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konferencija**

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prekogranična saradnja**

**ZBORNIK RADOVA**

**Pirot, decembar 2021.**



**ZBORNİK RADOVA**  
**BOOK OF PROCEEDINGS**



**REGIONALNI RAZVOJ I PREKOGRANIČNA  
SARADNJA**  
**REGIONAL DEVELOPMENT AND CROSS-BORDER  
COOPERATION**

**Urednici/Editors:**

Bojan Đorđević Phd

Dragan Kostić Phd

Aleksandar Simonović

**Pirot, decembar 2021.**

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**UREDNICI / EDITORS:**

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Dragan Kostic PhD

Aleksandar Simonović

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**LEKTURA / PROOFREADING**

Jelena Stamenović

**TEHNIČKI UREDNICI / TECHNICAL EDITORS: Aleksandra Madić**

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U današnje vreme, u okviru aktuelnih procesa globalizacije i integracije, savremenih ekonomskih trendova, intenzivnih migracija, i posebno aktuelne pandemije, kojoj se ne vidi kraj, prekogranična saradnja i uopšte saradnja među državama i narodima u rešavanju ovih izazova dolazi u fokus interesovanja ne samo stručne i naučne, već i šire društvene javnosti. Izazovi su veliki i jedino zajedničkim naporima mogu se uspešno rešavati. I u ovakvim teškim izazovima u organizaciji Srpske akademije nauke i umetnosti – ogranaka u Nišu, grada Pirot, Privredne komore Pirot, Fakulteta za menadžment Zaječar i Univerziteta Metropoliten, održana je peta po redu Međunarodna naučna konferencija “ Regionalni razvoj i prekogranična saradnja” u Pirotu 04. decembra 2021.

Opravljanost pokretanja i održavanja međunarodne konferencije sa ovakvim nazivom, potvrđuje i činjenica da i ovakvim uslovima, izazvane pandemijom i dalje vlada veliko interesovanje za ovu konferenciju kako u samoj Srbiji tako i u inostranstvu. To potvrđuje i činjenica da je za konferenciju pristiglo 48 naučnih radova iz osam zemalja.

Tematska područja, koja su posebno bila predmet ove konferencije su:

- Ekonomska politika u službi regionalnog razvoja;
- Edukacija i razvoj ljudskih resursa u funkciji regionalnog razvoja;
- Industrija, logistika i transport 4.0 i regionalni razvoj;
- Međunarodne strategije i projekti i regionalni razvoj;
- Poljoprivreda, proizvodnja zdrave hrane i turizam u funkciji regionalnog razvoja;

U zborniku koji je pred Vama publikovana su saopštenja učesnika skupa, koja su zadovoljili kriterijume recezetske komisije. U radovima se dalje produbljuju naučna istraživanja na ovu izuzetno značajnu društvenu i naučnu temu, koju smo pokrenuli pre pet godina. Zadovoljni smo što možemo konstatovati da je svi više radova, koji nude ne samo teorijska objašnjenja, već i praktična rešanja, kako smanjiti regionalne razlike, i kako povećati i unaprediti prekograničnu saradnju. U nadi da smo ponudili neke od odgovora, ali i da ćemo ovim naučnim skupom pokrenuti još širu naučnu raspravu na navedene teme, a koja će na kraju dovesti i do boljeg razumevanja značaja i uloge prekogranične saradnje u savremenom društvu, predajemo ovaj zbornik radova naučnoj, ali i široj čitalačkoj publici.

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Decembar 2021

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## FOREWORD

Nowadays, within the current processes of globalization and integration, modern economic trends, intensive migration, and especially the current pandemic, which has no end in sight, cross-border cooperation and cooperation between states and nations in solving these challenges is the focus of interest not only and scientific, but also the general public. The challenges are great and only joint efforts can successfully solve them. The fifth International Scientific Conference "Regional Development and Cross-Border Cooperation" was held in Pirot 04 in such difficult challenges in the organization of the Serbian Academy of Sciences and Arts - Nis branch, Pirot, Pirot Chamber of Commerce, Zajecar Faculty of Management and Metropolitan University. December 2021.

The justification for initiating and holding an international conference with this name is confirmed by the fact that even with such conditions, caused by the pandemic, there is still great interest in this conference both in Serbia and abroad. This is confirmed by the fact that 48 scientific papers from eight countries arrived for the conference.

Thematic areas, which were especially the subject of this conference are:

- Economic policy in the service of regional development;
- Education and development of human resources in the function of regional development;
- Industry, logistics and transport 4.0 and regional development;
- International strategies and projects and regional development;
- Agriculture, healthy food production and tourism in the function of regional development;

In the collection that is in front of you, the announcements of the participants of the gathering were published, which met the criteria of the reception committee. The works further deepen scientific research on this extremely important social and scientific topic, which we started five years ago. We are pleased to note that there are more and more papers, which offer not only theoretical explanations, but also practical solutions, how to reduce regional disparities, and how to increase and improve cross-border cooperation. In the hope that we have offered some of the answers, but also that with this scientific gathering we will initiate an even broader scientific discussion on these topics, which will eventually lead to a better understanding of the importance and role of cross-border cooperation in modern society. but also to a wider readership.

The editors and editors express their gratitude to all the authors who contributed their works.

Pirot,

Editorial Board

December 2021

P. A. & D. K.



1. TRETIRANJE PODATAKA U NAUČNIM ISTRAŽIVANJIMA Prof. dr Tihomir Radovanović dr Marko Filijović Prof. dr Pavle Radanov.....	15
2. ULOGA OBRAZOVANJA U ODRŽIVOM RAZVOJU I U PREVAZILAŽENJU NEJEDNAKOSTI/NEUJEDNAČENOSTI Dr Biljana ilić, vanredni profesor Dr Gordana Đukić, istraživač saradnik Dr Aleksandar Simonović, doktorand .....	25
3. MEĐUGRANIČNA SARADNJA I ODREĐENI PROBLEMI KAO IZVOR MOGUĆE NESTABILNOSTI U RAZVOJU MEĐUGRANIČNIH DRŽAVA Akad. SKANU, prof. dr Radomir D. Đorđević Akad. S.U.D, prof. dr Marina Denić.....	35
4. FOREIGN TRADE OF THE REPUBLIC OF SERBIA & DEVELOPING COUNTRIES Assistant Professor, Mihailo Ćurčić, Ph.D., Research Associate Assistant Professor, Danijela Pantović, Ph.D. Associate Professor, Marija Lakićević, Ph.D. ....	47
5. ZNAČAJ I PERSPEKTIVE RAZVOJA VINSKOG TURIZMA U SRBIJI MSc. Miloš Zrnić PhD. Đorđe Stojanović MSc. Jelena Košutić PhD. Ana Kalušević .....	59
6. SAJBER BEZBEDNOST U KONTEKSTU REGIONALNOG RAZVOJA Doktor političkih nauka, Sanja Klisarić.....	67
7. APPLICATION OF IoT TECHNOLOGY IN BEEKEEPING Jelena Arandžević, Ph.D. student Darjan Karabašević, Associate Professor Gabrijela Popović, Associate Professor .....	75
8. ULOGA I ZNAČAJ OPERACIJA NA OTVORENOM TRŽIŠTU NARODNE BANKE SRBIJE Prof. dr Jadranka Đurović-Todorović Prof. dr Marina Đorđević Student doktorskih studija Snežana Colić.....	87
9. IMPLIKACIJE BLOCKCHAIN TEHNOLOGIJE NA OPERATIVNI RIZIK U BANKARSKOM SEKTORU* Istraživač pripravnik, Andreja Todorović Istraživač pripravnik, Andrija Popović Istraživač pripravnik, Ana Milijić.....	105
10. ANALIZA PROCESA NABAVKE I IZBOR DOBAVLJAČA PRIMENOM SWARA-WASPAS PRISTUPA Vukašin Pajić, asistent dr Milan Andrejić, profesor Tijana Jovanović, student master studija .....	119
11. ORGANIZACIJA MEĐUNARODNIH ROBNIH TOKOVA SA ZEMLJAMA ČLANICAMA CEFTA SPORAZUMA Barbara Todorović, student master studija dr Milan Andrejić, profesor Vukašin Pajić, asistent .....	137
12. FINANSIRANJE ZAJEDNIČKE AGRARNE POLITIKE EVROPSKE UNIJE U REFORMSKOM PERIODU DO 2027. GODINE Snežana Colić, Student doktorskih studija .....	157
13. TURISTIČKI POTENCIJAL SRBIJE U VREME PANDEMIJE COVID-19 Vanredni profesor, Boban Dašić Predavač, Milan Veselinović Vanredni profesor, Dejan Dašić.....	175

14. ZNAČAJ I ULOGA POLITIKE ZAŠTITE KONKURENCIJE U PROCESU PRISTUPANJA REPUBLIKE SRBIJE I ZEMALJA ZAPADNOG BALKANA EVROPSKOJ UNIJI prof. dr Vladan Vučić prof. dr Saša Ivanov prof. dr Dejan Dašić .....	187
15. IZAZOVI U SNABDEVANJU PRIRODNIM GASOM U EVROPI I REGIONALNA SARADNJA Asistent, Strahinja Obrenović Istraživač, Marko Filijović .....	203
16. POLITIČKI SISTEM REPUBLIKE SRBIJE ANALIZIRAN KROZ PRIZMU DRUŠTVENO-GEOGRAFSKOG FAKTORA Naučni saradnik, Vanredni profesor, Ratko Ljubojević Docent, Andrija Blanuša Docent, Slobodan Petrović .....	215
17. EKOLOŠKA DIMENZIJA ZAJEDNIČKE AGRARNE POLITIKE EVROPSKE UNIJE POSLE 2020. GODINE* Istraživač pripravnik, Andreja Todorović Istraživač pripravnik, Andrija Popović Student , Bojan Blagojević .....	221
18. FINANSIJSKI RIZICI U GLOBALNIM LANCIMA SNABDEVANJA SA POSEBNIM OSVRTOM NA 3PL PROVAJDERE Mladen Božić, mast. inž. saobraćaja Saradnik u nastavi, Nikola Pavlov , mast. inž. saobraćaja .....	233
19. SKLADIŠTE 4.0 Prof. dr, Dragan Đurđević, dipl. inž. saobraćaja Saradnik u nastavi, Nikola Pavlov , mast. inž. saobraćaja .....	249
20. THE ROLE OF BLOCKCHAIN TECHNOLOGY IN DISASTER RELIEF GLOBAL SUPPLY CHAINS dr Svetlana Dabić-Miletić, vanredni profesor dr Vladimir Simić, vanredni profesor .....	265
21. SELO U SRBIJI – IMA LI NADE PORUKE DRAGOLJUBA JOVANOVIĆA I NJIHOVA AKTUELNOST DANAS Prof.dr Petar Anđelković .....	277
22. NACIONALNO OBRAZOVANJE I NACIONALNA BEZBEDNOST U GLOBALNIM VREMENIMA Doktorand, Nemanja Anđelković .....	289
23. PRAVNI ASPEKTI PREKOGRANIČNE SARADNJE LOKALNIH SAMOUPRAVA Dr Ivan Nikčević, profesor strukovnih studija Dr Milica Krulj-Mladenović, profesor strukovnih studija MA Jovana Anđelković, Asistent .....	301
24. ULOGA JAVNOG BELEŽNIKA U STATUSNIM STVARIMA U REGIONU Prof. Dr Milena Trgovčević Prokić .....	315
25. ZADRUGE KAO OSNOVA EKONOMSKOG RAZVOJA AGRARNOG SEKTORA I REGIONA U REPUBLICI SRBIJI PhD student, Aleksandar Đorđević Viktorija N. Rjapuhina, docent katedre strategijskog menadžmenta PhD student, Aleksandra Đorđević.....	327
26. NOVE TEHNOLOGIJE I MODELI OBRAZOVANJA U FUNKCIJI RAZVOJA LJUDSKIH RESURSA dr Dragana Trifunović, vanredni profesor dr Goran Lalić, vanredni profesor Zorica Radovanović, student master studija .....	339

27. UTICAJ ZEMALJA BIVŠE SFRJ NA KOHEZIONU POLITIKU REPUBLIKE SRBIJE U DRUGOJ DECENIJI 21. VEKA dr Slobodan Petrović , docent dr Dragana Trifunović , vanredni profesor dr Ratko Ljubojević, vanredni profesor .....	349
28. CROSS-BORDER COOPERATION USING ERP BUSINESS SOFTWARE IN SUPPLY CHAIN MANAGEMENT PhD Milica Ničić, prof. PhD Dragan Dukić,prof. PhD Dragan Rastovac,prof. ....	359
29. TRENDovi U KONJIČKOJ INDUSTRIJI Milorad Damjanović Dr Kosana Vićentijević .....	371
30. THE NEW PRODUCT DEVELOPMENT OF PACKAGE FMCG Rositsa Nakova, Phd .	379
31. RADNIČKA KLASA, TRANZICIONI GUBITNICI U GLOBALIZACIJSKIM VREMENIMA Marko Stanojević, Doktorand .....	393
32. ZNAČAJ FORMIRANJA ZAJEDNICE OTVORENI BALKAN ZA SPOLJNOTRGOVINSKU RAZMENU REPUBLIKE SRBIJE saradnik u nastavi, Adrijana Jevtić student doktorskih studija, Jelena Veljković redovni profesor, Dejan Riznić.....	403
33. ODNOS IZMEĐU IMIDŽA ZEMLJE POREKLA I IMIDŽA MARKI NJENIH PROIZVODA prof. dr Vesna Milanović prof. dr Andrea Bučalina Matić doc. dr Biljana Pejović .....	419
34. ZEMLJE EVROPSKE UNIJE KAO SPOLJNOTRGOVINSKI PARTNERI REPUBLIKE SRBIJE Prof. dr Silvana Ilić Doc dr Dragica Stojanović.....	429
35. SPECIJALNE EKONOMSKE ZONE NOVI PRAVAC RAZVOJA SLOBODNIH ZONA SRBIJE Dr Dragan Kostić Aleksandar Simonović, doktorand .....	445
36. UTICAJ COVIDA -19 NA POLITIKU REGIONALNOG RAZVOJA Teodora Simonović, Student Ekonomskog fakulteta Univerziteta u Nišu <sup>®</sup> .....	461
37. MOTIVACIJA ZAPOSLENIH KAO NAJVAŽNIJI ČINILAC USPEŠNOSTI POSLOVANJA Dr Leposava Jovanović Mirjana Božović Stošić Saša Ivanov .....	485
38. EMPIRIJSKO ISTRAŽIVANJE PRIMENE DRUŠTVENIH MREŽA U PROMOCIJI PONUDE HOTELA REPUBLIKE SRBIJE Doc. Dr Milena Podovac Dr. Danijel Drpić Vedran Milojica, mag.oec. ....	499
39. SOCIAL COHESION AND CROSS-BORDER COOPERATION IN THE BALKAN REGION PhD. Zoran Matevski PhD. Dushka Matevska .....	513
40. DIGITAL EUROPE - ADAPTABILITY TO MODERNIZATION Dr. Desislava Botseva, Chief Assist. Dr. Elka Vasileva, Assoc. Prof. Dr. Georgi Tzolov, Chief Assist. ....	523
41. INTELLIGENT CLUSTERS THE FUTURE BASIS OF COMPETITION Dr. Nikola Tanakov, Chief Assist. Dr. Georgi Nikolov, Assoc. Prof. Dr. Veselina Lyubomirova, Chief Assist. ....	535

42. UTICAJ COVID-19 NA TRŽIŠTE AKCIJA BEOGRADSKJE BERZE: PANEL REGRESIONA ANALIZA Prof. dr Bojan Đorđević Doc. dr Sunčica Stanković .....	543
43. PREKOGRANIČNA SARADNJA BUGARSKE I SRBIJE U CILJU RAZVIJANJA I PROMOCIJE OMLADINSKOG VOLONTERIZMA U OBLASTI PRIRODNIH KATASTROFA doc.dr, Anđelija Radonjić dr, Nebojša Veljković dr, Jasmina Radonjić Dimitrijević .....	557
44. PREKOGRANIČNA SARADNJA I TEHNIČKO-TEHNOLOŠKI PROGRES I STRUKTURA ZAPOSLENIH Akad.SKANU, EMERITUS, Prof. Dr ANDON G. KOSTADINOVIĆ .....	567
45. CONTEMPORARY CONCEPTS FOR ELECTRONIC GOVERNANCE. E-SERVICES FOR ECONOMIC DEVELOPMENT IN THE REGIONS Dung Van Dinh .....	583
46. IMPORTANCE OF E-GOVERNANCE FOR STRENGTHENING DEMOCRACY. CASE OF ALBANIA Valbona Sakollari Phd Halit Xhafa Prof. Dr. ....	599
47. THE IMPACT OF COVID – 19 ON LINER SHIPPING, PORTS AND FREIGHT LOGISTICS: AN INTEGRATED ASSESSMENT Prof. Dr. Sotirios Theofanis Prof. Dr. Maria Boile Prof. Dr. Aristotelis Naniopoulos Dr. Georgios Palantzas .....	609
48. PRIMENA GIS-A U REGIONALNOJ I PREKOGRANIČNOJ SARADNJI mr Goran Stamenović dr Dejan Rančić.....	621

## APPLICATION OF IoT TECHNOLOGY IN BEEKEEPING

Jelena Arandžević, Ph.D. student<sup>1</sup>  
Darjan Karabašević, Associate Professor<sup>2</sup>  
Gabrijela Popović, Associate Professor<sup>3</sup>

**Abstract:** Serbia is globally recognized as a country with extraordinary potential, especially when it comes to agriculture. Resources, climatic conditions, significant diversification, following the microclimatic and pedological conditions provide a remarkable potential for the further economic development of our country. As one of the prosperous branches, which has not achieved its total capacity, in terms of development, beekeeping is unavoidable. Speaking of IoT (Internet of Things), it was necessary to find a valid reason, in the free opinion, of establishing a real connection between beekeeping and the Internet of Things. To an ordinary observer, all this might sound strange from the outside because people, especially in our area, are always turned to the traditional, with the fear of new variants in a business. The main point is that with the application of this technology, the level of education of beekeepers increases, but also the hives, as a society, improve living conditions and enable easier management of activities at the level of the hive.

**Keywords:** IoT, beekeeping, modern technologies, ICT.

### Introduction

In the last few decades, the Internet, with its simplicity and efficiency, has imposed itself as the leading medium, but above all, as the ultimate way of communication between people on the planet, whether business processes or personal contacts. That was the reason why telecommunications were used in all branches of human activity. Namely, the availability of the Internet and unimagined opportunities that have arisen due to each microevolution in this field of telecommunications, and line with the latest technical and technological advances, have caused the industry to be primarily controlled by computer programs, which are connected with certain plants, which enables better process management, in essence,

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<sup>1</sup> Faculty of Applied Management, Economics and Finance, University Business Academy in Novi Sad, Serbia, jeja.arandjelovic@gmail.com

<sup>2</sup> Faculty of Applied Management, Economics and Finance, University Business Academy in Novi Sad, Serbia, darjan.karabasevic@mef.edu.rs

<sup>3</sup> Faculty of Applied Management, Economics and Finance, University Business Academy in Novi Sad, Serbia, gabrijela.popovic@mef.edu.rs

but also, on the other hand, leaves more time for research and development, to improve the production process itself.

With the improvement of the Internet and communication devices, a level of development has been reached. The use of mobile applications and computer programs in beekeeping can be widely debated. The offer of free mobile applications is significant, both in the Google and Apple application stores. Internet of Things (IoT), as a representation of networking processes, i.e., objects (things), is of great importance for beekeeping because the activity itself is performed on tens, hundreds, and thousands of bee societies. This concept, empirically, enables more accessible and more precise monitoring of the process in each cell individually, which enables timely and efficient action in unwanted situations. It is necessary to mention the constant progress in scientific work related to beekeeping, where domestic experts are leaders.

The subject of this paper is the possibilities of applying IoT technology in the modern beekeeping system and the impact on raising the overall quality of beekeeping. Accordingly, the report aims to conclude the prism of several internationally recognized authors by presenting adequate data related to beekeeping, which would contribute to future research related to this, specific topics, modernization of beekeeping. The paper presents the precise identification of key factors influencing the quality of beekeeping associated with IoT and the formation of recommendations for applying these technologies in beekeeping, with possible reference to prices and cost-effectiveness of introducing this innovation.

### **IoT (Internet of Things)**

The Internet of Things is a concept, i.e., a vision in which the Internet expands into a reality that includes everyday objects, i.e., objects used every day, both in personal and private life. Ordinary things, like white goods, etc. they are no longer inaccessible to the virtual world, can be controlled remotely, and act as physical access points for certain Internet services. The Internet of Things makes computing and computer technology truly ubiquitous - is a statement made by Mark Weiser almost three decades ago, at the beginning of the last decade of the 20th century. This development opens up enormous opportunities for the economy and individuals. However, like any benefit of scientific and technological progress used in everyday life, IoT also carries certain risks and undoubtedly represents a substantial technical and social challenge, looking at one global picture. The vision of the IoT is based on the belief that steady progress in the field of microelectronics, telecommunications, and information technologies is, in fact, a trend that will almost certainly continue shortly. Namely, their physical size, constant decline in prices (mass production), and energy consumption, which draws on processors, communication modules, and other electronic components, are increasingly integrated into things present in everyday life (Mattern & Floerkemeier, 2010).

The Internet of Things is a computer concept that describes everyday physical objects connected to the Internet, and other devices can identify that. The term is closely related to RFID as a method of communication, although it may include other sensor technologies, wireless technologies, or QR codes. IoT is significant because an object that can be presented digitally becomes slightly larger than the object itself. The thing no longer refers



## APPLICATION OF IoT TECHNOLOGY IN BEEKEEPING

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only to its user but is now linked to surrounding objects and database data (Nauman et al. 2020; Jia et al., 2012.)

The concept of IoT is inextricably linked to the emergence and use of "smart" devices. Namely, intelligent devices are considered an essential part of all IoT concepts because they are built into almost all devices used every day, with which they have practically evolved. Using sensors, they can recognize their role, and through embedded network solutions, they could communicate with any other device, access Internet services, and communicate with people. In this way, the conventional object "Digital Upgrade" adds a new use-value, which is no longer exclusively physical, thus creating a significant added value that did not exist before. The forerunners of this "Digital Upgrade" are the following: more and more devices such as sewing machines, exercise bikes, electric toothbrushes, washing machines, electricity meters, and photocopiers are "computerized" and equipped with network interfaces (Stojkoska & Trivodaliev, 2017).

### *IoT factors*

The Internet of Things is often considered a single concept based on itself. This general opinion is certainly not correct. The IoT is rightly considered a complex whole. This complex consists of various scientific achievements in information technology, whose benefits are symbiotically combined to achieve the best possible effect. These diverse achievements, the outcome of which was ultimately this concept, can represent the factors of IoT. However, it must be noted that these are not factors in the classical sense but features that a "smart" device has and which have contributed to various achievements in information technology. These factors are (Mattern & Floerkemeier, 2010):

Communication and collaboration: facilities can network via the Internet indirectly, or even directly with each other, to use data and services and to be able to update their status promptly.

Addressability: within the IoT, objects can be very quickly located, and their "address" literally discovered through discovery, search, or naming services, and it is possible to change it remotely, that is, change the location,

Identification: objects are uniquely recognizable, according to specific parameters. RFID, NFC (Near Field Communication), and optically readable bar codes are examples of technologies for identifying so-called "passive objects" that do not have built-in energy resources with which to identify (this is solved with the help of "intermediaries" such as RFID reader or mobile phone).

Device perception: these devices are designed to function with the help of their sensors.

Mobility: devices from this group also can move, with the help of which they control specific processes from their environment.

Integrated information processing: "smart" devices have built-in processors for information processing and, in addition, a specific capacity to record data.

Localization: this feature is directly related to the GPS (Global Positioning System) and other possibilities of locating the object.

User interface: smart objects can communicate with people in an appropriate form (directly or indirectly, for example, via a smartphone).

### ***Three "C's" in IoT***

When it comes to the Internet of Things, attention must be paid to its impact on the business itself. Namely, all studies that deal with this concept warn of how important this concept is for human activity or the whole company. IoT affects every business. Mobile devices and IoT, i.e., their development, will change the types of devices still used as connection systems at the company level. The logical fact is that these newly connected devices will produce new kinds of data. IoT shows a tendency to help every enterprise where it is implemented to improve efficiency, use artificial intelligence from a wide range of equipment, improve business conditions and increase end-user satisfaction. IoT will also have a profound impact on people's daily, personal lives. This impact aims to enhance public safety, improve transport and health care with better information and faster exchange of this information. Although there are many ways in which IoT can affect society and business, at least three main benefits of IoT have affected every industry, including the famous three letters "C," namely (Kramp et al., 2013; [https://www.cisco.com/c/dam/en\\_us/solutions/trends/iot/introduction\\_to\\_IoT\\_november.pdf](https://www.cisco.com/c/dam/en_us/solutions/trends/iot/introduction_to_IoT_november.pdf)):

communication;

control; and

cost savings.

IoT transmits information to people and control systems, such as, for example, the condition of equipment (e.g., if it is on or off, full or empty, or if there is a malfunction on it) and even the presentation of data by sensors that monitor vital signs. In most cases, the person did not have access to this information before, or it was relatively rarely collected and manually entered into the records. For example, the IoT may allow specific air filtration systems to notify the administrator whether their air filter is clean and functioning correctly. Likewise, equipment that supports the GPS signal can communicate with the owner, giving him his current location and trajectory. The area is essential for moving items, such as trucks, but it is also used to locate objects and people within an organization. In healthcare, IoT can help the hospital system keep track of where everything is from equipment, from wheelchairs to cardiac defibrillators to surgeons. In logistics, IoT provides real-time tracking and status of packages and pallets. For example, large transportation companies can use sensors to monitor the location of a refrigerated container and its current temperature at any time. This benefit in communication has immensely affected the stability of business because good communication is the basis for the healthy functioning of the company.

When it comes to controlling, in the sphere of business where everything is based on device connectivity, a specific operational part of the business process will have insight into the device's state. In many cases, the company or consumer will also be able to control the device remotely. For example, just running a business process can remotely turn on or off a particular piece of equipment or adjust the temperature in an air-conditioned environment. Meanwhile, the consumer can use the IoT to unlock his car or start the washing machine.

## APPLICATION OF IoT TECHNOLOGY IN BEEKEEPING

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Once the primary connection to the device is established, the process itself can send alerts for anomalies, and it is possible to give an automated response to those anomalies. For example, if the brake pads on a truck have failed to fail, the system signals the company to remove the vehicle from traffic and automatically make a maintenance plan for that vehicle.

Better cost control is also one of the great benefits of IoT. Just imagine one transportation company where energy-related abuses occur, specifically fuel theft by workers. The IoT enabled the practical installation of a probe, which monitors the tank's condition, compares it with the mileage, and possible misuse can be very easily detected. This concept has been adopted in the world of business because it is believed that it will primarily save specific amounts of money to the companies themselves.

### *IoT applications*

As the development of science and technology takes place, at these moments, it seems practically impossible to predict the future development of IoT applications and their applications in all areas of life. The future of this concept is undoubtedly bright, but it is practically impossible to predict the scale and possibilities in the exact number that IoT provides. This subchapter will deal with the practical applications, where an attempt will be made to cover as wide a range of possible applications as possible. It is necessary to note that all the most successful companies were the first to implement this concept and successfully apply it. It is safe to say that the timely observation of all the advantages of this technology has significantly affected the business system, i.e., the business success of these companies. According to data from 2016, the most successful companies that have applied this concept are Amazon Web Services, Bosch, Dell, General Electric, Google, Hitachi, Huawei, IBM, Intel, Microsoft, Oracle, Samsung, Siemens, and others (<http://tsis.edu.rs/tsis/user/internetStvari.pdf>). In addition to influencing the finances of given companies, according to the identical author, IoT has a significant perspective in enabling independent communication between intelligent devices and, based on that, realizes the full financial potential, which is rightly considered the strongest in the entire IT industry.

### **IoT and beekeeping**

It has already been said that beekeeping has an extremely long tradition on the territory of our country, which is highly naturally diversified. However, one mental thing often inhibits progress on the environment of our country in almost all branches of human activity, including beekeeping. This cognitive problem is reflected in the attachment to a conservative view of things and in the lack of desire to improve something because it is considered that the current situation is perfect. It is only essential to give an example of how long it took domestic beekeepers to stop the practice of primitive killing of bees during honey extraction and switch to modern hives, the types of which have already been explained. The introduction of IoT in beekeeping itself must be imperative. Figure 1 shows the fundamental motive for using intelligent technologies in beekeeping.

Figure 1. The motive for the implementation of IoT in beekeeping



Source: <http://bee-sensing.com/eng/>

This motif imposes itself as a simple and, above all, logical thing. Beekeepers often do not have adequate education about certain things, nor the equipment with which they could manually determine specific parameters in bees, especially when it comes to sensitive parameters for the bee society. The left part of the picture shows an example of a traditional beekeeper who regularly visits his hives and, based on assumptions, concludes a hypothetical factual situation, which in some cases can be wrong and lead to a mistake that destroyed the beehive. The picture on the right shows a beekeeper who has implemented IoT technologies in his flock and uses his "smart" phone to monitor all valid parameters in the hive; based on whose changes, he directly plans his activities to prevent unwanted consequences.

IoT technology is represented through the above, but also many unlisted examples. Every specific industry, or human activity, that can be facilitated and made more efficient in front of using IoT has the prefix Io and the initial letter of this activity in English. This led to a concept called IoB, which primarily serves beekeeping. The IoB concept is a narrowly specialized activity, which is essentially based on the IoT architecture but differs only in the specifics and method of measuring certain parameters essential for this activity. The application of this technology itself will be differentiated into several mini-units to be more clearly understood and explained. First, it will start with the information obtained about the bee society through this technology. The availability of information about the queen and the brood itself, then about swarms, information about bee nutrition, about recognizing attempted theft will be processed, etc.

The information that such a system provides about the queen and the bee colony itself is reflected in the fact that the queen's activity and the colony itself are determined based on the temperature in the hive itself. It is necessary to state that the temperature in the center of the bee colony is constant throughout the year. These systems of the IoB concept, based on temperature sensors, determine the activity of the entire society. If the temperature in the center of the hive changes, it is immediately a sign that something is wrong with the hive. In addition, there are other sensors that, based on the sound itself, assess whether everything is OK with the hive or not.

## APPLICATION OF IoT TECHNOLOGY IN BEEKEEPING

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Detection of the swarm itself is reflected in devices whose sensors are sensitive to sound. These are programmed devices to respond to a change in sound according to predefined parameters.

Detecting theft is one of the perhaps most significant benefits that this concept of IoB brings with it. Namely, the theft is identified based on sensors that sense the change in the hive's weight (if it is the theft of honey frames). Specifically, there are various mechanisms here, by which only the presence of a few people in the apiary can be authorized so that the alarm is not activated, which reports potential theft.

When it comes to bee nutrition, the system on which this sensor works can be considered the opposite of detecting theft. Namely, it is also based on estimating the mass of the entire hive according to pre-set parameters. Based on that mass, the sensor sends signals that are reflected in the fact that all free frames are filled and that it is necessary to add new frames for the bees to store honey on time.

Monitoring winter food stocks is one exciting fact. At the level of our public, there is a well-known debate regarding the winter nutrition of bees. Some advocates of the fact that bees need to be left with large amounts of honey, in order to "winter" naturally and be fully prepared for the next production season, while on the other hand there are conflicting opinions about it, which say that society should be maximally exploited, and during the winter it opened and fed several times. The concept of IoB is based on the bee "wintering" acceptably, with a sufficient amount of honey that the bees will later use for their diet. This concept monitors the level of food available to the bees and informs via sensors is based on the mass, the level of food that has dropped, and that the bees must be fed.

### ***Technological description of the process***

The IoB concept, to be explained, must also contain some description of the technological components that make up this system. This unit will look at the explanations about energy, i.e., sensors, how they are charged, and what principle they work. In addition, Table 5 will show specific devices used in this concept, with prices and technical characteristics.

When we talk about energy, the use of electronic devices means electricity, which is drawn from the battery by the nature of things. The energy used to charge the batteries must come from another source, such as a solar panel, or the battery must be connected to the mains using a power adapter. Of course, there are certain modifications to this concept, which concern the consumption of electricity and the reduction of energy costs. This is the use of Bluetooth Low Energy (BLE), another technique in IoT devices. BLE uses less energy than traditional Bluetooth or WiFi transmitters because it transmits data, i.e., signals only when needed (Zetterman, 2018).

### **The needs of beekeepers for IoB technology**

One of the most detailed researches concerning the application of IoB technology in beekeeping is related to Sweden, and the author's work is cited. Namely, this work was

based on several facts, starting with the needs of beekeepers. Namely, through general analyses performed, such as surveying beekeepers and describing their activities, the author researched all the activities of beekeepers during one production season and which actions take the most time, which could be used more rationally. Also, based on these surveys, beekeepers have empirically given a picture of what significant data they lack the most related to bees.

The author Zetterman (2018) first examined the degree of visits to beehives. The research is divided into winter and summer to correctly interpret specific data and create a clear picture of these activities because the degree of the visit to beehives differs from the season. Based on this research, during the winter season, beekeepers visited hives every month (49.1%), fortnightly (17.6%), weekly (9.9%), daily (1.8%). According to an identical source, at the height of the season, beekeepers visited their apiaries weekly (55.4%), biweekly (25.7%), daily (9.5%), monthly (3.8%). When it comes to visiting beehives and opening hives, one scientific recommendation is about how bee colonies should be disturbed as little as possible. Daily visits to beehives, even weekly ones unrelated to the summer or winter season, and the opening of hives can disrupt the "metabolism" of the hive and negatively affect it. Another advantage of this IoB system is reflected here, which monitors all adequate parameters, and opening the hives is an option when it is essential. The second part of this author's examination showed how beekeepers currently come to information, which suggests that it is necessary to do something to return to normal. That research started several facts, which also help beekeepers take some action if unwanted situations are noticed. As the main answer for detecting a problem, i.e., checking the condition in the hive, the respondents mentioned manual, i.e., manual access to the hive, visual observation, and listening, with a share of over 93%. The following percentage concerns activities after noticing the problem, where according to the respondents, in 37.5% of cases, the solution to the problem is sought on the Internet, or by consulting older, more experienced beekeepers, which speaks of the benefits that the Internet has brought, specifically to the world of beekeeping.

## APPLICATION OF IoT TECHNOLOGY IN BEEKEEPING

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### Conclusion

The facts presented in the paper can be considered encouraging. In this regard, it is necessary to refer to the analysis regarding implementing innovations in beekeeping. The IoT concepts or technologies, the Internet of Things, are excellent services exploited from overall technical-technological progress. It is superfluous to talk about how much these concepts have facilitated business in absolutely all possible human activities, starting from transport, through the food industry, to particular branches of animal husbandry. It is also encouraging that this potential has been recognized to facilitate the daily human routine. One of the critical imperatives that the omnipotent application of IoT brings is energy saving, i.e., the "green character" of the concept itself.

The main advantage of the application of IoT is that with the application of this technology, the level of education of beekeepers increases, but the hives, as a society, improve living conditions and enable easier management of activities at the level of the hive. The application of IoT in beekeeping (the concept of IoB) represents, it can be freely said, a real revolution in the development of beekeeping. All those problems that concerned the inability to determine the actual state of the litter or swarms at a given time, the late detection of a problem, or the erroneous assumption that a problem exists, are a thing of the past with this concept. , through the various available applications, beekeeping is facilitated, and daily routine work is later modeled based on data entered and parameters measured by sensors in and around the hive (Gil-Lebrero et al., 2017; de Souza et al., 2018; Meyer et al., 2013).

It is realistic to expect that the increasing application and the presence of IoT technologies in beekeeping lead to a more efficient and effective organization of activities and jobs. Through the reduced number of field trips, only when needed, considerable time is left for other ancillary activities, such as advertising and sales of the products themselves, as well as education to make the activity as efficient and profitable as possible (Nguyen & Simkin; 2017; Zancul, 2016; Jara, 2012).

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## APPLICATION OF IoT TECHNOLOGY IN BEEKEEPING

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### PRIMENA IoT TEHNOLOGIJE U PČELARSTVU

**Abstract:** Srbija je na globalnom nivou prepoznata kao zemlja sa izvanrednim potencijalom, naročito kada se govori o poljoprivredi. Resursi, klimatski uslovi, velika diverzifikacija, u skladu sa mikroklimatskim i pedološkim uslovima, zaista obezbeđuje osoben potencijal za dalji ekonomski razvoj naše zemlje. Kao jedna od prosperitetnih grana, koja nije ostvarila svoj puni kapacitet, što se tiče razvoja, nezaobilazno je i pčelarstvo. Govoreći o IoT (Internet stvarima), neophodno je bilo pronaći valjan razlog, po slobodnom mišljenju o uspostavljanju prave veze između pčelarstva i Internet stvari. Običnom posmatraču, sa strane bi sve to moglo zvučati čudno, jer su ljudi, naročito na našim prostorima, uvek okrenuti tradicionalnom, sa strahom od novih varijanti u nekom poslu. Glavna poenta je, da se uz primenu ove tehnologije, uporedo povećava i nivo obrazovanja samih pčelara, ali i košnici se, kao društvu, poboljšavaju uslovi za život i omogućava lakše upravljanje aktivnostima na nivou same košnice.

**Ključne reči:** IoT, pčelarstvo, savremene tehnologije, ICT.

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