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THE IMPACT OF THE INTERNET OF THINGS CONCEPT DEVELOPMENT ON CHANGES IN THE OPERATIONS OF MODERN ENTERPRISES

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Abstract: This article is an attempt to analyze the impact of the IoT concept on the operations of modern organizations and the implementation of changes related to its use. The main areas of possibilities arising from the development of this concept have been analyzed and identified in this context, and basic types of emerging new business models have been identified. Key obstacles and limitations of technical and non-technical, as well as internal and external nature have also been analyzed and identified.

Key words: IoT, smart connected products, new business models, transformation of business processes

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Introduction

Although the concept of the Internet of Things – IoT – appeared many years ago in 1999 (O'Leary, 2013), it is only the last few years that the related issues became the subject of broader considerations and growing interest. The clear potential that this concept has and the opportunities it provides for modern organizations in the context of building and strengthening their competitive position on the market began to be seen. McKinsey included the Internet of Things to the group of twelve so-called disruptive technologies, i.e., the technology with the greatest transformative potential in terms of its impact on the modern economy in the coming years (Bisson et al., 2013). Pivotl analytical company had a similar idea by classifying IoT in the group of nine disruptive trends of 2016 (Pivotl, 2016). Internet of Things is also seen as one of the three main factors stimulating the fourth phase of the industrial revolution referred to as Industry 4.0 (Schwab, 2016). At the same time, the potential of this concept is clearly perceived by the management of business organizations, as confirmed by various studies (KPMG, 2015; eMarketer, 2015).
One can show a whole range of factors stimulating the development of this concept and resulting in its significant acceleration in the last few years. Undoubtedly, the key factor is the continuous technological progress. It caused the critical building blocks of computing, needed to create Internet of Things (IoT) ecosystems and growing exponentially for years reached such a level of technical maturity

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and correspondingly low price that the universal implementation of solutions based on this concept became possible (Brynjolfsson and McAfee, 2014). At the same time actions taken to eliminate the limitations of connectedness between the components of the Internet of Things ecosystems, such as the introduction of IPv6 have become an important element stimulating the development of the Internet of Things (Barbier et al., 2013).
The purpose of this article is to identify the potential impact of the Internet of Things concept on the functioning and competitive capabilities of modern business organizations both in the context of the major opportunities and challenges that emerge in relation to the development of this phenomenon.

Internet of Things and the Main Elements of the IoT Systems Architecture

Critical analysis of the literature on the subject shows that there is no single agreed definition of the Internet of Things, and the authors emphasize different issues in their approaches (see Table 1).

Table 1. The overview of the Internet of Things definitions

Study	Definition
Bauer et al. (2014)	The Internet of Things refers to the networking of physical objects through the use of embedded sensors, actuators, and other devices that can collect or transmit information about the objects.
Bisson et al. (2013)	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.
Aharon et al. (2015)	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.
Dobbs et al. (2015)	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.
European Commission (2015)	Devices of all sorts (…) equipped with sensors and actuators, connected to the Internet, allowing them to monitor their status or the environment, to receive orders or even to take autonomous action based on available information.
Evans (2011)	IoT is simply the point in time when more “things or objects” were connected to the Internet than people.
Heppelmann and Porter (2014)	The phrase “Internet of Things” was created to reflect growing number of smart, connected products and highlight the new opportunities they can represent.

And so Heppelmann and Porter emphasize the increasing number of smart, connected products and the opportunities which they bring about (Heppelmann and Porter, 2014). On the other hand, another group of definitions applies the concept of IoT to the use of sensors, actuators, and communication technologies embedded in physical objects and the opportunities that they bring about (Aharon et al., 2015; Bauer et al., 2014; Bisson et al., 2013; Dobbs et al., 2015; European Commission, 2015). However, the definition given by (The White House, 2014) emphasizes the Internet of Things as the capability of devices to communicate with other devices. In turn, the consulting company PwC defines IoT as an ecosystem created by the equipment, tools, and facilities (PwC, 2016). For Schwab, the Internet of Things is a relationship between things and humans which can be realized through the use of various technological solutions (Schwab, 2016). In turn, Cisco suggests the definition of IoT which is entirely different from others. For them, this is a point in time when the number of things or objects connected to the Internet exceeds the number people living in the world at this moment (Evans, 2011).
However, regardless of the adopted definition, the typical Internet of Things system consists of similar components (see Figure 1).

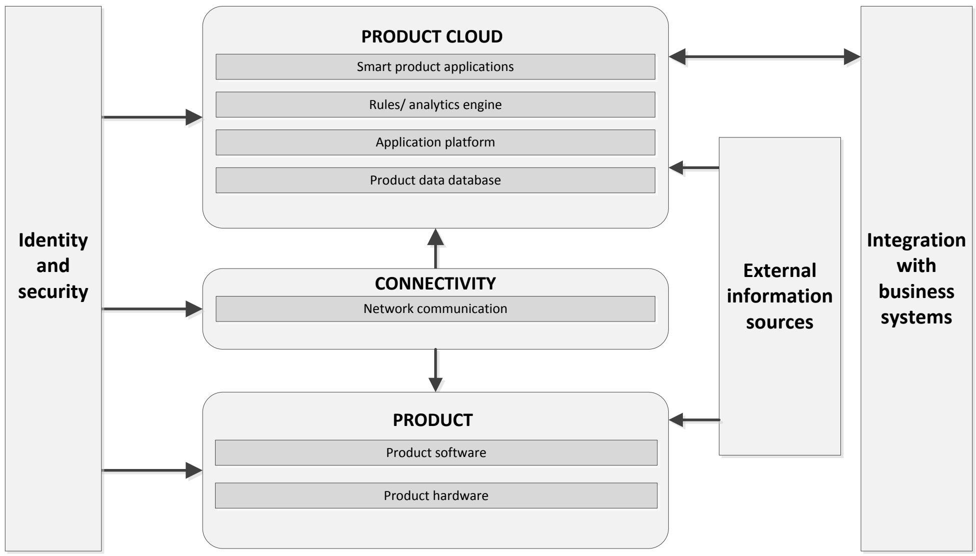

Figure 1. IoT technological infrastructure
(Heppelmann and Porter, 2014)

Product hardware consists of sensors, processors and elements providing communication (antenna ports, etc.) embedded in the product and supporting its traditional mechanical and electrical components. In turn, the product software is the operating system, on-board applications, user interface, and product control components embedded in the product.

At the communication level, suitable communication protocols (such as MQTT, CoAp, AMQP) providing communication between the product and product cloud are the necessary element of the system (Dwyer, 2015; Perera, 2015). The latter element of the IoT system is composed of four layers.

The first one (product data database) is a system that allows the aggregation, normalization, and data management both in real-time and on historical data acquired from the product. The application platform is an application development and execution environment, which allows quick creation of smart networked business applications that use data access, visualization, and run-time tools.

Another layer of product cloud (rules/analytics engine) is related to the rules, business logic, and Big Data analytical capabilities providing algorithms used during the product operation and revealing the related new product insights. The last layer of product cloud (smart product application) are applications run on remote servers, which manage the monitoring, control, optimization, and autonomous operations of product features.

Besides, tools for managing system access and authentification of users and product security, connectivity, and individual layers of the product cloud are an extremely important component of the IoT system. The entire infrastructure also has to have access to external sources of information (weather, traffic, energy prices, social media, etc.) necessary from the point of view of the capabilities offered by the product. As the technological infrastructure of IoT is part of the overall IT infrastructure in an organization, the tools which integrate data from smart connected products into key IT systems of a company, such as ERP, CRM or PLM are necessary (Heppelmann and Porter, 2014).

At the same time, it is not possible to create the technological infrastructure of the IoT system without the use of a number of leading technologies, which in itself carry an enormous transformation potential. This applies to cloud computing, Big Data tools, and mobile solutions. Regarding the first one, the role of “cloud” solutions is crucial due to the number of devices operating in the Internet of Things ecosystem and the amount of obtained, collected, and processed data. It would be difficult to imagine the creation of IoT without these solutions, both for technical (e.g. scalability) and economic reasons. The progress in the “cloud” technology taking place in recent years has become an important driver of IoT market development (Dwyer, 2015). “Cloud” technologies are also the basis for the advanced Big Data analytical systems, which are one of the foundations of the operation of solutions based on the Internet of Things concept.

On the other hand, the use of mobile technologies is necessary to ensure the operation of the IoT ecosystem in the communication layer (Bauer et al., 2014; Burkitt, 2014; Heppelmann and Porter, 2014; Heppelmann and Porter, 2015; ITU, 2015).

Key Opportunities Arising from the Development of the Internet of Things Concept for Business Organizations

The possibilities related to the use of smart connected products, which allow the creation of value in Internet of Things solutions result from four basic functionalities. The first ones are sensors built into smart products that enable to monitor:

– Its health, operation, and use,
– External environment.

In turn, software contained both in the product itself and in the infrastructure layer offers even more possibilities. Namely, it enables to remotely control the product and its functions and personalization of its operation on a scale which previously was not possible to achieve. Monitoring capabilities and the resulting wide data stream combined with the control opportunities offered by smart products allows the organizations to optimize their performance in an extremely wide range. This applies to aspects such as the significant improvement in the operation of the product itself or its predictive diagnostics and repair (Heppelmann and Porter, 2014).

The three functionalities discussed above allow the smart products to achieve an unprecedented degree of autonomy. Moreover, different levels of autonomy can be achieved, that is (Heppelmann and Porter, 2014):

– Independent operation,
– Independent coordination of operation with other products or systems,
– Autonomous improvement of the product and its personalization,
– Autonomous self-diagnosis and support service.

These four functionalities offered by smart combined products provide business organizations with two basic types of opportunities (Figure 2).

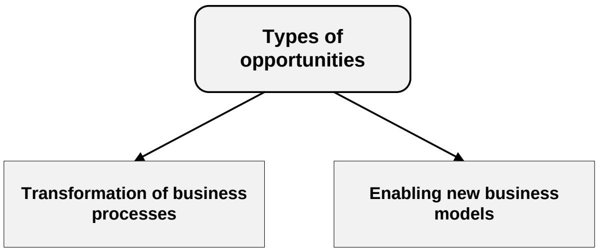

Figure 2. Two basic types of opportunities offered by the Internet of Things
(Aharon et al., 2015)

When it comes to the reconstruction of business processes, there are a number of related opportunities which different depending on the settings to which they relate. These are, e.g. changes in the design of domestic appliances in the home setting. Namely, the process is based on the analysis of usage-based design. In the retail environments, the key application areas of the Internet of Things solutions are: check-out automation, goods layout optimization or individualization of promotional activities in stores. On the other hand, in the office setting, the IoT applications include: organizational redesign and the monitoring of employees or the use of augmented reality for training purposes. Regarding the transformation of business processes in the factories, the key issues include: optimization of operations and the related improvement in productivity, optimization of the use of equipment and supplies, predictive maintenance, the maintenance of equipment, and the occupational safety and health. Another setting which enables a deep reconstruction of business processes is related to non-standard production worksites, such as oil and gas or construction sites. In this case, the most important capabilities are similar to the previous case, with additional IoT enabled R&D activities. When it comes to the setting associated with the various types of vehicles, the key areas of IoT-based solutions include: repair and condition-based maintenance, equipment design based on an analysis of their usage or pre-sales analytics. Vehicles are also related to the capabilities of reconstruction of logistics processes. This applies to things such as real-time routing, the use of connected navigations or the use of transport monitoring systems (Aharon et al., 2015).

Regarding the opportunities associated with the implementation of new business models, we can identify ten basic types in this context. These include:

- Business models based on “anything-as-a-service” concept,
- Business models based on the use of new forms of outsourcing,
- Business models based solely on the data and their use,
- Business models based on additional services related to the physical product offered to customers,
- Business models based on smart products which are sources of added value for the customer,
- Business models based on behavioral profiling,
- Hybrid business models,
- Business models based on offering a IoT platforms,
- Business models based on offering comprehensive IoT infrastructure solutions,
- Business models based on offering extended services.

The model being the product-as-a-service is the “mainstream” in the first group. Its development is related to more and more widely observed processes of migration from the customer buying the product to the one in which the manufacturer retains ownership of it, and the customer uses it, paying for its real use. The development of functionalities related to intelligent, connected products provides big opportunities in this area. One of the companies being a pioneer in this field is Rolls Royce, which offers airlines their engines in the “power-by-the-hour” model. In this model, they pay for the real engine use time, instead of incurring one-off costs associated with its purchase and additional costs for its maintenance and repair. Xerox also employs such a model by monitoring the actual use of their photocopiers via the installed sensors (Heppelmann and Porter, 2015).

The development of smart systems also allows for the implementation of business models based on offering new forms of outsourcing. Another example in this regard is Pacific Control Company operating in Dubai. It offers the remote monitoring of buildings, airports, and hotels based on the Internet of Things (The Economist, 2010).

For the third category, the development of smart connected devices enables to collect vast amounts of different types of data that can be used to create business models based on their usage. An example of this approach is Skyhook Wireless Company, which offers specific information acquired based on geolocation data they collect. They can include information such as which local bars will be the most successful on a specific day and time, how many people will go near the billboard at a given date and a specific time, or what is the density of people in a specific urban area on a given day and time. The company uses anonymous geolocation data collected from mobile users of its services in every major American city during the past twenty four months to carry out this analysis (Mims, 2010; The Economist, 2010).

The development of the Internet of Things also enables to implement business models based on providing customers with additional services related to the physical product they purchased and use. Caterpillar Company is an example of this approach. Specialized teams advise customers on how to optimize the deployment of equipment, when a smaller number of machines suffice and how to achieve better fuel efficiency through the stock of machines based on analysis of data collected from each their machine used on the construction site (Heppelmann and Porter, 2015). Heidelberger Druckmaschinen, a manufacturer of printing presses offers a similar type of service based on over a thousand sensors installed in them (The Economist, 2010).

Another group is business models based on providing customers with smart products which are sources of additional benefits to them. Play Pure Drive is an example of such a solution. In this case, Babolat has transformed a traditional product into a smart one which gives players the opportunity to improve their technique by the use of a dedicated application, a tennis racket equipped with appropriate sensors and a system enabling the connection to the smartphone. Clothing manufacturer Ralpf Lauren made a similar move by offering smart PoloTech Shirt. It collects all parameters including pulse, the intensity of the movement, calories burned, and many others with built-in sensors in real-time during exercise and transmit them to the smartphone or smartwatch (Heppelmann and Porter, 2014).

Another group of business models are those based on behavioral profiling. The system for establishing insurance rates based on monitoring of the driving behavior through the suitable telemetry device mounted in the vehicle is an example of this type of solution. The American insurance company Progressive offers this solution called Snapshot (Burkitt, 2014). Coverbox uses a similar system on the British market (The Economist, 2010).

Hybrid business models are a compromise between the models of product-as a service and traditional purchase of products by customers. They connect sales with e.g. different types of service contracts based on the monitoring of the device operations.

Another group is business models based on offering IoT platforms to the users. Apple HomeKit is an example of such a solution. It controls various home devices from different manufacturers through the smartphone application. HealthKit platform, which enables the integration of devices for monitoring people's health and activity, is another example of a solution of the same company (Burkitt, 2014).

The next group of business models is those based on providing comprehensive IoT infrastructure solutions. ThingWorx platform is one of well-known examples of this approach. It offers comprehensive services for the creation of Internet of Things solutions (ThingWorx, 2016).

The last group is business models based on offering extended services. This forward-looking category includes solutions based on the use of data and information collected by the providers of various IoT services and offering their own services based on them. Operations of insurance companies working on solutions based on creating their own portfolio based on cooperation with companies offering various types of IoT systems designed to monitor health and physical activity are an example of this approach (Burkitt, 2014).

The Most Important Challenges and Limitations Related to the Use of Opportunities Arising from the Development of the Internet of Things Concept

There is a whole range of different kinds of challenges, barriers or limitations related to the implementation of the Internet of Things concept, and the scale and diversity of IoT systems is significant because they are complex solutions based on various technologies. They can be both purely technical and non-technical and exist at an external and internal level in an organization. There are three key areas in the technical context related to the creation of IoT ecosystems, which could both limit and stimulate their development. They concern (Aharon et al., 2015):

- Technology, both in terms of hardware and software necessary for the creation of the Internet of Things infrastructure,
- Security,
- Interoperability.

In the first area, the widespread adoption of the IoT concept is limited to a large extent by the number of basic issues such as (Aharon et al., 2015; Evans, 2011):

- 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.

On the other hand, ensuring an adequate level of security becomes a key issue due to the fact that Internet of Things systems include a large number of different connected devices, possibly creating new points of unauthorized access. These issues are more important because, as mentioned above, a significant part of the technological infrastructure of an IoT system operates in a "cloud" model. Therefore, guaranteeing the security both at the hardware and software level is critical, the more that solutions for production or electricity systems come into play. As shown by the early and relatively simple implementations of IoT, the scale of potential problems in this area can be significant (Blaich, 2015).

When it comes to ensuring the interoperability, McKinsey consulting company estimates that this is a critical aspect of the future and development of Internet of Things systems. They are related to working out of open standards in all areas and at all levels (communication protocols, access to external data sources, etc.), so as to allow smooth and seamless cooperation and communication between devices from different manufacturers and building local IoT ecosystems based on them. According to McKinsey, at least forty percent of the potential benefits associated with the Internet of Things will not be attained without ensuring interoperability (Aharon et al., 2015).

At the same time, one can indicate a whole range of non-technical challenges. Value in the Internet of Things systems is mainly created on the basis of acquired, transmitted, processed, and analyzed data, the related issues are one of the key areas that can be barriers to the development of this concept or stimulate its development. The most important ones relate to various legal issues. Undoubtedly, one of the key such challenges related to data, are those concerning intellectual property, and the ownership of collected data is one of the most important aspects in this area. Legal challenges also apply to a number of other issues related to privacy and confidentiality. They relate to such issues as: data protection, sharing and methods of their use, data storage and access location or the applicability of the law relating to data protection. As the IoT infrastructure is based on the cloud computing model and the concept of Big Data, such challenges shown and revealed in their context will increase even more (Kerr, 2014). Hence, the creation of appropriate solutions and regulations regarding the collection, storage, use, and sharing of data, to make it clear, is crucial in this area. This applies to systems designed both for the consumer market and B2B.

Also, behavioral challenges may play an essential role in the development of systems based on the Internet of Things concept. They are related to things such as consumer attitudes in the context of acceptance, or lack thereof, of specific IoT solutions due to e.g. trust towards them. The available results of research show that this can be a serious barrier to the development of the Internet of Things. Research conducted by Pew Research Center shows that potential users are more likely to protect their privacy than attaining benefits based on sharing information about their behavior or habits. This was the case in the aforementioned system for establishing insurance rates based on the monitoring of driving behavior, but also in relation to smart thermostats (e.g. Google Nest). The solution was acceptable to 37% of respondents in the first case, and not acceptable to 45%. In the second one, the results were even less beneficial. Smart thermostats monitoring not only temperature and humidity, but also movement in the room were acceptable to only 27% of respondents and unacceptable to 55% of them (Duggan and Rainie, 2016).

Another area is noteworthy that could be important to the development of Internet of Things, which is structural changes. They will be necessary in various sectors, and the lack of their implementation may create significant barriers to the development of IoT systems. Transport industry and the introduction of comprehensive solutions for the movement of autonomous vehicles on public roads is an example of this issue (Aharon et al., 2015).

At the same time it should be noted that the limitations or challenges that could turn into stimulators, exist at different levels, i.e.: global (the creation of global standards, e.g. in "cloud" solutions for Big Data systems – ITU, 2015), regional (e.g. EU standards and regulations on various aspects of the Internet of Things), national (e.g. standards and regulations in the markets of individual countries), sector (e.g. industry regulations and standards). At the same time, a whole series of challenges will also occur at an internal level of individual companies. These may include:

– Technical,
– Organizational,
– Ethical and legal.

In the case of technical issues, one of the key aspects is the adaptation of the IT infrastructure architecture in an organization to the one optimized for possible use of IoT solutions in the company business (Deichmann et al., 2015). Important in this context are such things as ensuring the reliability and safety on the internal level at the organization. At the same time, due to the need to process and analyze massive amounts of unstructured or semi-structured data, a major challenge is to provide adequate solutions which improve the process. In this context, organizations are increasingly turning to solutions known as data lakes. These are data repositories in which different data streams are stored in their native formats and then analyzed by new analytical tools (Heppelmann and Porter, 2015; Gittlen, 2016). As for the organizational challenges, undoubtedly the most important aspect includes the necessary changes in the organizational structure of companies. They result primarily from the need for a different approach to three key aspects:

– Data management,
– Creating new solutions related to products and services,
– New approach to customer relationship management.

It is indicated in this context that organizations are beginning to organize three new types of functional departments. Creating the first one, referred to as unified data organization, results from the need to manage and analyze massive amounts of data collected from the IoT ecosystem. Therefore, it is necessary to create an organizational unit responsible for this, managed by a person at the top level of management. Therefore, more and more organizations create a job called chief data officer (NVP, 2016).

The second entity which is created at organizations stems from the necessity of constant collaboration in developing new smart products and ensuring the proper operation of the existing ones. Hence the appearance of cells which integrate the work of IT, research and development, and production departments, called development-operations groups. The third type of entity appearing increasingly at organizations, customer success management, integrates the operations of marketing, sales, and customer service and support (Heppelmann and Porter, 2015). An important challenge in the context of these organizational changes is also ensuring adequately trained and prepared personnel.

An important organizational challenge is also to develop and implement appropriate procedures ensuring the safety of IoT infrastructure at the internal level of the organization. We should also emphasize one more aspect. It is the necessity to make changes in the organizational culture. One of the key issues in this context are aspects such as the acceptance of data-driven decision making or general culture of information sharing (Aharon et al., 2015).

There is one more important area of internal organizational challenges, which are of ethical and legal nature. They are related to data management and organizational policies in this area. They refer to aspects such as data retention time, making data anonymous, sharing data with other entities, the transparency of policy regarding the management of data, or the capabilities to control data related to the user and the scope of these capabilities. These has been emphasized earlier in the context of Big Data phenomenon (Wielki, 2015), and they become even more important in relation to IoT systems. Figure 3 shows the summary of the major internal and external challenges of a technical and non-technical nature.

	Internal	External
Non-technical	- legal and ethical aspects - organizational issues - security (policies and procedures)	- legal aspects and regulations, - behavioral issues, - structural issues
Technical	- IT architecture, - security, - reliability (in-house solution)	- software and hardware technology, - security, - interoperability, - reliability (cloud infrastructure)

Figure 3. The major internal and external challenges of a technical and non-technical nature

Conclusions

The development of IoT requires modern business organizations to make a decision related to this concept and the possibilities of its practical use in their operations. The situation in which it is possible to increasingly use the Internet infrastructure to receive data from virtually any type of physical object provides companies with a whole range of unprecedented opportunities in terms of their performance and value creation. They mainly concern two fundamental issues, namely:

- Deep reconstruction of business processes they carry out,
- Implementation of new business models.

In this new situation, every company must perform a deep analysis of how the Internet of Things is a part of their operations and the processes of digital transformation and decide on a strategy for its use as well as its place in the emerging IoT ecosystem. Opportunities in this area are very big (Aharon et al., 2015; Burkitt, 2014). At the same time, every organization should take into account a number of factors while planning its future in terms of the use of IoT, such as the experience and capabilities in the development and implementation of solutions based on the Internet of Things concept or the challenges it will face. It will also have to determine the necessary extent of changes.

We should also emphasize that when creating a vision and strategy for the use of the Internet of Things concept, one should take into account the fact that it is in a relatively early stage of development at the moment, hence adequate and fast positioning in the emerging IoT ecosystem may be a determining factor for the further development of the organization and its competitive position for many years to come.

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WPŁYW ROZWOJU KONCEPCJI INTERNETU RZECZY NA ZMIANY W DZIAŁANOŚCI NOWOCZESNYCH PRZEDSIĘBIORSTW

Streszczenie: Niniejszy artykuł poświęcony jest próbie analizy wpływu koncepcji IoT na funkcjonowanie współczesnych organizacji i implementacji zmian związanych z jej wykorzystaniem. W tym kontekście przeanalizowano i wskazano najważniejsze obszary możliwości tworzących się wraz z rozwojem tej koncepcji oraz zidentyfikowano podstawowe typy wyłaniających się nowych modeli biznesowych. Wskazano również oraz przeanalizowano kluczowe bariery i ograniczenia natury tak technicznej, jak i pozatechnicznej o charakterze wewnętrznym i zewnętrznym.

Słowa kluczowe: IoT, inteligentne połączone produkty, nowe modele biznesowe, przebudowa procesów biznesowych

事物的概念開發互聯網對變化現代企業的操作。在衝擊

摘要：本文是企圖使分析物聯網概念在現代組織和有關它的用途變更的實現的業務的影響。的可能性，從這個概念的發展而產生的主要領域已經確定，並在這方面進行分析，基本類型不斷出現的新的商業模式已經確定。關鍵的障礙和技術性和非技術性，以及內部和外部的自然限制，也已經被鑑定和分析。

關鍵詞：物聯網，智能連接產品，新的商業模式，業務流程改造。