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Research paper

An Analysis of Opportunities, Challenges and Key Strategic Implications Connected with the Utilization of the Internet of Things by Contemporary Business Organizations

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Abstract

The rapid development of the Internet of Things and its growing influence on functioning of business organizations and utilized by them business models was the main motivation of undertaking the research presented in the paper. In this context the most important areas of opportunities created with the development of this concept were determined. The main internal and external challenges of a technical and non-technical nature were also identified. The major finding of the paper is suggested in its final part a strategic framework connected with the implementation of the concept of the Internet of Thing in business organizations.

Keywords: *Use IoT; smart connected products; new business possibilities; organizational threats and impediments*.

1. Introduction

The rapid development of IT technologies causes that they enter into the next stage of their evolution. It is the phase in which computers are able, for the first time, to obtain data from virtually all types of physical objects [1]. This situation arises from the fact that elements such as sensors, processors and software, are increasingly becoming an integral part of products and, at the same time, due to their connectivity, they are able to connect with the accompanying network and cloud services. In this context the concept of the Internet of Things has arisen. The scale of development of this phenomenon is rapidly growing although estimates in this scope differ to a large extent [3], [2], [4].

There are a number of factors stimulating the development of this phenomenon. The continuous technological progress is unquestionably a key factor. It caused that critical building blocks of information technology necessary for the development of ecosystems of the Internet of Things, growing at an exponential rate for years, reached such a level of technical maturity and correspondingly low price level that it was possible to implement solutions based on this concept [5]. Also, actions undertaken to eliminate limitations related to connectedness between the components forming the ecosystems of the IoT were also an significant element triggering the development of the IoT. An important issue in this respect was to introduce the protocol IPv6 solving the problem of the limited number of available IP addresses, thus, removing one of the important obstacles to the development of the IoT [2]. In respect of the above-mentioned phenomena business organizations face a whole range of new opportunities and challenges which are extremely important from the point of view of their further development and future situation [6]. Undoubtedly, the significance of the Internet of Things will be different in different sectors, but the development of this phenomenon and its integration into the global economy will be the reason for its profound transformation [1], [7], [8]. Research shows that its significance and transformation potential have been already seen by the persons managing the companies [9].

Therefore, taking the role and the growing importance of the Internet of Things in the next years into consideration, the basic aim of this article is to make an attempt to identify the most important opportunities and challenges that are emerging before companies with the development of this phenomenon. In this respect the attempt to "capture" key strategic implications arising in the context of using IoT by economic organizations was also made.

Research methods used in the article include among other things the critical literature analysis, case study analysis and the logical deduction.

2. Internet of Things – Notion and Basic Components Forming the Ecosystem of the Iot Structure

In spite of an increasing number of publications and research on the Internet of Things, there is no one commonly agreed and accepted definition of IoT [10]. According to Porter and Heppelmann, the phrase "Internet of Things" was created to "reflect growing number of smart, connected products and highlight the new opportunities they can represent" [6]. In this respect Ericsson clarifies that according to the assumptions made by it, the notion of the „connected device" should be understood as "a physical object that has an IP stack enabling two-way communication over a network interface" [3].

Dobbs R. et al. describe this notion in more detail than Porter and Heppelmann; they define the Internet of Things as "embedded sensors and actuators in machines and other physical objects that are being adopted for data collection, remote monitoring, decision making and process optimization in everything from manufacturing to infrastructure to health care" [11]. A similar definition of

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the Internet of Things was given in 2013 by McKinsey, the consulting company. According to it, "the Internet of Things refers to the use of sensors, actuators, and data communications technology built into physical objects—from roadways to pacemakers—that enable those objects to be tracked, coordinated, or controlled across a data network or the Internet" [1]. The definition presented by McKinsey two years later in the report dedicated to the Internet of Things is even more developed. It defines the Internet of Things as "Sensors and actuators connected by networks to computing systems. These systems can monitor or manage the health and actions of connected objects and machines. Connected sensors can also monitor the natural world, people, and animals" [7].

The Internet of Things is quite differently defined by Cisco Internet Business Solutions Group (IBSG). According to it, „IoT is simply the point in time when more "things or objects" were connected to the Internet than people". By making the above assumption, IBSG estimates that the beginning of the Internet of Things dates back to the period between 2008 and 2009. It means that it took place a decade after the beginning of works by MIT Auto-ID Center on the RFID technology and other emerging sensing technologies [12].

Regardless the definition adopted, the proper functioning of the ecosystem of the Internet of Things requires appropriate infrastructure (network and cloud services). Solutions offered as part of this infrastructure should ensure [6], [9]:

- continuous connection to the Internet of all elements of the ecosystem at all of its levels and by means of different transmission channels (broadband connection, WiFi, mobile connection, Bluetooth),
- appropriate computing power or disc spaces necessary for the collection and processing of huge amounts of data delivered from innumerable endpoints of the system,
- software started on external servers, managing the monitoring, control, optimization and autonomous operations of functionalities offered by a given product,
- connection to social networks,
- services connected with data management and analysis,
- opportunities to develop necessary software.

The development of the above-mentioned network and cloud services is not possible without using a number of leading technologies which have an enormous transformational potential. They include: cloud computing, Big Data tools and technologies and mobile technologies. As far as cloud computing is concerned, due to the number of devices functioning in the ecosystem of the Internet of Things and the amount of obtained, collected and processed data, "cloud" solutions play a key role; without them it would be hardly possible to develop them for both technical (e.g. scalability issued) and cost reasons. They are also the basis for the development of advanced analytical systems (Big Data) being one of the foundations of the operation of solutions based on the concept of the Internet of Things. On the other hand, it is necessary to use mobile solutions in order to ensure proper operation of the ecosystem of the Internet of Things at the communication level [6], [7], [9], [13].

3. Opportunities and Benefits Associated with the Use of the Internet Of Things By Companies

As far as the opinions of persons responsible for the management of the companies, related to the main benefits associated with the use of the concept of the Internet of Things are concerned, these benefits can be grouped into five main categories according to the study conducted in 2015 by KPMG. The key categories include the improvement of productivity (20%) and the acceleration of the innovation cycle in organizations (20%). Issues associated with opportunities, such as greater diversity of products or services offered by the company (16%), reduction of costs (13%) and increase in the profitability (10%) are considered to be other important aspects. At the same time, in the same study the persons responsible for the management of the companies indicated these areas in which they see the greatest potential for financial gain (monetization) for their companies arising out of the fact of using by them solutions belonging to the Internet of Things. Those related to consumers and consumer markets definitely dominate among them (22%). They are followed by other areas, such as: technology (13%), aircraft, aerospace and defense industry (10%), education (10%) and automotive and transport industry (9%) [14]. The opportunities associated with the use of smart, connected products for developing values in the solutions of the Internet of Things arise out of four basic types of functionalities offered by them.

As far as the first of them is concerned, sensors embedded in smart, connected products make it possible to monitor:

- their condition, operation and ways of using such products,
- External environment.

However, software contained both in the product alone and in the network and cloud services offers even bigger opportunities, namely it allows for remote control of the product and its functions and personalization of its operation to the extent previously impossible to achieve.

Monitoring capabilities and the resulting wide data stream in connection with the potential in the area of the control offered by smart, connected products allow organizations to optimize their actions to an extremely large extent. It relates to such aspects as a significant improvement of the functioning of the product or its predictive maintenance or repair [6].

These three functionalities mentioned above make it possible for smart, connected products to reach an unusual degree of autonomy. At the same time, it is possible to ensure different levels of technical development, i.e. [6]: independent operation, coordination of operation with other products and systems, autonomous improvement of operation of the product and its personalization, self-diagnosis and servicing.

These four types of functionalities presented above, offered by smart, connected products give economic organizations two basic types of opportunities. They are associated with the redesign of business processes and the development of new business models [7].

As far as the issues connected with the redesign of business processes are concerned, there are a whole range of opportunities associated with it depending on settings to which they relate, e.g. home settings relate to issues concerning changes in ways of designing household appliances, and namely to issues concerning usage-based design processes. In the settings related to retails environments key areas of application of solutions of the Internet of Things include: the automation of check-outs, the layout optimization and the individualization of promotional activities in shops. In case of office settings, the Internet of Things is used in the following areas: organizational redesign, monitoring of employees and use of augmented reality for training purposes.

As far as the transformation of business processes is concerned, in the settings related to factories key issues relate to: the optimization of the operation and the improvement of productivity connected with it, predictive maintenance, servicing of equipment and health and safety. The next setting in which a profound transformation of business processes is possible is the one related to worksites, i.e. places of oil and natural gas extraction, construction sites etc. In this case the most important opportunities are similar to those presented in the previous case; they also include IoT enabled R&D. However, when it comes to the settings related to various types of vehicles, key areas of IoT-based solutions include: condition-based maintenance and repair, usage-based design and pre-sales analytics. The opportunities for transformation of logistic processes are also associated with vehicles. It mainly relates to such issues as: real-time routing, using connected navigations and transport monitoring [7].

As far as opportunities connected with the implementation of new business models are concerned, there are already numerous their types that can be indentified in this context.

One of the most important type of business models, in the context of IoT, are those based on the philosophy „anything-as-a-service" and the model „product-as-a-service" is the most important „trend" in this context. Its development is connected with more widely observed process of migration from the scheme based on the purchase of the product by the customer towards the scheme in which the manufacturer retains the ownership right to the product whereas the customer uses it and pays for its real use. The development of functionalities connected with smart, connected products offers great opportunities in this respect. One of the pioneers in this field is Rolls Royce, a company offering engines to airlines in the model "power-by-the-hour". Within this model airlines pay for the real time of using the engine, instead of incurring one-time costs connected with its purchase and additional costs for its maintenance and repairs [9].
The development of the Internet of Things gives also the opportunity to implement business models based on offering customers additional services connected with the physical product purchased and used by them. Caterpillar can be an example of this approach. On the basis of the analysis of data collected from every machine used on a given construction site relevant teams of the company advice customers on how to optimize the deployment of equipment, when it is enough to used a smaller number of machines or how to achieve better efficiency of fuel consumption by used machines. Heidelberger Druckmaschinen, the manufacturer of printing presses, offers similar services based on more than a thousand of sensors installed in them [15].
The group of new business models also worth mentioning are those based on the use of behavioral profiling. The system of determining insurance rates based on the information obtained from the monitoring of the performance of drivers by means of appropriate telemetry devices installed in their cars can be an example of this solution. This solution known as Snapshot is offered by an American insurance company Progressive [9].

4. The Most Challenges, Obstacles and Limitations Associated with the Implementation of the Concept of the Internet of Things and Factors Stimulating the Development of this Concept Step Before the Final Submission

There are a number of different kinds of challenges, obstacles and limitations that relate to the Internet of Things just like in the case of the implementation of each new concept. Since the ecosystems of the Internet of Things are complex solutions based on various technologies, their scale and diversity is significant.
Opinions on challenges and obstacles connected with the concept of the Internet of Things can also vary; for instance, Cisco presents a purely technical approach [12]. However, there are a number of other obstacles or limitations than those of technical nature.
Three key areas can be indicated in relation to issues of technical nature, connected with the development of ecosystems of the Internet of Things which can limit or stimulate their development. They relate to [8]: technology, both in terms of hardware and software necessary for the creation of the Internet of Things infrastructure, security and interoperability.
As far as the first area is concerned, the wide adjustment of the concept of the Internet of Things is largely determined by several essential issues, such as [9], [12]:

- Universal access to affordable equipment necessary for its implementation, such as MEMS sensors.
- Progress in creating low-cost power supply systems.
- Providing ubiquitous connectivity for the components of IoT ecosystems.
- Access to the additional computing power, disk space, and high throughput links in the "cloud" model.

However, the fact that systems of the Internet of Things consist of a huge number of different connected devices constituting potential new points of unauthorized access causes that issues connected with ensuring appropriate level of security are considered to be key ones. Therefore, ensuring security at the level of hardware and software is crucial; this is all the more important because solutions intended for production or energy systems are also involved. Early and relatively simple implementations in the field of the Internet of Things show that the scale of potential problems in this field is significant [16].
According to the consulting company McKinsey issues connected with ensuring interoperability are crucial for the future and the development of the systems of the Internet of Things. They involve the development of open standards in all areas and at all levels (communication protocols, access to external sources of data etc.) so that the smooth cooperation and communication between devices delivered by different manufacturers and the development of local ecosystems of the Internet of Things on their basis could be possible. According to McKinsey, at least forty percent of potential benefits associated with the Internet of Things will not be achieved without ensuring the interoperability [7].
At the same time, a whole number of challenges of non-technical nature can be indicated. As the value in the systems of the Internet of Things is largely created on the basis of obtained sent, processed and analyzed data, the issues associated with them constitute one of the key settings which may turn into development barriers of this concept or stimulate its development. The most important issues relate to different kinds of legal issues. Undoubtedly, challenges related to issues connected with intellectual properties are one of the key challenges of this nature and the issues connected with the ownership of collected data are one of the most important aspects in this area. Legal challenges also relate to other matters connected with issues of privacy and confidentiality. They relate to such aspects as: data protection, data sharing, ways of using data, place of storing data, access to data, application of law connected with data protection. As the IoT infrastructure is based on the model of cloud computing and the concept of Big Data, challenges of this type indicated and disclosed in their context will escalate. Therefore, the development of appropriate solutions related to the collection, use and sharing of data is crucial in this area. It relates to systems intended for both the consumer market and B2B market.
Also behavioral challenges may have significant impact in the context of developing systems based on Internet of Things concept. They refer to such aspects as attitude of consumers, in the context of acceptance, or lack of acceptance, to specific IoT solutions e.g. due to trust. Available research results indicate that this problem may constitute a significant barrier in the development of Internet of Things. The results of the research conducted by Pew Research Center indicates that potential users are more inclined to protect their privacy than to seek benefits from sharing information on their behavior or habits. Just as was the case with previously mentioned system for determination of insurance premiums based on monitoring of car driver's habits, and with smart thermostats (e.g. Google Nest, already referred to). In the first case the solution would be acceptable to 37% and not acceptable to 45% of respondents. In the second case results were even worse. Smart thermostats, not only monitoring temperature and humidity, but also movements in the room, would be acceptable only to 27% and not acceptable to 55% of respondents [17].
One more area is worth mentioning, as having significant impact on development of IoT, namely structural changes. Such changes are required in a number of sectors, and their lack may create significant barriers in development of IoT systems. For instance the transport sector, with issues of implementing comprehensive solutions for movement of autonomic cars on public roads [7].
It has to be pointed out that such barriers, or challenges, may turn into stimulators, on various levels:

- regional level - e.g. EU standards and regulations concerning various aspects of IoT;
- national level - e.g. regulations and standards in individual markets;
- sectorial level - e.g. sectorial regulations and standards.

Simultaneously numerous challenges will appear at an internal level of each individual enterprise. They will be related to technical, organizational, ethical and legal aspects.

5. Strategic Implications Related to Using Internet of Things by Businesses Organizations

Considering their involvement in IoT area, each organization has to establish own IoT strategy. Such strategy should, obviously, be aligned with organization's general digital business strategy. Establishing such a strategy requires first the assessment of own IoT readiness. In this context, Gartner proposes using two dimensional IoT maturity assessment matrix. Such matrix allows assessing technical capabilities as well as vision. At the same time adoption of three maturity levels is proposed - basic, intermediate and advanced (see Fig. 1).

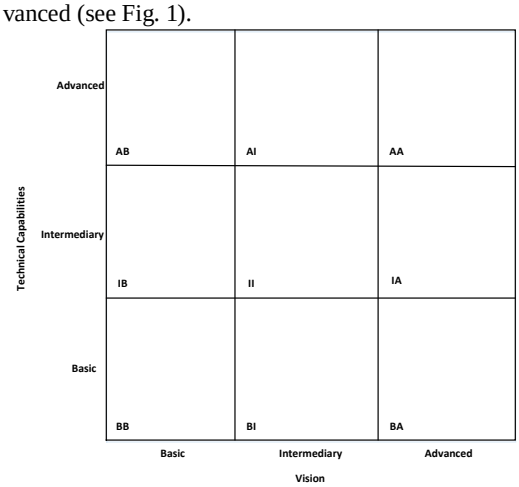

Fig. 1: IoT maturity assessment matrix (source: based on [18])

In technical aspect, basic level means the company with no prior experience with respect to handling or managing IoT or M2M solutions. In vision, basic level means the organization involved in creating some ideas (ideation) referring to use of Internet of Things, whereas such formulation of vision is at the early stage [4]. The next step in establishing of the strategy is developing vision-specific components. Obviously, the critical question here is the question about the role and place of given business in the IoT ecosystem being established. As far as this aspect is concerned, from the strategic point of view, three ample categories can be isolated where business may pursue their operations. They include [9]:

- entities developing and implementing technologies required for Internet of Things to function (enablers);
- entities designing, integrating and providing IoT services to customers (engagers);
- entities designing their own added value services, expanding and integrating the offer provided by companies in the former category (enhancers).

Further, when creating the vision of using Internet of Things, organizations should take into account that there are certain foundations for competition in IoT market, giving them opportunities to achieve extraordinary benefits. According to McKinsey, such opportunities include [7]: owning distinctive technology, owning distinctive data, the ability to produce own platforms, the ability to provide end-to-end solutions. In this context some detailed questions arise, obviously, as to e.g. whether having created own platform an organization should offer it as an open system or as a closed system [13].

The next step in the work on vision is the assessment where, from the viewpoint of the present stage of development and maturity, an organization intends to be in the next stage of their road towards using IoT. This is a critical issue, as according to Gartner it is very often really difficult to plan ahead more than for 6 to 18 months [4].

The final stage is preparing the IoT roadmap, based on the current vision and IoT maturity. An organization has to consider a whole set of factors (e.g. condition of engineering infrastructure) and plan all necessary actions and changes, both internal and external [4]). Among such factors is the issue of optimizing the architecture of organization's IT infrastructure for implementation of IoT solutions in organization operations [19]. In this context such factors as reliability and security of such infrastructure are very important. Among the number of aspects to be considered in planning, it is also worth mentioning necessary changes in organizational structure. It refers, among other things, to mentioned above issues as establishing new functional departments. There is yet another aspect worth mentioning, namely the need to implement changes in organizational culture. In this context appear critical issues, such as data-driven decision making or the culture of common sharing of information [7].

The whole process should be iterative in nature, with consecutive iterations allowing more and more precise, perfected IoT strategy for use by the organization (see Fig. 2).

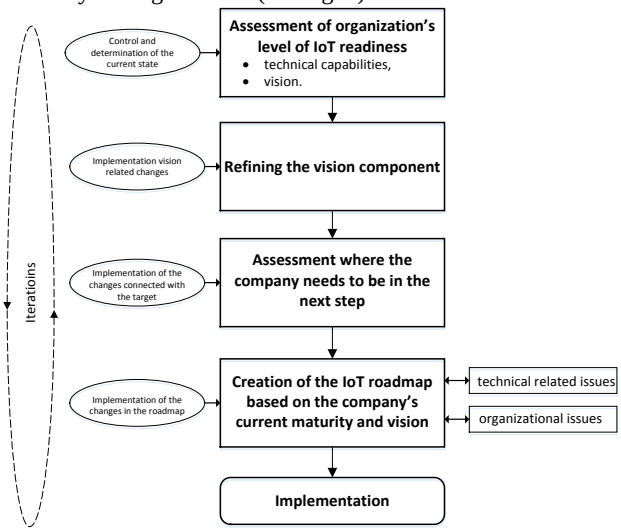

Fig. 2: IoT strategic framework (source: own source)

6. Conclusion

Organizations running business operations in present reality should expect material changes to the way they function. Such changes are due to rapid developments in the IT area. In the consequence using of Internet infrastructure to receive data from virtually all types of physical objects is more and more common. Such situation offers organizations the whole lot of new opportunities. As far as value building is concerned, they refer to two basic aspects, namely implementation of new business models and deep reconstruction of business processes realized by them.

In the emerging situation each business has to carry out in-depth analysis of the extent to which Internet of Things corresponds with their business philosophy, and of ways of adding value, and to take decision on their IoT strategy and their own place in emerging IoT ecosystem. In the light of the above, it is necessary to establish the framework for operations in this respect. When establishing the framework, whole series of factors has to be considered, such as experience and capabilities in creation and implementation of solutions based on IoT philosophy, or challenges to be met by the organization. Also the scope of necessary changes has to be determined. When creating the strategic framework, an organization has to consider the fact that as of present Internet of Things is at the early stage of development, and therefore proper and timely entering the IoT ecosystem may decide on organization's development for years to come.

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