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IMPACT OF THE INTERNET OF THINGS ON THE ECONOMY AND SOCIETY

Summary. The IoT (Internet of Things) is a pervasive innovative technology building on the universal connectivity of things and people. The emergence of the IoT is a global phenomenon, but there is still much discussion about the rate of growth, the most attractive market development opportunities, and the challenges to be met in a wide range of issues, from privacy and security, to the governance of these complex systems. In this paper the role of IoT in the general world economy and, in particular, what concerns the state and level of development of an enterprise will be presented.

Keywords: Internet of Things, machine-to-machine communication, wireless sensor networks, Big Data.

WPŁYW INTERNETU RZECZY NA GOSPODARKĘ I SPOŁECZEŃSTWO

Streszczenie. Internet Rzeczy (IRz) staje się wszechobecną technologią innowacyjną, tworzoną w celu umożliwienia uniwersalnej łączności rzeczy i ludzi. Pojawienie się IRz jest zjawiskiem globalnym. W artykule zostanie przedstawiona rola Internetu Rzeczy w ogólnej gospodarce światowej, a w szczególności w zakresie stanu i poziomu rozwoju przedsiębiorstwa.

Słowa kluczowe: Internet Rzeczy, komunikacja maszyny z maszyną, sieć bezprzewodowych czujników, gigadane.

1. Introduction

The emergence of the Internet of Things (IoT) is a global phenomenon, but there is still much discussion about the rate of growth, the most attractive market development

opportunities, and the challenges to be met in a wide range of issues, from privacy and security, to the governance of these complex systems[1].

The IoT (Internet of Things) is a pervasive innovative technology building on the universal connectivity of things and people, now moving in Europe from the pioneer phase to widespread adoption. In combination with cloud computing and Big Data the IoT is opening the new age of the hyper-connected society and acting as a powerful driver of business innovation, but also facing equally strong barriers in terms of security risks, concerns about privacy protection, and resistance to organizational change[2].

IoT is a disruptive innovation as it radically changes business processes within and across sectors. A key mechanism of this disruption is the convergence between traditional Information Technology and Operation Technology in production and logistics processes, combined with the real time monitoring capabilities enabled by Big Data[3].

2. What Internet of Things means for the economy

The Internet of Things is a giant network of "things" - including industrial equipment and machinery, everyday products like dishwashers and thermostats, and local networks of sensors to monitor farms and cities. In an IoT solution, objects can be sensed and controlled through the Internet. Information can be made available to applications, data warehouses, and business systems via the Internet. The IoT means the convergence of embedded computing, broadband and mobile networking, the highest level of distributed cloud computing, advanced distributed database architectures, cutting edge web and mobile user interfaces and deep enterprise integrations[4].

Andrew Hughes from LNS Research published a new eBook on "Manufacturing Metrics in an IoT World: Measuring the Progress of the Industrial Internet of Things"[5] in which he, i.a., writes that manufacturing is changing. The traditional view of production plants as islands of automation, expertise, and control no longer stands up in an ever more connected world. Exciting things are occurring across Manufacturing Operations Management (MOM) as forward looking organizations begin to digitally transform and integrate operations within their companies to revolutionize performance.

This eBook, presents results from the fourth iteration of the biennial Metrics that Matter research study conducted between LNS Research and MESA International. It places particular

[1] Definition of a Research and Innovation Policy Leveraging Cloud Computing and IoT Combination – Final Report; Luxembourg, Publications Office of the European Union; 2014, p.16.
[2] Ibidem, p. 9.
[3] Ibidem, p. 9.
[4] The ThingWorx Guide to the Internet of Things; http://www.thingworx.com/thingworx-analytics (25.05.2016).
[5] Andrew Hughes**:** Manufactoring metrics in an IoT world. Measuring the Progress of the Industrial Internet of Things*;* www.lnsresearch.com (25.05.2016).

focus on what Industrial Internet of Things (IIoT) means to manufacturers in the MOM space. Highlights of this 2016 year's study include:

- Why the number of respondents who don't understand IoT has fallen from 44% to 19% over the past year, with technology investments on the rise
- Why 27% of respondents with MOM deployments have moved to the cloud, and how this is affecting the traditional model hierarchy
- The key identified trends and challenges across industries such as Aerospace and Defence, Oil & Gas, Chemicals, and more
- A snapshot of industry analytics capabilities, maturity, and current use cases
- Notable year over year improvements across operational metrics such as improvement in manufacturing cycle time, new product introductions, health & safety incidences, and more

In the above mentioned EU Final Report on Definition of a Research and Innovation Policy Leveraging Cloud Computing and IoT Combination the following IoT definition was introduced: *The Internet of Things enables objects sharing information with other objects/members in the network, recognizing events and changes so to react autonomously in an appropriate manner. The IoT therefore builds on communication between things (machines, buildings, cars, animals, etc.) that leads to action and value creation*[6].

This definition corresponds to an emerging digital ecosystem characterized by complex interactions between suppliers and users. Much of the IoT market is based on business-to-business interactions, meaning that Information and Communication Technologies (ICT) vendors provide IoT technologies and solutions to business users, who leverage them to deliver services and applications to their customers. Cloud service providers and Big Data companies also play an increasing role in the IoT ecosystem.

A key feature of the ecosystem is the dynamic interaction between the providers of horizontal IoT platforms and of vertical solutions/industry specific environments. This interaction is constantly evolving. Current solutions and implementations tend to have a strong vertical market component, but in time broad-based, open horizontal platforms will emerge, especially if Europe will be able to insure open standards and widespread interoperability. The potential optimal balance between horizontal platforms and vertical environments is one of the critical issues of the IoT market evolution in the next 10 years[7].

Based on the short outline of the present IoT ecosystem the following key distinct features that need to be considered when projecting the IoT ecosystem's vision over the next few years were highlighted[8]:

[6] Definition of a Research and Innovation Policy Leveraging Cloud Computing and IoT Combination – Final Report; Luxembourg, Publications Office of the European Union; 2014, p. 18.
[7] Ibidem, p. 18.
[8] Ibidem, p. 21.

- The IoT ecosystem may still be in a nascent state but is constantly changing, rapidly evolving and already solidly established both in Europe and in the developed World.
- Because of its constant evolution, the identified stakeholders' categories are not discrete, rather they overlap significantly. Thus the IoT market is, from the outset, a highly competitive and complex one with some actors playing multiple roles.
- Partners are essential to smooth operations within the IoT market. Not one supplier can provide everything in the IoT stack, so partnerships with like-minded companies who can complement each-other are essential.
- The growing number of industry-specific IoT use cases and concrete applications is clearly contributing to put industry sectors at the core of the IoT ecosystem today. However, the IoT suppliers develop horizontal platforms that enable core service elements to be managed across vertical silos.
- The IoT ecosystem is therefore still predominantly supply-driven but powerful demand forces, led by socio-demographic trends, government initiatives and the expanding consumer market, are rapidly gaining momentum and driving the development of the IoT towards a more user-oriented perspective

3. Present state of IoT according to McKinsey Global Institute (MGI)

The ability to link the physical world to the Internet and other data networks has profound implications for society and the economy. The Internet of Things makes it possible to monitor and manage operations thousands of miles away, track goods as they cross the ocean, or detect changes in the blood pressure of a diabetic that might be a sign of a heart attack. More than the next evolution of information technology, the Internet of Things redefines how we engage with the physical world and makes possible computer-mediated ways of doing business.

The Internet of Things is still in the early stages of growth. Every day more machines, shipping containers, infrastructure elements, vehicles, and people are being equipped with networked sensors to report their status, receive instructions, and even take action based on the information they receive. It is estimated that there are more than nine billion connected devices around the world, including smartphones and computers. Over the next decade, this number is expected to increase dramatically, with estimates ranging from 25 billion to 50 billion devices in 2025. McKinsey Global Institute undertook a research to develop an updated perspective on the potential impact of the Internet of Things across the entire

economy[9]. They wanted to understand how and where the use of IoT technologies could create value and to isolate the sources of that value. They also wished to understand how IoT can create value up and down value chains. After reviewing IoT applications, they concluded that using only a conventional approach to sizing the potential impact, by examining how the applications might reduce costs or improve quality only through the lens of individual industries or sectors, would not be adequate. However, by viewing IoT applications through a "settings" lens-that is, within the context of the physical environments in which systems can be deployed-they can capture ways in which they create value for all parties in that setting (companies, consumers, workers). By focusing on the user, the settings lens helps capture the value that users gain from multiple IoT systems and, most importantly, from the interconnections among different IoT systems and other IT systems and databases. On average, interoperability is required for nearly 40 percent of the total value of IoT applications. They have defined nine settings that capture IoT use in places such as homes, offices, factories, worksites (mining, oil and gas, and construction), and cities (see: Table 1). They - account for health and fitness uses (monitoring chronic disease or exercise, for example) under the human setting (for devices that attach to the body).

Table 1

Settings" where IoT creates value

Setting	Description	Examples
Human	Devices attached to or inside the human body	Devices (wearables and ingestibles) to monitor and maintain human health and wellness; disease management, increased fitness, higher productivity
Home	Buildings where people live	Home controllers and security systems
Retail environments	Spaces where consumers engage in commerce	Stores, banks, restaurants, arenas-anywhere consumers consider and buy; self-checkout, in-store offers, inventory optimization
Offices	Spaces where knowledge workers work	Energy management and security in office buildings; improved productivity, including for mobile employees
Factories	Standardized production environments	Places with repetitive work routines, including hospitals and farms; operating efficiencies, optimizing equipment use and inventory
Worksites	Custom production environments	Mining, oil and gas, construction; operating efficiencies, predictive maintenance, health and safety
Vehicles	Systems inside moving vehicles	Vehicles including cars, trucks, ships, aircraft, and trains; condition based maintenance, usage-based design, pre-sales analytics

[9] James Manyika | San Francisco Michael Chui | San Francisco Peter Bisson | Stamford Jonathan Woetzel | Shanghai Richard Dobbs | London Jacques Bughin | Brussels Dan Aharon | New York: The Internet of Things: Mapping the Value Beyond the Hype, McKinsey Global Institute (MGI), June 2015, p.125, www.mckinsey.com/mgi (10.08.2015).

cont. table 1

Cities	Urban environments	Public spaces and infrastructure in urban settings; adaptive traffic control, smart meters, environmental monitoring, resource management
Outside	Between urban environments (and outside other settings)	Outside uses include railroad tracks, autonomous vehicles (outside urban locations), and flight navigation; real-time routing, connected navigation, shipment cracking

Source: McKinsey Global Institute analysis, June 2015, p. 3, *Exhibit E1*.

4. Solution patterns for the IoT[10]

If the Internet of Things (IoT) really is a technology paradigm rather than an industry, then it is important to map how that paradigm provides solutions across different industries. Real-world IoT implementations tend to fall into three major solution patterns: Smart, Connected Products; Smart, Connected Operations; New, Disruptive Experiences.

Smart, Connected Products:

- Products live at the edge of the IoT and are the "Things" in the IoT paradigm. Products which are used for years-like dishwashers and photocopiers-are enhanced through connectivity. Since 2012, a major trend towards manufacturers designing connectivity into their products was seen.
- Connectivity has implications across product design, development, and service. Often, the product manufacturer wants to collect and analyze usage data in order to refine future generations of the product. This refinement may be enabled by a better understanding of failure modes so that product engineers may create a more reliable product or proactively schedule maintenance.
- Connecting high-value products allows service teams to remotely troubleshoot and react to product issues. Customer Relations Management (CRM) or other existing customer portals may be involved but the value of the core solution is a function of the connected product and the applications and analytics that are the main value drivers.

Smart, Connected Operations:

- Sometimes the "Thing" is not a single product or device but rather an operation-like a factory or the management of a city infrastructure-that is instrumented with access to real time data and control capabilities from the cloud. The operation itself may have existed for years or decades, but the environment of the operation had not been instrumented for data collection or remote control. In this scenario, the IoT brings efficiency to the existing processes.

[10] The ThingWorx Guide to the Internet of Things; http://www.thingworx.com/thingworx-analytics (25.05.2016).

- Smart, Connected Operations typically begin with a specific Return On Investment (ROI) target and objective in mind. It is critical for the Smart, Connected Operation to inform other critical systems such as Enterprise Resource Planning (ERP), logistics, or manufacturing execution systems.

New, Disruptive Experiences:

- Products and services are emerging that have jumped the development curve thanks to the confluence of cheap microprocessors, ubiquitous WiFi, fast cellular connections, and shrinking devices. IoT innovations are truly changing the game and challenging our expectations of what Things and the Internet can do for us.
- Wearables such as smartwatches are good examples of the way IoT disruption is changing the landscape. It's conceivable that data obtained from a smartwatch could be streamed to your healthcare provider, your personal trainer, and maybe even your refrigerator using IoT applications operating without any user intervention. Connectivity combined with data aggregation and analysis transforms the traditional experience of wearing a watch.
- As one can see, solution patterns give a common mental framework to discuss the infinite design possibilities and permutations of the IoT. These patterns drive one to understand the importance of using a technology platform to handle the security, scale, application logic and user experience (UX), and business system integration challenges that are uniform across each of these three patterns.
- While it may be tempting to jump straight into coding, the first step in software development for the IoT requires an understanding of the complete IoT solution and its architecture. According to industry experts, there will be approximately 25 billion Things – smart, connected products – connected to the IoT by 2020. That's an increase of more than 20 billion Things over the next five years as compared to what is in use today.

5. Main trends in the IoT ecosystem[11]

The IoT ecosystem is rapidly evolving and is subject to multiple forces. For the benefit of clarity, these can be grouped as the technology push and the demand pull. The technology push forces include:

- Enhanced connectivity infrastructure
- Cloud computing
- Big Data
- The increasing role of smart devices
- Horizontal Platforms

[11] Definition of a Research and Innovation Policy Leveraging Cloud Computing and IoT Combination – Final Report; Luxembourg, Publications Office of the European Union; 2014, p. 19-21.

The following demand-side pull forces are also in play:

- Demographic trends
- Environmental consciousness
- Public Sector driving role
- Business demand
- Consumers demand

Of particular interests are the last three pull forces. The public sector as a whole is playing a major role in the IoT market around smart cities initiatives, public transportation and transport, tourism, public safety, and military programmes. As connected objects can provide real-time updates, they can help monitor the status or behavior of people and assets to make better and timelier public management decisions. The public sector also exerts a considerable influence on the overall IoT ecosystem by providing continuous stimulus, financial resources and raising awareness around IoT current and future applications.

As far as the business demand is concerned the demand for IoT solutions seems to be coming from all industry verticals. IoT offers the potential to both increase efficiency (through the automation of support to remote equipment, for example) and create new business opportunities (by capturing data that was previously lost or unavailable).

Finally, IoT also opens up the potential for businesses to develop new relationships with consumers. For example, there is much in the media about connected cars. Part of the rationale behind this from the motor manufacturers is the wish for a relationship with drivers beyond the sale and annual servicing of the vehicle. This is a B2C (Business to Consumer) play. Other examples include Nike running shoes and white goods (refrigerators etc.). As patients receiving healthcare through an IoT solution, or consuming a public service (such as being directed to a free parking space), we are acting as consumers too.

6. Recapitulation based on conclusions by McKinsey[12]

The Internet of Things has transformative potential for many types of participants and stakeholders. Technology suppliers are presented with the opportunity to develop new and valuable systems and create new sources of revenue and lines of business. Businesses that adopt IoT systems can improve operations and gather greater insights for data driven decision making; some will have the opportunity to build new businesses with IoT technology and data. Consumers will have the most to gain-perhaps years of life from IoT health applications

[12] James Manyika | San Francisco Michael Chui | San Francisco Peter Bisson | Stamford Jonathan Woetzel | Shanghai Richard Dobbs | London Jacques Bughin | Brussels Dan Aharon | New York: The Internet of Things: Mapping the Value Beyond the Hype, McKinsey Global Institute (MGI), June 2015, p.125, www.mckinsey.com/mgi (10.08.2015).

and safer transportation, greater convenience and time savings, and less costly goods and services.

To build competitive advantage in the IoT market, technology suppliers will need to create distinctive technology, distinctive data, software platforms, or end-to-end solutions. Those that fail to do so risk commoditization and loss of business.

Business users of IoT technology will need to change their systems and organizations in order to make the most of the Internet of Things. They will need to invest in capabilities, culture, and processes as well as in technology. Smaller companies will need to find ways to obtain data on the scale required to compete with larger companies that will have access to sufficient data in-house.

While consumers stand to reap the greatest benefits from the Internet of Things, they will have to balance potential benefits with privacy concerns. They can gain access to an unprecedented amount of information about themselves and the world around them that can improve their quality of life. But consumers will have to be discerning about how they engage with that information and with whom they share it.

Finally, policy makers and governments will have to ensure that these new systems are safe and that IoT data are not being stolen or abused. They can help to balance the needs for privacy and protection of private data and intellectual property with the demands of national security. With vital infrastructure connected to the Internet, security threats will multiply, which governments will need to address. Policy makers also have an important role in enabling the Internet of Things by leading and encouraging standards that will make interoperability and widespread adoption possible.

7. Final conclusions

In a study prepared for the European Commission, the DG Communications Networks, Content & Technology[13] formulated the following conclusion: a sophisticated industry ecosystem consisting of vendors (providing components), suppliers (creating solutions), service providers, and enterprise users in all sectors of the economy will have emerged that will be measured in billions of Euro in Europe alone, and that will extend across the world too. Cloud computing and Big Data/analytics will be central elements of, and key contributors to, enabling the growth of the European and worldwide IoT ecosystems.

[13] Definition of a Research and Innovation Policy Leveraging Cloud Computing and IoT Combination – Final Report; Luxembourg, Publications Office of the European Union; 2014, p. 24.

Bibliography

1. Definition of a Research and Innovation Policy Leveraging Cloud Computing and IoT Combination – Final Report; Luxembourg, Publications Office of the European Union; 2014.
2. Hughes A.: Manufactoring metrics in an IoT world. Measuring the Progress of the Industrial Internet of Things (www.lnsresearch.com).
3. McKinsey Global Institute analysis, June 2015, p. 3, Exhibit E1.
4. Manyika J. – San Francisco, Chui M. – San Francisco, Bisson P. – Stanford, Woetzel J. – Shanghai, Dobbs R. – London, Bughin J. – Brussels, Aharon D. – New York: The Internet of Things: Mapping the Value Beyond the Hype. McKinsey Global Institute (MGI), June 2015, p. 125 (www.mckinsey.com/mgi).
5. The ThingWorx Guide to the Internet of Things (http://www.thingworx.com/thingworx-analytics).

Omówienie

Internet rzeczy (IRz) umożliwia wymianę informacji rzeczom z innymi rzeczami w sieci, rozpoznając wydarzenia i zmiany w celu autonomicznego zareagowania we właściwy sposób. Zatem IRz opiera się na komunikacji pomiędzy rzeczami (maszyny, budynki, samochody, zwierzęta itp.), co prowadzi do działania i tworzenia wartości.

W artykule dokonano krytycznego przeglądu najnowszych światowych źródeł odnoszących się do obecnego stanu Internetu Rzeczy, ujawnianych trendów rozwojowych tej wszechobecnej, globalnej technologii innowacyjnej oraz jej potencjalnego wpływu na gospodarkę i społeczeństwo.