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# THE INTERNET OF THINGS: THE REVOLUTION OF TOMORROW OR THE OVERRATED TECHNOLOGY OF TODAY?

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## ABSTRACT

***Purpose:*** *To analyze problematic aspects related with the practical approaches of Internet of Things (IoT).*
***Design/methodology/approach:*** *The article discusses problematic issues related with the IoT from various angles. The debates concerning IoT and its possible application fields continue for more than ten years. While the technological framework is created there are many challenges in the field concerning technological, legal and social perspectives. In this article we analyze the application issues related with the IoT. The topic is examined by different authors from narrow views thus lacking the big picture of global technology potential. The objectives of this paper are to overview and analyze the holistic approach towards the application fields of IoT in order to highlight strengths and weaknesses which come with the technology.*
***Theoretical findings:*** *The necessity for web-based services is increasing along with the technological gadgets which support them. Applying things, which are connected in networks, could revolutionize many industry and service sectors thus creating new service provisions and administration methods based on information technology. Practical cases show that the applicability potential for IoT is wide; however, standardization, legal regulation and usability problems approach while the IoT solutions are advancing technologically and its potential market share increases. These issues should be taken into consideration while seeking for better balance among different sectors where the impact of IoT will be most significant.*
***Research limitations / implications*** *– There are few comprehensive studies and projects which emphasize on benefits of IoT. Despite that, the usage of the technology will have its negative effects. It is only the matter of time when next generation networks will create systems which may be too sluggish for effective maintenance or architectural changes. Moreover, the area for application of IoT is so wide that the threats are hard to identify. Because of that it is possible to review the topics only focusing on narrow, but most comprehensively analyzed spectrum of problematic issues.*
***Practical implications*** *– Theoretical framework for future research in the field was developed.*

**Keywords:** internet of things, internet of services, future internet
**Research type:** conceptual paper

## INTRODUCTION

It took less than twenty years for internet to become one of the most valuable information gathering channel and a gate for new business models all over the world. Not many understood the mass and significance of this technology at the beginning but it is now clear that internet is one of the most important inventions, which transformed the understanding about information, communication and data exchange. While the quality and speed of the internet based services is improving steady, the possible internet evolution questions arise. One of the most probable steps for the next generation internet based service is the Internet of Things (IoT). The main idea of the IoT is circling around a connected network or networks in which things and other sensor-based objects communicate with each other. The ability to integrate small, energetically efficient and cheap sensor based objects into clouds of networks would cause the new business and service models and would expand beyond the human-machine interaction approach which is most frequently used in internet-based environments. The grid of "smart" objects connected together is a conception which may be dated back to 1991 with Mark Weiser's idea of ubiquitous computing (Weiser, 1991). Later on he developed the idea and predicted that the IoT objects will communicate without direct human interaction and will use the specific protocols and communication channels. The usage practices of IoT are not widespread at the moment, but the advances in wireless networking technology, price drop and further standardization of communication protocols is facilitating the process. However, the enthusiasm related with the possibilities of IoT is more based on future predictions then an actual spread at the moment. According to Thomson Reuters (2012): "Rogers Communications Inc , Canada's largest wireless company, says the "Internet of things" - fridges that write shopping lists and smoke alarms that send text messages - will be a C$400 million ($384 million) market in Canada by 2015 and that it wants a significant share". It seems like the IoT is at the doorstep and the major players in the market are trying to keep pace with one of the most promising technologies. On the one hand starting the competition in the newly established business branch enables the company to quickly react to emerging changes and to keep up with the technological base, on the other hand there are few main issues related with the development of IoT technology that should be seriously reconsidered before stepping into this area.

The firs problematic issue is related with the core element of every technology that is made – the user. The final target of and the determinant factor of any innovations is the user who is able to operate and willing to pay for the technology. The rational arguments about life facilitating features and wide opportunities of IoT may be not heard by the end-user if he would not understand the potential and possible benefits from the technology. The user experience and engagement elements are the key components for the success of IoT.

The second issue is the overall cost of the technology. And it is not just the price of the sensors, but also and infrastructure or business solutions as a whole. The internet - main framework for the sensor based objects together the Radio-Frequency Identification (RFID) microchips enable the IoT implementation. But the lack of standardization agreements is stopping the development while the legal and technical questions, related to data gathering and privacy protection arise. The sensor grid needs to reflect physical world and create a cheap and efficient information channel which could be easily accessed with certain type of controllers. The user interface network control application as well as the price and efficiency solutions will determine how easily IoT will find a way to homes and offices.

The last problematic issue comes from legal and ethical field and relates with the data protection and privacy control questions. It is clear that quantities of data which are processed by sensor based objects are massive. The potential value for this type of information is undeniable and is closely related with the most popular application fields for the IoT. RFID – the most popular technological realization of IoT – makes it possible to harvest a wide array of new data types, enabling data mining to predict consumer behavior and monitor other aspects of the physical environment (Winter, 2012). The data about consumer actions may be used by business structures for various purposes and in some cases the final user may not feel pleased if his heart performance data would go to health insurance office which may modify the contract conditions according to the newly obtained information. Preparation of clear privacy policies should be one of the main concerns while examining the issue.

In this article authors discuss and analyze these topics and try to answer the question: "is the IoT the revolutionary technology of tomorrow or is it the overrated technology of today?" The field of IoT is examined by many authors from even more different perspectives. However, the wide and globally usable network of things is still more a conception than the reality. Countries, even regions are competing in this area, because the success of applying the IoT may result an economic wellbeing for those who will be the first and most efficient in the field. Knowing the strengths and weaknesses of the technology opens the ways for solutions and innovations which will be definitely needed in the forthcoming age of IoT.

**Internet of things – from the concept to the practice**

The term "internet of things" was introduced by MIT Auto-ID Center, which later evolved into organization named EPCglobal. Radio-frequency identification (RFID) chips are used as the backbone of the IoT because of its ability to track a large number of uniquely identifiable objects with the use of Electronic Product Codes (EPC) (Aggarwal, Ashish, Sheth, 2013). Using unique addressing schemes, objects bearing RFID tags are able to interact and cooperate with other objects or detect alterations in their surroundings. RFID is the technological solution of how smart cooperative environment may be organized at the current technological advancement level. The possibilities concerning IoT are even broader. Internet of Services (IoS), 3D Internet, Internet of Content, are only few names of the technologies, which should be considered as a linked parts of the future internet (Haller, Karnouskos, Schroth, 2009). The IoS describes an infrastructure that uses the Internet as a medium for offering and selling services (Cardos, Voigt, Winkler, 2009). Service-oriented Architectures (SOA) and Web services will mainly serve as technological solutions that enable enterprise functionality to be made available to users as shared and re-usable services on a network (Curbera, M. Duftler, R. Khalaf, et al, 2002). With the help of the IoT, the IoS gains more significance and possible solutions for personalization and customization of a service. But IoS represents only one of the layers supported by IoT. These areas overlap, and it is hard distinct them by certain parameters. According to Information Society Technologies Advisory Group (2008), over the last decade, the service sector has become the biggest and fastest-growing business sector in the world and employs most people worldwide. The additional application of ICT solutions may help to expand this area even more, and with the help of IoT the next – generation services become possible, thus giving the boost for IoS. Moreover, if the IoT technology will succeed and find its way towards business and personal use, the snowball effect may occur in related industry sectors. However, it is not an easy task, because technological and social development (need for technology) was not fast (or smooth)

enough during last 20 years. Although the idea of cooperative objects may seem tempting, there are still some unfulfilled fields compared to the early vision of ubiquitous computing. Back in 1991, Weiser predicted, that "ubiquitous computing will enable nothing fundamentally new, but by making everything faster and easier to do, with less strain and mental gymnastics, it will transform what is apparently possible". In later publication Weiser (1993) states: "the challenge is to create a new kind of relationship of people to computers, one in which the computer would have to take the lead in becoming vastly better at getting out of the way so people could just go about their lives". The main idea was to minimize the necessity of human - computer interaction in daily activities by ensuring the smooth and constant data flow from sensor based devices to the processing and control units. All of these activities should have been invisible to human eye thus creating a "calm integrated world". Weiser believed, that over next 20 years "ubiquitous computing will gradually emerge as the dominant mode of computer access". According to the early predictions, at the moment we should be surrounded by smart things which would exchange data among each other, with only small pieces of information visible to humans through user interface modules. So why do we not share calm environments after more than 20 years of progress? First of all, not all scientists agree with the idea of cooperative surroundings which relieves human beings from their mental and physical stress. Rogers (2006) claim that ubiquitous computing (ubicomp) technologies should be viewed as a key to enhanced learning, and contribute to the development of human intellect through creativity stimulation and better decision making. While Gaver (2006) sees object interaction as an environment for exploration and curiosity exercise by applying principles of gamification.

The real world structures and systems may seem al lot more complicated then the computerized model and it is hardly possible to represent the full scale of the environmental processes. At some sense the Weiser's vision is implemented in nowadays world. Smart houses, RFID tags in the product lines, environment aware cars, robots and other machinery show that technologically it is possible to implement the vision. However, Cáceres and Friday (2012) note that "there are nascent building blocks of the ubicomp visions that hint at the more tractable problems and help us identify the many challenges that stubbornly remain". Authors emphasize on world complexity problems, data transmission and security issues, technical aspects of ubiquitous computing. Despite all of these concerns the popularity of cloud computing and price decrease of sensory devices makes IoT one of the most perspective technologies of near future. Its influence will possibly be visible starting from international stage and ending with separate business sectors or individuals (figure 1).

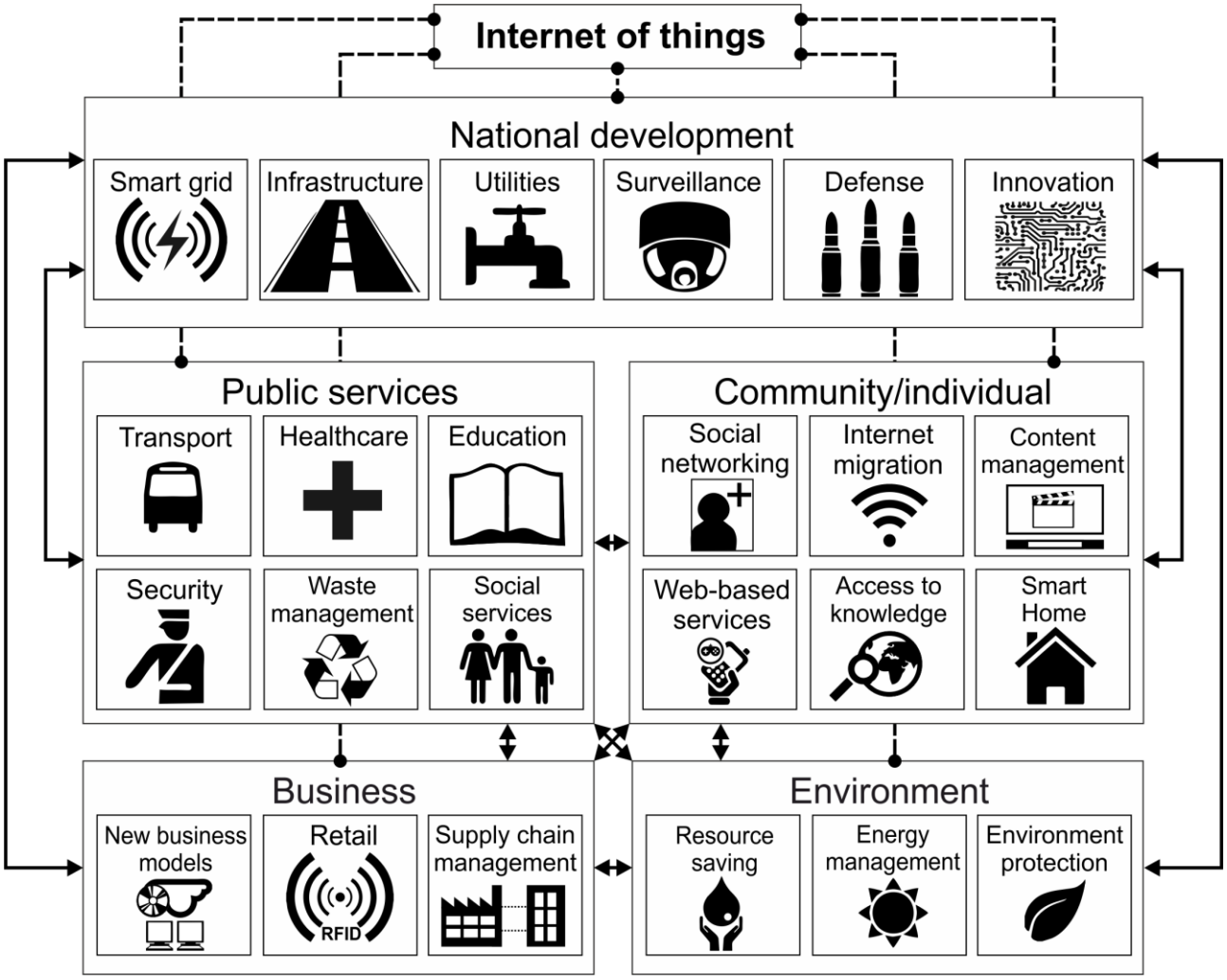


Figure 1. The impact of IoT to national development and related sectors

Looking from national perspective, the IoT may influence the infrastructure development directions. The coverage, speed and quality of telecommunication infrastructure are crucial for the IoT. By supporting or investing into ICT sector, countries may boost the other related industries or increase the living standards of individual households. The IoT technology may help optimizing resource usage, improve surveillance and defense systems and open new possibilities for innovation in associated fields. Grimes, Ren and Stevens (2009) note that better internet infrastructure has the positive impact towards the productivity of the firm. West (2010) supports the idea by concluding that: "high-speed broadband facilitates the adoption of remote wireless health monitors, GIS mapping, social media, distance learning, smart energy grids, file-sharing, and video conferencing". The investment to the internet infrastructure and communication sector allows faster and smoother flow of information. The counties are competing on statistical numbers in the area of internet penetration, broadband connection rate, user count who works on the internet on daily bases and ect. This trend will be more significant when IoT will gain its momentum. While the internet penetration rates mostly affect people who are directly using the technology, the IoT may have an influence in a much broader scale, where the end users may be not aware of its presence. The European Commission is decided to implement its IoT policy for supporting an economic revival and

providing better life to its citizens, and it financed several IoT research projects as part of the 7th Framework Programme on European Research (CERP IoT, 2010). While going deeper into subject, scientists reveal the weak spots of the IoT conception. On the April 12th of 2012 European commission issued a press release named "Digital Agenda: Commission consults on rules for wirelessly connected devices - the Internet of Things". The Commission is seeking to get the opinions from interested parties on "privacy, safety and security, security of critical IoT supported infrastructure, ethics, interoperability, governance and standards" in the context of IoT (ibid). On the summer of 2013 Commission is planning to present the recommendation of IoT in which problematic questions will be examined more directly. Until then it is clear that the legal, ethical and social issues are none of the less important than the technological barriers and that the countermeasures against the negative effects of IoT should be considered seriously. At the end, the idea of "calm integrated world" seems reachable and possible in nearly future. The problem is, that current evolution of the technologies is not fast and smooth enough in order to create unified network (or networks) of "smart" things, which would revolutionize the way people live. It may take a lot more time to fully develop the IoT than Weiser predicted, because technological nuances reflect only one side of the deal, and the flipside may be not as appealing for the end users, together with its challenges and transformations which may be not too desirable at the moment.

**The technological background for Internet of Things**

Wireless technologies allow fast and quality information exchange and one of the first inventions which enabled this type of communication was the radio. Radio has been along with us for some time and the reduction of its price, energy consumption and size created new application opportunities in the area of IoT. RFID technology is a major breakthrough in the embedded communication paradigm which enables design of microchips for wireless data communication (Gubbi, Buyya, Marusic, Palaniswamia, 2012). The IoT is partly inspired by the success of RFID technology. RFID tag is a "smart" device equipped with an electronic chip and an antenna. RFID reader interacts with the tag and sends a signal to someone for further elaboration. RFID-enabled system will interpret the data and take actions according to situation. Radio Science and related Technology, represented by tag, makes the physical object an energy consumer, because RFID technology uses energy alimented active tags, or some energy is applied to the passive tags in order to ask them to activate the sending of data (Simonov, Zich, Mazzitelli, 2008). These microchips are widely used in retail businesses, supply and manufacturing chains, animal tracking or logistics. Embedded intelligence can further enhance the power of the IoT by devolving information and knowledge processing capabilities to the edges of the network (ibid). In the near future the application domains may expand towards healthcare, environment mapping or automotive solutions. However, there are few issues related with the application of RFID. First of all, the RFID device must have a unique identification method, which would allow distinguishing it from the millions of other objects. The EPC network may serve the purpose, but it is not the only standard. In Japan, the unicode is gaining popularity, and other groups propose to use IPv6 addresses for this purpose, there are also specific devices which are not mapped to EPC (Haller, et al, 2009). According to Vermesan, Friess, Guillemin, Gusmeroli, ... Doody, (2011) the open standards are key enablers for the success of wireless communication technologies. Without global recognized standards the expansion of RFID and IoT solutions cannot reach a global scale.

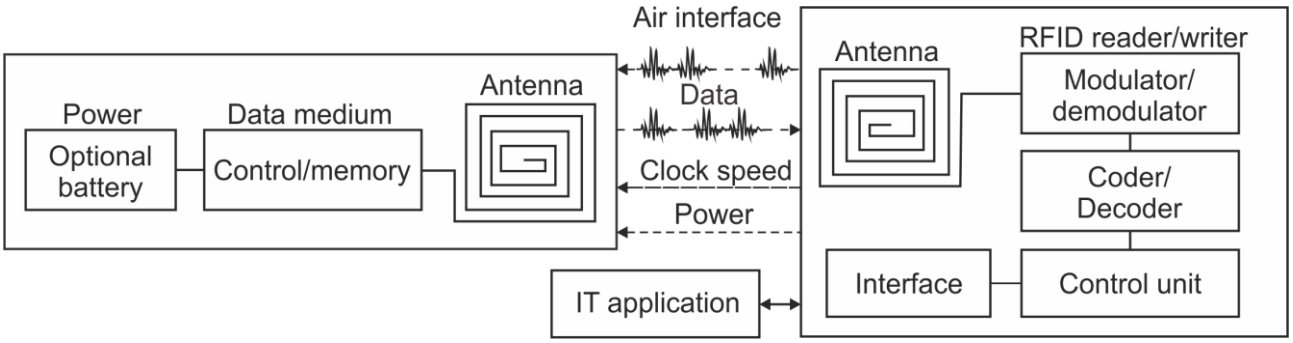


Figure 2. The working principle of RFID

This problem is common to all wide-used technological innovation and is real challenge for industrial and government bodies. Standardization has been sluggish, impacting large-scale commercial deployment of related services. Fortunately, companies are beginning to prioritize standardization (Zhihao, Yongfeng 2010). The EU is trying to move towards in order to apply IoT standards that cover multiple layers including technology, operation, and services. Standardization could reduce the costs of the technology and ensure availability to consumers which are one of the key elements in the field.

RFID standardization may be considered as a case of a good practice and as success, mostly thanks to the efforts of former Auto-ID center (now EPC Global), however, applying standards to the industry of robotics or nanotechnology is a complicated matter (ITU Internet Reports 2005).

RFID still stands at the forefront of the technologies driving the vision. This is a consequence of the RFID maturity, low cost, and strong support from the business community. However, they state that a wide portfolio of device, network, and service technologies will eventually build up the IoT. Near Field Communications (NFC) and Wireless Sensor and Actuator Networks (WSAN) together with RFID are recognized as the components which will link physical and virtual worlds (Atzori, et al., 2010). The EU sees RFID as one of the main technologies which better empower the calm digital environments, compared to the bar codes or magnetic tapes. In the EU vision, the concept of Digital Territory is an ambient layer of connectivity over Europe in order to deliver real-time services to citizens and RFID is seen as the glue to this wireless spectrum (Kranenburg, 2007). However the usage of the tags has its flaws and these negative aspects are mainly related with the legal and ethical issues concerning the data storage and usage. The sensor devices generate a large amount of information which must be transmitted, processed and reacted to. The environment generates data all the time and it is practically impossible to track the entire spectrum. The algorithms which support the data collection and processing should be “intelligent” enough in order to make sense from the data. State-of-the-art non-linear, temporal machine learning methods based on evolutionary algorithms, genetic algorithms, neural networks, and other artificial intelligence techniques are necessary to achieve automated decision making (Gubbi, et al., 2012) in the areas like automation, environmental control or waste disposal. The other challenging issue is related with the origin and usage of the data. This is the area where legal, ethical and technological nuances come into actions and different regulation rules in separate regions may affect the IoT’s positions in future market.

**Privacy and data protection concerns**

In the EU policy framework for RFID (2007) it is stated that application of RFID must be socially and politically acceptable, ethically admissible and legally allowable. RFID will only be able to deliver its numerous economic and societal benefits if effective guarantees are in place on data protection, privacy and the associated ethical dimensions that lie at the heart of the debate on the public acceptance of RFID. It is also noted that databases in which private data are stored should comply with neutrality and neutrality requirements. The report, "Internet of Things – an action plan for Europe" (2009), proposes 14 action points, including work on the policy governance of RFID, continuous monitoring of the privacy and data security issues arising, action over the recycling of the potentially vast number of smart chips and cards, and pan-European standards work. The right to silence a RFID chip may sound the most controversial. It gives the additional responsibilities to the industry, but the idea itself aims to limit the approach towards data to the third parties. This enables the better control of information stream and may raise the trust in the IoT sector. The question is especially important when speaking about sensitive personal data. Healthcare sector shows one of the biggest potentials for the IoT, however it is also one of the risky ones from the personal data protection perspective. It is possible to implant a microchip which would track the vital body parameters. On the one hand, this type of information is useful to the medical personnel and for the data subject. On the other hand, the leakage of the data to the third parties may result a conflicting situations. For example, health insurance companies could manipulate the terms and conditions in the health insurance contracts, advertisers may try to sell the medicine or other products to the people, who have problems with their health. According to Directive 95/46/EC of the European Parliament and of the Council, data associated with human health are considered as sensitive. It means that usage of technologies create many more legal and ethical questions which need to be answered. In the International Telecommunication Union report for the IoT (2005) it is stated that protecting privacy must not be limited to technical solutions, but encompass regulatory, market-based and socio-ethical considerations. Unless there are concerted efforts involving all government, civil society and private sector players to protect these values, the development of the IoT will be hampered if not prevented. Winters (2012) highlighted six main conflicts with novel practices related to the internet of things. But the most significant ones are related to location data, health data and identity data. Some applications used in smartphones track the location coordinates of the phone. The "smart" object may as well have this functionality and if the IoT grid has a wide coverage it is possible to track a person and his actions. The data may be used in marketing purposes or for illegal surveillance. So the ability to "hide" one's movement or activities should be available in these types of devices, because the tracking object may not always want to reveal its location to the third parties. The second issue is related with the health data problems, which were discussed earlier in the paper. Thirdly, the identity data (including biometric information) helps to determine who the person is, what he does and how he behaves. This type of information varies from sensitive to insignificant, however, the ability to collect identity dada at significantly low cost allow businesses to perform faster and more precise business intelligence actions. The end user does not necessary want to be recognized for his habits or behavior and the privacy policies legal regulation updates solve problem only partially. It is expected that attacks on privacy will become more popular with the growth of the IoT, since an increasing number of personal items will be reachable for queries and intrusions (Radomirović, 2010). So the cyber criminal activities may also appear more often. The privacy protection issues cannot be solved that all interested parties would be happy. The

stricter the regulation model is, the harder financial and management burden lays on the shoulders of the business. While on the opposite, business structure gain tons of valuable data, but customers are annoyed by target marketing complains or personalized advertisements. Moreover, the criminal elements may have a better access to information due to the IoT networks, so there is no simple solution to this issue. It is clear that the regions which try to regulate the IoT field in the context of privacy and data protection are a bit late, because the technology evolves a lot faster than the social norms. The win-win situation is hardly possible when the privacy issues and the development of IoT collide. The most likely regulatory mechanism will sacrifice something from the both sides, but while it's done on the national or regional level, the results may be unsatisfactory in the global scale.

**Challenges and opportunities related to business and end-users**

While there are many optimistic predictions towards implementing IoT, technical, social, legal and ethical questions are considered a challenging issue. Business, individuals and society are the main pillars on which IoT is based upon. Business is looking for the new opportunities in order to improve productivity and gain competitive advantage. The ICT sector plays an important role in the field and IoT, as one of the most intriguing technologies which may help reducing operation cost and improve resource management. Secondly, business companies are trying to sell more of their products according to customers' needs, expectations and wishes. Environment aware object may become the trending technology of the near future if leading ICT companies will decide to use it as a marketing tool in the fight for customers' pockets. Back in 2005 few would have thought that the phone with a touch screen and a price of a computer will be number one on the wish list. The same situation is with other "smart" devices. Seven years ago nobody cared about a smartphones, because there were no such things on the market, at least in a larger scale. Apple was not the first company which entered the smartphone industry, yet with a refreshing design and many innovations, Apple's iPhone quickly made inroads in the market (Lin, Ye, 2009). Wise marketing moves made by Apple created an army of loyal users who were attracted to something that was not even present a few years ago. The same scenario fits to the tablets. Figure 3 shows Google search trends from 2007 till 2013. The search phrases like "smartphone" or "tablet" compared to each other show an increase of query activity on Google search engine starting from 2010, while on 2007 it was rather low. The comparison of "smartphone" and "Internet of things" phrases show that the second query phrase is almost nonexistent. And it's not because the technology seems too futuristic or not interesting to the masses. The reason for these results comes from the fact, that IoT is more of a conception than a widely accepted phenomenon. Secondly, ICT companies do not push the IoT as a marketing brand.

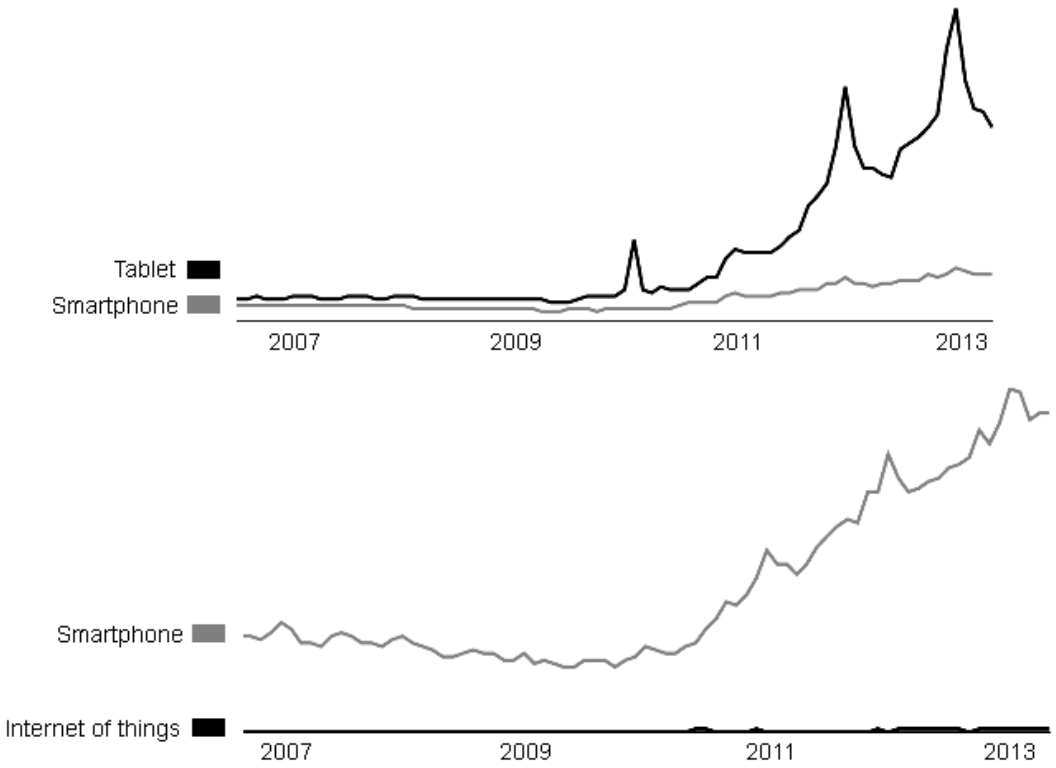


Figure 3. Google search trends since 2007. Keywords: tablet, smartphone, internet of things.

However, the comparison of more related terms like "internet of things, web of objects or ubiquitous computing" shows that the interest towards IoT is growing. It is obvious that Google search keywords related with the IoT cannot compete with popular names of "smart" gadgets. But the Figure 4 show that in some sense, the search trends reflect the social acceptability of the IoT technology as consumers look for more data about various topics of interest (Gubbi, et al., 2012). In order to apply the technology in the larger scale it is necessary that big players of the ICT market would convince the buyers that they are in need of intelligent environments together with the IoT.

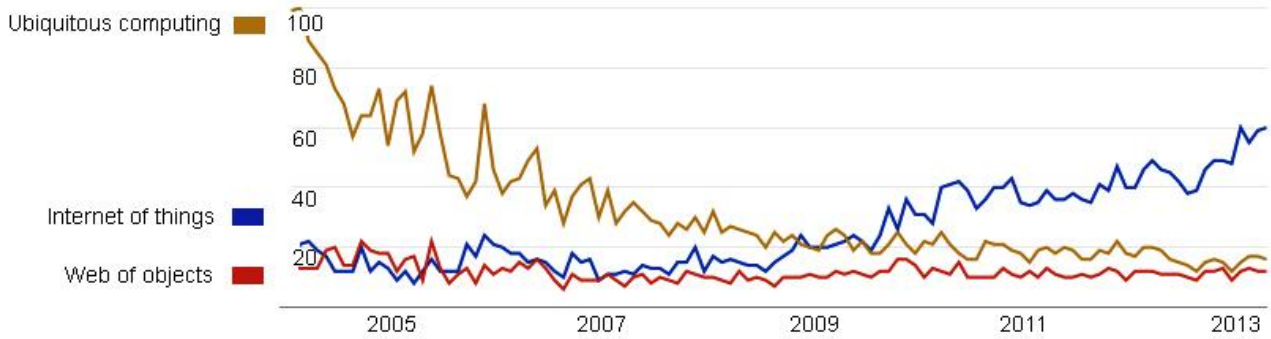


Figure 4. Google search trends since 2005. Keywords: ubiquitous Computing, internet of things, web of objects.

But convincing is only one part of the deal. Business subjects can create a market for the new product if the time is right and the offer is good. The hardest part is to keep the clients interested into product. Firstly, the smartphones and tablets own an entire set of digital products and solutions which makes them an attractive choice, plus they have a well-polished purpose and business model behind them. In the case of IoT all of these elements are lacking. Secondly, the IoT technology is less visible to the naked eye and the changes which it brings may be not so obvious for the end user. It seems like the IoT success is more dependant from business needs and expectations rather than regular user. According to Haller et al (2009), due to the rapid advances in the embedded systems domain, the manufacturing domain is undergoing significant changes as ubiquitous computing is applied to the shop floor. An entirely new dynamic network of cooperating devices can be created which effectively shows that the IoT can reshape the manufacturing domain". Moreover, the tracking of objects in the supply chain during the manufacturing process allows ensuring smoother operations. Real-time information processing technology based on RFID and near field communication (NFC) can realize real-time monitoring of almost every link of the supply chain (Atzori, Iera, Morabito, 2010). So the segment which will gain most out of IoT is the business organizations.

Business sector will be the most important piece on the board when speaking about application of IoT technology. However, at the moment the end-users are not too interested in the topic. European Union is trying to introduce the positive effects and potential areas of interest while publishing the roadmaps, communication plans and press releases (IoT – Strategic Research Roadmap, 2009), but none of these measures will give a significant effect unless the business structures will create new products and services, based on IoT technology. Moreover, these inventions must be presented in the appropriate light and create a real additional value to the end-user or society.

## DISCUSSION AND CONCLUSIONS

The IoT is a technology which has truly great potential in improving business productivity, the well-being of individuals or the development of the state. While the first insights, concerning the creation of "calm integrated world" were rather optimistic, it is clear that advantages of the IoT do not come without a price. The technological background is there and governmental policies support the development of "smart" networks. The cost of the IoT infrastructure now seems acceptable, but technological penetration is relatively low. There are some problematic aspects down in the technological field, like the lack of standardization, data transmission, processing and management, middleware problems and system security issues. The next level questions are related with the privacy and data protection concerns. When the sensory objects collect such huge amount of data, or these data have an especial value, are sensitive or may be tampered by the criminal elements – it becomes a really hard equation for the state officials and privacy policy makers to put a balance between the technological progress and the fundamental human rights. But at the final end is the created value for the business subjects and the end-users. Though the optimism around the IoT is not lacking, the masses of the regular users do not seem too interested in the near future technology. Their attention is attracted by the big ICT market players advertising campaigns of other "smart" devices, which are more visible, sensible and understandable. The companies of ICT market have a strongest positions and responsibilities in the field of IoT. Firstly, they get the biggest additional value from the improved supply chain management,

logistic process optimization or object tracking. Secondly, they control the assets which could convince the end-user to accept the innovations related to the IoT. The price, business models and support products or services should also be the priority. So, is the IoT the revolution of tomorrow or the overrated technology of today? The answer lies somewhere in-between these statements. It is hardly possible that many interconnected sectors would apply the IoT in the nearest future. Sometimes development of technology comes chaotic and sometimes the little boost may break the dam, but in this case the nudge should be global and all of the interested parties should be prepared for the emerging changes. Is the technology overrated? No, it is not. But the application fields are so broad and the experience in the IoT is so fragmented, that the utopian scenario of "calm integrated world" will have to wait, maybe, not for too long. So the research on problems and challenges in technological, legal and social areas should be emphasized in order to better prepare for the upcoming era of IoT.

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