure compatibility, and it can also influence reliability. The IoT's most critical component is the physical system, which might lead to unanticipated system failures. Engineers and mathematicians have spent a long time analysing these systems as part of hardware reliability to lower accident rates and preserve human life [7].

5. Elements of a data-driven IoT system

Erroneous reports of data monitoring, long delays, and even data loss can diminish people's interest in IoT communication and their trust in data. The Internet of Things requires a high level of reliability to keep up with its rapid growth [8].

As a result, an IoT-based system's reliability depends on the IoT components (elements) and data that make up the system.

5.1. Reliability of IoT hardware

MIL-HDBK-217 has been used to determine the reliability of electronic devices since the sixties of last century. The first version of this product (version A) was developed in 1961. Despite its shortcomings, more than 80% of engineers still use MIL-HDBK-217 to determine reliability. In addition, of course, the industrial and commercial sectors have their standards for calculating reliability. However, MIL-HDBK-217 has been replaced by RIAC's 217PlusTM methodology and a software tool, and it is no longer available for free use. In addition, this new MIL-HDBK-217 is significantly more difficult to comprehend than the previous one [9].

In spite of having MIL-HDBK-217, determining the reliability of hardware is a difficult task. Because there is no standard method for creating hardware reliability predictions, the results can vary widely in terms of methodological rigour, data quality, and the extent to which analysis and uncertainty are taken into account [10]. Furthermore, not all prediction processes are documented. IEEE Std.1413 was established in 2009 as a response (Standard Framework for Hardware Reliability Prediction). The Internet of Things comprises a wide range of hardware components of varying quality and dependability. To accurately calculate the reliability of commercial hardware, there is often no established reliability and no data on the failure rate, the mean time to failure (MTTF), or the mean time between failures (MTBF).

5.2. Reliability of IoT software

An important criterion to consider is the quality of the software as a finished product. There are numerous models for assessing software reliability, but none are universally accepted [11,9]. For the most part, it is difficult to define the requirements for software reliability. This is especially the case in the Internet of Things. Because software is fundamentally different from hardware, the problem is made worse. Even though software reliability is probabilistic, it is not a time-dependent function. It is also true that there are not any standard practices for predicting software reliability. Reliability and software experts must ensure that software is included in a system's reliability case.

There is a real problem with reliable software when a critical feature fails. "Failing safe" is often misunderstood to mean "never failing." Software safety and reliability go hand in hand because they aim to create secure and dependable software. Engineers who specialize in both software and reliability must collaborate once more. Despite this, few educational institutions or industry professionals devote adequate time to teaching the fundamentals of software reliability and safety [4].

It is challenging to improve reliability by using redundant software because the error is present in every copy [4].

5.3. Reliability of humans in IoT

As we stated in the introduction, a human can participate in the IoT system. As a result, the Internet of Things is susceptible to human error.

A person's dependability can be improved by preventing accidents and minimising damage. In addition to working with hardware and software, these issues can arise solely with stored data. People's actions impact the technological systems in which they live. There are many instances where a series of decisions or actions taken by one or more individuals while using, maintaining or repairing a technological system results in disasters and major system failures. Reliability engineers

can significantly impact the outcome if they work with others, such as risk managers, environmentalists, and life safety engineers. The consequences of human error in handling data can be pretty severe. Human reliability can be approached in various ways and with a variety of models [9]. Procedures, rules, codes, standards, and laws cannot prevent all system failures, but they can be made less likely in the author's opinion.

When it comes to the author of this paper, reliability has always been an important consideration, taking humans into account as well, and as a result, it is included in all of his textbooks.

5.4. Reliability of data in the IoT or data trustworthiness

It is essential that data is reliable, which means that it is complete and accurate to build trust in it. Therefore, to maintain data security, data quality, and regulatory compliance, the primary goal of data integrity initiatives is to ensure data reliability [12].

To make sound decisions, business leaders need accurate information. As a result, in data-driven organisations, data reliability is essential. However, data validity and reliability are not the same thing. A dataset's trustworthiness is based on the dataset's validity, completeness, and uniqueness. Data can be missing, incomplete, or corrupted due to the unreliability of the Internet of Things.

Unfortunately, there is no adequate theory and practice on how to assess reliability of data.

5.5. Reliability of artificial intelligence in IoT

The data-driven Internet of Things is no exception to the trend of using artificial intelligence (AI). Machine learning (ML) and AI are changing many aspects of the economy, education, and people's lives. A vital area for detecting cyber-attacks on the Internet of Things, ML is becoming increasingly significant. ML can also detect sophisticated assaults using knowledge-based strategies. However, the lack of publicly accessible and regularly updated data sets is the most severe issue with IoT security [13].

AI has evolved from ML through deep learning to practical AI. AI allows a machine to learn from experience, adapt to new inputs, and perform specific jobs without human involvement. Face recognition, speech recognition, and chess game triumph are all feasible. It is currently seeing the most use due to the recent surge in IoT data, fast internet, and high-performance computers. Statistical and computational techniques are currently used in AI research [14].

AI detects patterns and abnormalities in data from intelligent sensors and devices without being told where to look. In addition, ML algorithms "learn" to give increasingly accurate results over time. As a result, ML outperforms traditional business intelligence tools in speed and accuracy. Deep learning, computer vision, natural language processing, and ML in time-tested prediction or optimization are AI technologies that complement the Internet of Things [15].

It is possible that even artificial intelligence (AI) can go disastrously wrong. Artificial intelligence has the potential to fail in the same way that human reasoning has if it attempts to replace machine intelligence with human intelligence. Then why do people make erroneous conclusions (decisions) in their reasoning? Is there a way to raise the issue of AI's reliability or how to avoid AI failures?

Considering the importance of this issue, ISO/IEC decided to look into it. AI systems' so-called trustworthiness is surveyed in [16], including the following: AI systems trustworthiness can be established through transparency, (1) controllability and other means; (2) engineering pitfalls and associated threats and risks to AI systems, along with possible mitigation techniques and methods; and (3) a method for achieving availability, resiliency, reliability, accuracy, safety, security, and privacy of AI systems. Many characteristics make something trustworthy, including reliability, availability, resilience, security, privacy, safety, accountability, integrity, authenticity, quality, and usability. These attributes are all included in this definition of trustworthiness. Like any other product, AI needs to be maintained to continue to be valuable and robust.

One factor in determining IoT reliability is the rate of hardware and software failure. In addition, protocols, energy efficiency (green), standardisation, and other influences, such as security, are also necessary. For example, regarding the protocols, a reliable protocol lets the sender know whether or not data was successfully delivered to the intended recipients in computer networking [17].

The type of user determines the reliability of a product it is being used by. The reliability and availability of a service can vary widely depending on who uses it. This means that IoT system design approaches can vary depending on the type of user. The Internet of Things is also data-driven.

According to Google services' function and market position, their availability targets are typically set. However, several factors need to be considered [18]. If the question is what customers can reasonably expect from the company in terms of customer service, then the answer must be:

Do the customers' purchases of this service directly translate into revenue for the company; this service is for-profit; if there are competitors on the market, what is their level of service; does this service cater to individuals or companies, and the reliability of data-driven IoT systems is number five.

6. Reliability of the IoT system

A data-driven IoT system is more complicated than an IoT system, which includes hardware, software and sometimes humans and artificial intelligence, which can be seen as subsystems of an IoT system, so we recommend changing the equation in [1,19]

$$R_S(t) = R_{HW}(t) R_{SF}(t) R_H(t) R_D R_{AI} \tag{1}$$

where R_W, R_S, R_H, R_D and R_A stand for reliability of hardware, software, human, data, and the artificial intelligence subsystems, respectively.

The above-mentioned formula looks simple, but it is valid only if failures of hardware, software, human, and data subsystems are mutually exclusive. In the reliability block diagram, this represents the series model. Calculation of reliability of these subsystems is another problem which depends on the type of subsystem.

In the aforementioned equation, reliability means probability. If we can consider that a subsystem is reliable, we can put in the formula that probability for that subsystem is 1.

As we mentioned before, there is theory and practice of calculating reliability of hardware and software, and it is not simple, especially if hardware comprises many components (elements). Calculating reliability of software is another problem, and there is no adequate theory and practice on how to calculate reliability of human, data, and AI.

There is no easy way to analyse the reliability of the Internet of Things because of its apparent complexity. Because of the IoT's complexity, we recommend testing its reliability through simulation. Pokorni and Janković [20] and Pokorni et al. [21] conducted simulations of complex systems and found that the results were insightful. As with other subsystems, artificial intelligence can be treated as a subsystem in an IoT data-driven system and included in equation (1).

7. Five IoT reliability research directions

Reliability of data-driven Internet of Things is obviously an open area for research. There are a number of papers dealing with it. For example, [22] points out five critical features for an IoT dependability management system as follows:

1. Measurement in the vertical and time
   If the IoT is to manage critical infrastructure like security and traffic systems, we need to be able to assess the system's resilience in real time or near real time. We must pay special attention to apps that operate emergency services and demand swift and dependable responses. Moreover, each domain's reliability criteria must be defined. For example, a smart-building solution may tolerate a few seconds of delay. On the other hand, a manufacturing process can likely only tolerate microsecond delays. As a result, conducting research is essential so as to categorise these needs and build appropriate solutions for each vertical domain.
2. All devices, all protocols
   A wide range of protocols and devices connect to and use IoT services. Many research groups are working to build more lightweight and efficient communication protocols. Every day, new IoT gadgets and hardware hit the consumer market. So a reliable solution must be independent of hardware, software, and communication protocols.
3. Full-stack awareness
   The literature review concluded that, while many researchers have solved a specific problem or group of problems in IoT reliability research, no study has addressed end-to-end reliability. In light of the scope and complexity of emerging IoT deployments, that does not mean researchers should try to create a one-size-fits-all reliability method, as that would go against the first research objective stated above. Instead, they should propose dependability solutions custom-made for each IoT vertical. Making the IoT more reliable would be an essential and innovative research finding that might tremendously benefit IoT end users.
4. Using anomalies to get dependability data
   Anomalies in IoT services have been detected and reported extensively. While this kind of work is valuable and required, it does not necessarily improve reliability. An anomaly does not warn the user if the IoT system is less trustworthy. So we need to explore ways to synthesise information about emerging abnormalities in IoT systems into knowledge about dependability. For example, if a sensor in an intelligent house is monitoring assisted living malfunctions, there may not be a life-threatening situation. In a smart factory, faulty heat sensors can cause the dangerous gear to malfunction.
5. Anticipate and manage failure
   This feature discusses measuring reliability extensively. However, predictive maintenance can be considered as an option if the research goes beyond this. For example, can we derive an exact maintenance date from a system's quantifiable reliability? Furthermore, is it possible to classify this as a dynamic process based on real-time dependability data rather than a history of past failures to predict future failures? Solving this research challenge would be an essential milestone in IoT reliability research.

8. Conclusions

Traditional offline businesses will be able to turn into digital businesses owing to new industries and technology like cloud computing, artificial intelligence, and the Internet of Things. This necessitated an overhaul of business models. This will become vital for companies that wish to survive the increasingly intense market rivalry. However, the Internet of Things elements and system's reliability assessment and analysis all require knowledge from various technical and non-technical areas, so teamwork must be provided.

Data-driven Internet of Things is a multifaceted system that includes hardware, software, humans, and data. The reliability of each of these subsystems should be considered, and for some of them there is no adequate theory and practice. As a possible subsystem, artificial intelligence must be tested for resiliency.

Reliability is not always a top priority when it comes to data-driven Internet of Things. However, knowing what to look for and how a series of failure consequences can occur during decision making because of incomplete or corrupted data can help in the event of a failure.

There has been a dramatic shift in how we interact with technology in the modern world due to the Internet

of Things. Low-cost devices can connect flexibly and widely thanks to the notion of the Internet of Things, which is employed in crucial applications, such as traffic infrastructure, health care, and home security. Being able to quantify the reliability of these IoT devices because of their limited resources is a vital function. Following an in-depth analysis of the current state of the art in dependability quantification in the IoT, this study looks at the many problems connected with this undertaking. Key research directions for IoT reliability have been identified following an in-depth examination.

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Primena veštačke inteligencije i mašinskog učenja u visokom obrazovanju, dostupne platforme i ispitivanje svesti učenika

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Apstrakt: (I) Pristup studenata veštačkoj inteligenciji (AI), platformama za mašinsko učenje (MU) i moćnim računarima moguć je samo ako obrazovne institucije ove alate učine dostupnim. Studenti koji nemaju direktan pristup ovim tehnologijama ipak mogu da ih koriste zahvaljujući računarskim laboratorijama ili studijima na fakultetu. (M) Ovaj rad, zasnovan na metodi anketiranja, bavi se istraživačkim problemom studenata koji nisu upoznati sa veštačkom inteligencijom ili tehnologijom mašinskog učenja, ili koji poseduju samo elementarno znanje o njima, zbog čega im je teško da usvoje sisteme zasnovane na veštačkoj inteligenciji. Stoga, ovaj istraživački rad proučava svest i znanje o AI i MU tehnologiji među studentima odabranih visokoškolskih institucija (VŠI). (R) Zahvaljujući eksplorativnom istraživanju, došli smo do saznanja koja nam pružaju uvid u visoko obrazovanje u Republici Srbiji, kao i u način razmišljanja srpskih studenata. (D) Rezultati pokazuju da su studenti posmatranih VŠI svesni postojanja ovih tehnologija i da ih svakodnevno koriste, što ukazuje da će se lako prilagoditi sistemima zasnovanim na veštačkoj inteligenciji, koji su trenutno u fazi razvoja.

Ključne reči: veštačka inteligencija (AI), mašinsko učenje (MU), visokoškolske institucije (VŠI), sistemi zasnovani na veštačkoj inteligenciji

1. Uvod

Proučavajući veštačku inteligenciju, Organizacija za ekonomsku saradnju i razvoj (OECD) definisala je AI kao mašinski sistem sposoban da daje predviđanja, preporuke ili da utiče na okruženje pomoću datih ciljeva koje definiše čovek. Kao i svaki sistem, sistemi veštačke inteligencije poseduju različite nivoe autonomije, u zavisnosti od dizajna. Prikupljanje i obrada podataka, razvoj i tumačenje modela, kao i verifikacija i validacija, čine faze životnog ciklusa AI sistema [1].

AI i MU dizajnirani su da primaju informacije iz automatizovanih senzora i mašina, ali sami odlučuju gde da traže određene informacije. Algoritmi u sistemima mašinskog učenja koriste samorazvijajuće algoritme, što im omogućava da sa vremenom dobijaju tačnije rezultate. MU sistemi su brži i bolji od tradicionalnih alata poslovne inteligencije, jer nude tačnija i brža operativna predviđanja. Veštačka inteligencija je sastavni element interneta stvari zbog tehnologija poput dubokog učenja, računarskog vida, obrade prirodnog jezika i mašinskog učenja. Može da se koristi kako za predviđanje, tako i za optimizaciju [2].

Novi tehnocentrični obrazovni modeli u značajnoj meri pomažu studentima da razumeju sopstvene kognitivne sposobnosti neophodne za održavanje različitih nivoa znanja. Veštačka inteligencija najefikasnije olakšava personalizaciju i prihvatanje novih tehnoloških izazova [3]. Budući da se obrazovanje oslanja na široki spektar tehnologija, ni personalizovano obrazovanje nije izuzetak. Veštačka inteligencija, mobilne aplikacije, virtuelna stvarnost i druge tehnologije analizirane su u različitim istraživanjima i otkriveno je da u značajnoj meri mogu da poboljšaju obrazovni sistem [4] [5]. Veštačka inteligencija je proces koji studente osnažuje da savladaju računarske programe koji im omogućavaju da dizajniraju konkretne projekte i izvršavaju zadatke koji zavise od ljudske pomoći. Često se koriste kao pomoć studentima, jer im pribavljaju neophodne informacije kad god je potrebno [6].

MU je oblik AI-ja koji omogućava učenje pomoću kompjutera. Usredsređeno je na analizu podataka, pomoću koje se identifikuju novi modeli koji omogućavaju određenu modifikaciju ponašanja [7]. Interakcija između učesnika i obrada informacija su ključne u obrazovnom procesu. Metode mašinskog učenja grade savršenu osnovu za modelovanje, predviđanje i upravljanje sistemom uopšte [8].

Vilijamson [9] je otkrio rešenja za psihološka stanja i moždanu aktivnost primenom analitike velikih podataka. Tsai i saradnici su kreirali bazu podataka mogućih pokazatelja učenja na osnovu AI-ja i MU-a kako bi utvrdili šta je to što motiviše studente tokom procesa učenja [10]. Tim visokostručnih istraživača razvio je posebnu aplikaciju koja je revolucionisala oblast medicinskog obrazovanja [11].

Dve najvažnije studije o uvođenju AI-ja i MU-a u obrazovni sistem su:

- Institucije spremne za budućnost: Analiza usvajanja AI-ja i sposobnosti u vezi sa veštačkom inteligencijom u sektoru američkog visokog obrazovanja (sproveo IDC – International Data Corporation, naručilac: Majkrosoft) [12];
- HolonIQ Global Executive Panel [13].

IDC u svom istraživanju tvrdi da najznačajnija ograničenja u vezi sa primenom AI-ja jesu finansijske prirode, budući da uspešna primena ove tehnologije može da bude vrlo skupa, zatim nedovoljno razvijene kompetencije unutar kompanije koje bi omogućile razvoj adekvatnog rešenja, nemogućnost njihovog privlačenja, ali i činjenica da data strategija

nije prioritetna [12].

Drugo istraživanje u kome su učestvovali direktori EdTech kompanija navodi da je glavna prepreka u primeni veštačke inteligencije u obrazovanju zapravo nedostatak adekvatnih resursa koji bi mogli da proizvedu takvo rešenje (39%); sledi nedostatak finansijskih sredstava za AI inicijative (34%), i manjak podataka (30%), pri čemu u manjak podataka takođe spadaju fragmentirani sistemi iz kojih se podaci prikupljaju, odnosno problemi u vezi sa politikom privatnosti. Autori ovog istraživanja zaključuju da vizija i primena veštačke inteligencije prevazilaze funkcionalne granice i generišu visoke troškove implementacije, zbog čega nije iznenađujuće što menadžment kompanije i nedostatak tehničke infrastrukture predstavljaju dodatne prepreke, koje se moraju uzeti u razmatranje [13].

Najistaknutiji trendovi u obrazovanju podrazumevaju poboljšan pristup obrazovanju, koji je dodatno olakšan primenom sistema učenja na daljinu i novih tehnologija. Uticaj ovih tehnoloških promena najbolje se može videti u povećanoj primeni veštačke inteligencije i mašinskog učenja u visokom obrazovanju. Takođe, primetni su viši nivo individualizacije u pristupu studentima i uzimanje u obzir njihovh pojedinačnih potreba, znanja i veština. Nemogućnost pronalaženja dovoljnog broja nastavnika ubrzala je primenu softvera koji zamenjuje nastavnike, kako u državnim tako i u privatnim visokoškolskim institucijama. Rast obrazovne industrije, koji traje već neko vreme, od obrazovnih institucija i EdTech kompanija zahteva uvođenje inovacija kako bi mogle da održe korak.

AI i MU mogu da reše mnoge probleme visokoškolskih institucija, koji uključuju upis i finansiranje, visoke cene školarina, nedovoljan broj nastavnika, uz što objektivniju procenu učeničkog znanja [14]. U radu su predstavljene najbolje platforme zasnovane na veštačkoj inteligenciji, uz analizu karakteristika i problema u vezi sa njihovom potencijalnom primenom u visokoškolskim institucijama i EdTech kompanijama. Pored toga, eksplorativno istraživanje pruža dragocen uvid u znanje i primenu AI-ja i MU-a u posmatranim visokoškolskim institucijama.

2. Materijali i metode

U istraživanju je korišćena metodologija koja uključuje posmatranje, participativno posmatranje, analizu dokumenata i sadržaja, i anketu. Istraživanje je sprovedeno na uzorku studenata master strukovnih studija, uz saglasnost ispitanika. Autori rada su angažovani kao gostujući predavači, zbog čega je istraživanje sprovedeno u njihovoj grupi. Jedan od autora je student master strukovnih studija, pa otud participativno posmatranje. U okviru analize dokumenata, konsultovani su različiti istraživački radovi, naučni radovi i EduTech portali kako bi se došlo do dostupnih aplikacija zasnovanih na AI-ju i tehnologija koje omogućavaju AI i MU. Deo istraživanja predstavljen je u uvodnom pasusu (Pregled literature), dok Poglavlje III (Rezultati) prikazuje analizu sadržaja i dokumenata.

Anketa (tj. eksplorativno istraživanje) sprovedeno je na uzorku od 83 studenta Visoke škole strukovnih studija za informacione tehnologije – ITS u Beogradu kako bi se razumeo nivo svesti i znanje ispitanika o veštačkoj inteligenciji i mašinskom učenju. Anketa je dizajnirana pomoću modela Dhawan, Shivangi and Batra [15]. Ispitanicima su postavljana pitanja u kojima se tražilo da ocene sopstveno poznavanje pomenutih tehnologija (prepoznavanjem osnovne definicije), kao i svakodnevnu upotrebu ovih tehnologija.

Primarno istraživanje započelo je od pretpostavki u obliku hipoteza:

- H0 (nulta hipoteza): Upotreba veštačke inteligencije u svakodnevnom životu ne zavisi od starosti ispitanika.
- H1 (alternativa): Upotreba veštačke inteligencije u svakodnevnom životu zavisi od starosti ispitanika.

Promenljive korišćene u istraživanju prikazane su u tabeli 1. Tabela 1 objašnjava kodove i imena analiziranih promenljivih.

Tabela 1. Analizirane promenljive

Kod	Ime promenljive
Pol	Pol
Starost	Starost
Obrazovanje	Završeno
Aktivnost	Vrsta aktivnosti
Upotreba AI-ja	Upotreba AI-ja u svakodnevnom životu
Definicija AI-ja	AI predstavlja teoriju i razvoj računarskih sistema sposobnih da obavljaju zadatke koji obično zahtevaju ljudsku inteligenciju, kao što su vizuelna percepcija, prepoznavanje govora, donošenje odluka i prevođenje sa jednog jezika na drugi.

3. Rezultati

3.1. Najbolje platforme zasnovane na AI-ju i tehnologije koje ih omogućavaju, analiza dokumenata i sadržaja

Najpopularnije strategije za pozicioniranje koje kompanije koriste u vezi sa primenom veštačke inteligencije i mašinskog učenja u visokoškolskim institucijama i EdTech kompanijama jesu personalizacija i prilagođavanje, analitika i izveštavanje o učinku, virtuelni učitelj (Virtual tutor), podrška učenju (zasnovana na četbotovima) i igrifikacija (gejmifikacija). Adaptivno (prilagođeno) učenje je omogućeno zahvaljujući rešenjima poput Century Tech [17] platforme, koja polazi od pretpostavke da će svaki učenik u procesu učenja pre ili kasnije naići na prepreku koja će ga usporiti i uticati na kvalitet stečenog znanja, a nastavnik je taj koji treba da identifikuje te prepreke i da ih ukloni. Međutim, praćenje svakog pojedinačnog učenika, analiziranje individualnih rezultata i kreiranje materijala u skladu sa potrebama

svakog učenika oduzima previše vremena i gotovo je nemoguće. Zbog toga je stvorena Century platforma, uz pomoć tima edukatora iz kompanije Century Tech, koja edukatorima omogućava da preduzmu „pametne intervencije" kod svakog učenika na osnovu podataka o znanju i potrebama svakog učenika koje platforma prikuplja. Platforma kombinuje veštačku inteligenciju, nauku o učenju i neuronauku. Pored toga, da bi učenicima pomogla da razviju sopstvene veštine i zadrže znanje tokom čitavog života, Century platforma koristi princip učenja kao što je preplitanje. Učenici uče nekoliko predmeta u isto vreme, umesto da uče samo jedan. To stimuliše mozak da povezuje različite teme i uspostavlja veze između njih, što poboljšava dugoročno pamćenje.

Odličan primer sistema zasnovanog na AI-ju jeste platforma Knewton ALTA [18]. Ova kompanija je konstruisala ALTA platformu kako bi učenici mogli da pohađaju predavanja. Poput drugih platformi zasnovanih na principu adaptivnog učenja, i ova platforma uči od učenika i prepoznaje praznine u njihovom znanju. ALTA platforma edukatorima omogućava da organizuju kurseve, vežbe i kvizove koje učenici rešavaju, pružajući uvid u njihov učinak „u realnom vremenu". Na primer, pretpostavimo da učenik ima poteškoća sa nastavnim materijalom ili određenom vežbom. Platforma to prepoznaje i nudi „pravovremenu intervenciju" – povratnu informaciju, pomoć ili vraćanje na već pređeni materijal, što će učeniku pomoći da reši zadatak. Glavna prednost ove platforme jeste „pravovremena intervencija" za učenike i „vidljivost u realnom vremenu" za nastavnike. To je platforma koja pokušava da zadrži učenika u procesu učenja kroz neposrednu pomoć u slučajevima kada učenik ima poteškoća da savlada određeni zadatak. Zbog toga je broj učenika koji odustanu od kursa mnogo manji od broja onih koji ga uspešno završe. Nastavnik ima jasan uvid u učinak svojih učenika, ali i podršku u kreiranju novih kurseva ili vežbi.

Automatizacija obrazovanja je moguća pomoću Majkrosoftovog paketa. Međutim, nemogućnost edukatora da se u dovoljnoj meri posvete svakom pojedinačnom učeniku u grupi (odeljenju) uzrokuje osrednji učinak i postojanje velikog broja učenika koji napuštaju školovanje/kurseve. Osnovni element automatizacije jeste QBot. Kada učenik postavi pitanje, QBotovi koriste oznake (tagove) lekcije na koju se pitanje odnosi i nastavnika od kojih se očekuje odgovor. Nakon određenog perioda u kome su samo nastavnici odgovarali na pitanja, četbot prepoznaje segmente odgovora na postavljena pitanja i predlaže moguće odgovore. Ukoliko četbot ne uspe da pronađe odgovarajući odgovor u svojoj bazi, on prosleđuje pitanje nastavniku. Istovremeno, pored davanja odgovora na pitanja, četbot takođe uzima u obzir rasprave u kojima se razgovaralo o sličnim temama.

Kada se govori o igrifikaciji, aplikacija Memrise je dobar primer [19]. Ova aplikacija koristi tehnologiju igrifikacije da učenje jezika učini zanimljivijim za učenike/korisnike. U ovom slučaju, korisnik je astronaut koji kreće na dug put učenja jezika. On ima različite kartice sa rečima i načinima da ih zapamti, ali može i da uperi kameru svog telefona ka nekom stvarnom predmetu, i telefon će ispisati tu reč na ekranu i izgovoriti je na jeziku koji astronaut uči. Učenik sakuplja poene, i što je broj poena veći, to će njegov „ljubimac vanzemaljac" više porasti. Pored svega ovoga, aplikacija mu pruža stalan uvid u sopstveni napredak i puna je šarenila i zabavnih načina za pamćenje reči. Njena svrha jeste da reši problem učenja reči i izraza sa kojima se učenici sreću na standardnim kursevima i u udžbenicima. Aplikacija pruža različite načine za učenje i pamćenje reči.

Još jedna odlična aplikacija zasnovana na AI-ju jeste Sololearn [20], koja koristi tehnologiju igrifikacije za kreiranje kurseva programiranja. Kao i svaka obrazovna platforma, Sololearn sadrži lekcije i nastavni materijal za učenje gotovo svih programskih jezika. Ova platforma nudi Code Playground (igralište za kodiranje), gde igrači mogu međusobno da se takmiče u izazovima u vezi sa kodiranjem, a pobednik zarađuje XP (iskustvene) poene. Moguće je i praćenje kurseva na mobilnim telefonima, računarima i tabletima. Platforma Sololearn koristi napredovanje, EXP (iskustvene poene) i tabele najboljih igrača da podstakne igrače da nastave sa učenjem kodiranja. Platforma istovremeno rešava problem velikog interesovanja za kodiranje i nedostatka kurseva koji su dovoljno izazovni za polaznike. Učeći programske jezike, učenici postepeno savladavaju osnove, a aplikacija im pruža dovoljno izazovan materijal i zadatke. Platforma nudi veliki broj izazova i priliku da se takmiče sa drugim polaznicima. Sololearn se neprestano vraća nastavnom materijalu i pitanjima koje učenik nije u potpunosti savladao.

Primena veštačke inteligencije uvek zavisi od postojanja odgovarajućeg skupa podataka. Ukoliko kritični podaci ne postoje ili nisu dovoljno „čisti", primena AI-ja neće biti uspešna. Kod primene veštačke inteligencije, računarski program sastavljen od algoritama izvodi zaključke na osnovu skupova podataka. Bez podataka, algoritamski skup nije u stanju da prepozna trendove, i zbog toga nema dobru osnovu za donošenje odluka. Moguće je savršeno postaviti jednačine, ali AI neće dobro protumačiti niti predvideti informaciju bez jednako dobrog skupa podataka. Takođe, da bi predviđanja bila dobra, neophodno je da podaci budu čisti.

U istraživanju kompanije HolonIQ ispitanici su zamoljeni da razmisle o tome koje su tehnologije ostvarile najveći uticaj. Većina je odgovorila da su algoritmi ti koji su ostvarili najveći uticaj, a potom obrada prirodnih jezika / lingvistika. „Sledeće su glasovne AI aplikacije, čiji je uticaj rasprostranjeniji, a srednja vrednost uticaja iznosi 7, što je stavlja na istu poziciju sa hardverskim AI-jem i vizuelnim AI-jem. Hardverski AI ima stroži skup pogleda od vizuelnog AI-ja, koji više naginje ka nižem uticaju/potencijalu od srodnih tehnologija" [13]. Programski jezici koji se često koriste za implementaciju AI i MU rešenja su Python, Java, R, MATLAB, Lisp i Haskell.

3.2. Rezultati ankete

Glavni rezultati ankete prikazani su u tabeli 2. Većina ispitanika su žene (53,01%), dok 46,99% čine muškarci. Ispitanici su starosti od 18 do 24 godine (54,22%), potom od 25 do 31 godine (26,51%), i od 32 do 40 godina (19,28%). Većina ispitanika završila je visoko obrazovanje (višu školu) – 77,11%, dok srednju školu ima njih 22,89%. Ispitanici su studenti (master strukovnih studija) – 69,88% ili bivši studenti – 30,12%. Ispitanici su upoznati sa postojanjem AI-ja – 86,75%, nisu upoznati – 9,64% ili nisu sigurni u vezi sa AI-jem – 3,61%; koriste ovu tehnologiju u svakodnevnom životu – 63,86%, ne

koriste je – 6,02%, ili je možda koriste (nisu sigurni) – 30,12%. Tabela 2 prikazuje pitanja i promenljive od značaja.

Tabela 2. Analizirana pitanja i promenljive

Varijable	N	Kod %
Odaberite pol		POL
Muško	39	46,99
Žensko	44	53,01
Ne želim da se izjasnim.	0	0,00
Koliko imate godina?		STAROST
Između 18 i 24	45	54,22
Između 25 i 31	22	26,51
Između 32 i 40	16	19,28
Odaberite samo jednu opciju u vezi sa svojim obrazovanjem (stečeni nivo obrazovanja):		OBRAZOVANJE
srednja škola	19	22,89
visoko obrazovanje	64	77,11
Odaberite jednu aktivnost:		AKTIVNOST
Ja sam student.	58	69,88
Planiram da upišem studije.	0	0,00
Ja sam bivši student.	25	30,12
Veštačka inteligencija predstavlja teoriju i razvoj računarskih sistema sposobnih da izvršavaju zadatke…		DEF AI-ja
Tačno.	72	86,75
Netačno.	3	3,61
Ne znam.	8	9,64
Da li koristite AI u svakodnevnom životu?		UPOTREBA AI-ja
Da.	53	63,86
Ne.	5	6,02
Možda. (Nisam siguran/-na.)	25	30,12

Predmet istraživanja je ispitivanje veze između upotrebe veštačke inteligencije u svakodnevnom životu i starosti ispitanika. Radi provere postojanja pomenute veze, korišćena je metoda statističkog zaključivanja, odnosno izračunavanje koeficijenta korelacije. Koeficijent korelacije predstavlja najčešće korišćenu statističku metodu koja prikazuje odnos između promenljivih. Vrednost korelacije utvrđuje se merenjem koeficijenta korelacije, koji predstavlja brojčanu vrednost koja pokazuje stepen korelacije između dve promenljive. Ovaj pokazatelj može imati vrednosti u rasponu od -1 do 1. Iako je broj opservacija u uzorku veći od 30, što bi potvrdilo hipotezu o normalnoj raspodeli promenljivih, odgovori ispitanika o veštačkoj inteligenciji su nemetrički (izmereni na ordinalnoj skali), dok su podaci o starosti rangirani po vrednosti, stoga je najrelevantniji pokazatelj moguće veze Spirmanov koeficijent korelacije. Zbog toga je Spirmanov koeficijent korelacije izračunat pomoću SPSS softvera za statističku obradu i analizu podataka. Testirane su sledeće hipoteze:

- H0: Upotreba veštačke inteligencije u svakodnevnom životu ne zavisi od starosti ispitanika.
- H1: Upotreba veštačke inteligencije u svakodnevnom životu zavisi od starosti ispitanika.

Correlations

			AGE	AIMLUSE
Spearman's rho	AGE	Correlation Coefficient	1.000	.866**
		Sig. (2-tailed)	.	.000
		N	83	83
	AIMLUSE	Correlation Coefficient	.866**	1.000
		Sig. (2-tailed)	.000	.
		N	83	83

Slika 1. Neparametarske korelacije

Na osnovu dobijenih rezultata dolazi se do statističkog zaključka da postoji visoka pozitivna, linearna korelacija između promenljivih *starost* i *upotreba veštačke inteligencije*, tj. da Spirmanov koeficijent korelacije iznosi 0,866. U kontekstu jačine korelacije, prema Koenu, korelacija je visoka zato što je vrednost koeficijenta korelacije veća od 0,5. Uzimajući u obzir značajnosti dobijenog rezultata (Značajnost 2-tailed), koeficijent korelacije je statistički značajan na nivou od 1%. Dobijena verovatnoća ne govori o jačini veze, već pre o stepenu pouzdanosti na kome dobijene rezultate treba prihvatiti.

4. Diskusija

Većina ispitanika su žene (53,01%), starosti između 18 i 24 godine, sa završenim visokim obrazovanjem (strukovne studije), i sa statusom studenta (master strukovnih studija) – 69,88%. Većina ispitanika je svesna postojanja AI-ja (86,75%) i upotrebljava ovu tehnologiju u svakodnevnom životu (63,86%). Takođe, 30,12% ispitanika je odabralo opciju „Možda. (Nisam siguran/-na.)" na pitanje da li koriste AI u svakodnevnom životu, što implicira da nisu sigurni da li koriste AI ili ne. U pomenutom istraživanju, koje se koristi kao polazna tačka [15], autori navode: „Povremeno koristimo tehnologije zasnovane na veštačkoj inteligenciji, iako ih ne svrstavamo u veštačku inteligenciju. To mogu biti potpuno svakodnevne stvari poput filtera za neželjenu elektronsku poštu ili ID skener za prepoznavanje lica na telefonu."

Na uzorku od 83 ispitana studenta i na osnovu dobijene vrednosti Spirmanovog koeficijenta korelacije, zaključeno je da korišćenje veštačke inteligencije u svakodnevnom životu zavisi od starosti ispitanika. Ovakav rezultat se objašnjava činjenicom da se sa starošću ispitanika povećava i njihov pristup tehnološkim rešenjima bez ograničenja ili nadzora, a postoje i interesovanja koja nisu postojala u određenim godinama, kao i svest o beneficijama veštačke inteligencije u svakodnevnom životu.

5. Zaključak

Obrazovanje mora biti što dostupnije u 21. veku. Pristup obrazovanju i celoživotnom učenju uključen je u najznačajnije globalne strategije, uključujući strategije UN. Nijedan sektor ekonomije nije uspeo da izbegne upravljanje podacima, zbog čega sistemi u vezi sa obrazovanjem treba da koriste analizu podataka kako bi dizajnirali nove personalizovane obrazovne programe koji mogu brzo i precizno da premoste „praznine u znanju". Pored toga, odavno se veruje da je predavanje istog gradiva velikom broju studenata nefunkcionalno. Probleme na visokoškolskim institucijama samo je dodatno pogoršao nedostatak edukatora u mnogim obrazovnim sistemima. Edukatori mogu da se informišu o sposobnostima i slabostima studenata pomoću pametnih sistema zasnovanih na veštačkoj inteligenciji i mašinskom učenju. Budući da potražnja za visokoobrazovanim radnicima nastavlja da raste, obrazovne institucije i kompanije planiraju da i u budućnosti nastave sa korišćenjem AI-ja i MU-a.

Članak se bavi istraživanjem činjenice da studenti koji nisu upoznati sa tehnologijama veštačke inteligencije (AI) i mašinskog učenja (MU) imaju poteškoća da usvoje rešenja zasnovana na AI-ju. Zbog toga istraživanje proučava njihovu svest i znanje o AI i MU tehnologijama. Eksplorativno istraživanje pruža uvid u srednjoškolsko obrazovanje u Srbiji, kao i u način razmišljanja srpskih studenata. Studenti odabranih visokoškolskih institucija su dobro upoznati sa ovim tehnologijama, što ukazuje da će se lako prilagoditi sistemima zasnovanim na veštačkoj inteligenciji, koji su trenutno u fazi razvoja.

Istraživačka tvrdnja predstavljena u uvodnom delu glasi: Studenti koji nisu upoznati sa AI i MU tehnologijom, ili koji poseduju samo elementarno znanje o njima, imaće poteškoća da prihvate sisteme zasnovane na AI-ju. Praznine u istraživanju ukazuju na nedostatak terenskih istraživanja koja bi potvrdila ovu pretpostavku. Zbog toga bi buduće studije trebalo da se usredsrede na terensko istraživanje kako bi se ukazalo na moguću vezu između svesti o AI-ju i prilagodljivosti sistemima zasnovanim na AI-ju.

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Application of Artificial Intelligence and Machine Learning in higher education, available platforms and examining students` awareness

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Abstract: (I) Student access to Artificial Intelligence (AI) and Machine Learning (ML) platforms and powerful computers is only possible if educational institutions make these tools available. Students who do not have direct access to these technologies can still access this technology through university computer labs or studios. (M) The paper based on survey method addresses the research problem that students who are not aware of artificial intelligence (AI) and machine learning (ML) technologies, or have a rudimentary understanding, find it challenging to adopt AI-powered systems. Therefore, the research paper explores the awareness of AI&ML among students of chosen Higher education institution (HEI). (R) Exploratory research provided results that gives us insight in Hight education in Republic of Serbia, and state of mind of Serbian students. (D) The results show that students of chosen HEI are aware of these technologies and use them on a daily basis, indicating that they will easily adapt to AI-powered systems currently, during the development phase.

Keywords: artificial intelligence (AI), machine learning (ML), higher education institutions (HEI), AI-powered systems

1. Introduction

In the study of artificial intelligence, OECD defined AI as a machine-based system able to make predictions, provide recommendations, or influence an environment by using given sets of human-defined objectives. As with any system, artificial intelligence systems have varying levels of autonomy, depending on their design. Data collection and processing, model building and interpretation, as well as verification and validation, comprise AI system lifecycle phases [1].

AI and ML specialise in extracting information from automated sensors and machines, all the while deciding on their own where they should be looking. ML algorithms use self-improving algorithms, providing more accurate results over time. ML works faster and better than traditional business intelligence tools, offering faster and more accurate operational predictions. Artificial intelligence is an essential supplement to the Internet of Things because of technologies like deep learning, computer vision, natural language processing, and machine learning. It can be used for prediction and optimisation [2].

New technology-based educational models contribute significantly to helping students understand their cognitive abilities in maintaining different levels of knowledge. Personalisation and acceptance of new technical challenges are best facilitated by Artificial Intelligence [3]. As education relies on a wide range of technologies, personalised education does, too. Artificial intelligence, mobile applications, virtual reality, and other technologies have been analysed by different studies, and it was found that the educational systems could be significantly improved in this way [4] [5]. Artificial intelligence is a process that empowers students with computer programs that enable them to design specific projects and perform tasks, which otherwise depend on human assistance. They are often utilised to help students and serve as their assistants by procuring information when needed [6].

ML is a form of AI that provides the ability to learn through a computer. It focuses on data analysis, through which new models are identified which allow certain conditions of behaviour modification [7]. Stakeholder interactions and information processing are vital in the education process. Machine learning methods provide a perfect foundation for modelling, prediction, and system control in general [8].

Williamson [9] discovered solutions for psychological states and brain activity in the learning process by applying big data analytics. Tsai et al, based on AI and ML, created a database of possible learning indicators to determine what motivates students in the learning process [10]. A team of highly educated researchers developed a specialised application that has revolutionised the medical education industry [11].

Two critical studies on the introduction of AI and ML technologies in education systems are:

- Future-ready institutions: Assessing US Higher Education Sector's AI Adoption and Capabilities; (implemented by IDC, commissioned by Microsoft) [12].
- HolonIQ Global Executive Panel [13].

IDC states in its research that the most significant constraints related to AI implementation are financial constraints, since successful implementation can be very costly, a lack of developed competencies within the company that could develop an adequate solution and the inability to attract them, and the fact that the given strategy is not a priority [12].

According to another study in which the CEOs of EdTech companies took part, the primary obstacle to the application of AI in education is the lack of adequate resources capable of producing such solution (39%); then comes the lack of funds for AI initiatives (34%), and lack of data (30%), where the lack of data also includes fragmented systems from which data are collected, i.e. problems related to privacy policies. The authors of this study concluded that AI's vision and use transcend functional boundaries and come with high implementation costs; it is not surprising that company management and lack of technical infrastructure are additional obstacles to consider [13].

The most noteworthy education trends involve improved access to education, which is further facilitated by implementing distance learning systems and new technologies. The impact of these technological shifts is shown by the increased use of artificial intelligence (AI) and machine learning (ML) in higher education. Also, there is a greater level of individualisation in how each student is treated, considering their knowledge, needs, and skills. Inability to find a sufficient number of teachers has necessitated the use of software to replace teachers in both public and private higher education institutions (HEI). The recent education market growth requires education institutions and EdTech companies to innovate to keep pace.

AI and ML can solve HEI's many problems involving enrolment and funding, dropout rates, high admission costs, insufficient number of educators, along with assessing the students' level of knowledge as objectively as possible [14]. The paper presents the best AI-powered platforms and analyses the features and problems they address for potential application in HEI and EdTech. Also, exploratory research provides valuable insight into the awareness and usage of AI and ML in chosen HEI.

2. Materials and Methods

The research used the methodology that includes observations, participation observation, document and content analysis and survey. The research was conducted within the master's vocational studies at a higher vocational school with the respondents' consent. The paper's authors are partly engaged as professors, and the research was conducted in their group. One of the authors is a student of master vocational studies. Therefore, it is an observation with participation. As part of the document analysis, various numerous research studies, scientific papers and EduTech web portals were consulted to conclude available AI-powered applications and technologies that enable AI & ML. This part of the research is presented in the introduction paragraph (literature review), and chapter III Results shows content and document analysis.

Survey (exploratory) research among 83 students of Information Technology School ITS – Belgrade was conducted to understand the level of awareness of AI and ML among students. The survey was designed using the model of Dhawan, Shivangi & Batra [15]. The respondents were asked questions identifying their awareness of the mentioned technologies (by recognising basic definition) and their daily usage of these technologies:

The primary research started from assumptions in the form of hypotheses:

- (null hypothesis) H0: The use of artificial intelligence in everyday life does not depend on the age of the respondents.
- (alternative) H1: The use of artificial intelligence in everyday life depends on the age of the respondents.

The variables analysed in this research are given in table 1. The table 1 explains code and names of the variable analysed.

Table 1. Variable analysed

Code	Variable name
Sex	Gender
Age	Age
Schooling	Already completed
Activity	Type of activity
AIUSE	Use AI in your daily lives
AIDEF	AI represents the theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages.

3. Results

3.1. Best AI-powered platforms and technologies that enable them, document and content analysis

The prominent positioning strategies used by companies related to the application of AI and ML in higher education institutions and EdTech companies are most often personalisation and customisation, analytics and performance reporting, Virtual Tutor and Learning Support (Based on AI chatbots), and Gamification. Adaptive learning is provided within solutions such as the Century Tech [17] platform, which starts from the assumption that every student in the learning process encounters obstacles that slow him down, affect the quality of knowledge acquisition and that the educator is the one who needs to identify these obstacles and remove them. However, monitoring each student individually, analysing individual results and creating materials according to the needs of students requires much time and is almost impossible. Therefore, the Century platform, which was created with the help of a team of educators at Century Tech, allows educators to undertake "smart interventions" with each student based on the data that this platform collects about

students' knowledge and needs. The platform combines knowledge from Artificial Intelligence, Learning Science and Neuroscience. In addition, to help students develop skills and retain knowledge for a lifetime, the Century platform uses learning principles such as interweaving. Students study multiple subjects over time, not just one. This stimulates the brain to connect different topics and establish connections between them, improving long-term memory retention.

An excellent example of an AI-powered system is the Knewton ALTA platform [18]. This company has constructed an ALTA platform through which students attend courses. Like other platforms based on the adaptive learning principle, this platform learns from the learner and identifies gaps in their knowledge. The ALTA platform enables the educator to organise courses, exercises and quizzes that students will attend and solve, and provides "real-time" insight into student performance. For example, suppose the student has problems with the material or with a particular exercise. In that case, the platform recognises this and offers "just-in-time remediation" – feedback, help, return to previous material that can help the student solve the task. The advantage of the platform is "Just-in-time remediation" for students and "Real-time visibility" for educators. It is a platform that tries to keep the student in the learning process through immediate help when they are struggling with solving the task. Therefore, the number of "dropout" students is significantly less than the number of those who complete the course. The teacher has a very transparent insight into student performance and is supported in creating new courses and exercises.

Education automation is possible using the Microsoft package. However, the inability of educators to devote themselves sufficiently to each student in the group (class) causes mediocre performance and a large number of student dropouts. An essential part of automation is QBot. When students ask questions, they use the tags of the lessons to which the questions refer, and the teachers from whom they expect to receive an answer. After an initial period in which only the teachers answered the questions, the Chatbot recognises which answer refers to and gives suggested answers. If the Chatbot cannot find an appropriate answer in its database, it forwards the question to the teacher. At the same time, in addition to answering questions, Chatbot referred to discussions in which similar topics were discussed.

Regarding gamification, a good example is the Memrise application [19]. This application uses gamified technology to make language learning enjoyable for users. The user is an astronaut embarking on a journey of language learning. He has different flip cards with words and ways to remember them and the ability to point his camera at the phone at a real object and get a written word and pronunciation in the target language. The student collects points, and with a higher number of points, his "alien pet" grows. In addition to all this, the application gives him a constant insight into his progress and is full of colours and fun ways to memorise words. Its intention is to solve the problem of learning vocabulary and phrases through standard courses and textbooks. The app provides ways to learn and memorise words.

A good AI-powered application is Sololearn [20] which uses gamified technology in creating programming courses. Like any educational platform, Sololearn contains lessons and materials on almost every programming language. The platform offers Code Playground, and players can compete head-to-head in a coding challenge, and the winner earns XP. Course tracking is also available for mobile phones, computers and tablets. Sololearn utilises progression, EXP, and leader boards to encourage players to continue learning to code. The platform solves the problem of great interest in learning coding and the lack of courses that are difficult to follow. In learning a programming language, students progressively go through the basics, while the application provides challenging material and tasks. The platform provides many challenges and the opportunity to compete with other participants. Sololearn repeatedly returns to the material and to questions that the student did not master well.

The application of AI is always conditioned by the existence of an adequate data set. If there is no critical data or the data is not "clean", the application of AI will not be successful. When AI is applied, a computer program composed of algorithms derives conclusions based on data sets. Without data, the algorithmic set cannot identify trends and therefore has no basis for decision making. The equations can be set up perfectly, but AI will not correctly interpret or predict information without an equally good data set. Also, in order to obtain good predictions, the data must be clean.

In the HolonIQ study, respondents were asked to consider which technologies have led to the most significant impact. The majority answered that Algorithms followed by Natural Language Processing/Linguistics had created the most impact. "Voice-based AI applications followed, having a broader spread on higher impact with a median impact score of 7 shared with hardware and vision. Hardware has a tighter set of views than vision-based AI, which is more spread towards lower impact/potential than peer technologies "[13]. Frequently used programming languages in implementing AI & ML solutions are Python, Java, R, MATLAB, Lisp, and Haskell.

3.2. Survey results

The main survey results are displayed in table 2. Most of the respondents are female, 53,01%, while 46,99% are male. Respondents are aged from 18 to 24 years (54.22%), then from 25 to 31 years (26,51%), and 32 to 40 years (19,28). Mainly, respondents have completed Higher education (vocational studies) within 77,11% and high school 22,89%. The respondents are students (master vocational studies) 69,88% or former students (30,12%). Respondents are aware (86,75%), not aware (9,64) and not sure (3,61%) of AI, and they use this technology in their daily lives (63,86%), do not use it (6,02%) and maybe (not aware of it) 30,12%. The table 2 shows questions and variables of interest.

Table 2. Questions and variables analysed

Variables	N	Code %
Please choose your gender		GENDER
Male	39	46,99
Female	44	53,01
I do not want to specify	0	0,00
How old are you?		AGE

from 18 to 24 years old	45	54,22
from 25 to 31 years old	22	26,51
from 32 to 40 years old	16	19,28
Regarding your schooling, please choose only one of the options (already completed):		SCHOOLING
High school	19	22,89
Higher education	64	77,11
Regarding your activity, please choose only one of the options:		ACTIVITY
I am a student	58	69,88
I plan to become a student	0	0,00
I am a former student	25	30,12
Artificial intelligence represents the theory and development of computer systems able to perform tasks...		AIDEF
True	72	86,75
False	3	3,61
I do not know	8	9,64
Do you use Artificial Intelligence in your daily lives?		AIMLUSE
Yes	53	63,86
No	5	6,02
Maybe (not aware of it)	25	30,12

The subject of the research is to examine the connection between the use of artificial intelligence in everyday life and the age of the respondents. In order to check the existence of the mentioned connection, the method of inference statistics was used, i.e. the calculation of the correlation coefficient. The correlation coefficient is the most commonly used statistical method that indicates the relationship between variables. The correlation value is determined by measuring the correlation coefficient, which is a numerical value that indicates the degree of correlation between the two variables. This indicator takes values from -1 to 1. Although the number of observations in the sample is greater than 30, which would accept the hypothesis of a normal distribution of variables, the answers of respondents about artificial intelligence are non-metric (measured on the ordinal scale), and the data on age are ranked, so the most relevant indicator of a possible relationship is Spearman correlation coefficient. Therefore, the Spearman correlation coefficient is calculated using the SPSS program for statistical processing and data analysis. The test hypotheses are as follows:

- H0: The use of artificial intelligence in everyday life does not depend on the age of the respondents.
- H1: The use of artificial intelligence in everyday life depends on the age of the respondents.

Correlations

			AGE	AIMLUSE
Spearman's rho	AGE	Correlation Coefficient	1.000	.866**
		Sig. (2-tailed)	.	.000
		N	83	83
	AIMLUSE	Correlation Coefficient	.866**	1.000
		Sig. (2-tailed)	.000	.
		N	83	83

Figure 1. Nonparametric Correlations

Based on the obtained results, a statistical conclusion is made that there is a high positive linear correlation between the variable age and the use of artificial intelligence, i.e. the Spearman correlation coefficient equals 0.866. In the context of the correlation strength, according to Cohen, the correlation is high because the value of the correlation coefficient is higher than 0.5. The correlation coefficient is, considering the level of statistical significance of the obtained result (Sig. 2-tailed), statistically significant at the level of 1%. The obtained probability does not speak about the strength of the connection, but rather about the level of trust for which the stated results should be accepted.

4. Discussion

Most of the respondents are female 53,01%, aged 18 to 24 years old, with completed Higher education (vocational studies), and in the status of student (master vocational studies) within 69,88%. In general, respondents are aware of AI (86,75%) and use this technology in their daily lives (63,86%). Also, 30,12% of respondents, regarding whether they use AI in everyday lives, chose the option "maybe (not aware of it)" that implicates that they are uncertain whether they use AI or not. In mentioned research that is used as a starting point [15], the authors stated: "At times, we are using technologies powered by AI without labelling them as AI. These could be something as mundane as email spam filters or face ID unlocks."

In a sample of 83 surveyed students, and based on the obtained value of Spearman's correlation coefficient, it is concluded that the use of artificial intelligence in everyday life depends on the age of the respondent. This result is justified by the fact that as the respondent's age grows, also grows their access to technological solutions without restrictions or someone's supervision, and there are interests that did not exist in specific years, as well as the awareness of the benefits that AI can bring in everyday life.

5. Conclusion

Education must be as accessible as possible in the 21st century. Access to education and lifelong learning is incorporated into significant strategies, UN included. No economic sector has escaped data management, which is why education-related systems need to utilise data analysis in order to deliver new personalised educational programmes that can quickly and precisely bridge the "learning gaps". Also, it has long been believed that teaching the same type of material to many students is dysfunctional. Problems within HEI have been made even worse by an insufficient number of educators in many educational systems. Educators can be informed of the strengths and weaknesses of students with intelligent systems supported by AI and ML technology. As the demand for highly educated workers increases, education institutions and businesses are utilising AI and ML or plan to do so in future.

The article addresses the research topic that students unfamiliar with artificial intelligence (AI) and machine learning (ML) technologies find it difficult to embrace AI-powered solutions. Thus, the study examines students' awareness of AI&ML (HEI). Exploratory research gave insight into high school education in Serbia and the mindset of Serbian pupils. Students at the chosen HEI are well aware of and familiar with these technologies, implying that they will readily transition to AI-powered systems now in development.

The research problem statement presented in an introduction is: Students who are not aware of AI & ML technologies, or have a rudimentary understanding, will find it challenging to adopt AI-powered systems. The research gap indicates the lack of field research studies to support this assumption. Therefore, future research should inspire more field research studies indicating the possible relation of AI awareness and the adaptability of AI-powered systems.

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Razvoj dimenzionog modela za analizu upotrebe informacionih i komunikacionih tehnologija u Srbiji

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Sažetak: Savremene informacione i komunikacione tehnologije utiču ne samo na digitalnu transformaciju poslovanja već i društva u celini. Uticaj informacionih i komunikacionih tehnologija na ekonomski razvoj prepoznala je Evropska unija i svojom Digitalnom strategijom razvoja do 2030. godine u prvi plan stavila razvoj digitalnog društva, dok je Evropska komisija pokrenula Digitalnu agendu razvoja Evrope sa ciljem razvoja jedinstvenog digitalnog tržišta. Radi iskorišćenja potencijala informacionih i komunikacionih tehnologija Vlada Republike Srbije usvojila je niz strategija u proteklih nekoliko godina sa krajnjim ciljem podizanja kvaliteta života i veće zaposlenosti. Polazeći od javno dostupnih podataka Republičkog zavoda za statistiku, kao i podataka dostupnih na oecd.stat. i veb-adresi https://stats.oecd.org/# cilj ovog diplomskog rada je usmeren na razvoj dimenzionog modela za analizu upotrebe informacionih i komunikacionih tehnologija u Srbiji i njihovo poređenje sa podacima zemalja Evropske unije.

Ključne reči: Dimenzioni model, informacione i komunikacione tehnologije, višedimenzione analize podataka, e-poslovanje, veb, digitalno društvo

1. Uvod

Krajem 20. i početkom 21. veka informacione i komunikacione tehnologije uslovile su brz tehnološki razvoj u svim segmentima privrede. Gotovo da ne postoji oblast poslovanja i ljudskog delovanja u kojoj informacione i komunikacione tehnologije nisu zastupljene u manjoj ili većoj meri. Primena informacionih i komunikacionih tehnologija olakšava svakodnevni život i rad ljudi, pomaže u bržem i efikasnijem obavljanju poslova. Koriste se u medicini, industriji, poljoprivredi, transportu, državnoj upravi itd.

Razvojem interneta kao jedne globalne računarske mreže stvorila se mogućnost globalnog povezivanja računara, kao i brže razmene podatka, što je pokrenulo proces globalizacije. Internet takođe omogućava da se sve informacije istog momenta distribuiraju drugim ljudima i organizacijama [11]. Razvoj interneta i informacionih i komunikacionih tehnologija u celini doprineo je razvoju novih poslovnih modela i digitalne ekonomije u celini.

Uticaj informacionih i komunikacionih tehnologija na ekonomski razvoj prepoznala je Evropska unija i svojom Digitalnom strategijom razvoja do 2030. godine u prvi plan stavila razvoj digitalnog društva, dok je Evropska komisija pokrenula Digitalnu agendu razvoja Evrope sa ciljem razvoja jedinstvenog digitalnog tržišta. Radi iskorišćenja potencijala informacionih i komunikacionih tehnologija Vlada Republike Srbije usvojila je niz strategija u proteklih nekoliko godina sa krajnjim ciljem podizanja kvaliteta života i veće zaposlenosti (Strategija razvoja informacionog društva u Republici Srbiji do 2020. godine, Strategija razvoja elektronskih komunikacija u Republici Srbiji od 2010. do 2020. godine i Strategiju razvoja digitalnih veština za period 2020–2024).

2. Materijali i metode

Predmet ovog rada je upotreba informacionih i komunikacionih tehnologija u Srbiji i njihovo poređenje sa zemljama Evropske unije. Cilj rada je da pokaže nivo njihovog korišćenja analizom različitih trendova i pokazatelja. U radu su korišćeni javno dostupni podaci Republičkog zavoda za statistiku, kao i podaci dostupni na *OECD.Stat*. Sa veb-sajta Republičkog zavoda za statistiku preuzeti su podaci koji pružaju informacije o domaćinstvima koja poseduju „računar, internet priključak i širokopojasnu internet konekciju, u odnosu na region u Srbiji, visinu prihoda, kao i tip naselja u kome žive“[1], zatim „pojedinci – frekvencija upotrebe računara i interneta prema nivou obrazovanja, prema radnom statusu, prema polu, prema godinama starosti i upotrebi“[1]. Sa veb-stranice *OECD.Stat* preuzeti su podaci o domaćinstvima koja poseduju „internet priključak i računar“[2], kao i za „pojedince koji poseduju internet priključak u zavisnosti od starosne dobi (raspon godina je od 16 do 74)“[2]. Preuzeti podaci obuhvatili su period od 2011. do 2020. Za potrebe razvoja i implementacije dimenzionog modela korišćeni su softverski alati Microsoft Excel i Microsoft Power BI.

U prvom delu rada opisan je razvoj informacionih tehnologija, konkretno razvoj Web-a 1.0, Web-a 2.0 i Web-a 3.0. Drugi deo rada se odnosi na to kako su informacione tehnologije menjale način rada, poslovne procese i poslovne modele. Opisani su Web 1.0 e-poslovanje, Web 2.0 koji uključuje krajnje korisnike u kreiranje usluga i Web 3.0 smart tehnologije i smart poslovanje. U trećem delu rada opisan je način kako su se podaci prikupljali i njihova modifikacija, takođe su opisani postupci kreiranja tabela dimenzija i tabela činjenica i razvoj dimenzionog modela podataka za upotrebe informacionih i komunikacionih tehnologija u Srbiji i njihovo poređenje sa zemljama Evropske unije.

Na kraju rada donet je zaključak o uporednoj analizi Srbije sa zemljama Evropske unije, konkretno Slovenije, po istim indikatorima i prikazan je konačan rezultat.

3. Razvoj informacionih tehnologija

Dvadeset prvi vek je doba koje karakterišu radikalne promene u gotovo svim oblastima poslovanja. Upravljanje organizacijom se razlikuje sa aspekta industrijske ere i informatičke ere. Dok je u informatičkoj eri značaj intelektualnih resursa veći od značaja materijalnih resursa, u industrijskoj eri je to obrnuto. Budući da je ovo era podataka, informacija, mudrosti i znanja, dolazimo do zaključka da će jedna organizacija biti uspešna ukoliko dovoljno ulažu u intelektualne resurse i na pravilan način upravljaju njima. Nekada su vrednost organizacije određivala samo merljiva finansijska i materijalna sredstva, dok je danas to drugačije, jer su danas to i nematerijalne vrednosti i kvalitet ljudskih resursa. Današnja ekonomija je potpuno drugačija od nekadašnje, a ono što je omogućilo takvu različitost jeste pojava interneta. Upravo zato današnju ekonomiju nazivamo „Ekonomijom 24 časa", jer ona obezbeđuje stalnu i neprekidnu komunikaciju sa poslovnim partnerima kao što su: dobavljači, banke, kupci i ostali [7].

Razvoj interneta je, osim drugačijoj i raznovrsnijoj ekonomiji, doprineo i samom nastanku i razvoju elektronskog poslovanja (engl. *Electronicbusiness* ili *E-business*). Elektronsko poslovanje predstavlja vođenje poslova elektronskim putem, što se najčešće zapravo dešava putem interneta i ono, pored kupovine i prodaje, podrazumeva i brigu o klijentima, kao i organizaciju.

Samim tim što se poboljšala ekonomija i što je nastanak interneta pospešio elektronsko poslovanje koje je danas jedan od najpoznatijih vidova poslovanja, kao nova disciplina nastale su i informacione tehnologije (IT). One predstavljaju primenu računara za skladištenje, analizu, preuzimanje i prenos podataka ili informacija i uglavnom se odnose na poslovanje organizacija i preduzeća, jer su upravo i nastale kao posledica njihovih zahteva. Informacione tehnologije bi se prema sveobuhvatnoj definiciji mogle definisati kao skup alata, procesa i opreme za prikupljanje, obradu i prezentovanje podataka i informacija [7].

Pored svoje osnovne definicije, sam pojam „informacionih tehnologija" se može upotrebiti i u drugačijem, dosta širem značenju, gde ono podrazumeva sve aktivnosti kojima se IT profesionalci bave, što predstavlja širok spektar mogućnosti, od instalacije aplikativnih programa pa sve do projektovanja informacionih sistema i računarskih mreža.

Sposobnost upotrebe informacionih tehnologija podrazumeva:

- posedovanje svih neophodnih veština za efikasnu upotrebu ovih alata;
- dobro poznavanje svih alata koji se koriste u računarstvu;
- prepoznavanje situacija u kojima se informacione tehnologije mogu iskoristiti da bi se rešio određeni problem.

U savremenoj informatičkoj tehnologiji je gotovo sve okrenuto procesima umrežavanja, a do toga je doveo sve veći razvoj veb-tehnologija, pa su se samim tim stvorile nove forme elektronske komunikacije kao što su: onlajn-diskusije, imejl, čet, forumi i ostalo. Ovim su stvoreni potpuno inovativni oblici društvenih odnosa koji se danas sve više koriste u svakodnevnom životu [7].

Ako bi danas postojalo sve ono što čini jednu „mrežu svih mreža" takvom kakva jeste, naučnici u prošlosti morali su da realizuju svoju ideju. Tako je 60-ih godina prošlog veka grupa američkih naučnika došla na ideju da poveže sve računare kako bi svaki od njih mogao da pristupi podacima onog drugog bilo kada i bilo gde. Ideja je bila da se povežu dva računara koja su smeštena na različitim američkim univerzitetima preko telefonske linije, odnosno dial-up vezom. Na taj način nastala je prva svetska mreža računara. Kada je 1991. godine Tim Berners-Li sa CERN instituta u Švajcarskoj razvio projekat koji je bio namenjen i zamišljen kao medij za naučnu razmenu sa nazivom World Wide Web (WWW), nije mogao ni da zamisli da će ovaj naizgled mali projekat postati jako popularan širom sveta. Na samom početku razvoja veba on se temeljio na jednosmernom prikazu informacija, da bi tek kasnije zapravo nastao prvi linijski veb-čitač [10]. Zatim se 1993. godine dogodio prelaz sa tekstualnog na grafički prikaz veb-stranica kada je Mark Andrisen (Marc Andreessen) predstavio prvi grafički veb-brauzer Mosaic, koji je prikazivao više od jednostavnog ASCII teksta. Ovaj Mosaic razvio je NSCA (National Centar for Supercomputing Applications) na Univerzitetu Illionis u SAD.

Prva verzija Mosaic-a podržavala je File Transfer Protocol (FTP) i mogla je da prikaže HTML fajlove koji su sadržali tekst, slike različitih formata, kao i video-format Postscript. Ova verzija mogla je da pristupa podacima koristeći veb-protokole i dozvoljavala je korisnicima razne opcije kao što su izbor fonta ili veličina prozora. Tada su veb-stranice bile nepromenljive i imale su vrlo jednostavan raspored, što je veoma otežavalo ulogu autora koji je morao da ih obnavlja u određenim vremenskim intervalima, a samim tim i ažurira čim se pojavi neka nova informacija. Budući da je HTML bio jedini jezik za kodiranje veb-stranica, stranice su bile napravljene za funkcionalnu komunikaciju i njihova uloga bila je da prikažu informacije korisniku. Kasnije su dial-up moderni modeli stvarani tako da maksimiziraju vreme očitavanja zbog bržeg prenosa podataka, te je veb primenio klijent–server model koji je prikazan na slici 3 [10].

Model se naziva klijent–server, jer je postojala određena interakcija između klijenta i servera u kojoj je klijent tražio uslugu serveru, a server mu je tu uslugu nudio. U trenutku kada klijent zatraži uslugu, on zapravo šalje odgovarajući zahtev koji server obrađuje, nakon čega mu pruža odgovor. Kada odgovor stigne, od tog trenutka klijent može da nastavi sa radom [10]. Nakon određenog vremena gotovo svi korisnici su jako uspešno i brzo uspevali da prepoznaju kako mogu doći do informacija koje se nalaze na različitim mestima. Raniji pretraživači nisu pokazivali bukvalno ništa od stranica sve dok stranica nije bila u potpunosti učitana, međutim 1994. osnivač Silicon Graphics-a Džim Klark (Jim Clark) zajedno sa Markom Andrisenom napravio je Mosaic Communications, koji je kasnije preimenovan u Netscape Communications, i ovo je upravo donelo potpuno novi značaj učitavanju veb-stranica koje su se sada učitavale u letu (on-the-fly), pa su se određene stvari prikazivale i dok stranica nije bila u potpunosti učitana [10].

Netscape Communications je zapravo prikazao korisnicima mogućnost da čitaju sadržaj dok se stranica učitava, a pored toga je dodao podršku za standarde kao što su JavaScript i Coockies. JavaScript predstavlja programski jezik koji se koristi za definisanje funkcionalnosti veb-stranica na klijentovoj strani, dok Coockies predstavlja male tekstualne

fajlove dobijene od servera koji služe za identifikaciju. Netscape je kao jedna potpuno inovativna stvar dominirao sve dok Microsoft nije izdao Internet Explorer, čiji je kasniji razvoj do verzije 6.0 gotovo u potpunosti zauzeo tržište [10].

Nakon određenog vremena, isto kao što je mesto Netscape-a zauzeo Internet Explorer, tako je i sledeći veliki pretraživač Mozila Firefox zamenio Internet Explorer i tako postao jedan od vodećih koji je zbog svog ogromnog kvaliteta dobio na značaju i popularnosti [10].

Pored ovih, od kojih su neki i danas jako popularni, razvili su se i mnogi drugi pretraživači kao što su Safari za Macintosh platformu, Opera, a kasnije i Google Chrome. Danas je stanje veb-klijenata takvo da je programerima omogućeno da razviju samo neke delove klijentskog dela distribuiranih aplikacija, a da za ostale delove iskoriste već postojeće funkcionalnosti [10].

4. Primena informacionih tehnologija kao preduslov razvoja privrede i društva

U razvoju interneta postoji nekoliko faza i sve one mogu se grupisati u sledeće četiri faze. Period od 1991. predstavlja prvu fazu razvoja, u kojoj najviše dominira nauka, odnosno spoj različitih naučnika i inženjera koji su radili na razvoju digitalne transformacije. Pre svega, u tom periodu postojao je rad IETF-a (engl. Internet Engineering Taks Force), koji je omogućio dostupne standarde za korišćenje interneta. Tačnije, svako ko je želeo da koristi internet mogao je to da uradi putem RFC (engl. Request for Comments) dokumenta, koji je opisivao različite metode i standarde. Takođe, jedna od bitnih stavki koje su obeležile ovu fazu razvoja jeste i NSFNet (engl. Backbone) i hiljade univerzitetskih (engl. Campus) mreža, gde su konačno internet počeli da koriste i akademski građani [8].

Kada je akademski svet već uveliko koristio internet, negde od 1992. godine pa sve do 1997. godine trajao je period koji predstavlja drugu fazu razvoja. Tada FNC (engl. Federal Networking Council) dozvoljava novim kompanijama poznatim kao ISP's (engl. Internet Service Providers) da se međusobno povežu, ali ono što je najviše obeležilo ovu fazu i što se i danas koristi kao nešto od najpoznatijih dostignuća jeste pojava World Wide Web-a. U ovoj fazi došlo je najpre do razvoja veb-čitača koji su doveli do toga da se aplikacija prikazuje na celom monitoru, a onda i do razvoja hardvera koji je omogućio da računari kreću da koriste i manje institucije budući da je cena opala, a proizvod se naglo proširio. Ono što je možda i najveći poduhvat druge faze razvoja jeste da su računari počeli da se koriste i u kućnoj upotrebi, gde su modemi postizali brzine do 56 kbita/s. Od statične pretrage veb-sadržaja klijenti su zapravo postali dinamičan učesnik u njegovom kreiranju [8].

Treća faza razvoja obuhvata period od 1998. do 2005. godine i to je period kada internet konačno počinje da dostiže međunarodne i internacionalne granice. Došlo je do napretka u razvoju veb-tehnologija, aplikacija i do velikog poboljšanja veb-pretraživača, kao i do mogućnosti interakcije sa vebom putem Flash i JavaScript tehnologija. Ovaj period, pored širenja interneta na međunarodnom nivou, doveo je i do toga da je bilo moguće pridruživanje podataka i video-usluga na jednoj mrežnoj tehnologiji [8].

U četvrtoj fazi razvoja internet je već počeo da se koristi širom sveta i postao je „mreža svih mreža". Ovo predstavlja period od 2006. godine, kada je došlo do pojave 100-gigabitnog prenosa, pomoću (engl. Dense Wave Division Multiplexing) optičkih kablova, pojave VoIP-a (engl. Voice over Internet Protocol), koji omogućava telefonsku komunikaciju preko interneta, korišćenje interneta na mobilnim telefonima i drugim pokretnim uređajima, IPTV (engl. Internet Television Protocol) širokopojasni prenos digitalnog TV signala preko IP strukture. Dakle, u četvrtoj fazi internet zvanično postaje svetska univerzalna mreža, a određeni pronalasci postaju svakodnevica gotovo svakog domaćinstva [8].

4.1. Web 1.0 – e-poslovanje

Ključne oblasti interesovanja i delovanja su [3,4]:

- protokoli, HTTP;
- otvoreni, standardizovani jezici za označavanje sadržaja HTML i XML;
- prvi veb-pretraživači;
- softverske platforme i alati za razvoj veb-aplikacija;
- veb-programski jezici, poput Jave i JavaScript-a;
- kreiranje veb-sajtova;
- komercijalizacija veba i razvoj veb biznis modela.

Protokoli, HTTP

HTTP (engl. HyperTekst Transfer Protocol) je mrežni protokol koji predstavlja glavni i najčešći metod prenosa informacija na vebu. HTTP zapravo predstavlja protokol za komunikaciju između klijenta i servera po principu da klijent podnosi zahtev, a server mu nakon njegove obrade pruža odgovor. Njegova osnovna namena jeste da isporuči HTML dokument, odnosno veb-stranicu.

HTTP server čeka zahteve na mrežnom portu (uglavnom portu 80) i čeka trenutak kada će klijent postaviti svoj zahtev kako bi mogao da mu pruži adekvatan odgovor. Nakon što server pruži odgovor, konekcija se prekida sve do sledećeg zahteva [5,6].

Jezici za označavanje sadržaja HTML i XML

HTML (engl. Hyper Tekst Markup Language) jeste jezik za označavanje hiperteksta, odnosno za opis veb-stranica.

Njegova najznačajnija osobina jesu određeni metapodaci koji su jasno odvojeni od sadržaja dokumenta. Pomoću njega možemo da odvojimo određene celine u tekstu kao što su naslovi, paragrafi, citati, ali i da vidimo standarde koji opisuju sam dokument kao što su ključne reči, podaci o autoru i ostalo.

XML je skraćenica za Extensible Markup Language, tj. proširivi (meta) jezik za označavanje tekstualnih dokumenata, i njegov format se može prilagoditi različitim oblastima kao što su elektronska razmena podataka, njihovo čuvanje, glasovna pošta i izrada novih jezika za označavanje [9].

Prvi veb-pretraživači

Prvim internet pretraživačem smatra se Archie, tj. alat za indeksiranje FTP arhiva, koji omogućava lakšu identifikaciju datoteke. Nastao je tako što je 1990. Alan Emtidž (Alan Emtage) pretraživao imena datoteka i naslove, ali nije indeksirao taj sadržaj. Zatim je došao na ideju da preko noći prikuplja informacije o strukturi fajlova tako što je pristupao javnim FTP-ovima (engl. File Transfer Protocol). Nakon njegovog velikog poduhvata nije više bilo potrebe da se ručno pretražuju FTP-ovi, već bi korisnik na Archie-u ukucao željeni naziv fajla i dobio spisak svih FTP-ova koji imaju traženi fajl. Sledeći u redu bio je Google pretraživač, koji je bio zasnovan na analiziranju odnosa između veb-sajtova i kao takav davao bolje rezultate od već postojećih tehnologija, jer su one rangirale rezultate prema broju pojavljivanja traženog pojma na stranici. Novina koju je uneo Google pretraživač jeste da se pretraživanje vršilo pomoću sistema posećenosti korisnika, odnosno što je jedna stranica bila posećenija, to se više rangirala, to jest nalazila na vrhu stranice rezultata pretrage. Ovaj pretraživač je veoma brzo privukao korisnike svojom funkcionalnošću i dobrim dizajnom [11].

4.2. Web 2.0 – uključivanje krajnjih korisnika u kreiranje usluga

Prelazak sa statičkih HTML veb-stranica na dinamičniji veb, koji je veoma organizovaniji, desio se stvaranjem druge generacije World Wide Web-a, odnosno pojavom Web-a 2.0, koji je bio usredsređen na sposobnost ljudi da međusobno komuniciraju i sarađuju što bolje.

Druge funkcionalnosti Web-a 2.0 uključuju otvorenu komunikaciju i otvorenije razmene informacija. Web 2.0 sadrži tri toka razvoja:

- prvi je „Tehnološki tok", koji obezbeđuje osnovnu infrastrukturu (hardver i softver). Pored toga, uključuje uslužno-orijentisane arhitekture (SOA), kao što su RSS feeds, CMS, veb-serveri, Mashups;
- drugi je „Aplikacijski tok", koji uključuje Rich Internet Application (RIA), čije su usluge nalik desktop aplikacijama i aplikacijama koje se koriste na internetu. Njihova osnovna osobina jeste da dolaze do neograničene navigacije. U budućnosti će doći do toga da skoro svi programi budu postavljeni kroz veb kao usluge, pa će samim tim ove aplikacije obezbeđivati komponente koje će se koristiti u drugim;
- treći je „Društveni tok", koji uključuje učešće korisnika i njegov doprinos na vebu. Takozvani socijalni veb uključuje društvene medije, etiketiranje, Wikis, podcasting, vodcasting, blogging, društvene mreže itd. [3,4].

Različite internet kompanije smatrale su da će ostvarivati dosta veći profit zahvaljujući naglom porastu veb-sajtova, pa je u periodu od 1995. godine do 2001. godine veb dobio jako veliki značaj i došlo je do fenomena nazvanog **dot.com balon**.

Nastanak dot.com balona naveo je različite programere i inženjere da se posvete poboljšanju prikaza veb-stranica i uvođenjem raznih dodatnih mogućnosti. Nakon toga je postavljen sistem za ciljno oglašavanje koji je omogućavao povratak na internet i veb i bio nazvan „Adwords".

Koristeći potpuno nove aplikacije, veb je sam po sebi zapravo počeo da se ponaša kao računar, jer su servisi i aplikacije sada bili dostupni i na vebu. Upravo zato se smatra da Web 2.0 predstavlja novu generaciju veb-zajednica i uslužnih servera koji imaju jedan jedini cilj, a to je olakšanje saradnje. Ovim se omogućava korisnicima da većinu zadataka obavljaju u Web klijentima (browser) [3,4].

4.3. Web 3.0 – Smart tehnologije i smart poslovanje

Treću generaciju usluga zasnovanih na internetu predstavlja Web 3.0, koju je smislio Džon Markof (John Markoff). Web 3.0 predstavlja zapravo „Inteligentni veb", tj. sve ono što zajedno čine semantički veb, pretraživanje prirodnog jezika, mikroformati, mašinsko učenje i ostalo. Sveobuhvatno Web 3.0 bi predstavljao čitanje, pisanje i istraživanje u vebu.

Web 3.0 predstavlja jedan veliki pomak koji uključuje pretvaranje veba u bazu podataka i stvaranje sadržaja dostupnog sa više aplikacija koristeći veštačku inteligenciju. Zapravo, ovaj pojam predstavlja različite evolucije upotrebe i interakcije na vebu [3,4].

5. Razvoj dimenzionog modela za analizu upotrebe informacionih i komunikacionih tehnologija u Srbiji

Da bi se analizirala upotreba informacionih i komunikacionih tehnologija u Srbiji i izvršilo poređenje sa podacima zemalja Evropske unije, razvija se dimenzioni model podataka. Prvo su u MS – Excel-u kreirane tabele dimenzija i tabele činjenica, a zatim učitane u softver Power BI.

Podaci za tabele činjenica preuzeti su iz sledećih izvora:

- https://www.stat.gov.rs/sr-latn/oblasti/upotreba-ikt/;
- https://stats.oecd.org/.

Sa pomenute adrese vezane za Srbiju uzeti su podaci o uređajima zastupljenim u domaćinstvima u periodu od 2011. do 2020, a to su podaci koji su vezani za domaćinstva koja poseduju *„računar, internet priključak i* širokopojasnu

internet konekciju po regionima, prema visini prihoda, prema tipu naselja"[1], zatim *„pojedinci – frekvencija upotrebe računara i interneta prema nivou obrazovanja, prema radnom statusu, prema polu, prema godinama starosti i upotrebi"*[1].

Sa druge veb-adrese vezane za zemlje Evropske unije preuzeti su podaci o domaćinstvima koja poseduju *„internet priključak i računar"*[2] i takođe za *„pojedince koji poseduju internet priključak starosnih godina od 16 do 74"*[2].

Za kreiranje tabele činjenica Srbije preuzeti su podaci u vezi sa indikatorima, periodom i teritorijom.

Tabele dimenzija su kriterijumi po kojima se vrše analize. Na bazi podataka Srbije i zemalja Evropske unije, kreirane su tabele dimenzija:

- Indikator (*„Domaćinstva koja poseduju računar, po regionima"*; *„Domaćinstva koja poseduju internet priključak, po regionima"*; *„Domaćinstva koja poseduju širokopojasnu internet konekciju, po regionima"*; *„Pojedinci – frekvencija upotrebe računara"*; *„Pojedinci – frekvencija upotrebe interneta"*; *„Pojedinci – korisnici računara (u poslednja 3 meseca), prema godinama starosti"*; *„Pojedinci – korisnici interneta (u poslednja 3 meseca), prema godinama starosti"*; *„Pojedinci – korisnici računara (u poslednja 3 meseca), prema nivou obrazovanja"*; *„Pojedinci – korisnici interneta (u poslednja 3 meseca), prema nivou obrazovanja"*; *„Pojedinci – korisnici računara (u poslednja 3 meseca), prema polu"*; *„Pojedinci – korisnici interneta (u poslednja 3 meseca), prema polu"*; *„Pojedinci – korisnici računara (u poslednja 3 meseca), prema radnom statusu"*; *„Pojedinci – korisnici interneta (u poslednja 3 meseca), prema radnom statusu"*; *„Domaćinstva koja poseduju računar, prema visini prihoda"*; *„Domaćinstva koja poseduju internet priključak, prema visini prihoda"*; *„Domaćinstva koja poseduju širokopojasnu internet konekciju, prema visini prihoda"*; *„Pojedinci – trgovina putem interneta (e-commerce), po polu"*; *„Pojedinci – trgovina putem interneta (e-commerce)"*; *„Uređaji zastupljeni u domaćinstvima"*); [1]
- Teritorija (REPUBLIKA SRBIJA, Beogradski region, Region Vojvodine, Region Šumadije i Zapadne Srbije, Region Južne i Istočne Srbije);
- Godina (2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020);
- Indikator – kategorija (do 300 evra, 300–600 evra, preko 600 evra, nikad nije koristio/koristila, u poslednja 3 meseca, pre više od 3 meseca (manje od 1 godine), pre više od godinu dana, bez obrazovanja i niže obrazovanje, srednje, više i visoko, zaposlen, nezaposlen, student, ostali, muško, žensko, 16–24, 25–34, 35–44, 45–54, 55–64, 65–74, TV, mobilni telefon, personalni računar (PC), kablovska TV, laptop);
- Države u Evropi (Austrija, Belgija, Češka, Danska, Estonija, Finska, Francuska, Nemačka, Grčka, Island, Irska, Italija, Letonija, Litvanija, Luksemburg, Holandija, Norveška, Poljska, Portugal, Slovačka, Slovenija, Španija, Švedska, Švajcarska, Mađarska, Turska, Ujedinjeno Kraljevstvo).

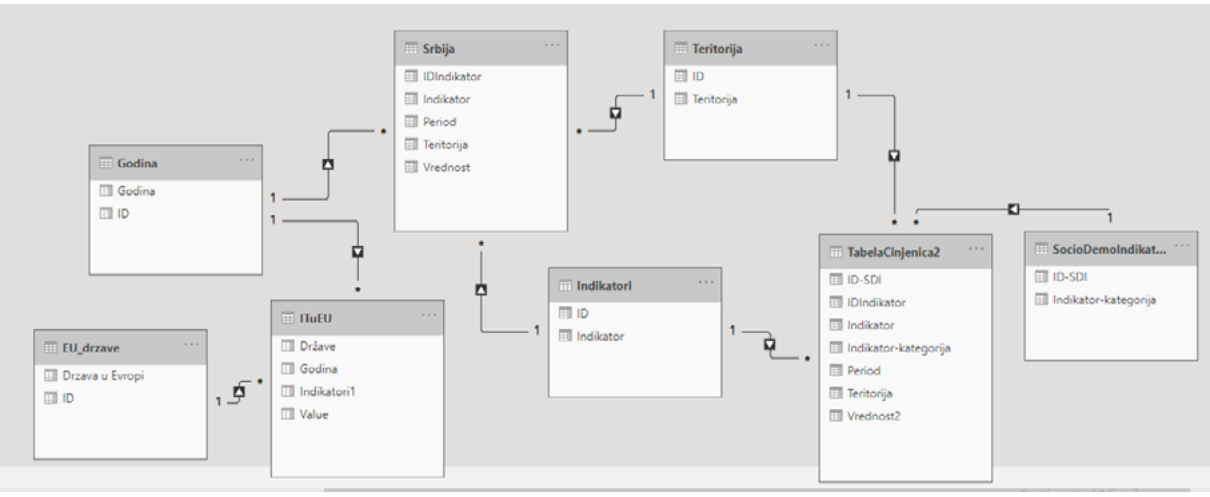
Tabele Indikator i Indikator – kategorija su povezane, kao i tabele Godina i Države u Evropi. Sledeći korak je kreiranje tabele činjenica. Postupak tabele činjenica:

- Preuzimaju se podaci za Srbiju. Zatim, ta tabela se modifikuje i dodaje joj se nova kolona „Teritorija". [1]
- U ovu tabelu učitani su podaci za „Domaćinstva koja poseduju računar, internet priključak i širokopojasnu internet konekciju, po regionima".

Nakon toga kreirana je još jedna tabela činjenica koja dobija nove kolone: Indikator – kategorija i ID-SDI, što ukazuje na to da će dimenzioni model podataka biti tipa sazvežđa. A to znači da postoje dimenzije koje su zajedničke za različite tabele činjenica.

Da bi se kreirao dimenzioni model podataka, gorenavede tabele dimenzija i tabele činjenica su učitane u softver Power BI. Softver Power BI je zbirka softverskih usluga, aplikacija i konektora koji zajedno rade na pretvaranju nepovezanih izvora podataka u koherentne. Podaci mogu biti Excel tabele ili zbirka skladišta podataka zasnovanih na oblaku. Power BI omogućava lako povezivanje sa izvorima podataka i vizuelizaciju.

Podaci su prethodno pripremljeni u MS – Excel-u i potom učitani u softver Power BI. Nakon učitavanja podataka kreiran je dimenzioni model u softver Power BI. Ovaj dimenzioni model korišćen je za analizu upotrebe informacionih i komunikacionih tehnologija u Srbiji i njihovo poređenje sa zemljama Evropske unije (slika 1).

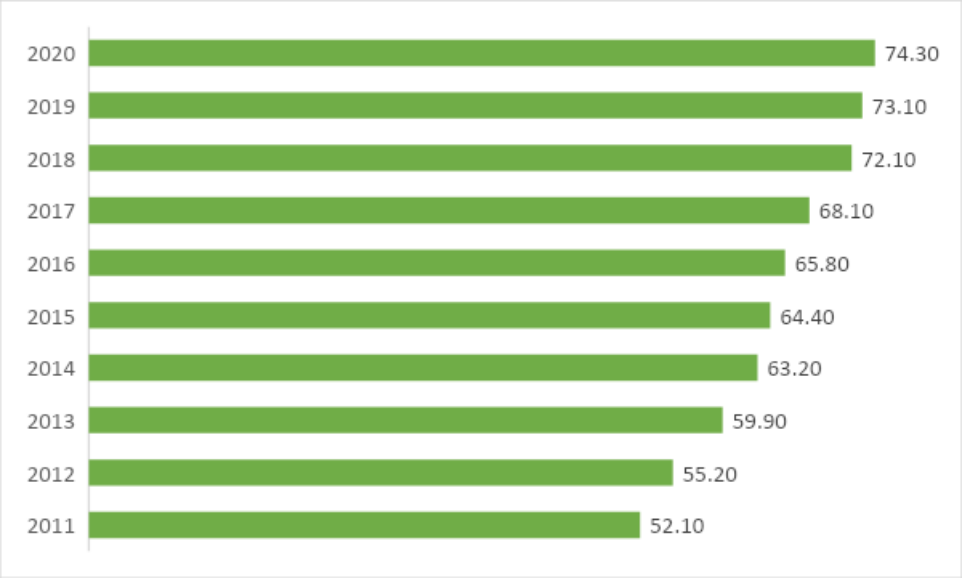


Slika 1. Dimenzioni model tipa sazvežđe [12]

Za analizu upotrebe informacionih i komunikacionih tehnologija u Srbiji, na osnovu dimenzionog modela urađena je analiza koja pokazuje upotrebu računara, interneta i širokopojasne internet konekcije od strane domaćinstava

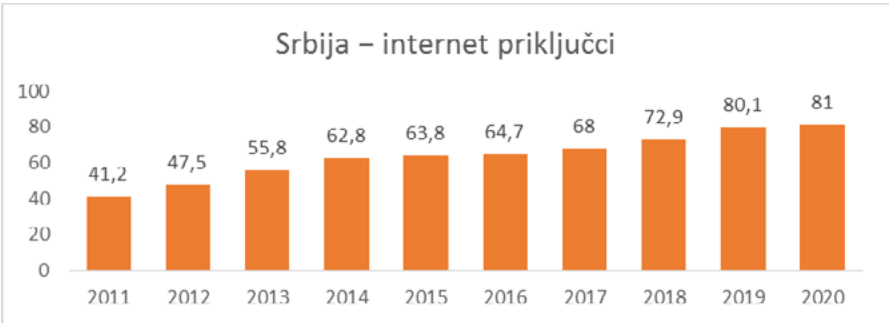
i pojedinaca prema regionima, visini prihoda, nivou obrazovanja, godinama starosti, radnom statusu, polu i upotrebi. Sledeća urađena analiza je analiza koja upoređuje Srbiju sa zemljama Evropske unije prema njihovim indikatorima.

Dijagram na slici 2 je procenat domaćinstava u Srbiji koja poseduju računar. U 2011. taj procenat je iznosio 52,1%, dok je u 2020. taj procenat porastao na 74,3%.



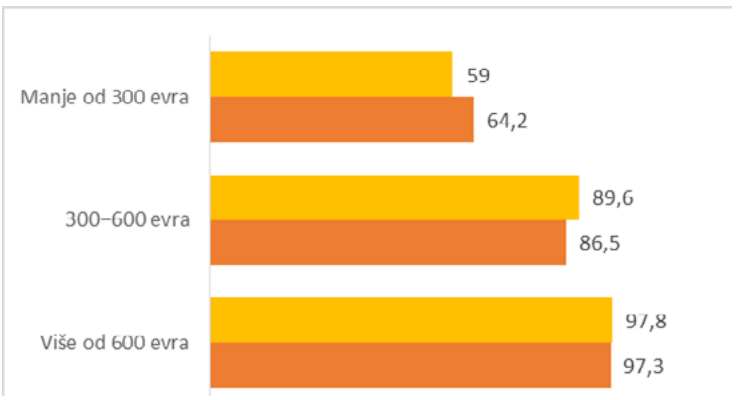
Slika 2. Srbija – računari u domaćinstvu (%)

Kada je u pitanju broj internet priključaka, takođe je primetan rast. U 2011. broj domaćinstava sa internet priključkom iznosio je 39%, dok je u 2020. taj procenat porastao na 81% (slika 3).



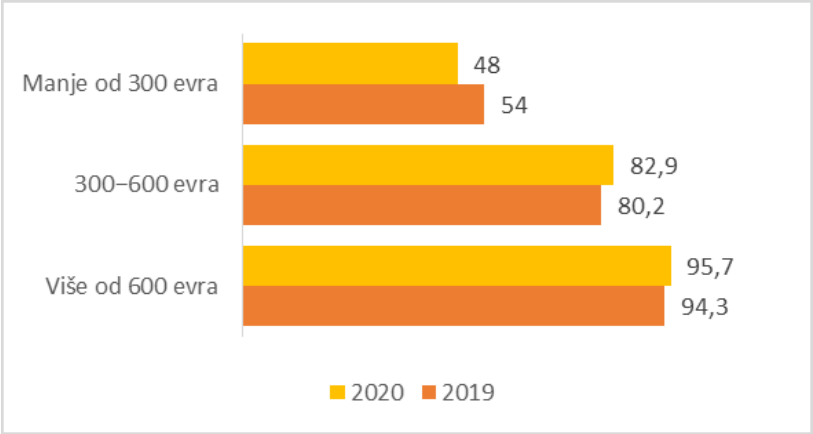
Slika 3. Srbija – internet priključci (%)

Radi preglednosti dijagrama, na sledećim slikama prikazan je trend upotrebe IKT-a u dvema uzastopnim godinama, 2019. i 2020. Rezultati analize koji prikazuju broj domaćinstava koja poseduju računar prema visini prihoda u 2019. i 2020. u Srbiji u procentima prikazani su na slici 4.



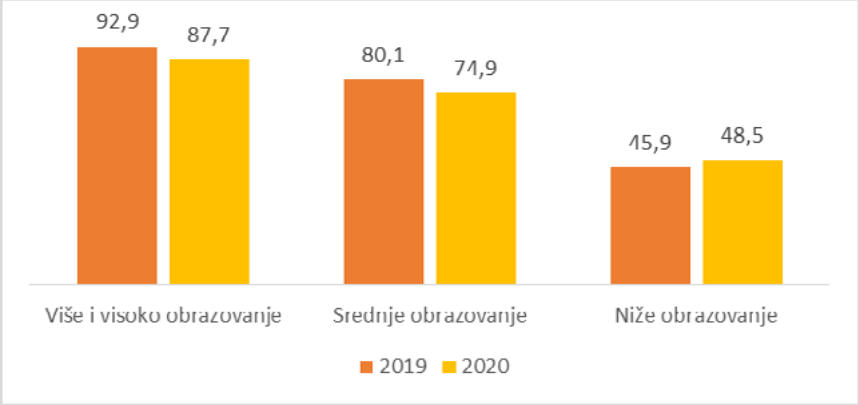
Slika 4. Domaćinstva koja poseduju računar prema visini prihoda

Rezultati analize koji prikazuju broj domaćinstava koja poseduju internet priključak prema visini prihoda u 2019. i 2020. u Srbiji u procentima prikazani su na slici 5.



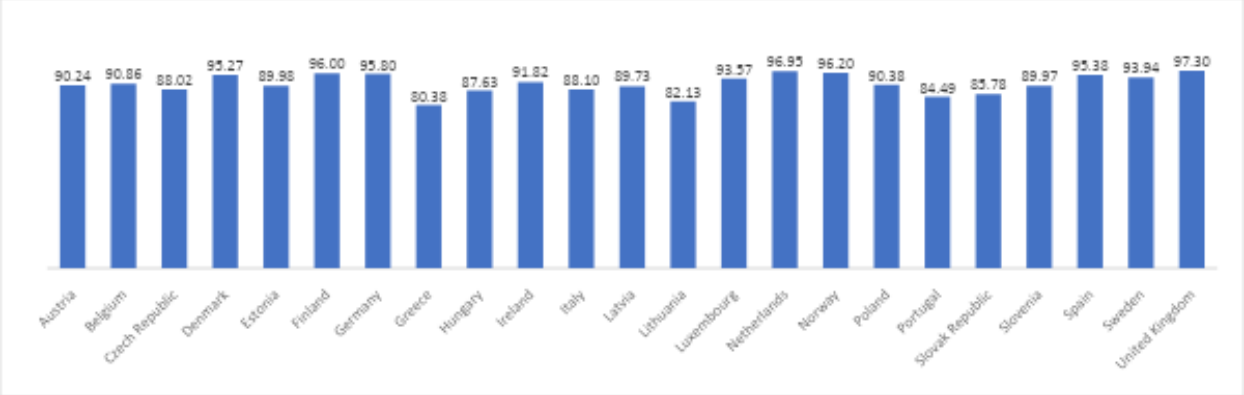
Slika 5. Domaćinstva koja poseduju internet priključak prema visini prihoda

Slika 6 daje prikaz korisnika računara prema nivou obrazovanja. Na ovom dijagramu primetan je trend pada.



Slika 6. Pojedinci korisnici računara i interneta prema nivou obrazovanja

Dijagram na slici 7 se odnosi na zemlje Evropske unije i pokazuje domaćinstva sa internet priključkom u 2020. godini.



Slika 7. Zemlje Evropske unije – domaćinstva sa internet priključkom u 2020. godini

Dijagram na prethodnoj slici pokazuje da se procenat domaćinstava sa internet priključkom u zemljama EU kreće od 80,38% u Grčkoj do 97,30 u Ujedinjenom Kraljevstvu.

6. Zaključak

U ovom radu prikazana je analiza upotrebe informacionih i komunikacionih tehnologija u Srbiji, posmatrano sa aspekta domaćinstava i pojedinaca koji poseduju računar i internet priključak. Prikazane analize pokazuju da u Srbiji postoji trend rasta upotrebe informacionih i komunikacionih tehnologija, kako u domaćinstvima tako i od strane pojedinaca. U odnosu na 2011, kada je 52,1% domaćinstava posedovalo računar, taj procenat u 2020. iznosi 74,3%. Takođe, broj domaćinstava koja su posedovala internet priključak u 2011. iznosio je 41,2%, dok je u 2020. taj procenat iznosio 81%.

Takođe, prikazane analize pokazuju da Srbija ne zaostaje za zemljama Evropske unije kada je u pitanju upotreba informacionih i komunikacionih tehnologija.

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The development of a dimensional model for the analysis of information and communications technology use in Serbia

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Abstract: Modern information and communications technology (ICT) affects not only the digital transformation of business, but that of society in general. The impact of ICT on economic development has been recognised by the European Union through its Digital Decade strategy that highlights the development of a digital society by 2030, while the European Commission has launched the Digital Agenda for Europe, aimed at creating a unique digital market. In order to fully use the potential of ICT, the Government of the Republic of Serbia has adopted a series of strategies in the past few years with the end goal of improving employment opportunities and the quality of life. Using the publicly available data provided by the Statistical Office of the Republic of Serbia and the information provided by oecd.stat. at https://stats.oecd.org, this paper focuses on the development of a dimensional model for the analysis of information and communications technology use in Serbia and the comparison with data from EU countries.

Key words: Dimensional model, information and communications technology, multidimensional data analysis, e-business, web, digital society

1. Introduction

In the late 20th and early 21st century, ICT accelerated technological development in all segments of the economy. One struggles to think of a business aspect or field in which ICT has no application. The use of ICT facilitates everyday life and work and makes business more efficient. It is used in medicine, industry, agriculture, transport, public administration, etc.

The development of the Internet – a global computer network – has broadened the possibilities for global computer connections and data exchange, which has initiated the globalisation process. The Internet also enables instant distribution of information to people and organisations [11]. The overall evolution of the Internet and ICT has contributed to the development of new business models and the digital economy in general.

The impact of ICT on economic development has been recognised by the European Union through its Digital Decade strategy that highlights the development of a digital society by 2030, while the European Commission has launched the Digital Agenda for Europe, aimed at creating a unique digital market. In order to fully use the potential of ICT, the Government of the Republic of Serbia has adopted a series of strategies in the past few years with the end goal of improving employment opportunities and the quality of life (Strategy for the Development of an Information Society in the Republic of Serbia by 2020, Strategy on Development of Electronic Communications in the Republic of Serbia for period 2010-2020, and Digital Skills Strategy (2020-2024).

2. Materials and methods

The topic of this paper is the use of ICT in Serbia and related data comparison with EU countries. The paper aims to illustrate the extent to which ICT is used by analysing different trends and indicators. The paper uses publicly available data of the Statistical Office of the Republic of Serbia, as well as data available at *OECD.Stat*. The following data was taken from the Statistical Office of the Republic of Serbia website: information regarding households that have "a computer, internet connection, and broadband, in relation to the region in Serbia, earnings, and type of settlement in which they live"[1], "individuals – computer and internet use frequency in relation to education level, employment status, gender, age, and use"[1]. The following data was taken from the *OECD.Stat* website: information regarding households that have "internet connection and a computer"[2], and information regarding "individuals who have internet connection in relation to age (16–74)"[2]. The data collected refers to the period 2011–2020. Microsoft Excel and Microsoft Power BI were used to develop and implement the dimensional model.

The first part of the paper describes the development of information technology, specifically Web 1.0, Web 2.0 and Web 3.0. The second part of the paper highlights how information technology changed working methods, business processes and business models. It describes Web 1.0 e-business, Web 2.0 which involves end users in creating services, and Web 3.0 smart technology and smart business. The third part of the paper illustrates the process of collecting and modifying data, the process of creating dimension tables and fact tables, as well as the development of the dimensional model for ICT use in Serbia and data comparison with EU countries.

The final part of the paper includes the conclusion regarding the comparative analysis of Serbia and EU countries, specifically Slovenia, using the same indicators.

3. The development of information technology

The 21st century is an age of radical change in nearly all business areas. Managing a company differs when viewed from the perspective of the Industrial Age and the Information Age. In the Information Age, intellectual resources are more important than material resources, while in the Industrial Age it is the other way round. Given that we live in an age of data, information, wisdom, and knowledge, we can conclude that organisations will be successful only if they invest sufficiently in intellectual resources and manage them accordingly. The value of an organisation used to be determined solely by measurable financial and material resources; today, non-material values and the quality of human resources also contribute to this. The economy has changed over time due to the emergence of the Internet. We refer to today's economy as a 24-hour economy, given that it provides constant communication with business partners, i.e. suppliers, banks, buyers, etc. [7].

The Internet has contributed not only to a different and more diverse economy, but to the creation and development of **electronic business (e-business)**. E-business refers to conducting business transactions electronically, usually over the Internet, and it includes sales, purchases, customer support, and organisation.

Due to the fact that the economy has improved and that the emergence of the Internet has accelerated e-business, which is today one of the best-known types of business, **information technology (IT)** has emerged as a new discipline. IT entails the application of computers for storing, analysing, downloading and transferring data or information, and usually refers to company business operations, given that it was created as a consequence of company requirements. A comprehensive definition defines IT as a set of tools, processes, and equipment used for collecting, processing, and presenting data and information [7].

In addition to the main definition, the term "information technology" can also acquire a broader meaning to include all the activities of IT professionals, which include a wide range of options, from application instalment to information system and computer network design.

The ability to use information technology entails:

- all the necessary skills for the efficient use of these tools;
- proficiency in all tools used in computing;
- identifying situations in which information technology can be used in order to solve a problem.

Modern information technology practically revolves around networking processes due to the rapid development of web technology, which has paved the way for new forms of electronic communication, such as online discussions, email, chat, forums, etc. This has created entirely new and innovative forms of social relations which are more and more used in everyday life [7].

In order for the "network of all networks" to be the way we know it today, scientists in the past had to implement their idea. In the 1960s, a group of American scientists came up with the idea to connect all computers in a way that would allow them to access each other's data any time and from any location. The idea was to connect two computers located at different American universities using a telephone line, i.e. a dial-up connection. This is how the first global computer network was created. When in 1991 Tim Berners-Lee from the CERN institute in Switzerland developed a project conceived as a scientific exchange medium, called World Wide Web (WWW), he could not have imagined that this seemingly small project would become so popular around the world. Initially, the web was based on a one-way display of information, and it was only later that the first Line Mode Browser was designed [10]. In 1993, Marc Andreessen presented the first graphical Web browser, Mosaic, which displayed more than ASCII text and integrated text and graphics. Mosaic was developed at NSCA (National Centre for Supercomputing Applications) at the University of Illinois in the USA.

The first version of Mosaic supported the File Transfer Protocol (FTP) and could display HTML files containing text, different format images, as well as the Postscript video format. This version could access data using Web protocols and provided users with various options, such as font selection or window size. At that time, web pages were immutable and had a simple layout, which made it difficult for creators to update them over specific intervals with new information. Given that HTML was the only web page coding language, pages were designed for functional communication and their role was to display information to the user. Later, modern dial-up models were designed to maximise reading time and accelerate data transmission, i.e. the web applied the client-server model displayed in figure 3 [10].

The model is called client–server because of the interaction between the client and the server in which the client asks the server to perform a service which the server offers. After receiving the request from the client, the server processes it and sends a response. Once the response arrives, the client can continue working [10]. After a while, nearly all users could successfully and efficiently identify how to locate information in different places. Earlier browser versions displayed no content until a page was fully loaded. However, in 1994, the founder of Silicon Graphics, Jim Clark, together with Marc Andreessen, created Mosaic Communications, later named Netscape Communications, which allowed pages to be loaded on-the-fly). This allowed for partial content to be loaded while the page itself was not fully loaded [10].

Netscape Communications provided users with the possibility to read content while loading the page. In addition, it included support for standards such as JavaScript and Cookies. JavaScript is a programming language used for defining web page functionalities on the client's side, while Cookies are small text files received from the server for identification purposes. The innovative Netscape was dominant until Microsoft created Internet Explorer, whose evolution up to version 6.0 enabled it to practically conquer the market [10].

Later, just like the Internet Explorer replaced Netscape, the next big browser, Mozilla Firefox, replaced the Internet Explorer and became one of the leading and most popular browsers on account of its quality [10].

In addition to these, some of which are still very popular today, other browsers were developed, such as Safari for the Macintosh platform, Opera, and later Google Chrome. Today, the state of web clients is such that developers can develop sections of the client part of distributed applications, and use existing functionalities for other parts [10].

4. Information technology use as a prerequisite for the development of the economy and society

Internet development has several stages, all of which can be grouped into the following four phases. The first stage began in 1991 and was mostly dominated by science, i.e. a combination of scientists and engineers who worked on the development of digital transformation. One of the most important features in this period is the IETF (Internet Engineering Task Force), which provided standards for Internet use. In other words, anyone who wanted to use the Internet could do so using the RFC (Request for Comments) document, which described different methods and standards. Also, one of the important elements that marked this stage is NSFNet (Backbone) and thousands of university (campus) networks that enabled scholars to use the Internet [8].

The second developmental phase was the period from 1992 until 1997, when the academic world was already making extensive use of the Internet. In this stage, FNC (Federal Networking Council) allowed new companies known as ISPs (Internet Service Providers) to interconnect. However, the most important feature of this stage and the most significant achievement to this day is the emergence of the World Wide Web. This stage saw the development of browsers, which now allowed apps to be displayed on the entire screen, as well as the development of hardware, which allowed smaller organisations to use computers due to a decrease in price and the significant expansion of the product. Perhaps the biggest achievement of the second stage was the fact that computers were now increasingly used at home, where modems reached a speed of up to 56 kbit/s. In other words, customers moved from a static web content search to being dynamic participants in web content creation [8].

The third stage (1998–2005) is the period in which the Internet finally expanded internationally. The features of this phase were advancement in web technology and app development, significant search engine enhancement, as well as the possibility to interact online using Flash and JavaScript technology. In addition to international expansion, this improvement also enabled users to share data and video services on a single network technology [8].

In the fourth stage, the Internet became a global "network of all networks". This phase, which began in 2006, was characterised by the emergence of the 100-Gbit transmission using Dense Wave Division Multiplexing, the Voice over Internet Protocol which enables telephone communication over the Internet, Internet use via mobile phones and other portable devices, Internet Television Protocol (IPTV), i.e. broadband transmission of digital TV signal through IP structure. Consequently, in the fourth phase, the Internet officially became a global network, while certain features became an integral part of everyday life in almost every household [8].

4.1. Web 1.0 – e-business

The key interest areas are [3,4]:

- protocols, HTTP;
- open, standardised markup languages HTML and XML;
- the first search engines;
- software platforms and web app development tools;
- web programming languages, such as Java and JavaScript;
- website development;
- web commercialisation and development of web business models.

Protocols, HTTP

HTTP (**Hypertext Transfer Protocol**) is a network protocol that is the main and most frequent information transmission method on the web. HTTP is a client–server protocol whereby the client sends requests which the server processes and sends back a response. Its main purpose is to deliver an HTML document, i.e. webpage.

The HTTP server *listens to* requests on a port (usually port 80) in order to provide the required response. Once the server has provided the response, the connection is interrupted until the next request [5,6].

HTML and XML markup languages

HTML (Hypertext Markup Language) is a markup language for defining web pages. Its main features are metadata which are clearly separated from document content. We can use it to divide text units, such as headings, paragraphs, quotes, and also to see the standards that describe a document, i.e. key words, information about the author, etc. XML is short for Extensible Markup Language, whose format can be adjusted to different areas, such as electronic data exchange, data storage, voice mail, and the development of new markup languages [9].

The first search engines

Archie, an FTP archive indexing tool, was considered to be the first search engine, which facilitated file identification. It was created in 1990 when Alan Emtage searched for names of files and titles, without indexing the content. Then he came up with the idea to collect information about the structure of files by accessing public FTPs (File Transfer Protocol). As a result of his work, there was no longer the need to manually browse FTPs; instead, users could type in a file name in Archie and receive a list of all FTPs with the requested file. The next search engine was Google, which was based on analysing the relations between websites. It yielded better results compared to other technologies which ranked results based on how many times the searched item appeared on the page. Google introduced a search based on user traffic. In other words, the more visits a page has, the better it ranks, i.e. Google places it at the top of the search results page. This search engine quickly attracted many users on account of its functionality and design [11].

4.2. Web 2.0 – including end users in service creation

The switch from static HTML web pages to a more dynamic and better organised web came with the second generation of the World Wide Web, Web 2.0, which focused on the ability of people to communicate and cooperate.

Other Web 2.0 functionalities include open communication and more open information exchange. Web 2.0 comprises three development aspects:

- the technological aspect, which provides the basic infrastructure (hardware and software). In addition, it includes service-oriented architecture (SOA), such as RSS feeds, CMS, web servers, and mashups;
- the application aspect, which includes Rich Internet Application (RIA), whose services resemble that of desktop apps and apps used on the Internet. Their main feature is unlimited navigation. In the future, almost all programs will be set as services on the web, thus providing components used in other apps;
- the social aspect, which entails the involvement of users and their contribution on the web. The so-called social web includes social media, tagging, Wikis, podcasting, vodcasting, blogging, etc. [3,4].

Owing to the fact that many internet companies believed they would make much higher profits because of the rapid expansion of websites, the Internet gained even greater importance from 1995 to 2001 which led to a phenomenon called **dot.com bubble**.

The dot.com bubble prompted developers and engineers to enhance web pages and introduce various additional features. Subsequently, a system for targeted advertising called AdWords was set up, which enabled a return to the Internet and the web.

Using entirely new apps, the web itself started to behave like a computer, as services and apps were now also available on the Internet. This is why Web 2.0 is considered to be the new generation of web communities and servers whose single goal is to facilitate cooperation. This allows users to perform most tasks in web clients (browsers) [3,4].

4.3. Web 3.0 – Smart technology and smart business

The third generation of Internet-based services is Web 3.0, designed by John Markoff. Web 3.0 is the Intelligent Web, i.e. a combination of the semantic web, natural language processing, microformats, machine learning, etc. In other words, Web 3.0 entails reading, writing and research on the web.

Web 3.0 is a great advancement that involves turning the web into a database and creating content available from multiple apps using artificial intelligence. In fact, this term refers to different evolutions of usage and interaction on the web [3,4].

5. The development of a dimensional model for analysing ICT use in Serbia

A dimensional model has been developed for the purposes of analysing ICT use in Serbia and comparing data with that from EU countries. Dimension tables and fact tables were created in MS Excel, which were then loaded into the Power BI software. The following sources have provided data for the fact tables:

- https://www.stat.gov.rs/sr-latn/oblasti/upotreba-ikt/;
- https://stats.oecd.org/.

The first website has provided data regarding devices used in households in Serbia in the period 2011–2020, and this information refers to households that have *"a computer, internet connection, and broadband by region, income, type of settlement"*[1]; and *"individuals – computer and internet use frequency by education level, employment status, gender, age, and use"*[1].

The second website has provided data for the EU regarding households that have *"internet connection and a computer"*[2] and *"individuals aged 16–74 who have internet connection"*[2].

The fact table for Serbia contains data collected in relation to indicators, period and territory.

The dimension tables are criteria used for analysis purposes. The following dimension tables have been created using databases for Serbia and EU countries:

- Indicator (*"Household that have a computer, per region"*; *"Household that have Internet connection, by region"*; *"Households that have broadband Internet connection, by region"*; *"Individuals – computer use frequency"*; *"Individuals – Internet use frequency"*; *"Individuals – computer users (in the last 3 months, by age"*; *"Individuals – Internet users (in the last 3 months), by age"*; *"Individuals – computer users (in the last 3 months), by education level"*; *"Individuals – Internet users (in the last 3 months), by education level"*; *"Individuals – computer users (in the last 3 months), by gender"*; *"Individuals – Internet users (in the last 3 months), by gender"*; *"Individuals – computer users (in the last 3 months), by employment status"*; *"Individuals – Internet users (in the last 3 months), by employment status"*; *"Households that have a computer, by income"*; *"Households that have Internet connection, by income"*; *"Households that have a broadband Internet connection, by income"*; *"Individuals – e-commerce, by gender"*; *"Individuals – e-commerce"*; *"Devices used in households"*); [1]
- Territory (REPUBLIC OF SERBIA; regions: Belgrade, Vojvodina, Šumadija and Western Serbia, Southern and Eastern Serbia);
- Years (2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020);
- Indicator – category (up to €300, €300–600, over €600, has never used, in the last 3 months, more than 3 months ago (less than 1 year), more than a year ago, no education and primary education, secondary and higher education, employed, unemployed, student, others, male, female, 16–24, 25–34, 35–44, 45–54, 55–64, 65–74, TV, mobile phone, personal computer (PC), cable TV, laptop);
- Countries in Europe (Austria, Belgium, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, the Netherlands, Norway, Poland, Portugal, Slovakia,

Slovenia, Spain, Sweden, Switzerland, Hungary, Turkey, the United Kingdom).

The Indicator and Indicator – category tables are linked, as are the Year and Countries in Europe tables. The next step was to create a fact table. The fact table procedure is as follows:

- Data collected for Serbia. The table is then modified, and a new column is added – *"Territory"*. [1]
- This table contains data for *"Households that have a computer, Internet connection and broadband Internet connection, by region"*.

Subsequently, another fact table was created with new columns: Indicator - category and ID-SDI, which indicates that the dimensional data model is the constellation type model. This means that some dimensions are common to different fact tables.

In order to create the dimensional data model, the abovementioned dimension tables and fact tables were loaded into the Power BI software. The Power BI software is a collection of software services, applications, and connectors that work together to turn unconnected data sources into coherent ones. The data can be Excel spreadsheets or a collection of cloud-based data warehouses. Power BI facilitates visualisation and connection with data sources.

The data were prepared in MS – Excel and then loaded into Power BI. The next step was to create the dimensional model in Power BI. This dimensional model was used to analyse ICT use in Serbia and compare data with EU countries (figure 1).

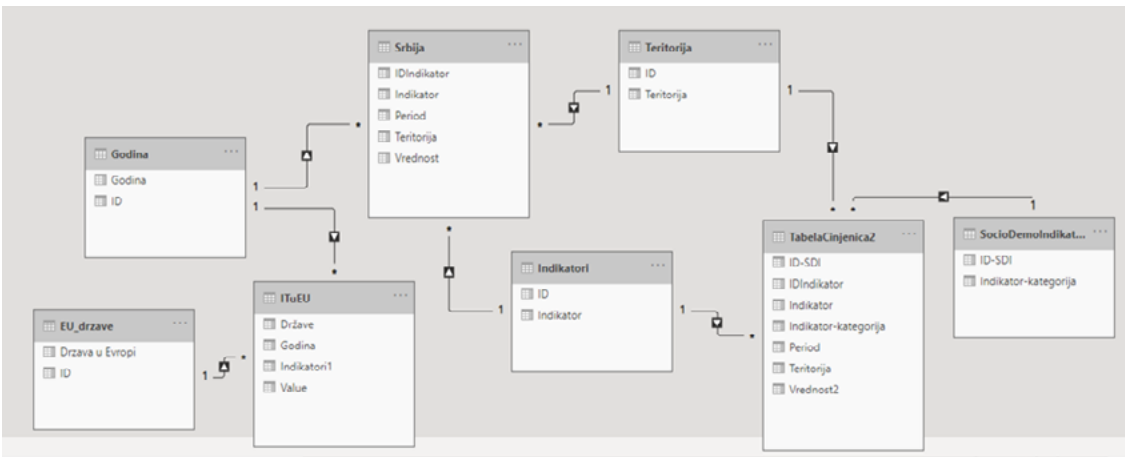

Figure 1. Fact constellation schema [12]

In order to analyse ICT use in Serbia, an analysis was done based on the dimensional model. The analysis refers to the use of computers, the Internet and a broadband Internet connection by households and individuals by region, income, education level, age, employment status, gender and use. The subsequent analysis compared Serbia with EU countries in relation to their indicators.

Figure 2 shows the percentage of households in Serbia that have a computer. In 2011, the percentage was 52.1%, while in 2020 it increased to 74.3%.

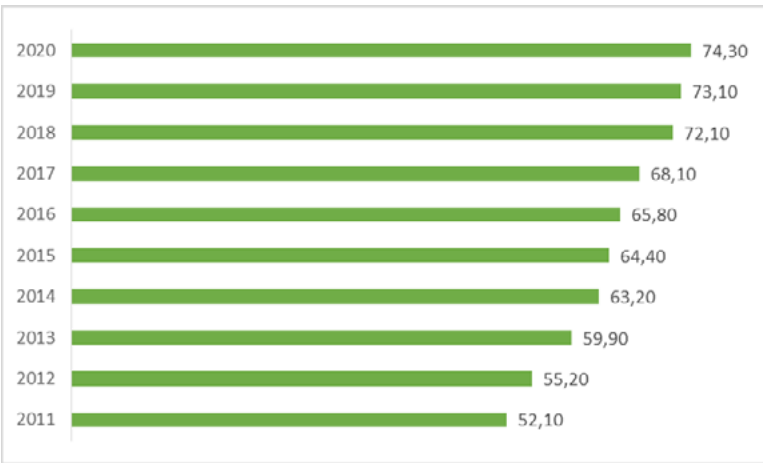

Figure 2. Serbia – households with a computer (%)

A significant increase has also been noted in relation to the number of Internet connections. In 2011, the number of households with an Internet connection was 39%, compared to 81% in 2020 (figure 3).

Figure 3. Serbia – Internet connection (%)

For comparison purposes, the following two figures show a trend in ICT use in two consecutive years, 2019 and 2020. The analysis results illustrate the number of households with a computer by income in 2019 and 2020 in Serbia, in percentage given in figure 4.

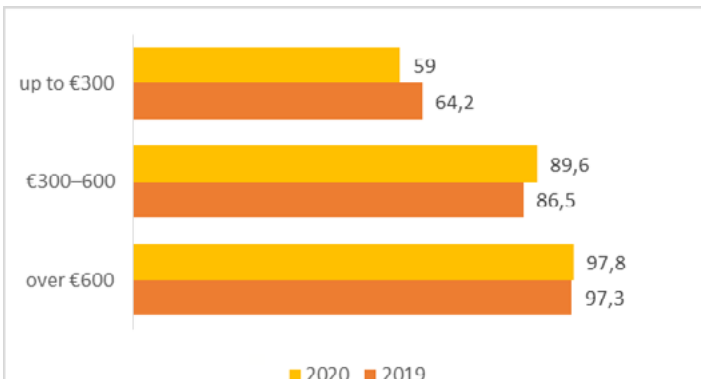

Figure 4. Households with a computer by income

Figure 5 shows analysis results regarding the number of households with an Internet connection by income in 2019 and 2020 in Serbia.

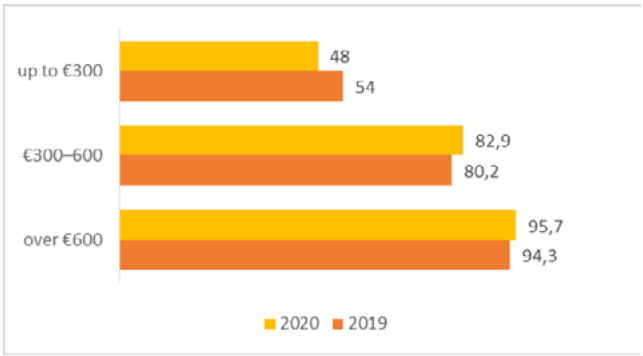

Figure 5. Households with an Internet connection by income

Figure 6 illustrates computer users by education level, with a clear decrease trend.

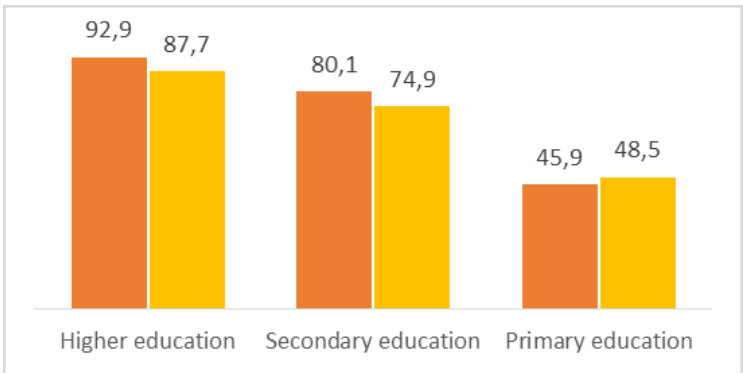

Figure 6. Individual computer and Internet users by education level

The diagram in figure 7 shows households with an Internet connection in EU countries in 2020.

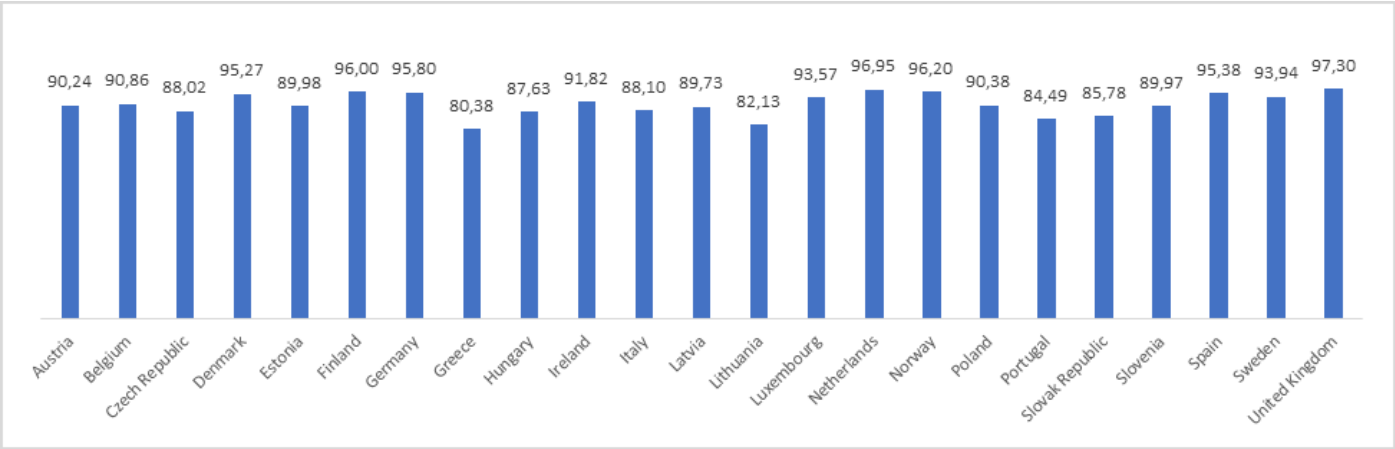

Figure 7. EU countries – households with an Internet connection in 2020

The diagram in the previous figure shows that the percentage of households with an Internet connection in EU countries ranges from 80.38% in Greece to 97.30% in the United Kingdom.

6. Conclusion

This paper presents an analysis of the use of information and communication technology in Serbia, observed from the aspect of households and individuals that have a computer and Internet connection. The analyses indicate a rising trend in ICT use in Serbia, by both households and individuals. In 2011, the percentage of households with a computer was 52.1%, compared to 74.3% in 2020. Also, the percentage of households with an Internet connection was 41.2% in 2011, compared to 81% in 2020.

In addition, the presented analyses show that Serbia is not lagging behind EU countries when it comes to the use of information and communication technology.

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Primena mobilnog bankarstva u savremenom bankarskom poslovanju

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Sažetak: Razvoj mobilnog bankarstva desio se usled uvećanja tržišta mobilnih telefona, kao i zbog naglog razvoja interneta i elektronske trgovine. Kako bi mobilno poslovanje dobro funkcionisalo, potrebna je dobra saradnja banaka sa mobilnim operaterima, kao i dobra softverska podrška za različite usluge. Danas skoro sve banke pružaju svojim korisnicima opciju mobilnog bankarstva. U početku su klijenti mogli da vide samo stanje računa, a danas mogu da izvrše transakcije i obave kupovinu. Mobilno bankarstvo se može opisati kao najnoviji kanal u elektronskom bankarstvu, koji će obezbediti pogodan način izvođenja bankarskih transakcija korišćenjem mobilnih telefona ili drugih mobilnih uređaja. Potencijal za mobilno bankarstvo može biti daleko veći nego što je to slučaj sa bankarstvom putem računara, jer postoji nekoliko puta više korisnika mobilnih telefona nego korisnika računara. Danas klijenti mogu da izvrše mnoge druge transakcije koje se odnose na njihove platne kartice, tekuće i devizne račune i kredite.

Ključne reči: internet bankarstvo, mobilno bankarstvo, sigurnost i zaštita podataka, e-Commerce

1. Uvod

Elektronski sistemi se svuda u svetu, pa i u našoj zemlji, ubrzano razvijaju. Mnoge kompanije, i to ne samo veliki multinacionalni sistemi već i manje kompanije i banke, zainteresovane su za uvođenje elektronskih sistema u svoje poslovanje kako bi lakše komunicirale sa klijentima, lakše i brže obavljale svoje poslovanje i kako bi uspele da dopru do onih klijenata koji nisu u stanju da dođu do njih ili ne žele to.

Mnogi stručnjaci i analitičari ističu značaj elektronskog poslovanja za ekonomiju jedne zemlje, a takva vrsta poslovanja donosi beneficije i korisnicima, kao i kompanijama i bankama. Jedna savremena banka ne može zamisliti svoje poslovanje bez odgovarajuće elektronske podrške.

Kao deo elektronskog poslovanja, elektronsko bankarstvo predstavlja kompleksan pojam koji zahteva rad mnogih analitičara i konstantno usavršavanje. Upravo navedeno jeste razlog zbog kojeg postoji mnogo radova i istraživanja na ovu temu.

Internet je relativno nov kanal kada je reč o obavljanju bankarskih usluga. Njegova ranija forma, koja je bila poznata kao *online banking usluge* i koja je zahtevala kompjuter, modem i softver koji je obezbeđivao dobavljač finansijskih usluga, bila je predstavljena ranih 80-ih godina prošlog veka. Ipak, ova forma nije bila široko prihvaćena i većina inicijativa nije imala kontinuitet. Sa bržim rastom drugih tipova elektronskih usluga od sredine 90-ih godina prošlog veka, banke su pokazale veću zainteresovanost za elektronsko poslovanje.

U novije vreme dolazi do razvoja mobilnog bankarstva kao grane savremenog bankarskog poslovanja. Mobilno bankarstvo je usluga koju pruža banka ili druga finansijska institucija koja svojim korisnicima omogućava da na daljinu vrše finansijske transakcije koristeći mobilni uređaj kao što je pametni telefon ili tablet. Za razliku od srodnog internet bankarstva, banka ili druga finansijska institucija koristi softver koji se obično naziva aplikacija i koji banka ili finansijska institucija obezbeđuje u tu svrhu. Mobilno bankarstvo je obično dostupno 24 časa. Neke finansijske institucije imaju vremenska ograničenja u pogledu pristupa računu putem mobilnog bankarstva, kao i ograničenja koja se tiču iznosa u okviru transakcije.

Mobilni telefoni, odnosno pametni telefoni i njihove aplikacije poslednjih godina se koriste sve više u elektronskom poslovanju. Pomoću telefona se u današnje vreme može imati stalan uvid u stanje računa u banci, mogu se izvršiti bankarske transakcije, ali i obaviti kupovina robe i usluga [1].

2. Mobilno bankarstvo – najnoviji kanal bankarskih usluga

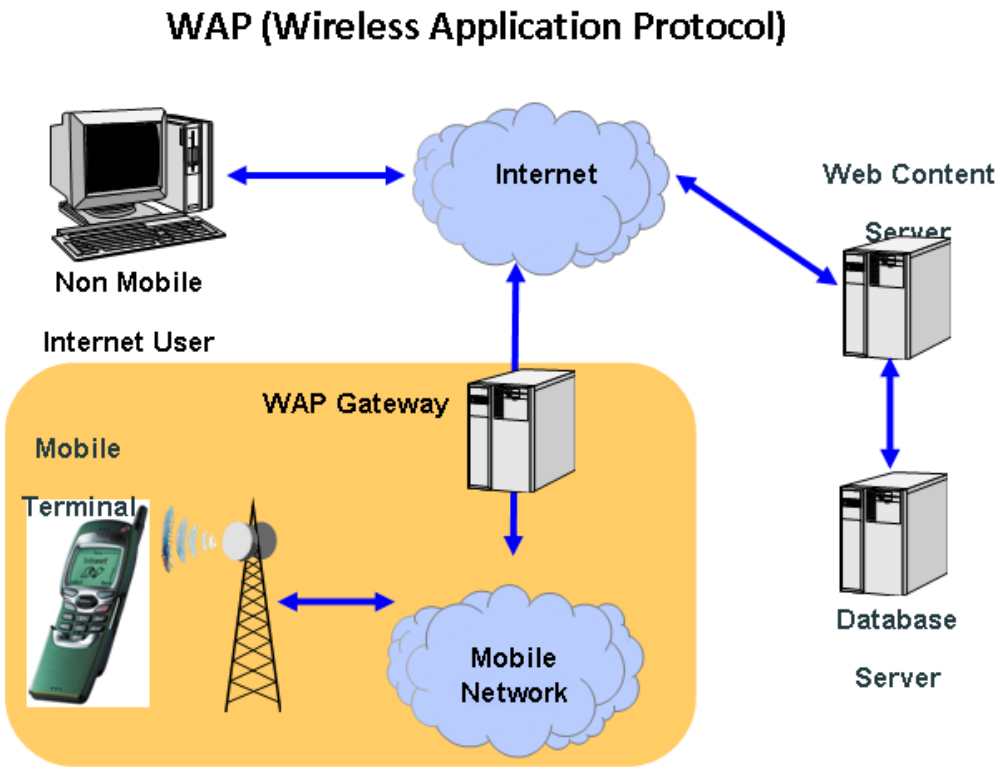
Bankarstvo je veoma važan sektor u našoj ekonomiji, koji je u poslednjih nekoliko godina bio značajno pogođen svim tipovima e-tehnologija. Bankarska industrija je shvatila da su neke od najvažnijih e-inovacija bile izvor komparativne prednosti i da su ih i ona i potrošači uzimali zdravo za gotovo. Na primer, u mnogim industrijalizovanim zemljama veb-bankarstvo je sada neophodno i predstavlja minimum kako bi banka preuzela nove klijente. Stoga će u budućnosti banke morati da istražuju, usvajaju i prihvataju različite tipove tehnologija kako bi ostale konkurentne. Mnoge od tih tehnologija će imati mobilnu komponentu: mobilno bankarstvo, mobilno plaćanje i onlajn-trgovina [2].

Neke banke dosta ulažu u mobilne sisteme kako bi povećale poslovne vrednosti i efikasnost, smanjile troškove i povećale kvalitet pružanja usluga korisnicima. Faktor koji je doprineo ovom razvoju bila je uvećana dostupnost i kapacitet

mobilne komunikacije širom sveta. Broj tipova mobilnih uređaja raste u funkcionalnom smislu. Smanjenje troškova slanja podataka i smanjenje troškova koji se odnose na uređaje prouzrokovali su razvoj mobilnih tehnologija i doveli do njihovog razvoja na svetskom mobilnom tržištu. U onim zemljama gde tradicionalna telekomunikaciona infrastruktura nije dobro razvijena mobilne tehnologije se transformišu u servise koji su bazirani na internetu.

Postoje dva glavna tipa tehnologija dostupnih za upotrebu u mobilnom bankarstvu:

- bežični protokol aplikacija (WAP protokol);
- bežični internet izlaz (WIG).



Slika 1. WAP bankarstvo, adaptirano prema [3]

WIG je servis baziran na SMS-u, gde je meni dostupnih bankarskih opcija prekopiran iz banke na telefonski uređaj. Ovo omogućuje korisnicima da obavljaju određene bankarske transakcije. Mobilno bankarstvo je u velikoj meri prihvaćeno u skoro svim zemljama. Međutim, postoji niz faktora koji dovode do manjeg korišćenja mobilnih tehnologija, a to su:

- Troškovi internet konekcije: Iako troškovi konekcije na mobilnim telefonima nisu veliki, u mnogim zemljama oni su za neke korisnike i dalje visoki, što smanjuje broj onih koji koriste mobilne tehnologije za mnoge aplikacije koje se tiču elektronskog bankarstva.

- Složen korisnički interfejs: Ljudski kompjuterski interfejs (HCI) ključan je faktor za prihvatanje mobilnih tehnologija. On uključuje korišćenje i kontekst kompjutera, ljudske karakteristike, kompjuterske sisteme i arhitekturu interfejsa, kao i proces razvoja [3]. Generalno pravilo glasi: što je lakši interfejs za usvajanje, veći je i broj korisnika.

- Nedostatak svesnosti među korisnicima: Mnogi bankarski korisnici nisu čak ni svesni mogućnosti koje pruža dostupnost mobilnog bankarstva, odnosno beneficija koje donosi mobilno bankarstvo. Kao i sa drugim tehnologijama, svesnost raste sa vremenom i potrebni su značajni napori kada je reč o promociji beneficija [4].

- Ograničenja u vezi sa funkcionalnostima mobilnih uređaja: Mobilne tehnologije imaju određena ograničenja, kao što su ograničeno trajanje baterije, nepouzdano konektovanje na mrežu, promenljive pristupne tačke, rizik koji se odnosi na gubljenje podataka i dr. Donedavno su čak i u razvijenom svetu bežične komunikacije mogućnosti bile vrlo ograničene kada je reč o funkcionalnostima uređaja i brzini komunikacije. Ograničenja kao što su veličina ekrana i memorije, mogućnosti za skladištenje, kao i cena prenosa podataka, utiču na količinu podataka koji mogu biti prikazani i kojima se može pristupiti. U mnogim zemljama ova ograničenja i dalje predstavljaju jednu od najvećih barijera za usvajanje mobilnih tehnologija.

- Pitanje dostupnosti: Brz javni pristup internetu nudi mogućnost da se dobije konekcija, kao i da korisnici ostanu povezani sa više lokacija. Hoteli čiji su klijenti poslovni ljudi danas u sobama uglavnom nude brz pristup internetu. Kako se ove pristupne mreže velikih brzina pojačavaju, mobilnim aplikacijama raste popularnost [5]. Verovatno će biti potrebno nekoliko godina da se dostigne cilj poznat kao „uvek povezan". Internet povezivanje u područjima sa manjom gustinom naseljenosti tada će zaostajati za visokorazvijenim tehnološkim koridorima.

- Bezbednosni problemi: Mobilna tehnologija i dalje ne pruža sigurnost, tako da ne može biti pogodna za prenos visoko poverljivih finansijskih podataka. Mobilni uređaji su sve češće meta virusa, hakera i kratkih SMS-ova. Prekid usluge i krađa podataka mogu izazvati mnoge probleme potrošačima, uključujući i izgubljene prihode i nezadovoljstvo korisnika kada su u pitanju mobilni operateri. Međutim, najveći gubitak trpe banke koje nude opciju mobilnog bankarstva. Iz tog razloga mnoge banke nemaju opciju mobilnog bankarstva. Da bi bila uspešna u mobilnom bankarstvu, industrija mora da razvije sposobnost efikasnog rešavanja problema koji se tiču malvera [6].

- Organizacione promene: Kako bi ponudile mobilno bankarstvo, mnoge organizacije će morati da menjaju svoje poslovne procese, način na koji pružaju informacije, mogućnost pristupa informacijama, radne prakse i radne odnose, radni stil i, najvažnije od svega, moraju se desiti promene i kada je reč o ulogama, odgovornostima i upravljačkoj strukturi.

- Broj opcija: Postoji veliki broj opcija kada je u pitanju pružanje usluga mobilnog bankarstva. Banke mogu potrošiti velike iznose novca na kupovinu hardvera, softvera i mreža, a da ne iskoriste u potpunosti njihov potencijal. Međutim, važno je zapamtiti da troškovi tehnologije čine samo mali deo mogućih ukupnih troškova. Po pravilu, ovi troškovi čine 30% tipičnog mobilnog projekta, preostalih 70% uključuje stavke kao što su obuke, održavanje, sigurnost, upravljanje i integracija. Ovo podrazumeva da stvarni troškovi mobilnog bankarstva mogu biti znatno veći od obećane uštede [4].

- Tehnologija kao teret/prepreka: Širenje ličnih uređaja poput kompjutera, mobilnih telefona i digitalnih organizatora, ali i razvoj novih medija kao što su imejl i World Wide Web – WWW, zauvek je promenilo način na koji se potrošači informišu i na koji im se pruža zabava. Ovako isparčani kanali za informisanje dovode do toga da korisnici prelaze sa jednog na drugi uređaj na neefikasan način, kao što je slučaj sa različitim medijima namenjenim za svakodnevnu upotrebu, npr. e-bankarstvo [7].

Kako bi se promovisalo usvajanje mobilnog bankarstva, korisnici treba da budu svesni prednosti koje mobilno bankarstvo nudi u odnosu na druge kanale. Kupci bi trebalo da isprobaju mobilno bankarstvo ili da im se demonstrira njegova upotreba, možda u filijalama ili preko elektronskih medija. To bi podiglo njihovu svest, te bi ljudi mogli bolje da razumeju opcije mobilnog bankarstva. Pored toga, usluge koje se nude treba da se prikažu ciljnom tržištu – mladim ljudima koji žele da usvajaju inovativne usluge. Nove verzije WAP-a koriste šifrovani digitalni potpis za poboljšanje bezbednosti. Funkcionalnost i korisnički interfejs na mobilnim uređajima poboljšavaju se sve vreme, dok se troškovi internet povezivanja u razvijenom svetu smanjuju. Ovi znači da su šanse za usvajanje mobilnog bankarstva veće nego ikada pre.

3. Lepeza usluga mobilnog bankarstva

Mobilno bankarstvo je usluga koju pruža banka ili druga finansijska institucija. One svojim korisnicima omogućavaju da na daljinu vrše finansijske transakcije koristeći mobilni uređaj kao što je pametni telefon ili tablet. Za razliku od internet bankarstva, one koriste softver. Obično je u pitanju aplikacija koju banka ili finansijska institucija koristi u tu svrhu. Mobilno bankarstvo je obično dostupno 24 časa. Neke finansijske institucije imaju ograničenja u pogledu dostupnosti računa kojima se može pristupiti putem mobilnog bankarstva, kao i ograničenja u vezi sa iznosom transakcije.

Transakcije putem mobilnog bankarstva mogu uključivati uvid u stanje računa i listing najnovijih transakcija, elektronsko plaćanje računa i transfer sredstava između računa klijenata ili drugih subjekata. Neke aplikacije omogućavaju preuzimanje kopija izvoda, a ponekad i njihovo štampanje, dok pojedine banke naplaćuju naknadu za slanje bankarskih izvoda poštom.

Sa stanovišta banke, mobilno bankarstvo smanjuje troškove transakcija time što umanjuje potrebu kupaca da dolaze u filijalu banke za bezgotovinske transakcije povlačenja sredstava i njihovog deponovanja. Mobilno bankarstvo ne uključuje transakcije koje podrazumevaju gotovinu, na primer kada klijent treba da poseti banku ili ATM aparat za podizanje gotovine ili depozita. Mnoge aplikacije imaju opciju za podizanje depozita na daljinu, jer koriste kameru za digitalni prenos čekova / digitalno plaćanje računa finansijskoj instituciji kod koje klijent ima račun.

Mobilno bankarstvo se razlikuje od plaćanja mobilnim uređajima, koje podrazumeva upotrebu mobilnog uređaja za plaćanje roba ili usluga bilo na prodajnom mestu ili na daljinu, što je analogno korišćenju debitne ili kreditne kartice radi izvršavanja EFTPOS plaćanja [8].

Najranije usluge mobilnog bankarstva podrazumevale su SMS, uslugu poznatu kao SMS bankarstvo. Uz uvođenje pametnih telefona sa VAP podrškom, koja omogućava korišćenje mobilnog veba, 1999. godine, prve evropske banke su svojim korisnicima počele da nude mobilno bankarstvo na ovoj platformi [5]. Mobilno bankarstvo pre 2010. godine najčešće se obavljalo putem SMS-a ili mobilnog veba. Prvi *Appleov* uspeh sa ajfonom i brz razvoj telefona zasnovanih na *Googleovom* Android operativnom sistemu doveli su do povećane upotrebe posebnih mobilnih aplikacija koje se preuzimaju na mobilni uređaj. Stoga je razvoj internet tehnologija kao što su HTML5, CSS3 i JavaScript podstakao mnoge banke da počnu sa korišćenjem usluga mobilnih mreža uz dodatne aplikacije / u kombinaciji sa dodatnim aplikacijama. Studija iz 2012. godine koju je sproveo Google Maps ukazuje na to da preko jedne trećine banaka ima prikaz mobilnih uređaja prilikom prve posete veb-strane banke [7]. Na ovoj ikonici moguće je izvršiti nekoliko stvari – preusmeravanje na prodavnicu aplikacija, preusmeravanje na određenu veb-lokaciju za mobilno bankarstvo ili pružanje menija sa opcijama mobilnog bankarstva koje korisnik može izabrati.

Mobilno bankarstvo se odnosi na pružanje i korišćenje bankarskih i finansijskih usluga pomoću mobilnih telekomunikacionih uređaja. Obim ponuđenih usluga može uključivati mogućnosti za obavljanje transakcija u bankama

i na berzama, administriranje računa i pristup prilagođenim informacijama.

Prema ovom modelu, mobilno bankarstvo se sastoji od tri međusobno povezana koncepta:

- mobilno računovodstvo;
- mobilno posredništvo;
- mobilne finansijske informativne usluge.

Većina usluga koje se nude kroz računovodstvo i brokerstvo u vezi su sa transakcijama. Informacioni servisi ne obrađuju transakcije, ali su od presudnog značaja za završavanje transakcija. Na primer, pre nego što se završi transakcija, mora se pogledati izvod iz računa. Većina usluga u kategorijama određenih knjigovodstvenih i brokerskih poslova zasnovana je na transakcijama. Zbog toga su računovodstvene i brokerske usluge uvek u ponudi u kombinaciji sa informacionim servisima. S druge strane, informativne usluge mogu biti u ponudi kao nezavisan modul.

Mobilno bankarstvo se može koristiti i kao pomoćno sredstvo u poslovnim i finansijskim situacijama.

Uobičajene opcije mobilnog bankarstva su [1]: informacije o nalogu; mini-izjave i provera izvoda računa; upozorenja o aktivnostima na računu ili informacije o postavljenim ograničenjima; monitoring oročenih depozita; pristup kreditnim izvodima; pristup izjavama u vezi sa karticama; izveštaji o uzajamnim fondovima/akcijama; upravljanje politikom osiguranja; transakcije; prenos sredstava između povezanih računa klijenta; plaćanje trećih strana, uključujući plaćanje računa i transfer sredstava trećih strana (npr. FAST); provera udaljenog depozita; investicije; usluge upravljanja portfeljem; grejs period; podrška; status zahteva za kredit, uključujući hipotekarno odobrenje i osiguranje; provera knjige i zahteva za kartice; razmena poruka, mejlova, žalbi, nadzor; informacije o lokacijama bankomata; opšte informacije poput vremenske zone i novosti; ponude u vezi sa lojalnošću; usluge na određenim lokacijama.

Izveštaj američkih Federalnih rezervi iz 2012. godine utvrdio je da je 21% vlasnika mobilnih telefona koristilo mobilno bankarstvo tokom perioda od 12 meseci [2]. Na osnovu ankete koju je sprovela kompanija *Forrester*, za mobilno bankarstvo su uglavnom zainteresovani mladi kupci. Jedna trećina korisnika mobilnih telefona kaže da bi razmislila o obavljanju neke vrste finansijske transakcije putem svog mobilnog telefona. Međutim, većina korisnika zainteresovana je za obavljanje osnovnih transakcija, kao što su upiti za stanje na računu i pravljenje računa.

Sa pojavom novih tehnologija i većom upotrebom pametnih telefona i tablet računara, funkcionalnosti mobilnog bankarstva bi bankama / finansijskim institucijama omogućile da se povežu sa celokupnim životnim ciklusom potrošača mnogo brže nego ranije.

Obogaćivanje funkcionalnosti podrazumeva:

- obogaćivanje komunikacije: video-interakcija sa agentima, savetnicima;
- mogućnosti za pervazivne transakcije: sveobuhvatni „mobilni novčanik";
- obrazovanje kupaca: „test drive" za demo bankarske usluge;
- povezivanje sa novim kupcima;
- povezivanje generacije Y i generacije Z kroz upotrebu društvenih mreža tokom reklamiranja banaka;
- unovčavanje sadržaja: mikronivoi prihoda putem tema kao što su muzika i e-knjige;
- vertikalno pozicioniranje: pozicioniranje ponude u specifičnim industrijama mobilnog bankarstva;
- horizontalno pozicioniranje: pozicioniranje ponude preko mobilnog bankarstva u svim industrijama;
- personalizovane korporativne bankarske usluge: iskustva sa personalizovanim korporativnim bankarstvom na osnovu trenutnog pomaka / trenutnog napretka i konteksta;
- izgradnja brenda: izgradnja brenda banke uz poboljšanje „mobilnih nekretnina".

Virtuelna banka nudi neke ili sve vrste računa i usluga koje tradicionalne fizičke banke nude, ali virtuelne banke postoje samo na mreži. One obično naplaćuju niže naknade i plaćaju veće kamate zbog niskih troškova.

Virtuelne bankarske transakcije mogu se proveriti u realnom vremenu, u trenutku dešavanja transakcije, a ne na kraju bankarskog dana ili na kraju meseca. Te usluge mogu biti dostupne i preko onlajn-filijala tradicionalnih banaka. Virtuelne banke nemaju filijale ili sopstvene bankomate, tako da se transakcije u vezi sa depozitom vrše elektronskim putem ili poštom. Virtuelna banka može nadoknaditi proviziju za korišćenje bankomata drugih banaka. Međutim, može postojati ograničenje koje se odnosi na broj transakcija koje virtuelna banka pokriva svakog meseca [16].

Onlajn-bankarstvo, poznato i kao internet bankarstvo, predstavlja elektronski sistem plaćanja koji korisnicima banke ili drugih finansijskih institucija omogućava da sprovedu niz finansijskih transakcija putem sajta finansijske institucije. Sistem onlajn-bankarstva obično je deo osnovnog bankarskog sistema kojim upravlja banka ili se povezuje s njim, a u suprotnosti je sa fizičkim bankama, kojima korisnici za vršenje bankarskih usluga tradicionalno pristupaju.

Da bi pristupio bankarskom objektu finansijske institucije, klijent sa pristupom internetu mora da se registruje kod ustanove za uslugu i da podesi lozinku i druge akreditive za verifikaciju. Mogućnosti onlajn-bankarstva obično nisu iste kao kod telefonskog ili mobilnog bankarstva. Finansijske institucije sada rutinski dodeljuju naloge, bez obzira na to da li su korisnici naznačili da imaju nameru da pristupe svojim onlajn bankarskim objektima. Brojevi kupaca obično nisu isti kao brojevi računa, jer se broj računa kupca može povezati sa jednim klijentskim brojem. Tehnički, broj kupca može se povezati sa bilo kojim računom u finansijskoj instituciji koju korisnik kontroliše, iako finansijska institucija može ograničiti opseg računa kojima se može pristupiti, među kojima su, recimo, ček, štednja, kredit, kreditna kartica i slični računi [9].

Korisnik posećuje sigurnu veb-stranicu finansijske institucije i ulazi u onlajn bankarski objekat koristeći broj kupca i prethodno uspostavljene akreditive. Finansijske institucije određuju vrste finansijskih transakcija koje klijent može izvršiti putem onlajn-bankarstva, ali obično su u to uključeni dobijanje računa, lista nedavnih transakcija, plaćanje elektronskog računa i transfer sredstava između računa klijenta ili nekog drugog subjekta. Većina banaka takođe omogućava klijentu da preuzima kopije bankovnih izjava, koje se mogu štampati u prostorijama kupca (neke banke naplaćuju naknadu za slanje kopija bankovnih izjava). Neke banke omogućavaju korisnicima i da direktno prenose transakcije u računovodstveni

softver kupca. Objekat takođe može omogućiti klijentu da naruči ček, izjave, da prijavi gubitak kreditnih kartica, da zaustavi plaćanje na čeku, da da informacije o promeni adrese i da obavi ostale rutinske radnje.

Danas mnoge bankarske institucije koriste samo internet. Ove „virtuelne banke" imaju niže režijske troškove nego njihove kolege koje posluju u fizički postojećoj banci. U Sjedinjenim Američkim Državama postoje mnoge onlajn-banke koje su osigurane od strane Federalne korporacije za osiguranje depozita (FDIC) i mogu ponuditi isti nivo zaštite za potrošačka sredstva kao tradicionalne banke [10].

U Srbiji su poslednjih godina skoro sve banke razvile usluge mobilnog bankarstva. Radi se o hibridnom distributivnom kanalu za koji je neophodna povezanost sa internetom, ali u suštini podrazumeva upotrebu pametnih telefona i tableta. Već je poznata činjenica da današnji klijenti u većoj meri koriste mobilne telefone negoli internet na svojim računarima. Zato se banke odlučuju za kreiranje aplikacija koje operativni sistemi mobilnih telefona mogu da podrže. Pomoću aplikacije korisnik može brže i jednostavnije da pristupi željenoj usluzi. Mogućnosti koje pruža ova vrsta bankarstva velikim delom se poklapaju sa internet bankarstvom, ali je ovde više reč o supstitutima, a manje o komplementarnim stvarima [11].

Najveći broj banaka u Republici Srbiji razvio je aplikacije za dva najveća mobilna operativna sistema, Android i iOS. Ipak, u ovom segmentu Telenor banka svojim klijentima pruža najnaprednije usluge. Početkom 2014. godine provajder usluga mobilne telefonije Telenor otkupio je licencu od KBC banke, koja se povukla sa tržišta Srbije. Telenor je već imao iskustva u bankarskom poslovanju, jer se na sličan potez odlučio u Pakistanu [12].

Princip rada Telenor banke je isključivo poslovanje sa stanovništvom, bez korporativnih klijenata i bez davanja dugoročnih kredita. Dakle, cilj banke je da poveća obim poslova koji se mogu izvršiti onlajn i putem mobilnog telefona. Fizičko prisustvo je neophodno jedino prilikom potpisivanja ugovora o otvaranju računa (jer sistem sertifikata nije još uvek implementiran), dok se samo otvaranje računa može izvršiti onlajn. Ovo je jedina banka gde korisnik može da bira broj računa, pa se može odabrati da osnova bude broj mobilnog telefona.

Naročito treba izdvojiti sledeće usluge (telenorbanka.rs):

1. slanje novca na imejl ili broj mobilnog telefona, pri čemu primalac po obaveštenju o prispeću sredstava navodi na koji račun želi da mu novac bude preusmeren (ako već nije klijent Telenor banke);
2. mogućnost podizanja i deponovanja dinara i evra na bankomatima;
3. prijava određenih mesečnih računa u okviru aplikacije, koja svakog meseca podseća korisnika da treba da ih plati; plaćanje se iz aplikacije obavlja samo jednim klikom bez provizije;
4. slanje novca u inostranstvo i prijem novca iz inostranstva preko mobilne aplikacije; nema potrebe za odlaskom na šalter, a novac može da se uplati ili podigne na bankomatu;
5. usluge kupovine i prodaje deviza po kursu kao u menjačnicama, bez velikih marži svojstvenih drugim bankama – obavlja se putem aplikacije;
6. onlajn promena PIN-a kartice; korisno je kada kartica nestane, a korisnik nije siguran da je ukradena i ne želi da krađu prijavi banci.

Nosioci mobilnog plaćanja u svetu su nefinansijske kompanije, najčešće iz IT sektora ili sektora maloprodaje. Slične platne aplikacije se još uvek ne primenjuju u Republici Srbiji, pa se u narednom periodu može očekivati da banke u saradnji sa maloprodajnim lancima ili telekomunikacionim kompanijama ponude ovu uslugu [13].

4. Zaključak

Mobilno bankarstvo ima veliki uticaj na poslovanje banke i ta tendencija pozitivnog uticaja raste sa razvojem elektronskih sistema i komunikacionih tehnologija. Elektronsko bankarstvo donosi povećanje produktivnosti, smanjenje troškova, privlačenje novih klijenata, a posledica toga je povećanje baze klijenata i zadovoljstva klijenata, što se pozitivno odražava na konkurentnost banke, jer je fokus na pojedinačnom klijentu. Ovo su sve pozitivni uticaji elektronskog bankarstva na poslovanje banke.

Ovaj vid bankarstva je unapredio poslovanje ne samo banaka već i poslovanje u celini. Od elektronskog bankarstva prednosti imaju ne samo pojedinci, odnosno fizička lica, već i kompanije koje žele da putem elektronskog obavljanja platnog prometa i transakcija sa poslovnim partnerima (od kojih je dosta njih sa inostranog tržišta) i uopšte poslovne komunikacije uštede troškove i učine poslovanje lakšim i pogodnijim za korisnike i partnere. Ono utiče na poboljšanje društva u celini. Korišćenje novih tehnologija u bankarstvu dovodi do opšteg opismenjavanja i većeg korišćenja sistema koji predstavljaju budućnost ne samo naše zemlje već i društva uopšte.

Sistem bankarstva zasnovan na elektronskim sistemima nije u potpunosti prihvaćen na našem tržištu. Kao i kod drugih sistema, tako su i kod bankarstva potrebni mere i vreme kako bi elektronsko bankarstvo zaživelo među korisnicima i kako bi bilo prihvaćeno u velikoj meri. Tada će korisnici shvatiti u potpunosti potencijale koje ova vrsta bankarstva nudi.

Telenor banka je napravila revoluciju u mobilnom bankarstvu u Srbiji, koja se desila 2013. godine, kada je ova kompanija kupila 100% KBC banke. Tada je kompanija Telenor ponudila građanima Srbije Telenor banku sa inovativnim i modernim mobilnim i finansijskim uslugama. Telenor banka je prva banka u regionu u kojoj je bankarstvo u potpunosti mobilno. Pomoću mobilne aplikacije Telenor banke cela banka se skladišti u mobilnom telefonu.

Eksperti predviđaju ekspanziju mobilnog bankarstva u godinama koje dolaze zbog činjenice da broj korisnika mobilnih telefona u velikoj meri prevazilazi broj korisnika interneta.

Mobilno bankarstvo u Srbiji razvija se zajedno sa razvojem modernih tehnologija i trendova u svetu i omogućava svojim korisnicima nove načine korišćenja bankarskih usluga. Ponuda na tržištu *m-Banking* usluga u Srbiji značajno se povećala. Klijenti preko mobilnih telefona mogu obaviti skoro sve poslove koji se mogu obaviti u filijali banke [14].

Podrška koja se pruža korisnicima u bankama pri korišćenju mobilnih aplikacija za bankarstvo značajno povećava njihovo zadovoljstvo i poverenje u banku koja nudi mobilne bankarske usluge.

Može se konstatovati da je m-bankarstvo tek u svojim početnim fazama razvoja u Srbiji, ali se očekuje njegova ekspanzija u budućem periodu.

Ubrzani razvoj mobilnog bankarstva je doveo do toga da se u svetu sve vrste plaćanja mogu izvršiti brzo i efikasno putem mobilnih telefona. Iskorak u ovoj vrsti plaćanja je napravio *Apple* tako što je omogućio plaćanje preko POS terminala jednostavnim postavljanjem telefona na ovaj terminal. Ovakav vid plaćanja je poznat kao *Apple Pay*. Samsung, kao njegov konkurent, brzo je uveo *Samsung Pay* [17].

Ubrzani razvoj mobilnih telefona i njihova široka upotreba naveli su mnoge delatnosti, pa i bankarski sektor, da unapređuju svoje usluge i da se prilagođavaju potrebama korisnika. Sigurno je da će se u budućnosti sa razvojem 5G mreže *m-Banking* još više usavršiti. Pravci i trendovi u mobilnom bankarstvu mogu da budu različiti, a sigurno će se najveća pažnja posvetiti otklanjanju nedostataka i povećanju sigurnosti prilikom transakcija [15].

Kako bi promovisali usvajanje mobilnog bankarstva, korisnici treba da budu svesni prednosti koje ono nudi u odnosu na druge kanale. Kupci bi trebalo da dobiju priliku da isprobaju mobilno bankarstvo ili da možda u filijalama ili preko elektronskih medija vide kako taj kanal radi. To bi podiglo svest i omogućilo ljudima da bolje razumeju opcije mobilnog bankarstva. Pored toga, usluge koje se nude treba da se prikažu ciljnom tržištu, kao što su mladi ljudi, koji lakše usvajaju inovativne usluge. Rizici, kao i kod mnogih inovacija, treba da se reše tako što će se ograničiti odgovornost kupaca i primeniti najnovije bezbednosne tehnologije. Nove verzije WAP-a koriste šifrovani digitalni potpis kako bi se poboljšala bezbednost. Funkcionalnost i korisnički interfejs na mobilnim uređajima poboljšavaju se sve vreme, dok se troškovi internet povezivanja u razvijenom svetu smanjuju. Sve ovo doprinosi tome da se mobilno bankarstvo usvaja sve više.

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The Implementation of Mobile Banking in Modern Banking Business

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Abstract: The development of mobile banking ensued after the development of the mobile phone market as well as the sudden emergence of the internet and electronic trade. In order for mobile banking to function properly, there needs to be a good collaboration between the banks and mobile phone companies, as well as a satisfactory software support for various services. Nowadays, almost all banks offer mobile banking to their customers. In the beginning, the clients had only the option of viewing their account information, while today they can complete transactions and do shopping. Mobile banking is seen as the newest means in e-banking, which will enable a suitable way of performing banking transactions by way of using the mobile phone or other mobile devices. The potential for e-banking can be a lot more feasible than by using the computer, because there are more mobile phone users than computer ones. In the beginning, clients were only able to have an insight into the balance of their accounts, and today they can perform many other transactions related to their payment cards, current and foreign currency accounts and loans. Mobile banking is the latest channel in electronic banking that will provide a convenient way to perform banking transactions using mobile phones or other mobile devices.

Key terms: : e-banking, mobile banking, safety and protection of data, e-commerce

1. Introduction

Electronic systems are developing at a fast pace everywhere in the world; including our country. Many companies, not only massive multinational systems but also smaller companies, and banks are interested in introducing electronic systems into their business organization in order to communicate with their clients more easily, to perform their business quickly and effortlessly, and in order to reach those clients who do not want or are unable to do business in person.

Many experts and analysts believe electronic business is beneficial for the economy of a country, since it is an advantage for clients, companies, and banks. A contemporary bank cannot fathom doing business without proper electronic support. E-banking, as a part of electronic business, is complex and requires the work of many analysts, which are updating and adjusting the system. This is the reason why so much research is being done and so many papers are written on this topic.

The internet is a relatively new means of doing banking. Its previous form, which was introduced in the 1980s, was known as providing "online banking services" and it required using a computer along with a modem and software supplied by the provider of financial services. Yet, this form was mainly not accepted, so that most of the initiatives regarding this service were not continued. During the mid 1990s, along with the growth of other electronic services, banks renewed their interest in electronic business operations due to rise of the Internet.

In recent decades, there is a development of mobile banking as a part of modern banking operations. Mobile banking is a service provided by the bank or some other financial institution, which enables their clients to do business via devices such as smart phones and tablets. Unlike the affined internet banking, it uses software popularly dubbed *an app*, which is given by the financial institution. Usually, mobile banking is available 24/7; although, some financial institutions have time frames within which you can access your account via a phone as well as withdrawal limits.

Mobile phones, i.e. smart phones, and their applications are used more and more in recent years. By using a phone, one can view account information at any time of the day, can perform banking transactions, and also shop for goods and other services. [1] The development of mobile banking is tightly connected to the development of the mobile phone market as well as the rise of the internet and e-shopping. An adequate cooperation of banks with mobile service providers as well as solid software support is needed in order for mobile businesses to function. Today, almost all banks offer mobile banking services to their clients. In the beginning, the clients could only view their accounts, whereas today they can perform transactions and do shopping.

2. Mobile Banking - the Newest Means of Banking Services

Banking is an important division in today's economy, which has been influenced in recent years by a variety of e-technologies. The banking industry has realized that one of the most important e-innovations was the source of comparative advantage, and that such sources were taken for granted by the consumers and the bank industry alike. For example, in many industrialized countries web banking is necessary and is a must when it comes to gaining new clients.

Therefore, in the future, banks will have to do research, accept and apply various technologies in order to stay in the game with their competitors. Many of those technologies will have a mobile component: mobile banking, mobile pay services, and online shopping [2].

Some banks are making considerable investments in mobile systems in order to bring a range of different business values from higher efficiency and lower costs to a more advanced operating efficiency as well as providing services to users in order to gain a comparative advantage. The factor that made a difference was a higher availability and capacity of mobile communications worldwide; thus, developing even more the types of mobile phones and their functionality. The decrease in the expense of sending data and the lower costs of devices have contributed to a global distribution of technologies and the rise in the global mobile market. In those countries in which the traditional telecommunications infrastructure is not well developed, mobile technologies are being transformed and available via internet.

Mobile banking can be described as the newest means in e-banking, which will provide a suitable way of performing banking transactions by using mobile phones or other mobile devices. The potential for mobile banking can be even greater than it is by using computers, because there are more mobile phone users than computer ones. There are two main technologies that are available in mobile banking:

- WAP Wireless Application Protocol
- WIG Wireless Internet Gateway

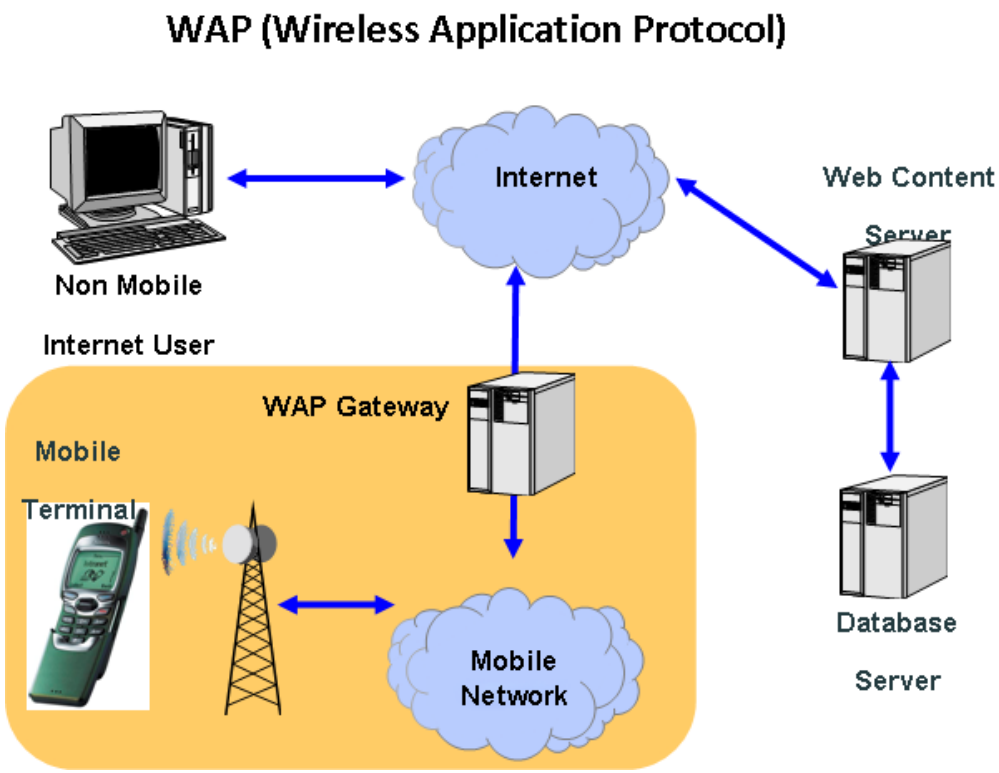

Figure 1. WAP Banking [3]

WIG service is based on SMS through which the menu of available banking options is downloaded onto the mobile device. This feature enables the users to perform certain banking transactions.

Mobile banking is accepted in almost all countries; however, there is a number of factors that contribute to a lower use of mobile technologies, and they are:

- The expenses of using the internet - Even though, some costs of connecting mobile phones are not high they are still high enough in some countries, which leads to deterring users from certain applications such as mobile banking.
- Difficult computer interface - The Human Computer Interface (HCI) is the key component for accepting mobile technologies. It includes the usage and context of computers, human traits, computer systems and the architectural interface and the process of development [3]. The general rule is that the easier it is to accept the interface, the more the users will use it.
- The lack of user awareness - Many banking users are not even aware of the possibilities that the availability of mobile banking gives or the mutual advantages that exist. As with other technologies, awareness grows with time and serious promotion is needed.[4]
- The limitations of mobile device functionality - Mobile technologies have certain limits such as battery life, unreliable web connection, varying access points, the risk of data loss and other ones. Even in developed countries, until recently, wireless communication came with limits when it came to the functionality of the device and the speed of transmitting data. The limitations such as the size of the screen, memory and data storage, and the price of data transfer all limit the amount of data that can be shown and which can be accessed. These limitations are still, in many countries, the greatest barrier when it comes to accepting mobile operations.
- Availability - Fast internet access in public places offers various possibilities of connection as well as staying connected from different locations. Nowadays, hotels make sure that business travelers have a fast internet connection in their rooms. As these networks increase, so does the number of various applications [5]. Maybe it

will take a few more years to achieve the "always connected" goal as is to stay connected in rural areas, which are currently outside the high technological paths.

- Security issues - Mobile technology still has issues with questionable security, so it is not suitable for the transfer of confidential financial data. Mobile devices are becoming more and more targets for viruses, hackers, and SMS spamming. The abruption of services and theft of data can cause serious problems for customers including loss of revenue and the lack of satisfaction with customer service. However, the greatest loss can be for the banks which provide mobile access, since in most cases fraudulent activity leads to loss of funds. Thus, this can be one of the main reasons why some banks refrain from providing mobile banking options. In order to be successful in mobile banking, the industry needs to develop the ability to withstand malware problems.
- Changes in organization - in order to offer business banking many organizations will have to change their business processes, the way they give information, the way information is accessed, work relations and practices, work ethics and most of all the changes in the roles and responsibilities of management.
- The number of choices - There are many options when it comes to providing mobile banking. One can spend anywhere from a few thousand to a few million pounds for any combination of hardware, software and network not even being aware of many of the advantages. With lower prices of mobile technologies, it is obvious that mobile work is cheap for implementation. However, it is important to remember that the price of technologies is only a portion of the possible total expenses. As a rule, these costs are only 30% of a typical mobile project, while the other 70% include training, maintenance, security, management, and integrations. These numbers imply that the real expenses of mobile work could be even greater than the promised savings [4].
- Encumbrance of technologies - The expansion of personal devices such as computers, mobile phones, and digital organizers along with the development of new media such as e-mails and the World Wide Web the ways in which consumers are informed and entertained have been forever changed. These fragmented means of informing result in inefficient ways in which users switch from one device to another as with different media that are used for everyday use such as e-banking [7].

As to promote usage, users need to be aware of the advantages which mobile banking offers in comparison to other means that are available. Customers should have the option of trying out mobile banking or seeing a demonstration of how it works at bank branches or via their devices. This would raise awareness and give people a better understanding of mobile banking options. Apart from that, the services that are offered need to be advertised to a targeted market, such as young people, who have the tendencies to accept the latest innovative services. The perceived risks, as with many innovations should be dealt with by limiting the responsibility of the customers as well as implementing the latest security technologies. The newer versions of WAP use coded digital signatures in order to better security. Functionality and the user interface on mobile devices are getting better while the expenses of internet connectivity in the developed world are costing less. These developments signify that the potential for a more global acceptance of mobile banking seem more promising than ever.

3. The Scope of Mobile Banking Services

Mobile banking is a service offered by the bank or another financial institution, which is given to its users, so that they can perform their financial transactions from a distance by using their mobile devices such as smart phones and/or tablets. Unlike connected internet banking it uses a software popularly called an App, which is provided by a specific financial institution. Mobile banking is usually available 24/7; although, some financial institutions pose some limits to accessing accounts via mobile banking as a well as setting withdrawal limits.

Transactions via mobile banking include statements and the list of recent transactions, paying bills, transferring funds from one account to another, and so on. Some applications also provide copies of statements, which can be printed out, while other banks charge sending out hard copies of statements.

From the bank's point of view, mobile banking reduces the costs of handling transactions by reducing the need of the customer to come to the bank in person for transactions such as transferring and depositing money. Mobile banking does not include transactions with cash for which the customer needs to pay a visit to the bank. Many applications have the option of distance deposits for which a camera is used to digitally deposit checks to their financial institution. Mobile banking differs from paying by a mobile device because it requires the use of a mobile device to pay for goods or services in person or online just as one would with a debit or credit card for EFTPOS paying. [8]

The earliest forms of mobile banking used SMS for SMS banking. However, with the advent of smart phones with VAP support, which enabled the use of the mobile web in 1999, many banks began offering mobile banking to their customers with this platform [5]. Before 2010, mobile banking was usually done via SMS or the mobile web. The first success of Apple with its iPhone and the development of phones based on Google's Android operating system brought to the use of specialized mobile applications downloaded to the device. Hence, the development of web technologies such as HTML5, CSS3, and JavaScript encouraged many banks to begin using the services of a mobile network together with additional applications. A study of Google Maps from 2012, documents that over one third of banks show the use of mobile devices as a means for the first access of the bank's webpage [7]. By using this one icon, it is possible to do a couple of things such as to get redirected to the App store, to get redirected to a specific web location for mobile banking, or for giving the user a menu of mobile banking options to choose from.

Mobile banking is defined by giving and using banking and financial services via the help of mobile telecommunication devices. The scope of offered services can include the ability to perform transactions in banks and at the stock market, account administration, and access to information. According to this model, mobile banking has three

interconnected parts:

- Mobile Accounting
- Mobile Brokerage
- Mobile Financial and Information Services

Most of the services offered through accounting or brokerage are regarding transactions. Information services do not deal with transactions but are of vital importance for completing transactions; for example, before completing a transaction one must view the statement. Because of this, accounting and brokerage services are always offered together in a package with information services. On the other hand, information service can be offered on their own as an independent module. Mobile banking can be used as an auxiliary service in business and financial situations.

The usual services of mobile banking:[1] Information regarding the account; Mini statements and checking statements; Warnings about account activity or information about account exceedance; Monitoring of term savings; - Loan statements; Access to card statements; Statements of funds/stocks; Managing insurance; Transactions; Transfer of funds between linked accounts of a client; Payment to third party; payment of bills; transfer of funds to third party; Check remote deposit; Investments; Services of managing a portfolio; Grace period; Support; Loan status, mortgage status and insurance; Credit card approval; Exchange of messages, e-mails, complaints, monitoring; ATM locations; General information such as time zones and news; Loyalty program; Services at certain locations

A report made by the American Federal Reserve from 2012 has established that 21% mobile phone owners used mobile banking in the last 12 months [2]. Based on a poll done by Forrester, mobile banking is used mainly by younger customers. One third of mobile phone users have said that they would consider performing some kind of financial transaction with their mobile phone. However, most users are interested in the basic functions such as statements and creating accounts.

With the advent of technologies and a greater use of smart phones and tablets, the functionality of mobile phone banking would make it possible for users to connect with the whole life cycle of consumers much sooner than before. The enrichment of functionality based on the objectivity in mobile banking are as follows:

- Enrichment of communication - video interactions with agents, advisers
- The possibility of pervasive transactions - the all-encompassing “mobile wallet”
- The education of buyers - a “test drive” for banking services
- Connecting with a new group of buyers - connecting with Gen Y and gen Z by using social media while advertising banks
- Content monetization - micro levels of revenue through themes such as music and e-books
- Vertical positioning - positioning offers in specialized industries of mobile banking
- Horizontal positioning - positioning offers via mobile banking in all industries
- Personalized corporate banking services - the experience of personalized corporate banking based on current advances and contexts
- Branding - Developing the bank’s brand while advancing “mobile properties”

A virtual bank offers some or all types of accounts as do traditional banks, while virtual banks exist only on the web. They usually have lower fees and higher rates due to lower costs. Virtual banking transactions can be checked in real time, at the moment when they are happening, and not at the end of the day or month. Such services can be available online for traditional banks. Virtual banks do not have branches or their own ATM machines, so deposits are made online or via the post office. Virtual banks can refund fees that ATM machines of other banks charge. However, there may be a limit to the number of transactions that can be done during a month.[16]

Online banking, also known as internet banking, is an electronic system of paying, which gives the users or other financial institutions the option of performing multiple financial transactions via a website of a financial institution. The system of online banking is connected to or is a part of the basic banking system of a bank, and is different from the actual banks that traditional clients use for banking.

In order for a client to access a bank of financial institution, they need to register with that institution via internet and to set a username and password and other client verification credentials. The potential for online banking usually is not the same as phone or mobile banking. Nowadays, financial institutions usually assign a number of customers regardless of whether or not the users said that they intend to access their online banking facilities. The numbers of the buyers are usually not the same as the number of accounts, because the number of the account of the buyer can be connected to one client number. So, it turns out that the number of the buyer can be connected to any account in the financial institution which the user controls, even though the financial institution can limit how big the account that one wants to access is; for example, a check, savings, loans, credit card. [9]

The user visits the webpage of the financial institution and enters the online banking facility using the number of the buyer via the established credentials. The financial institution determines the types of transactions which the client can perform via online banking, but it usually includes getting an account, a list of recent transactions, online bill paying, and the transfer of funds between the client and some other party. Most banks provide the client with the possibility to get copies of statements, which can be printed in the buyer’s facility (some banks charge a fee for sending a copy of the statements). Some banks enable the users to directly transfer transactions into the accounting software of the buyer. The facility can allow the client to order checks, statements, report stolen/lost credit cards, stop a payment, make a change of address or other routine activities.

Today, many banking facilities use only the internet. These “virtual banks” have lower maintenance fees than traditional banks. In the United States of America, there are many virtual banks which are insured by the Federal Deposit Insurance Corporation (FDIC) and can offer the same level of security for funds as do traditional banks.

In Serbia in recent years, almost all banks developed mobile banking. It is a hybrid distribution means for which an

internet connectivity is needed, and it essentially requires the use of smart or Android phone or a tablet. It is a well-known fact that today's clients prefer to use phones over computers, so a great many banks have decided to create applications which can be used on mobile phones. With the application, the user can access faster and easier the required service. The possibilities that type of banking offers coincides a lot with internet banking; however, it is more about substitutes and not actual complementary functions.[11]

Most banks in Serbia have developed applications for the two biggest operational systems Android and iOS. Still, in this segment Telenor bank offers the most advanced services to its customers. In early 2014, the mobile phone provider Telenor bought a license from the KBC bank, which withdrew from the market in Serbia. Telenor already had a banking experience, because they did a similar thing in Pakistan [12].

The basic principle of Telenor's business is dealing only with individuals and not with corporations and long-term loans. So, the aim is to increase business which can be done online and over mobile phones. The only time a client has to come in person is when the contract regarding opening an account is signed (since the certificate system is not yet implemented); however, just opening an account can be done online. Obrovački (2016, p.46) states that this is the only bank which allows the client to choose their account number, so it can even be the client's phone number.

The following services should be singled out (telenorbanka.rs):

1. Sending money to an e-mail account or phone number, at which point the person who receives money can choose the account where they want the money transferred to (if they are not already a Telenor client).
2. The possibility of withdrawing and depositing dinars or euros at ATM machines.
3. Registering certain monthly bills with the application, which then reminds the user when they need to be paid. Payments are made with one click without additional charges.
4. Sending and receiving money from abroad via the mobile App. There is no need to go in person. Money can be sent or receives at the ATM machines.
5. Foreign currency can be purchased via the mobile App at the same rate as in exchange offices without the high exchange rates that other banks have.
6. One can change the card PIN online. It's useful in cases when the card cannot be found and the user is not sure if the card had been stolen in the first place, so they do not want to report it stolen yet.

The carriers of mobile payments are non-financial companies, usually from the IT or retail sectors. Similar payment applications are still not used in the Republic of Serbia, so it is expected that banks in cooperation with retailers or telecommunication companies will offer this service in the future [13].

4. Conclusion

Mobile banking has a huge impact on the business of a bank, and this tendency has been growing with the development of electronic systems and communication technologies. Electronic banking brings an increase in productivity, a decrease in costs as well as gaining new clients, which in turn helps the growth of the client pool, who tend to be more satisfied. Such business helps maintain a healthy competitive edge and focuses on the individual client. These are the positive effects of electronic banking on banks.

This way of doing business has not only been beneficial for banks, but it has also been great for business in general. The advantages of electronic banking have not only been for individuals, but also for companies that wish to pay employees or perform transactions with their business partners, since some of them are abroad. This way they save on expenses and make doing business easier and more suitable for clients and partners. This type of banking reflects positively on society in general. The more technologies are used in banking, the more people become educated about doing business like this and so it contributes to using other technologies more, which is the future of not only our country but the global community as well.

The system of doing banking electronically is not fully accepted in our market. Certain measures and time are needed; not only with other systems but also with banking, in order for electronic banking to become widely used and accepted in general. Only then will users become aware of all the potentials that this type of banking offers.

Telenor banks has revolutionized mobile banking in Serbia in 2013 when it bought in totality the KBC bank. Then, Telenor bank offered citizens of Serbia a bank with innovative and modern mobile and financial services. Telenor bank is the first in the region which used completely mobile banking, and according to the Telenor bank application, the whole bank is stored in your phone. Nowadays, experts predict an even greater expansion of mobile banking in the years to come, since the number of mobile phone users is surpassing the number of internet computer users.

In Serbia, mobile banking develops at the same pace as the development of modern technologies and global trends, and enables their users to use new banking service. The offers of the m-banking market in Serbia have advanced significantly. In a short period of time, the services of mobile banking have drastically broadened and the number of clients has considerably gone up. Clients can perform almost all of the services over the phone that can be done in person at the bank. Customer support for using mobile banking applications significantly increases customer satisfaction as it does the trust they have in the bank which offers mobile banking services. [14]

It can be noted that m-banking is still in its beginning phases of development in Serbia, but an expansion of it is expected in years to come. The rapid development of mobile banking in the world has enabled customers to be able to make all kinds of payments quickly and efficiently via mobile phones. A leap towards this way of doing business was done by Apple for they enabled making payments via POS terminals by simply connecting telephones to the same. This way of making a payment is known as Apple Pay; thus, it was natural that Samsung, their main competitor, created Samsung Pay. [17] The rapid development of mobile phones and their manifold use have nudged many sectors, even banking, to advance their services and adjust them to the needs of the users. It is inevitable that in the future with the development of

the 5G network that m-banking will develop even more. The course and trends in mobile banking can be manifold, and the greatest attention will be given to mending flaws and increasing securities for completing transactions. [15]

As to promote acceptance, users should be aware of the advantages which mobile banking offers in comparison to other options. Buyers should have the option of trying out mobile banking or seeing a presentation, maybe at the local branches or over some form of media; to see how it works. That would raise awareness and give people the understanding regarding mobile banking. Apart from that, the services offered should be advertised for a targeted market, such as younger people who have the tendency to adopt innovative services. The perceptions of risks, as with many innovations should be dealt with by limiting the responsibility of buyers and applying the latest security technologies. The new version of WAP uses a coded digital signature as an upgraded security measure. The functionality and user interface on mobile devices are being upgraded constantly while the charges of internet connectivity are globally becoming lower. These changes mean that an outspread acceptance of mobile banking is becoming more and more a reality.

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Pouke iz prošlosti: epidemija velikih boginja u Jugoslaviji, njen uticaj na javno zdravlje i ekonomiju

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Sažetak: Velike boginje su smrtonosna zarazna bolest koju izaziva virus iz roda ortopoks virusa. Najčešći simptom jeste osip koji se javlja 12 dana nakon zaražavanja. Virus se brzo širi putem aerosola i može da izazove eksplozivne pandemije sa nesagledivim posledicama. Velike boginje su vekovima rasprostranjene širom sveta, a smrtnost od ove bolesti iznosi oko 30%. Najveća epidemija velikih boginja (Variola vera) u Evropi nakon Drugog svetskog rata izbila je 1972. godine, na teritoriji tadašnje Socijalističke Federativne Republike Jugoslavije (SFRJ). Stopa smrtnosti bila je 20%, tačnije u populaciji od 20.600.000 ljudi umrlo je 35 od 175 registrovanih slučajeva. Ove brojke učinile su epidemiju jednom od najdramatičnijih u 20. veku kada je reč o javnom zdravlju na Balkanu. Socijalne i ekonomske posledice epidemije bile su ogromne i dugoročne. Pored narušenog društvenog života (ogroman broj ljudi bio je u karantinu i nije bio u mogućnosti da stupi u kontakt sa porodicom, što je izazvalo stres i nezadovoljstvo), epidemija velikih boginja u SFRJ takođe je uticala na javno zdravlje i ekonomiju države. Vlada je potrošila ukupno 6 milijardi tadašnjih dinara (oko 600 miliona američkih dolara) na epidemiju iz 1972.

Ključne reči: velike boginje, javno zdravlje, vakcina, direktni troškovi, ekonomika zdravstvene zaštite, eksternalije

1. Uvod

Nulti pacijent bio je hodočasnik iz sela Danjane, jedan od 24 hodočasnika koji su krenuli na hadžiluk u Meku i Medinu. On je posetio svetinje derviškog reda u blizini Basre i Bagdada (u Iraku) između 2. i 6. februara 1972, gde su već postojali prijavljeni slučajevi velikih boginja. Pacijent je imao neodređene simptome. Ozdravio je brzo i nije imao druge kliničke manifestacije. Tek su naknadni serološki testovi utvrdili da je pomenuti pacijent bio zaražen virusom velikih boginja i da je njegova klinička slika bila laka i atipična [1].

Od 175 zaraženih preminulo je 35 (20 procenata). Poslednji prijavljeni slučaj velikih boginja u Jugoslaviji dogodio se 1930, a obavezna vakcinacija bila je na snazi duže od pola veka [2].

Ovaj pasus objašnjava početke ovog velikog zdravstvenog problema u SFRJ koji je ostavio značajne posledice na zdravlje i živote stanovnika ove zemlje, ali i dalekosežne ekonomske posledice. U tom kontekstu rad se bavi eksternim efektima u ekonomici zdravstvene zaštite kroz analizu sadržaja (metoda) i dostupnih izvora koji svedoče o uticaju epidemije na javno zdravlje, ali i analizom dostupnih izvora koji svedoče o njenom uticaju na direktne troškove.

2. Metoda

Metoda koja je korišćena u ovom istraživačkom radu jeste analiza sadržaja. Analiza sadržaja jeste metoda kojom se utvrđuje postojanje konkretnih reči, tema ili koncepata u datom skupu kvalitativnih podataka, tj. tekstu. Moguće je kvantifikovati i ispitati značenja i odnose između ovih reči ili koncepata pomoću analize sadržaja.

Analiza sadržaja je popularna metoda za sprovođenje kvalitativnih istraživanja. Postoje tri različite tehnike analize sadržaja: konvencionalna, usmerena i sumativna. Zbog toga se sve tri tehnike pridržavaju naturalističke paradigme kroz analizu sadržaja teksta. Šeme kodiranja, poreklo kodova i izazovi u vezi sa pouzdanošću predstavljaju glavne razlike između ova tri pristupa. Tradicionalna analiza sadržaja izvodi kategorije kodova direktno iz teksta. Nalazi srodnih istraživanja i teorija se koriste kao putokaz za početne kodove u usmerenoj analizi sadržaja. Postoji mnogo načina za sprovođenje sumativne analize sadržaja, ali se svi vrte oko analize podataka i izvođenja zaključaka iz njih. Primeri iz oblasti palijativne nege ilustruju analitičke pristupe za svaku pojedinačnu strategiju i tehniku koje se bave pouzdanošću [3].

Analizirali smo izveštaje SZO-a koji su pripremili Litvijenko, Arsić i Borjanović, 1973 [4] i Deklaraciju o globalnom iskorenjivanju velikih boginja (1980) koju je izdala Svetska zdravstvena organizacija [5] kao i dostupne istraživačke studije u PubMed i Saga bazama, i SFRJ biltene izdate u periodu 1972–1973.

S obzirom na ograničene političke slobode i politički kontekst perioda u kome je izbila epidemija velikih boginja u državi, nema mnogo zvaničnih podataka o direktnim troškovima izazvanih epidemijom. Sa druge strane, isto važi i za posledice epidemije na javno zdravlje. Analiza je sprovedena na osnovu dostupnih novinskih članaka i naučnih radova napisanih decenijama nakon epidemije.

3. Rezultati

U Jugoslaviji su velike boginje poslednji put zabeležene 1930. godine. U međuvremenu je redovno vršena obavezna vakcinacija dece (prva doza u uzrastu od 3 meseca do 3 godine, a revakcinacija od 7. do 14. godine života). Muški deo populacije takođe je vakcinisan tokom služenja obaveznog vojnog roka. Oko 80% vojnih obveznika je vakcinisano, ali u pojedinim sredinama uspešnost programa vakcinacije uopšte nije kontrolisana. Kako je vreme prolazilo, procenat vakcinisane dece je opadao, kao i procenat vakcinisane starije populacije, što je značilo da je veliki broj ljudi bio izložen riziku od velikih boginja [4].

Institut za javno zdravlje Srbije (Beograd) je 14. marta upozoren na osam pacijenata za koje se sumnjalo da su zaraženi velikim boginjama, a koji su u međuvremenu hospitalizovani, gde je svih osmoro bilo u srodstvu sa nultim pacijentom, a neki od njih su sa njim bili i u direktnom kontaktu. To je označilo početak epidemije. Njihovi uzorci su uzeti sledećeg dana. Dana 16. marta virusološkim testom utvrđeno je da se radi o velikim boginjama. Državni organi su odmah proglasili vanredno stanje i cela zemlja je stavljena u karantin. Vlasti su zatražili pomoć epidemiologa Svetske zdravstvene organizacije Donalda Hendersona i Rajnharta Lindnera iz Austrije [6]. Time je sprečena šira epidemija. Mere preduzete nakon uvođenja vanrednog stanja (16. marta) uključivale su zatvaranja čitavih sela i kvartova, blokadu puteva, zabranu javnih okupljanja, zatvaranje granica i zabranu putovanja koja nisu neophodna. Susedne zemlje su u isto vreme zatvorile svoje granice [7]. Kao što je prethodno rečeno, to je bila poslednja velika epidemija velikih boginja u Evropi, koja je odnela 35 života među 175 zaraženih [8].

Pomenutoj epidemiji doprineli su brojni razlozi, na primer takozvano tiho unošenje velikih boginja (kao posledica lake i atipične kliničke slike nultog pacijenta), zakasnelo otkrivanje zaraze, kao i zakasnelo uvođenje mera za kontrolu zaraze. Od ostalih razloga koji su doprineli širenju epidemije treba pomenuti sledeće: zemlji je nedostajala odgovarajuća strategija imunizacije koja bi generisala najbolje efekte u datim okolnostima, preciznije takozvana prstenasta vakcinacija (koja podrazumeva da se prvo vakcinišu kontakti na vrhuncu epidemije, a tek onda da se pređe na druge u koncentričnim prstenovima), teškoće u sprovođenju vakcinacije, npr. kašnjenja i nedostatak vakcine i specifičnih imunoglobulina, što je dovelo do neuspeha velikog dela vakcinalnog programa. Nije postojala strategija suzbijanja bolesti, niti je javnost blagovremeno i precizno obaveštena kako bi se upoznala sa epidemijom [9].

Epidemija velikih boginja je snažno uticala na zdravlje populacije SFRJ, ali i na ekonomsku situaciju u zemlji, donekle narušivši i društveni život (jer je ogroman broj ljudi bio u karantinu i nije imao mogućnosti da stupi u kontakt sa porodicom, što je izazvalo stres i nezadovoljstvo) [10].

Vakcinacija je dovela do suzbijanja bolesti. Poslednji zabeleženi i potvrđeni slučaj dogodio se 1977. godine (u Somaliji). Pokazalo se da su vakcinacija i izolacija pacijenata od najvećeg značaja u prevenciji bolesti. Iako je Svetska zdravstvena organizacija proglasila da su velike boginje iskorenjene [5] iskustvo stečeno tokom ove epidemije može doprineti obrazovanju i obuci zdravstvenih radnika u domenu prevencije i suzbijanja takozvane majke svih zaraznih bolesti, posebno s obzirom na rastuću opasnost od velikih boginja. Tabela 1 prikazuje zabeležene slučajeve i smrtne ishode u odnosu na starost i vakcinalni status.

Tabela 1. Broj slučajeva i smrtni ishodi u odnosu na starost i vakcinalni status [4].

	Starost (uzrast)	**<1 godina**	**1–6 godina**	**7–14 godina**	**15–19 godina**	**20+ godina**	**Ukupno**
Svi slučajevi	Vakcinisani	–	1	6	7	91	105
	Nevakcinisani	12	14	13	6	21	66
	Ukupno	12	15	19	13	110*	175*
Smrtni ishodi	Vakcinisani	–	-	1	1	6	8
	Nevakcinisani	8	3	3	2	7	23
	Ukupno	8	3	4	3	17*	35*
Odnos broja slučajeva i smrtnih ishoda		67%	20&	21%	23%	15%	20%

* Uključuje četiri slučaja nepoznatog vakcinalnog statusa/

U mnogim zajednicama epidemija se ne prihvata i ne priznaje zato što ugrožava specifične socijalne, ekonomske i institucionalne interese [11]. Ako do epidemije ipak dođe, autor primećuje obrazac koji se ponavlja već vekovima: doktori identifikuju nekoliko „sumnjivih" slučajeva i zadržavaju svoju zabrinutost za sebe ili svoje sumnje prijavljuju nadležnima, koji obično nerado priznaju prisustvo jednog tako opasnog uljeza u javnosti [11]. Epidemija velikih boginja u Jugoslaviji suočila se sa istim problemom.

3.1. Eksternalije u ekonomici zdravstvene zaštite

U ekonomiji eksterni efekti ili eksternalije predstavljaju koristi ili troškove koje jedan entitet nanosi drugom svojim ponašanjem (proizvodnjom ili potrošnjom) koje je izvan njegove kontrole. Troškovi, odnosno koristi koje nastaju na ovaj način, ne mogu biti predmet tržišnih transakcija [12].

Eksterni efekti, kako pozitivni tako i negativni, često se manifestuju u zdravstvu prilikom korišćenja zdravstvenih usluga. Zadovoljavajući svoje potrebe, potrošač često čini nešto što ima i širu društvenu korist. Prevencija i lečenje zaraznih

bolesti su tipičan primer takvog delovanja.

Ako je zaštitna mera vakcinisati većinu populacije protiv zarazne bolesti, onda je verovatnoća da se neko iz ostatka populacije razboli od iste bolesti značajno smanjena. Na primer, upravo iz tog razloga su razvijene zemlje zainteresovane za iskorenjivanje zaraznih bolesti u zemljama u razvoju. Barijera koja sprečava širenje bolesti se tako stvara daleko od njihovih granica, a neke bolesti, poput velikih boginja, bivaju čak potpuno iskorenjene. Ovakvi postupci mogu biti vođeni humanitarnim razlozima, ali tu je naravno i briga za zdravlje sopstvene populacije [13].

Rezultati medicinskih istraživanja takođe mogu imati ogromne pozitivne eksterne efekte (koristi). Medicinsko znanje i razvoj nauke u ovoj oblasti, saopštavanje novih rezultata i nova otkrića donose korist svuda gde postoje uslovi za njihovu primenu. Ovo naročito važi u slučajevima kada upotreba naučnih rezultata nije ograničena različitim preprekama i zainteresovanošću za profit.

Programe prevencije karakterišu i ogromne koristi koje zajednica ima od njihove primene. Promotivne aktivnosti koje doprinose suzbijanju prisustva bolesti kroz smanjenje stepena izloženosti populacije faktorima rizika koji izazivaju samu bolest mogu dugoročno uticati na smanjenje troškova zdravstene zaštite i unapređenje proizvodnog potencijala zajednice.

Ovakve promotivne aktivnosti za unapređenje zdravlja ne moraju biti ograničene isključivo na zdravstvene radnike i njihovo delovanje, iako su najčešće oni ti koji ih pokreću i sprovode. I drugi sektori mogu uspešno da pokreću i promovišu aktivnosti koje doprinose zaštiti i unapređenju zdravlja, kao što su obrazovanje, masovni mediji, kompanije itd.

Negativni eksterni efekti u vezi sa zdravljem javljaju se u različitim oblicima. Vožnja pod dejstvom alkohola je tipičan primer radnje koja dovodi u opasnost ne samo vozača i putnike u automobilu već i druge ljude. Zagađenje životne sredine može negativno da utiče na zdravlje velikog broja ljudi. Različiti oblici proizvodnje (npr. proizvodnja cigareta, alkohola itd.), trgovina ovim proizvodima i njihovo agresivno reklamiranje takođe mogu imati negativne posledice na opšte zdravlje populacije jedne zemlje.

Različite proizvodne aktivnosti mogu da pogoršaju uslove u kojima žive ljudi u blizini. Primera je mnogo: deponije sirovog pepela, pored termoelektrana i postrojenja hemijske industrije, mogu da izazovu aerozagađenje, zatim ispuštanje neprečišćenih otpadnih voda u reke itd. Upotreba opasnog naoružanja u regionima gde postoje krizna žarišta može imati dugoročne posledice na kvalitet životne sredine (npr. upotreba osiromašenog uranijuma itd.).

Farmaceutska industrija odnedavno primenjuje stroge procedure testiranja i analize prilikom uvođenja novih lekova. Oni su sada u obavezi da ispitaju neželjene efekte novih lekova u različitim okolnostima njihove upotrebe. Međutim, ako neke nuspojave novog leka ostanu nepoznate, budući korisnici tog leka mogu biti izloženi ozbiljnom riziku i pogoršanju zdravlja. Dobro je poznata priča o „talidomidskoj tragediji", koja je ušla u anale medicinske nauke.

U današnje vreme, u skladu sa smernicama Američkog centra za kontrolu bolesti (CDC), vakcine koje sadrže živi virus u SAD se preporučuju samo malom procentu stanovništva, i to za tačno određene istraživačke situacije i putovanja [14].

Svetska populacija mlađa od 40 godina je naročito ranjiva, jer od 80-ih godina 20. veka nije bilo nijedne javne kampanje za vakcinaciju protiv velikih boginja [15].

3.2. Troškovi velikih boginja

Godine 1966. zabeleženo je između 10 i 15 miliona slučajeva velikih boginja u više od 50 zemalja. Između 1,5 i 2 miliona ljudi umiralo je svake godine od ove bolesti. Budući da od 1978. nije zabeležen nijedan novi slučaj, velike boginje su proglašene iskorenjenim. Međutim, debata o tome da li soj velikih boginja treba čuvati u određenim laboratorijama zbog pretnje od bioterorizma se nastavlja.

Može se govoriti o programu ili intervenciji. Osnivanje SZO Jedinice za iskorenjivanje velikih boginja 1965. godine i zalaganje najvećeg finansijera kampanje, SAD, oživelo je međunarodne napore usmerene ka iskorenjivanju velikih boginja. Račvasta igla je olakšala vakcinaciju u onim zemljama gde je bolest uzela maha. U preostalih pet zemalja uloženi su koncentrisani napori tokom 1973. kako bi se pratila i suzbila epidemija. Somalija je svoj poslednji endemski slučaj velikih boginja prijavila 1977. godine. Skupština Svetske zdravstene organizacije je u maju 1980. proglasila velike boginje iskorenjenim, nakon dve godine posmatranja i proučavanja.

Godišnji troškovi kampanje protiv velikih boginja u SAD su iznosili 23 miliona dolara u periodu između 1967. i 1979. godine. Međunarodni donatori su donirali 98 miliona dolara, dok su države u kojima su zabeleženi endemski slučajevi bolesti dale 200 miliona dolara. Sjedinjene Američke Države danas mogu da uštede čitav iznos koji su ranije davale za suzbijanje velikih boginja u roku od 26 dana, jer više ne moraju da vakcinišu ljude, niti da ih leče od ovog oboljenja [16].

Prema procenama, iskorenjivanje velikih boginja je svet koštalo mnogo novca. Vakcina, zdravstveno osoblje i transport činili su najveći deo troškova ovog programa 1967. godine. To je ekvivalentno troškovima od 10 centi po jednoj dozi vakcine u zemljama u razvoju. Procenjuje se da je oko 50.000 dolara godišnje potrošeno na vakcinaciju petine od oko 2,5 milijardi ljudi koji su u to vreme živeli u nerazvijenim zemljama. Sa druge strane, zemlje u kojima su zabeleženi endemski slučajevi bolesti potrošile su svega 10 miliona dolara na ovaj projekat. Kada se radi o nerazvijenim zemljama, Indija je jedina koja je izračunala uticaj velikih boginja na ekonomiju. Procenjuje se da su troškovi lečenja po pacijentu u Indiji tokom 1976. iznosili 2,85 dolara, dok su ukupni godišnji troškovi lečenja pacijenata iznosili 12 miliona dolara. Procene zasnovane na navodnom udelu Indije u globalnoj incidenciji (broju novozaraženih) tvrde da su troškovi lečenja pacijenata obolelih od velikih boginja u zemljama u razvoju iznosili preko 20 miliona dolara tokom 1967. godine. Koristeći

celoživotni ekonomski učinak pojedinca, procenjuje se da svake godine Indija gubi 700 miliona dolara zbog smanjenja ekonomskog učinka. Suzbijanje velikih boginja je nerazvijene zemlje u celini koštalo oko jedne milijarde dolara tokom 1967. godine, pod uslovom da je broj umrlih iznosio 1,5 miliona, a treba napomenuti da se radi o konzervativnoj proceni zasnovanoj na podacima dostupnim u to vreme. Zbog čitave situacije industrijalizovane zemlje su morale da podmire troškove vakcinacije kako bi sprečile da se bolest ponovo pojavi. Tokom 1968. potrošeno je samo 92,8 miliona dolara na 5,6 miliona prvih doza i 8,6 drugih doza vakcine u SAD, odnosno 6,5 dolara po dozi. Lekarsku pomoć zatražilo je 8.024 ljudi, od čega je 238 hospitalizovano, 9 umrlo, a četvoro je postalo trajni invalid zbog posledica vakcinacije. Tokom 1968. godine program vakcinacije je koštao 75 centi po osobi, u šta spadaju i indirektni troškovi poput odsustvovanja sa posla. U slučaju drugih industrijskih zemalja sa nižim troškovima, godišnji troškovi ovih država iznosili su oko 350 miliona dolara, u zavisnosti od njihove populacije. Procenjuje se da su velike boginje koštale svet preko 1,35 milijardi dolara tokom 60-ih godina 20. veka, uključujući direktne i indirektne troškove. Doprinosi međunarodne zajednice i zemalja u kojima su zabeleženi endemični slučajevi zaraze iznosili su 98 miliona i 200 miliona dolara, tim redosledom, u periodu između 1967. i 1979, kada je sprovedena intenzivna operacija suzbijanja zaraze. Najveći donator, SAD, danas uštedi celokupan iznos doniran za borbu protiv velikih boginja u roku od 26 dana. Sprečavanje širenja velikih boginja pomoću vakcine predstavlja jedan od najisplativijih načina za očuvanje zdravlja [16]. Ukupni direktni troškovi epidemije iznosili su 6 milijardi tadašnjih dinara (odnosno oko 600 miliona dolara) tokom 1972. godine [10].

4. Diskusija

Na osnovu analize sadržaja uočeni su određeni nedostaci. Institut za javno zdravlje Srbije (Beograd) obavešten je da je osmoro ljudi hospitalizovano pod sumnjom da su zaraženi velikim boginjama, gde je svih osmoro bilo u srodstvu sa nultim pacijentom, a neki od njih i u direktnom kontaktu sa njim. Tako je došlo do epidemije. Pacijenti su testirani, a virusološki testovi su potvrdili da se radi o velikim boginjama. Državni organi su proglasili vanredno stanje i stavili celu zemlju u karantin. Svetska zdravstvena organizacija je zatražila pomoć epidemiologa i veća epidemija je izbegnuta. Tokom vanrednog stanja zatvorena su čitava sela i kvartovi, putevi su blokirani, javna okupljanja zabranjena, granice zatvorene i uvedena je zabrana svih putovanja, osim neophodnih. To je bila poslednja velika epidemija velikih boginja u Evropi, koja je odnela 35 života među 175 zaraženih [4].. Uzroci izbijanja ovako velike epidemije su zakasnelo otkrivanje zaraze, kao i zakasnelo uvođenje mera za njeno suzbijanje. Ostali faktori koji su doprineli širenju zaraze su to što je zemlji nedostajala odgovarajuća strategija imunizacije, tačnije takozvana prstenasta vakcinacija (koja podrazumeva da se prvo vakcinišu kontakti na vrhuncu epidemije, a tek onda da se pređe na druge u koncentričnim prstenovima), kao i teškoće u sprovođenju masovne vakcinacije, npr. kašnjenje i nedostatak vakcine i specifičnih imunoglobulina, što je dovelo do neuspeha velikog dela vakcinalnog programa. Nije postojala strategija suzbijanja bolesti, niti je javnost dobila tačne informacije kako bi znala šta treba da radi.

Epidemija velikih boginja ostavila je ogromne posledice na zdravlje i ekonomsku poziciju populacije SFRJ, ali i na njihov društveni život (jer je ogroman broj ljudi bio u karantinu i nije bio u mogućnosti da stupi u kontakt sa porodicom, što je izazvalo stres i nezadovoljstvo). Tokom 1972. godine troškovi epidemije iznosili su 6 milijardi dinara (oko 600 miliona dolara).

Vakcinacija je zaustavila dalje širenje virusa. Poslednji zabeleženi slučaj prijavljen je u Somaliji 1977. godine. Vakcinacija i izolacija zaraženih su bile ključne mere u suzbijanju zaraze. Zbog rastuće opasnosti da bi virus velikih boginja mogao biti upotrebljen kao biološko oružje [5]. iskustvo stečeno tokom ove epidemije može biti korisno u obuci i edukaciji zdravstvenih radnika o sprečavanju i suzbijanju širenja takozvane majke svih zaraza.

5. Zaključak

Epidemija velikih boginja u SFRJ u velikoj meri je uticala na zdravlje i ekonomiju, ali i na društvene nemire. Građani su bili u karantinu i nisu bili u mogućnosti da stupe u kontakt sa svojim porodicama, što je izazvalo stres i nezadovoljstvo, ali i druge psihološke posledice. Prema dostupnim podacima, za borbu protiv zaraze tokom 1972. potrošeno je više od 600 miliona dolara, odnosno 6 milijardi tadašnjih dinara.

Ogromno produženje životnog veka i rast globalne populacije do kojih je došlo tokom 19. i 20. veka može se pripisati otkrićima na polju medicine, tačnije vakcina i lekova kojima su izlečene ili iskorenjene mnoge bolesti. Otkriće antibiotika je značajno promenilo ljudske živote. Smrtnost od zaraznih bolesti je smanjena zahvaljujući lekovima koji su postali dostupni svim segmentima stanovništva. Međutim, treba napomenuti da su postojali snažan međunarodni interes i odgovarajuća ekonomska podrška za suzbijanje i iskorenjivanje određenih bolesti, npr. velikih boginja. Kada je reč o hroničnim bolestima, otkriveni su lekovi koji usporavaju napredovanje bolesti, sprečavaju i ublažavaju komplikacije, podižu kvalitet života i produžavaju životni vek.

Iskustvo stečeno tokom epidemije velikih boginja dodatno je doprinelo napretku medicine, osim što je uticalo na ekonomiku zdravstvene zaštite na globalnom nivou. Izvučene su važne pouke, na primer, koliko je važno na vreme vakcinisati ranjive grupe.

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Lessons from the Past - The Smallpox Outbreak in Yugoslavia, An Impact on Public Health and the Economy

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Abstract: Smallpox is a deadly disease caused by a virus from the group of orthopoxviruses. It is best characterised by a rash that appears 12 days after the infection. The virus spreads rapidly through aerosols and can lead to explosive epidemics with unforeseeable consequences. Smallpox has been widespread in the world for centuries, and about 30% of patients die from it. The largest outbreak of Smallpox (*Variola vera*) in Europe after World War II was that in the former Socialist Federal Republic of Yugoslavia (SFRY) in 1972. The death rate was 20%, i.e. 35 out of the 175 infected people died in a population of approximately 20,600,000. These numbers made the epidemic one of the most dramatic in the 20th century when it comes to public health in the Balkan region. Social and economic consequences were profound. In addition to disrupting social life (meaning that a lot of people were quarantined and had no chance to make contact with their families, which exposed them to stress and made them dissatisfied), the spread of smallpox in the SFRY had a significant impact on the country's health and economy. A total of 6 billion SFRY dinars (about 600 million US dollars) was spent on the epidemic in 1972.

Keywords: smallpox, public health, vaccine, direct costs, health economics, externalities

1. Introduction

The index case was a pilgrim from the village of Danjane, who was one of the 24 pilgrims to have visited Makkah and Medina. He had paid a visit to the holy places of Dervish Muslims in the vicinity of the cities of Basra and Baghdad (Iraq) in the period from 2nd to 6th February 1972, where smallpox had already been reported. The pilgrim's symptoms and signs were non-specific. The disease ended shortly, without any other clinical manifestations. Only the serological tests subsequently done revealed that the said person had, in fact, been infected with the smallpox virus, the clinical picture of the disease being light and atypical [1].

Out of the 175 infected people, 35 of them died (20 percent). Smallpox had not been reported in Yugoslavia since 1930, and mandatory vaccination had been in place for more than half a century [2].

This paragraph explains the beginning of this major health issue in the former Socialist Federal Republic of Yugoslavia (SFRY), which had significant consequences for the health and lives of people in this country and also caused profound economic consequences. In this context, through an analysis of the content (method) or available sources that testified to the impact of disease outbreaks on public health and an analysis of available sources attesting to their impact on direct costs, the paper also deals with external effects in health economics.

2. Method

Content analysis was used as a method for this research study. Content analysis is a method for determining the existence of specific words, themes, or concepts in a given qualitative dataset, i.e. text. It is possible to quantify and examine the meanings and relationships of these words or concepts through the use of content analysis.

Content analysis is a popular method for conducting qualitative studies. There are three distinct techniques to content analysis: conventional, guided, and summative, rather than a single way of conducting it. As a result, all three techniques adhere to the naturalistic paradigm by analysing text content. Coding schemes, the origins of codes, and the challenges to trustworthiness are the main differences between the approaches. Traditional content analysis derives coding categories from the text data directly. A theory or related research findings are used as direction for the initial codes in a directed approach to analysis. There are many ways to conduct summative content analysis, but they all revolve around analysing the data and drawing conclusions from it. Examples from the field of end-of-life care illustrate the analytic approaches for each strategy and technique addressing trustworthiness [3].

We have analysed WHO reports prepared by Litvinkenko, Arsic, and Borjanovic in 1973 [4] and the Declaration of global eradication of smallpox (1980) issued by the World Health Organization [5] as well as available research studies on PubMed and Saga and SFRY newsletters dating 1972-1973.

Given the limited political freedoms and political context that existed at the time of the smallpox epidemic in the country, there is not much official data on the direct costs caused by the epidemic. On the other hand, the same is true for the effects of the epidemic on public health. The analysis was done on the basis of available news articles and scientific papers written decades after the epidemic.

3. Results

In Yugoslavia, smallpox had been registered in 1930 for the last time. In the meantime, compulsory vaccination of children (primary vaccination at the age of 3 months to 3 years and revaccination at 7 and 14 years of age) was regularly carried out. Also, the male population was vaccinated in the army. About 80% of conscripts were vaccinated, but the success of the vaccination programme was not checked at all in some areas. As time went by, the percentage of vaccinated town children was decreasing, as well as the number of elderly citizens who had got their jab, which meant a great many people could contract smallpox [4].

On March 14, the Institute for Public Health of Serbia (Belgrade) was warned about the eight patients suffering from suspected smallpox who had been hospitalised in the meantime, all of them cousins of the index case, and some of them having been in contact with that person. That signified the outbreak. Their samples were taken the next day. On March 16, the virological examination confirmed the smallpox diagnosis. A state of emergency was immediately declared by the state authorities and the whole country was quarantined. The World Health Organisation's epidemiologists Donald Henderson and Reinhard Lindner from Austria were asked for help [6]. Thus, a broader epidemic was prevented. The measures taken following the imposition of martial law (on March 16) entailed blocking entire villages and neighbourhoods, the installation of roadblocks, the prohibition of public gatherings, closing borders and the prohibition of all non-essential travel. The neighbouring countries simultaneously closed their borders [7]. As has just been said, that was the last major outbreak of the smallpox disease in Europe, which took 35 lives out of the 175 infected individuals [8].

Numerous reasons contributed to the mentioned large outbreak, such as the so-called "silent" importation of smallpox (which was a result of the light and atypical clinical picture of the index case), the belated detection of the outbreak, as well as the belated introduction of the measures intended to control the disease. Of the other reasons that contributed to the spread of the epidemic, the following can be mentioned: the country lacked an immunisation strategy that would generate the best effects in the described circumstances, namely the so-called ring vaccination (which involves vaccinating contacts in the peak of the outbreak first, and only then moving on to others in concentric rings); there were difficulties in conducting the vaccination, e.g. delays and unavailability of the vaccine and the specific immunoglobulin, which resulted in a large portion of the vaccination programme being unsuccessful. There was no disease containment strategy and the public was not informed in a timely and accurate manner in order to be familiarised with the epidemic either [9].

The outbreak of smallpox had a powerful effect on the health of the population of the SFRY and the economic situation in the country, leading to the disruption of social life to some extent too (meaning that a lot of people were quarantined and had no chance to make contact with their families, which exposed them to stress and made them dissatisfied) [10].

Vaccination suppresses the disease. The last detected and confirmed case was registered in 1977 (Somalia). Vaccination and isolation of patients proved to be of the utmost importance in the prevention of the disease. Although smallpox was declared eradicated in 1980 by the WHO [5]. the experience gained from the outbreak may contribute to the training and education of healthcare workers in the domain of the prevention and control of the spread of this so-called "mother of all plagues", particularly considering the emerging threat of smallpox. Table 1 shows cases and deaths by age and vaccination status.

Table 1. Cases and Deaths by age and vaccination status [4].

	Age (years)	<1 age	1-6 ages	7-14 ages	15-19 ages	20+ ages	Total
All cases	Vacc.	-	1	6	7	91	105
	Unvacc.	12	14	13	6	21	66
	Total	12	15	19	13	110*	175*
Deaths	Vacc.	-	-	1	1	6	8
	Unvacc.	8	3	3	2	7	23
	Total	8	3	4	3	17*	35*
Case-fatality ratio		67%	20&	21%	23%	15%	20%

*Includes four unknown vaccination statuses.

In many communities, an epidemic is not accepted or acknowledged because it threatens specific social, economic, and institutional interests [11].When an outbreak begins, an author observes a pattern that has recurred over centuries: doctors identify a few "suspicious" cases and either keep their concerns to themselves or report their suspicions to authorities, who are usually reluctant to acknowledge the presence of such a dangerous intruder publicly [11]. The Yugoslav smallpox epidemic faced the same problem.

3.1. Externalities in health economics

In economics, external effects are the benefits or harms that one entity causes to another entity through its behaviour (production or consumption) in a way that it cannot control. Costs, i.e. benefits that occur in this way, cannot be the subject of market transactions [12].

External effects, both positive and negative, are often expressed in health care when using health services. By satisfying his needs, the individual consumer often does something that also has social benefits. Prevention and treatment of infectious diseases are typical examples of such actions.

If the majority of the population is vaccinated as a protective measure against infectious disease, the probability of a person belonging to the rest of the population getting sick will be significantly reduced. For example, it is for this reason that developed countries are interested in fighting infectious diseases in developing countries. A barrier preventing the spread of diseases is created far from their own borders, while some diseases such as smallpox are completely stopped. These actions can be driven by humanitarian reasons, but we can also see in them concern for the health of our own population [13].

Huge external benefits can also be found in the results of medical research. Medical knowledge and the progress of science in this field, communication of new results, and discoveries bring benefits wherever the conditions for their application exist. This is especially true if the use of scientific results is not limited by various barriers and an interest in profit.

Prevention programmes are also characterised by the enormous benefits that the community realises through their implementation. Promotional activities that contribute to curbing the prevalence of the disease by reducing the level of exposure of the population to risk factors that cause the disease can have a long-term effect on reducing health care expenditures and improving the productive potential of the community.

Such promotional activities for the improvement of health do not have to be exclusively limited to the actions of health care providers, although most often they appear to initiate them and carry them out. Other sectors can also be successful promoters and initiators of actions that contribute to the protection and improvement of health, such as education, mass media, companies, etc.

Negative external effects related to health occur in different forms. Driving under the influence is a typical example of an action that puts at risk not only drivers and passengers but also other people. Environmental pollution can lead to a deterioration in the health of a large number of people. Various kinds of production (e.g. the production of cigarettes, alcohol, etc.), trade in these products, and aggressive marketing have negative consequences for the health of a country's population.

Various production activities can worsen the living conditions of people living nearby. There are many examples: untreated ash dumps next to thermal power plants and plants in the chemical industry can be the cause of air pollution; the discharge of untreated wastewater into rivers, and so on. The use of dangerous weapons in regions where there are crisis hotspots can have long-term consequences on the quality of the environment (e.g. the use of depleted uranium, etc.).

As of recently, the pharmaceutical industry follows strict screening procedures when introducing new drugs. The side effects of new drugs in different circumstances of its use are now investigated. If, however, some adverse effects of a drug remain unknown, future consumers of the drug may be exposed to the risks of a dangerous deterioration of health. The "thalidomide tragedy" is well known and is already in the annals of medical history.

Nowadays, according to CDC's guidelines, live vaccines such as smallpox, anthrax, and typhoid are only recommended for a small percentage of the population in certain research and travel situations in the United States [14].

The world's population under the age of 40 is particularly vulnerable because there hasn't been a single public vaccination campaign against smallpox since the 1980s [15].

3.2. The costs of smallpox

About 10 to 15 million cases of smallpox occurred in more than 50 countries in 1966. Between 1.5 and 2 million people died each year as a result of the disease. With no new cases of smallpox reported since 1978, smallpox has been officially eradicated. Nevertheless, debate continues over whether smallpox strains should be kept in specific laboratories due to the threat of bioterrorism.

It could be a program or intervention. The establishment of the Smallpox Eradication Unit at the World Health Organisation in 1965 and a pledge from the campaign's largest donor, the United States, reinvigorated international efforts to eradicate smallpox. With the aid of the bifurcated needle, vaccination was made easier for those countries where the disease was prevalent. In the five remaining countries, a concentrated effort was made in 1973 to monitor and contain outbreaks. Somalia recorded its final endemic case of smallpox in 1977. Smallpox was declared eradicated by the World Health Assembly in May 1980, after two years of monitoring and searching.

Between 1967 and 1979, the annual cost of the smallpox campaign totalled US$23 million per year. International donors contributed 98 million dollars, while the endemic countries contributed 200 million dollars. The USA saves the entire amount of all its contributions every 26 days because it does not have to vaccinate people or treat the disease [16].

According to estimates, eliminating smallpox from the world cost a significant amount of money. The vaccine, personnel, and transportation accounted for the bulk of the programme's costs in 1967. This equated to around 10 cents per shot in developing countries. It is estimated that $50,000 a year were spent vaccinating about a fifth of the 2.5 billion people who lived in underdeveloped countries at the time. The endemic countries, on the other hand, spent only $10 million a year on the project. In underdeveloped countries, India is the only one to have calculated the economic impact of smallpox. It was estimated in 1976 that the cost of treating a smallpox patient in India was $2.85 per patient; the total annual cost of patient care for India was $12 million. Estimates based on India's claimed share of global smallpox incidence put the cost of caring for people with smallpox in developing nations at over $20 million in 1967. Using a person's lifetime economic output, it has been estimated that India loses $700 million each year due to a decrease in economic performance. Eradicating smallpox, underdeveloped countries as a whole were losing at least $1 billion a year in 1967, if 1.5 million people died of smallpox, which is a conservative estimate based on the data available at the time. As a result of this, industrialised countries suffered the costs of vaccination programmes in order to prevent the reappearance of the disease. Only $92.8 million was spent in 1968 on 5.6 million primary vaccines and 8.6 million revaccinations in the United

States, or $6.50 per injection. 8,024 people required medical attention, 238 people were hospitalised, 9 people died, and 4 were permanently disabled as a result of vaccination. In 1968, the vaccine programme cost 75 cents per person, which included various indirect costs like absenteeism from work. If other industrialised countries have lower costs, the annual cost for these countries is approximately $350 million, based on their population. Smallpox was estimated to have cost the world over $1.35 billion in the late 1960s, including both direct and indirect costs. International and endemic country contributions were $98 million and $200 million, respectively, between 1967 and 1979 for the enhanced eradication operation. The largest donor, the United States, saves the sum of all its contributions every 26 days. Preventing the spread of smallpox by means of vaccines is one of the most cost-effective ways to help people stay healthy [16]. The direct cost of the outbreak was reflected in a total of 6 billion SFRY dinars (an equivalent to approximately 600 million US dollars) in 1972 [10].

4. Discussion

Based on content analyses, some drawbacks were made. The Institute for Public Health of Serbia (Belgrade) was notified of eight people hospitalised with possible smallpox, all of them relatives of the index case and some in contact with him. That was the outbreak, patients were tested, and a virological test proved smallpox. The state authorities declared a state of emergency and quarantined the entire country. The WHO enlisted the aid of epidemiologists and a larger epidemic was avoided. To implement martial law, entire towns and neighbourhoods were blocked, roadblocks were set up, public meetings were prohibited, borders closed, and all non-essential movement was prohibited. That was the last significant outbreak of smallpox in Europe, and 35 people died of the 175 infected [4]. In the instance of smallpox, the grounds for the massive outbreak were the late detection of the outbreak and the late implementation of control measures. Other factors that contributed to the spread of the epidemic include: the country lacked an effective immunisation strategy, namely ring vaccination (vaccinating contacts during an outbreak, then progressing in concentric rings), and faced difficulties in conducting mass vaccinations, such as delays, unavailability of the vaccine and the specific immunoglobulin, which is why vaccination failed to a great extent. There was no disease containment strategy, and no accurate information was given to educate the community.

The smallpox outbreak had a tremendous impact on the health and economic position of the SFRY's population, as well as social life (meaning that a lot of people were quarantined and had no chance to make contact with their families, which exposed them to stress and made them dissatisfied). In 1972, the epidemic cost the SFRY 6 billion dinars (about 600 million USD).

Vaccination halted the spread. The last confirmed case occurred in 1977 in Somalia. Vaccination and patient segregation were crucial in preventing the sickness. In light of the emerging threat of using the smallpox virus as a biological weapon [5] the experience gained from the outbreak may be useful in training and educating healthcare workers about the prevention and control of the spread of this so-called "mother of all plagues".

5. Conclusion

The spread of smallpox in the SFRY had a tremendous influence on health and economics, as well as social unrest. Citizens were quarantined and had no chance to make contact with their families, which exposed them to stress and made them dissatisfied and had other psychological consequences. According to the available data, more than 600 million dollars was spent on fighting the disease in 1972, which cost 6 billion SFRY dinars.

The enormous contribution to the increase in life expectancy and the growth of the world's population that occurred during the nineteenth and twentieth centuries is due to discoveries in medicine, the discovery of vaccines and drugs that have made it possible to prevent or cure many diseases. The invention of antibiotics has greatly changed people's lives. Mortality from infectious diseases has been reduced by using drugs that could be made available to all segments of the population. There has been strong international interest and appropriate economic support for such actions to curb and eradicate certain diseases, e.g. smallpox. When it comes to chronic diseases, drugs that can slow the progression of the disease, prevent complications, raise the quality of life, and prolong life have been discovered.

The experience with smallpox contributed further to the progress of medicine, in addition to having an impact on the health economy on a global scale. Major lessons were learned, such as how important it is to vaccinate vulnerable groups in a timely manner.

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„Essential Discrete Mathematics for Computer Science" (Osnove diskretne matematike u informatici i računarstvu), Hari Luis, Rejčel Zaks, Princeton University Press, 2019 Prikaz knjige

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Apstrakt: Knjiga pod naslovom „Essential Discrete Mathematics for Computer Science" (Osnove diskretne matematike u informatici i računarstvu), autora Harija Luisa i Rejčel Zaks, koju je objavila izdavačka kuća „Princeton University Press" 2019. godine, predstavlja važan doprinos proučavanju matematičkih osnova informatike i računarstva. Pored uvoda u diskretnu matematiku kao naučnu disciplinu, ova knjiga od 400 strana sadrži čak 31 kraće poglavlje, ali i veliki broj vežbanja (preko 300). Važnost ove knjige se prvenstveno ogleda u dobroj organizaciji, budući da se svako poglavlje može iskoristiti za jedno predavanje, tj. svako poglavlje predstavlja posebnu nastavnu jedinicu/lekciju sa završnim analizama i zadacima pogodnim za domaće zadatke ili rad u grupi na času, pa može biti korisna kako na osnovnim, tako i na master studijama matematike i informacionih tehnologija. Zbog svog jedinstvenog koncepta i jednostavnog prikaza sadržaja, velikog broja primera i potvrđenih formula i teorema, knjiga može predstavljati dragocen resurs studentima i profesionalcima koji primenjuju diskretnu matematiku u oblasti informatike i računarstva.

Ključne reči: diskretna matematika, grafikon, logika, kriptografija, konačni automati

1. Uvod

Knjiga „Essential Discrete Mathematics for Computer Science" obrađuje matematičke koncepte neophodne u informatici i računarstvu. Koristi se kao udžbenik za istoimeni predmet koji predaje jedan od autora, tačnije profesor Luis na Univerzitetu Harvard. Autori navode sledeće u uvodnom poglavlju: „Ističemo važnost umetnosti dokazivanja, u nadi da će informatičari naučiti da razmišljaju na precizan i formalan način", i upravo pomenuta reč *dokazivanje*, tj. dokaz, predstavlja suštinu ove knjige, kao i deo njene metodologije.

Pored velikog broja vežbi, sve navedene formule i teoreme su u potpunosti dokazane, što dodatno daje na značaju kako samoj knjizi, tako i njenoj primeni u obrazovanju studenata osnovnih i master studija, budući da se uklapa u plan i program različitih predmeta i nivoa obrazovanja zbog svog jedinstvenog koncepta. Kako knjiga obuhvata širok spektar istraživanja, može se primeniti na različitim kursevima, u zavisnosti od koncepta nastavnog plana i programa.

2. Autori

Hari Luis je profesor računarstva i informatike u Školi inženjerstva i informatike na Univerzitetu Harvard od 1974, a bio je i dekan Harvard koledža od 1995. do 2003. On je čuveni američki matematičar i informatičar, koga su proslavila istraživanja računarske logike, kao i udžbenici iz teorijske informatike. Rejčel Zaks je diplomirala matematiku i informatiku (na Harvardu) i radi kao softver inženjer u Guglu.

3. Struktura knjige

Koncept knjige sadrži 31 kraće poglavlje, gde svaka lekcija podrazumeva rezime i desetak zadataka koji se odnose na temu pomenute lekcije. Poglavlja su raspoređena u četiri tematske grupe: Logika; Automati i formalni jezici; Diskretna raspodela verovatnoće; Modularna aritmetika i kriptografija.

Prvo poglavlje, nazvano „Dirihleov princip", raspravlja o opštim principima ponašanja računarskog programa i zaključivanju pomoću funkcija ili mapiranja, skupovima, Dirihleovom principu ili Principu kutija, proširenom Dirihleovom principu, redosledu, ali i o osnovnoj teoremi aritmetike. Drugo poglavlje, nazvano „Osnovne tehnike dokazivanja", uči nas kako da neformalne, konkretne argumente poput ovog pretvorimo u formalne, opše, matematičke dokaze. Treće poglavlje, „Dokazivanje pomoću matematičke indukcije", prvenstveno govori da je prvi korak u rešavanju problema razumevanje onoga što piše u tekstu problema/zadatka. Na osnovu ove sintagme autori objašnjavaju matematičku indukciju na primeru osnovnog scenarija, induktivne hipoteze i induktivnog koraka. Četvrto poglavlje, „Jaka indukcija", predstavlja nedostatke matematičke indukcije kao metode i načina za prevazilaženje ovih nedostataka.

Peto poglavlje, pod nazivom „Skupovi", govori o skupovima kao o zbirci različitih objekata koji se nazivaju članovima skupa, dok šesto poglavlje, „Odnosi i funkcije", diskutuje o odnosu kao vezi između različitih subjekata, ne nužno brojeva, i funkciji kao vrsti binarnog odnosa. Sedmo poglavlje, „Brojivi i nebrojivi skupovi", objašnjava pojam brojivih i nebrojivih skupova, dok osmo poglavlje, „Strukturna indukcija", objašnjava dokazivanje pomoću indukcije

i njen značaj za računarstvo i informatiku u pogledu dokazivanja istinitosti iskaza. Deveto poglavlje, „Propoziciona logika", predstavlja propozicionu logiku, ali i važnost preciznosti u komunikaciji sa računarima, dok deseto poglavlje, „Normalne forme", objašnjava normalne forme i dokazuje razliku između drugih normalnih formi u pogledu odnosa prema definisanoj normi. Jedanaesto poglavlje, pod nazivom „Logika i računari", pojašnjava vezu između logike i računara i njenu važnost, bitove, „tačno" i „netačno" („0" i „1"), dok dvanaesto poglavlje, „Kvantifikaciona logika", predstavlja logiku izraza poput „za svaki", „za sve" itd. Trinaesto poglavlje, „Usmereni grafikoni", čitaocu predstavlja usmerene grafikone kao binarne odnose, dok četrnaesto poglavlje, „Dijagrami i odnosi", predstavlja dijagrame i odnose, a petnaesto, „Stanja i invarijante", predstavlja lekciju o diskretnom stanju digitalnih računara.

Šesnaesto poglavlje, pod nazivom „Neusmereni grafikoni", objašnjava neusmerene grafikone kao kolekciju povezanih temena. Sedamnaesto poglavlje, „Povezivanje", bavi se povezivanjem grafikona u okviru društvene ili računarske mreže. Osamnaesto poglavlje, „Bojenje", uči nas o problemima u vezi sa bojenjem grafikona, dok je devetnaesto poglavlje, „Konačni automati", posvećeno konačnim automatima i njihovoj važnosti za sitne delove računarskog sistema. Dvadeseto poglavlje, „Regularni jezici", podrobnije objašnjava oblast konačnih automata kroz regularne jezike kao jezike prihvaćene u toj oblasti, dok dvadeset prvo poglavlje, „Označavanje redosleda", objašnjava računarske probleme. Dvadeset drugo poglavlje, pod nazivom „Prebrojavanje", objašnjava prebrojavanje kao sredstvo brojanja, uključujući pronalaženje opšte formule za ovu funkciju, dok dvadeset treće poglavlje, „Prebrojavanje podskupova", objašnjava kako se prebrojavaju podskupovi. Niz kao zbir sličnih izraza ili proizvod sličnih izraza objašnjen je u dvadeset četvrtom poglavlju – „Nizovi". Dvadeset peto poglavlje, pod nazivom „Rekurzivni odnosi", kao što mu i ime govori, objašnjava rekurzivne odnose. Dvadeset šesto poglavlje, „Verovatnoća", objašnjava verovatnoću i moguće ishode ponašanja sistema, dok dvadeset sedmo poglavlje, „Uslovna verovatnoća", objašnjava pojam uslovne verovatnoće. Dvadeset osmo poglavlje, „Bajesova teorema", predstavlja teoremu britanskog matematičara Tomasa Bajesa (Nyberg, 2018), dok dvadeset deveto poglavlje, „Slučajne promenljive i očekivanja", govori o slučajnim promenljivama i očekivanjima. Trideseto i trideset prvo poglavlje, „Modularna aritmetika" i „Kriptografija sa javnim ključem", uče nas modularnoj aritmetici i kriptografiji sa javnim ključevima, tim redosledom.

4. Dobre strane knjige

Knjiga pod nazivom „Essential Discrete Mathematics for Computer Science" obraća se širokom krugu čitalaca, iako je originalno napisana kao udžbenik za istoimeni predmet na Univerzitetu Harvard. Autori i izdavač je preporučuju kao obaveznu lektiru na osnovnim i master studijama za studijske programe koji su blisko vezani za predmet udžbenika, ali i za druge matematičke module (npr. linearna algebra ili infinitezimalni račun). Iz tog razloga, knjiga je koncipirana kao udžbenik sa 31 lekcijom, koje sadrže vežbanja sa dokazivanjem formula i teorema, dok su nastavnicima na zahtev dostupni rezimei i dodatni materijali. Knjiga se preporučuje i drugima kojima je potreban udžbenik koji insistira na dokazima.

Knjigu odlikuju dobar koncept i podjednako dobra organizacija. Metodologija koju su autori primenili je vidljiva, logična i sistematično vodi čitaoca sve dublje u datu oblast istraživanja. Poglavlja su raspoređena u četiri tematske grupe: Logika; Automati i formalni jezici; Diskretna raspodela verovatnoće; Modularna aritmetika i kriptografija. Odabrana metodologija čitaocu olakšava razumevanje i učenje, dok insistiranje na dokazima, koje se ogleda u potpunom dokazivanju postavljenih formula i teorema, poboljšava ishode učenja. Sistematičnost i doslednost prikazane u knjizi ilustruju empirizam autora. Koristeći metafore i analogije poput čuvenog „Hilbertovog beskonačnog hotela" (Kragh, 2014), autori rezimiraju poglavlja i ilustruju odabrane lekcije pomoću dovoljnog broja slika i grafikona, te time daju posebnu vrednost ovoj knjizi.

5. Zaključak

„Essential Discrete Mathematics for Computer Science" predstavlja jedinstvenu metodu za razumevanje matematičke osnove informatike i računarstva, jer je to osnovna disciplina u mnogim računarskim naukama. Autori definišu predmet istraživanja koji obuhvata 31 lekciju. One su neophodne za razumevanje i primenu postulata diskretne matematike u informatici i računarstvu. Knjiga Harija Luisa i Rejčel Zaks napisana je tako da čitaocima omogući da savladaju matematičko zaključivanje i veštine dokazivanja. Ona prvenstveno može biti korisna nastavnicima, jer im nudi uputstva pomoću kojih sami mogu doći do rešenja. Knjiga takođe može biti korisna studentima i profesionalcima iz oblasti informatike i računarstva, budući da se matematika nalazi u osnovi različitih računarskih nauka.

Autori koriste metafore i analogije da čitaocima objasne primenu diskretne matematike u informatici i računarstvu, kao i veliki broj ilustrativnih primera, koji studentima i profesionalcima u oblasti računarstva i informatike pomažu da uspešnije savladaju lekcije. Kada je reč o informatičarima, knjiga nudi kompletan materijal neophodan za kurs iz diskretne matematike (predavanja i vežbe) na studijama informatike i računarstva ili sličnim studijskim programima koji su usredsređeni na matematičke zakone i dokaze.

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"Essential Discrete Mathematics for Computer Science", Harry Lewis, Rachel Zax, Princeton University Press, 2019 Book review

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Abstract: The book entitled Essential Discrete Mathematics for Computer Science by authors Harry Lewis and Rachel Zax, published by Princeton University Press in 2019, constitutes an important contribution to the study of the mathematical foundations of computer science. In addition to an introduction to discrete mathematics as a science, this 400-page book presents us with as many as thirty-one shorter chapters and a large number of exercises (more than 300). The importance of this book primarily stems from its good organisation, because each chapter of the book is suitable for one lecture, i.e. every chapter is a separate lesson with concluding analyses and problems suitable for homework or group exercises in class, so it is useful for both undergraduate and master studies in the field of mathematics in information technology. Because of its unique concept and simplicity of presentation, a large number of examples and proven formulas and theorems, the book is valuable to students and professionals who use discrete mathematics in the field of computer science.

Keywords: discrete mathematics, graph, logic, cryptography, finite automata

1. Introduction

Essential Discrete Mathematics for Computer Science covers mathematical concepts required for computer science. It is used as a textbook for the subject of the same name taught by one of the authors (namely Prof. Lewis) at Harvard University. In the Introduction section, the authors state the following: "We stress the art of proof in the hope that computer scientists will learn to think formally and precisely" and it is exactly the aforementioned word "proof" that is the highlight of this book and a part of this methodology.

In addition to a large number of exercises, all formulas and theorems are fully proven, which further strengthens the importance of this book and its application in the education of undergraduate or master students, because it fits into the curricula of different subjects and different study levels due to its unique concept. As the book has a wide range of research, it can be applied to numerous courses, depending on the conceptualised curricula.

2. Authors

Harry Lewis has been teaching as a professor of Computer Science at the Harvard School of Engineering and Applied Sciences since 1974 and served as Dean of Harvard College from 1995 to 2003. He is an American computer scientist and mathematician well known for his research in computational logic and textbooks on theoretical computer science. Rachel Zax, AB in mathematics and secondary in computer sciences (Harvard), is a Google software engineer.

3. The Structure of the Book

The concept of the book implies as many as 31 short chapters, wherein each lesson is accompanied by a summary and about ten problems related to the topic of the lesson in question. The chapters are organised into four parts: Logic; Automata and Formal Languages; Discrete Probability; and Modular Arithmetic and Cryptography.

Chapter 1, entitled "The Pigeonhole Principle", discusses the general computer program behaviour principles and reasoning through function or mapping, sets, the pigeonhole principle, the extended pigeonhole principle, sequence, as well as the fundamental arithmetic theorem. Chapter 2, entitled "Basic Proof Techniques", teaches how to take informal, specific arguments and how to have them translated into formal, general, mathematical proofs. Chapter 3, entitled "Proof by Mathematical Induction", first of all, states that the first step in solving a problem is understanding what it says. Based on this syntagm, the authors explain mathematical induction in terms of the base case, the induction hypothesis and the induction step. Chapter 4, entitled "Strong Induction", discusses the shortcomings of mathematical induction and a way to overcome these shortcomings.

Chapter 5, entitled "Sets", speaks about a set as a collection of distinct objects, which are called the members of the set, whereas Chapter 6, entitled "Relations and Functions", discusses a relation as a connection between various subjects, not only numbers, and a function as the type of a kind of binary relation. Chapter 7, entitled "Countable and Uncountable Sets", explains countable and uncountable sets, whereas Chapter 8, entitled "Structural Induction", explains proof by induction and its importance for computer science concerning establishing the truth of propositions. Chapter 9, entitled "Propositional Logic", presents a lesson on propositional logic and the importance of precision in communication with computers, whereas Chapter 10, entitled "Normal Forms", teaches normal forms, and explains and proves the difference between other forms regarding the relation to the defined norm. Chapter 11, entitled "Logic and Computers", teaches the

connection between and the importance of logic and computers, explaining bits, true and false "0" and "1", whereas Chapter 12, entitled "Quantificational Logic", explains the logic of expressions such as "for any", "for all" and so forth. Chapter 13, entitled "Directed Graphs", presents the reader with directed graphs as binary relations, whereas Chapter 14, entitled "Digraphs and Relations", presents digraphs and relations and Chapter 15, entitled "States and Invariants", is a lesson about the discrete state of digital computers.

Chapter 16, entitled "Undirected Graphs", explains an undirected graph as a collection of vertices connected. Chapter 17, entitled "Connectivity", deals with the connectivity of these graphs within a social or computer network. Chapter 18, entitled "Coloring", teaches us a lesson about graph colouring problems, and Chapter 19, entitled "Finite Automata", is dedicated to finite automaton and its importance for small parts of a computer system. Chapter 20, entitled "Regular Languages", further discusses the field of finite automata by dealing with regular languages as the languages that the field accepts, whereas Chapter 21, entitled "Order Notation", deals with computation problems. Chapter 22, entitled "Counting", explains counting, including finding a general formula for this function, whereas in Chapter 23, entitled "Counting Subsets", counting subsets are explained. A series as a sum of similar terms, perhaps a product of similar terms, is explained in Chapter 24, entitled "Series". Chapter 25, entitled "Recurrence Relations", is about recurrence relations. Chapter 26, entitled "Probability", explains the probability and possible outcomes of the system behaviour, and Chapter 27, entitled "Conditional Probability", explains conditional probability. Chapter 28, entitled "Bayes' Theorem", presents the theorem of British mathematician Thomas Bayes (Nyberg, 2018), whereas Chapter 29, entitled "Random Variables and Expectation", speaks about random variables and expectation. The last two chapters, namely Chapter 30, entitled "Modular Arithmetic", and Chapter 31, entitled "Public Key Cryptography", teach the reader about modular arithmetic and public-key cryptography, respectively.

4. The Strength of the Book

The book entitled Essential Discrete Mathematics for Computer Science addresses a broad range of readers, although it was primarily written as a textbook for Harvard University intended for teaching the course of the same name. The authors and the publisher recommend it as compulsory reading for undergraduate and master courses related to the subject of this book, including other mathematical modules (such as linear algebra and calculus). Therefore, the book is formulated as a 31-lesson textbook accompanied by exercises through proving the formulas and theorems, and inclusive of summaries and supplemental materials for instructors upon request as well. The book is also recommended for others who need a book with an emphasis on proof.

The book is characterised by a good concept and it is organised well. The methodology used by the authors is visible, logical and systematically leads the reader deeper into the field of the research this discipline does. The chapters are organised into four parts: Logic; Automata and Formal Languages; Discrete Probability; and Modular Arithmetic and Cryptography. The selected methodology facilitates the readers' understanding and learning, whereas insisting on proof, which is manifested in the form of the complete proof of the set theorems and formulas, is conducive to better learning outcomes. The systematic quality and consistency demonstrated in the book are indicative of the authors' great empiricism. Through metaphors and analogies, such as the famous "Hilbert's Hotel" (Kragh, 2014), the authors summarise the chapters, and the lessons are illustrated by a sufficient number of figures that infuse additional value to this book.

5. Conclusion

Essential Discrete Mathematics for Computer Science is a unique method of understanding the mathematical foundation of computer science because it is the basic discipline of many computer sciences. In their book, the authors define the subject matter of the research study, which includes the thirty-one lessons necessary for understanding and using postulate discrete mathematics in computer science. The book by Harry Lewis and Rachel Zax is written in a way that makes it possible to teach the reader mathematical reasoning and proving skills. It is primarily useful for instructors, because it offers a manual with available solutions. The book is also valuable to students, researchers and professionals in the field of computer science, as mathematics is the basis of many computer disciplines.

The authors use metaphors and analogies to explain to the reader the application of discrete mathematics in computer science and present a large number of illustrative examples that will make it easier for academic readers and computer professionals to understand the lessons. The book provides computer scientists with complete material for lectures and exercises in discrete mathematics in computer science course and in other courses that insist on mathematical laws and proofs.

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Prilozi Uredništva / Editorial appendixes

O časopisu

EdTech Journal je naučni časopis otvorenog pristupa posvećen korišćenju informacionih tehnologija u obrazovanju. Ipak, u našoj „Naučnoj politici" priznajemo važnost istinske upotrebe IT-ja u društvu i privredi, jer obrazovanje predstavlja vitalni sektor društva. Obrazovanje za potrebe privrede i koncepti zasnovani na njemu su prekretnice koje se moraju uzeti u obzir pri razvoju budućeg opsega sektora obrazovanja.

Zašto EdTech? Računarski hardver, softver i obrazovna teorija i praksa stvaraju obrazovnu tehnologiju (EduTech ili EdTech). EdTech je skraćenica za opisivanje poslovanja razvoja obrazovne tehnologije. Pored informacionih tehnologija, u obrazovnu tehnologiju je zajedno sa praktičnim iskustvom ugrađen i širok spektar teorijskih znanja iz različitih oblasti kao što su komunikacija, obrazovanje, psihologija i sociologija. Teorija učenja, obuke zasnovane na računaru, onlajn-učenje i m-učenje, gde se koriste mobilne tehnologije, uključeni su u ovaj krovni termin. Disciplina se razvija dok o njoj govorimo, baš kao i IT i računarske nauke.

Primenjene obrazovne nauke, kao što su oprema, procesi i procedure proistekli iz naučnih istraživanja, uključeni su u „obrazovnu tehnologiju", pozivajući se na teorijske, algoritamske ili heurističke pristupe u zavisnosti od konteksta. Obrazovne ustanove moraju imati najsavremenije tehnologije kao saveznike u svakodnevnom funkcionisanju. Nastavnici uče kako da poboljšaju svoje rezultate i budu najefikasniji koristeći različita IT rešenja. Učenici uče kako da koriste računare i drugu tehnologiju u učionici i završavaju svoje zadatke u raznovrsnijem i inkluzivnijem okruženju kroz obrazovnu tehnologiju.

Zato EdTech Journal podržava doprinose autora i istraživača iz različitih disciplina i naučnih oblasti koje su opisane u našoj „Naučnoj politici", a koje se dotiču računarske nauke i IT-ja. Informaciona tehnologija pod kojom se podrazumeva upotreba računarskih programa za rešavanje poslovnih procesa ima višestruku primenu. Nova rešenja se integrišu u poslovni, obrazovni i društveni okvir svakodnevno, koristeći informacione tehnologije.

Dr Valentin Kuleto

Glavni i odgovorni urednik

About the Journal

EdTech Journal is a scientific open-access journal dedicated to the use of information technology in education. In our Scientific Policy, we acknowledge the importance of the genuine use of IT in society and the economy because education is a vital sector of society and education for the needs of the economy, and the concepts based on it are milestones that must be taken into account when developing the future scope of the education sector.

Why EdTech? Educational technology (EduTech, or EdTech) encompasses computer hardware, software, and educational theory and practice. EdTech is a commonly used abbreviation to describe the business of developing educational technology. A wide range of theoretical knowledge from various fields alongside information technology, such as communication, education, psychology and sociology, is incorporated into educational technology in addition to practical experience. Learning theory, computer-based training, online learning, and m-learning, which use mobile technologies, are all included in this umbrella term. The discipline develops as we speak, just like IT and computer sciences.

Applied educational sciences, such as equipment, processes, and procedures derived from scientific research, are all included in "educational technology," referring to theoretical, algorithmic, or heuristic approaches depending on the context. Education institutions must have cutting-edge technologies as an ally in everyday functioning. Educators learn how to improve their outcomes and be most effective using various IT solutions. Students learn how to use computers and other technology in the classroom and complete their assignments in a more diverse and inclusive environment through educational technology.

That is why EdTech Journal welcomes the contributions of authors and researchers from various disciplines and scientific fields implemented in our Scientific Policy that feel computer science and IT. Information technology - the application of computer programs to solve business processes - has a wide range of beneficial applications. New solutions are integrated into the business, education and social framework utilizing information technology on a daily basis.

Dr Valentin Kuleto

Editor-in-Chief

Izdavač

Izdavač Naučnog časopisa za savremeno obrazovanje i primenu informacionih tehnologija – EdTech Journal je Institut za moderno obrazovanje (IMO), Beograd, Srbija. Cilj Instituta za moderno obrazovanje (IMO) je unapređenje kvaliteta obrazovnog procesa kroz edukaciju sadašnjih i budućih zaposlenih u obrazovanju i promociju najsavremenijih obrazovnih tehnologija. Misija IMO je pomoć pojedincima da postanu uspešniji, kao i pomoć školama i obrazovnim ustanovama u implementaciji tehnologija i tehnika za unapređenje obrazovnog procesa. IMO je i savetodavni centar za sve lidere u obrazovanju, kao i mesto profesionalne nastavne prakse za buduće profesore.

IMO je deo vodeće multinacionalne EdTech kompanije LINKgroup, koja se 25 godina uspešno bavi profesionalnom edukacijom i sertifikacijom u oblasti informacionih tehnologija i savremenog poslovanja. Kao kompanija koja se bavi edukacijom u različitim sferama, LINKgroup je prisutan u Srbiji, Hrvatskoj, Bosni i Hercegovini, Rumuniji, Ukrajini, Moldaviji i Sjedinjenim Američkim Državama, a putem jedinstvenog e-Learning sistema za učenje na daljinu okuplja polaznike iz preko 120 zemalja sveta.

U okviru LINKgroup obrazovnog sistema (LINK Educational Alliance) postoji više od pedeset obrazovnih institucija i obrazovnih servisa. LINK Educational Alliance na jednom mestu okuplja obrazovne institucije bez obzira na naučnu oblast i nivo obrazovanja, kao i kompanije i pojedince koji su svesni da samo celoživotno učenje i usavršavanje donosi profesionalni uspeh.

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Publisher

The publisher of the Scientific Journal for Contemporary Education and Application of Information Technologies – EdTech Journal is the Institute for Contemporary Education (ICE), Belgrade, Serbia. The Institute for Contemporary Education (ICE) aims to improve the quality of the educational process through the education of current and future employees in education and the promotion of the most modern educational technologies. The ICE's mission is to help individuals become more successful and support schools and educational institutions in implementing technologies and techniques to improve the educational process. ICE is also an advisory centre for all leaders in education and a place of professional teaching practice for future professors.

ICE is part of the leading multinational EdTech company LINK group, which has been successfully engaged in professional education and certification in information technology and modern business for more than 20 years. As a company involved in teaching in various fields, LINK group is present in Serbia, Croatia, Bosnia and Herzegovina, Romania, Ukraine, Moldova and the United States, and a unique e-learning system for distance learning brings together students from over 120 countries.

There are more than fifty educational institutions and services within the LINK group education system (Link Educational Alliance). The LINK Educational Alliance brings together educational institutions regardless of scientific field and level of education and companies and individuals who are aware that only lifelong learning and improvement brings professional success.

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Naučna politika časopisa

Kvalitetno obrazovanje je osnov napretka i uspeha pojedinca i društva – dr Valentin Kuleto

U pogledu naučnih polja kojima časopis pretežno pripada, reč je o dva naučna polja: tehničko-tehnološke nauke (elektronika i informacione tehnologije) i društveno-humanističke nauke (pravo, ekonomija i političke i organizacione nauke) i društveno-humanističke nauke (filozofija, psihologija, pedagogija i sociologija).
Časopis neguje internacionalne, ali i identitetske nauke, posvećen je sledećim naučnim oblastima:

elektrotehničko i računarsko inženjerstvo; organizacione nauke; menadžment i biznis, pedagoške i andragoške nauke; ekonomske nauke, političke nauke; pravne nauke; psihološke nauke; sociološke nauke; filozofija; nauke o umetnostima.

- distance-learning sistemi;
- internet;
- informacione tehnologije;
- informacioni sistemi;
- digitalne kompetencije;
- mreža 5G;
- veštačka inteligencija (artificial intelligence – AI);
- autonomni uređaji (roboti, odnosno korišćenje veštačke inteligencije za automatizaciju funkcija koje inače obavljaju ljudi);
- blokčejn tehnologija (blockchain);
- proširena analitika (augmented analytics): big data u kombinaciji sa veštačkom inteligencijom, odnosno korišćenje mašinskog učenja za automatsko učenje i optimizaciju odluka korišćenjem dubinskih analiza podataka;
- *digitalni blizanci* (digital twins), odnosno virtualne replike stvarnog sveta ili entiteta;
- poboljšani edge computing (Internet of Things, komplementarni modeli sa rešenjima u klaudu);
- iskustva u pametnim prostorima – smart spaces (virtualna realnost – virtual reality (VR), proširena realnost – augmented reality (AR) i mešovita realnost – mixed reality (MR));
- inovacije u privredi
- menadžment;
- marketing;
- preduzetništvo (digitalno preduzetništvo, socijalno preduzetništvo);
- poslovna ekonomija;
- ekonomija u zdravstvu;
- poslovni informacioni sistemi;
- pedagogija i andragogija;
- poslovno pravo;
- primena IT-ja u obrazovanju;
- inovacije u obrazovanju;
- održivo obrazovanje;
- daroviti učenici;
- obrazovanje 4.0;
- NEETs;
- digitalna umetnost i data art;
- nauke o umetnosti;
- kultura;
- komunikologija;

druge oblasti od interesa za primenu informacionih tehnologija u društvu, privredi i obrazovanju.

U pogledu teorijskih i metodoloških smernica za obavljanje radova, časopis preporučuje IMRAD format za originalne naučne članke i PRISMA format za pregledne radove. Naučni radovi se upućuju na najmanje 2 recenzije, a stručni na najmanje jednu recenziju. Sve recenzije su *double-blind*.

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radovi su vidljivi u celini na sajtu časopisa.

Društvena, državna i kulturna uloga časopisa ogleda se u priznavanju značaja i uloge informacionih tehnologija i na njima zasnovanih rešenja u oblasti društva, privrede i obrazovanja.

Opšti, naučni i društveni karakter časopisa ogleda se u deljenju znanja, rezultata naučnoistraživačkog rada i promocije nauke.

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U Beogradu, 29. 12. 2021. godine

Glavni i odgovorni urednik

dr Valentin Kuleto

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The Scientific Policy of the Journal

Quality education is the basis of progress and success of the individual and society – Dr Valentin Kuleto

Regarding the scientific fields that the journal is mostly concerned with, there are two: technical-technological sciences (electronics and information technology) and social-humanistic sciences (law, economics and political and organisational sciences) and social-humanistic sciences (philosophy, psychology, pedagogy and sociology).
The journal nurtures international and identity sciences, and it is dedicated to the following areas:

electrical and computer engineering; organisational sciences; management and business; pedagogical and andragogical sciences; economic sciences; political science; legal sciences; psychological sciences; sociological sciences; philosophy; the sciences of the arts.

In terms of thematic guidelines for publishing papers, the journal welcomes papers from the areas including, and not limited to:

- e-learning;
- distance-learning systems;
- Internet;
- information technology;
- information systems;
- digital competences;
- 5G network;
- artificial intelligence (AI);
- autonomous devices (robots, i.e. the use of artificial intelligence to automate functions usually performed by humans);
- blockchain technology;
- augmented analytics: big data combined with artificial intelligence, i.e. the use of machine learning for automatic learning, and optimisation of decisions using in-depth data analysis;
- digital twins, or virtual replicas of the natural world or entities;
- edge computing (Internet of Things, complementary models with solutions in the cloud);
- experiences in smart spaces (virtual reality – VR, augmented reality – AR and mixed reality – MR);

- innovations in the economy;
- management;
- marketing;
- entrepreneurship (digital entrepreneurship, social entrepreneurship);
- business economics;
- health economics;
- business information systems
- pedagogy and andragogy;
- business law;
- application of IT in education;
- innovation in education;
- sustainable education;
- gifted student;s
- Education 4.0;
- NEETs;
- digital art and data art;
- the science of art;
- culture;
- communication science;

and other areas of interest for the application of information technology in society, economy and education.

Regarding theoretical and methodological guidelines for papers, the journal recommends the IMRAD format for original scientific articles and the PRISMA format for paper reviews. Scientific articles are submitted for at least 2 reviews, and professional articles for at least one review. All reviews are double-blind.

The journal uses authentication/plagiarism software and verifies the authenticity of each article that receives

positive reviews and reviewers' recommendations for publication.

The journal is open access and does not charge a fee for processing papers or their publication. In addition, all published scientific papers are visible in their entirety on the journal's website.

The social, national and cultural role of the journal is reflected in the recognition of the importance and role of information technologies and solutions based on them in society, economy and education.

The general, scientific and social character of the journal is reflected in the sharing of knowledge and the results of scientific research, and promotion of science.

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Belgrade, 29 December 2021

Editor-in-Chief

Dr Valentin Kuleto

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Na osnovu Statuta Instituta za moderno obrazovanje, član 3, stav 7, i Poslovnika o radu Uređivačkog odobra sa pravilnikom o uređivanju, Uređivački odbor Naučnog časopisa za savremeno obrazovanje i primenu informacionih tehnologija EdTech Journal na sednici održanoj dana 29 12. 2021. godine donosi sledeći:

Etički kodeks Naučnog časopisa za savremeno obrazovanje i primenu informacionih tehnologija – EdTech Journal

Članovi Uređivačkog odbora Naučnog časopisa za savremeno obrazovanje i primenu informacionih tehnologija – EdTech Journal nadziru primenu etičkih standarda u naučnoistraživačkom i izdavačkom radu i odgovorni su za očuvanje etike izdavača časopisa, Instituta za moderno obrazovanje. Nadzor podrazumeva detaljnu kontrolu nad plagijarizmom i podnošenjem netačnih informacija i kršenjem autorskih prava, kao i izjašnjenje o uočenom, ispravku, uklanjanje rukopisa i druge korake.

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dr Valentin Kuleto

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Scientific Journal for Contemporary Education and Application of Information Technologies – EdTech Journal

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Belgrade, 29 December 2021

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Potrebno je napisati detaljne opise Materijala i metoda, tako da ih drugi mogu ponoviti i vršiti dalja istraživanja na osnovu objavljenih rezultata. Svi materijali, podaci, kompjuterski kod i protokoli u vezi sa objavljivanjem vašeg rukopisa treba da budu dostupni čitaocima. Molimo vas da imate u vidu ovaj zahtev. Ukoliko postoje bilo kakva ograničenja u pogledu dostupnosti materijala ili informacija u trenutku predavanja teksta, molimo vas da ih navedete. Postojeće metode i protokoli mogu se ukratko pomenuti i navesti na odgovorajući način, dok je nove metode i protokole potrebno detaljno opisati.

3. Rezultati

U ovom segmentu poželjni su međunaslovi. On treba da pruži jezgrovit i precizan pregled rezultata eksperimenata, njihove interpretacije, kao i zaključaka koji se mogu izvesti.

3.1. Podsekcija

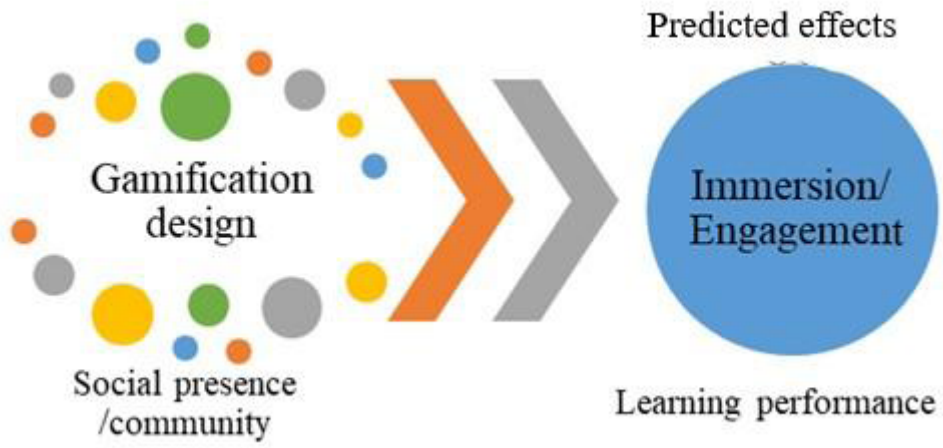
3.1.1. Potpodsekcija

Lista sa nabrajanjem treba da izgleda ovako:

- Stavka 1;
- Stavka 2;
- Stavka 3;

3.2. Slike, tabele i shematski prikazi

U glavnom tekstu, navodite sve slike i tabele kao Slika 1, Tabela 1 itd.



Slika 1. Veza između dizajna gejmifikacije i obrazovnih rezultata, adaptirano prema [16].

[1] Tabele mogu imati legendu (footer).

Tabela 1. Tabele treba postavljati u tekst u blizini mesta na kom se prvi put pominju.

Red	Naslov kolone 1	Naslov kolone 2
1	Vrednost 1	Vrednost 3
2	Vrednost 2	Vrednost 3

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Tekst se nastavlja ovde (Slika 2 i Tabela 2).

Primer jednačine:

$$a = b + c + d + e + f + g + h + i + j + k + l \qquad)$$

4. Diskusija

Autor(i) treba da detaljno razmotre rezultate i načine na koji se oni mogu razumeti iz perspektive ranijih istraživanja i radnih pretpostavki. Moramo razmotriti sve moguće ishode svojih rezultata i njihove posledice. Ovde se navode i mogućnosti kad je reč o smerovima u kojima bi se istraživanje moglo dalje razvijati.

5. Zaključak

Ukoliko je debata veoma duga ili kompleksna, u rukopis se može uvrstiti ovaj segment. Poželjan je pogotovo ako se ne koristi IMRAD model.

Dodatak (Appendix) 1

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3.1. Subsection

3.1.1. Subsubsection

This is what a bulleted list looks like:

- *Bullet 1;*
- *Bullet 2;*
- *Bullet 3;*

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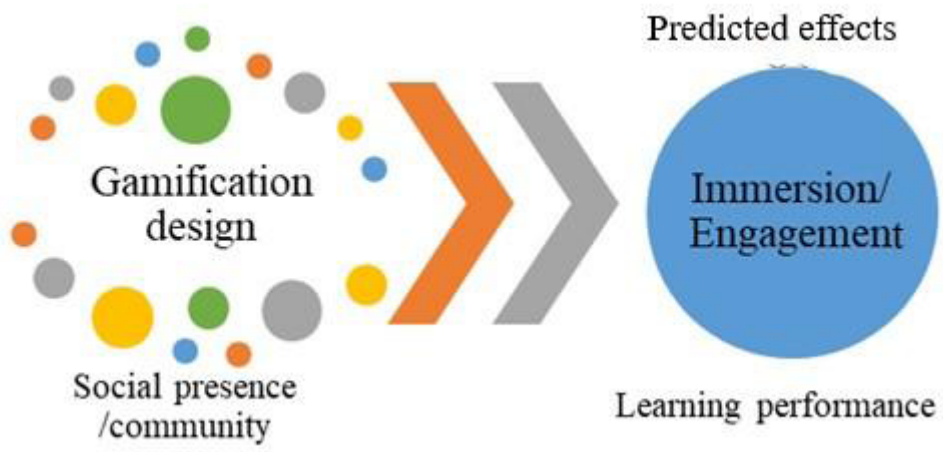

[1] Figures may have a footer.

Figure 1. Relating gamification design with the education performance, adaptation after [16].

Table 1. Tables should be put in the text around their initial citation.

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1	Value 1	Value 3
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[1] Tables may have a footer.

The text continues here (Figure 2 and Table 2).

An equation example:

$$a = b + c + d + e + f + g + h + i + j + k + l \qquad)$$

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Results and how they can be understood from the perspective of past studies and working hypotheses should be discussed in detail by the author(s). We must consider all the possible outcomes of our results and their consequences. There are also possibilities for future study directions to be mentioned here.

5. Conclusions

If the debate is particularly lengthy or complex, this section can be added to the manuscript. It is desirable especially if IMRAD model is not used.

Appendix 1

It is possible to include additional information and data in the appendix, such as explanations of experimental details that would otherwise interrupt the flow of the main text, but which are still critical to understanding and reproducing the research shown in the main text, or figures of replicates for experiments of which representative data is shown in the main text. An appendix can be used to include mathematical proofs of results that are not fundamental to the paper.

Acknowledgements

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Belgrade, 29 December 2021

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