e2 SYSTEM AS AN EXAMPLE OF THE INTELLIGENT PRODUCT IN RACKET SPORTS

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Abstract: The article presents the concept of the intelligent products. Based on a simplified business model in the area of racket sports and the example of innovative IT system that illustrates and records course of the racket games significantly highlighted the need to produce and use this kind of technology in sports and devoted much attention to the technical and innovative characteristics of discussed product.

Key words: Internet of Things (IoT), Intelligent Products, racket sports

1. Introduction

The common Internet user associated Internet with networked computers. At the beginning of this century it was truth, but today the Internet it is not just computers, at which people sits. It's also machines and devices, increasingly those that we use every day. Although some of us may not be aware of it, soon combined into Internet network will be almost everything. Smart products with network access create exponentially growing the chances of new features and offer also much greater reliability and usability.

"Computerization" of sport becomes an accomplished fact. The increasing use of information technology systems and gadgets in everyday sporting activities, sports facilities, in media relations and as a help for judging is visible at every step. Revolutionary admission of electronic systems as equivalent to the judge covers the most important and most popular sports (e.g. volleyball, basketball or football).

2. Internet of Things

"The Internet of Things" term, describing a concept created by Kevin Ashton, to simplify means the ecosystem, wherein equipped with sensors devices need to communicate with computers. Dynamic development of devices with access to the network caused that this idea has become not only a reality, but is simply indicated by consulting firms as one of the key drivers of development of the world economy of the future.

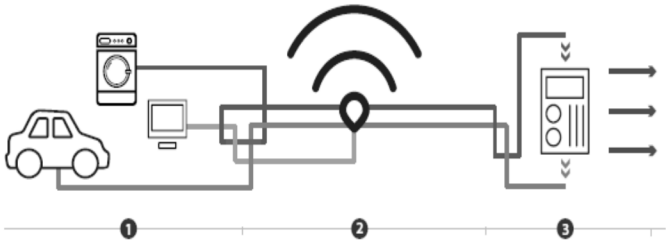

Figure 1. Idea of the Internet of Things

The main idea of Internet of Things is provided on the Figure 1, where corresponds [1]:

1. Products equipped with the dedicated sensors,
2. Computer network which combines all products,
3. System, which transmit and analysis the gathered data. Conclusions and information, which can be translate into business advantages like failure forecasting, optimization of the operation and resources planning.

The concept of the Internet of Things was created by British entrepreneur and start-ups founder – Kevin Ashton. The idea was formulated in 1999 to describe a system in which the material world is communicating with computers, i.e. exchanging data via ubiquitous sensors. Nearly a decade later, at the turn of 2008 and 2009, the number of devices connected the network has exceeded the number of inhabitants of our globe.

The Internet of Things is the next stage the information revolution. Similarly, as the rise of social media contributed to this, how we organize our lives and significantly modified the business models of many companies, also Internet of Things has already found its own place.

According to the analysis of International Telecommunications Unions (ITU), in 2020, the number of objects connected to the Internet increase from 8,7 billion in 2013 to 50 billion (475%) [2].

The key assumption of IoT is the possibility to connect each physical thing in the world with the Internet. Strictly speaking it is not about replacing products by the computers, only equipped products in the tiny computers. The term, smart/intelligent product means that things that are connected become "wiser" than things that are not labeled. The idea of the Internet of things is not new, but has become important because of the development of technology in the last decade. New technologies, as well as a decrease in energy costs allow for the production of small and inexpensive single-board computers. Main differences between the Internet and the IoT is that the IoT hardware looks much different and has a completely different purpose [3].

Achieving the highest business and financial benefits of the application of the Internet of Things is possible due to analyzing and data processing skills. Business Analytics provides techniques and tools to build useful knowledge and modern solutions effectively cope with decision-making in real time on high-speed and large volume of data. Internet of Things is also a collection of trends, which include smart homes, wearable technology and beacons. IoT allows to build a network of connected devices that are permanently installed in the house with those that we carry, such as a tablet or smartphones [4].

3. Intelligent/Smart products

Intelligent products have a built-in knowledge, artificial intelligence and communication skills. These products know what they are, what they should do and what they need to function correctly. They may even be consciously about its location and knowledgeable about the surrounding devices, users and the environment. Smart products, by means of sensors, actuators and ambient intelligence technology can proactively cooperate with users and other devices based on a multimodal interface, communicating and providing advice and suggestions.

Intelligent products with access to the Internet create growing exponentially the chances of new features and also offer much greater reliability and usability. They have the ability to penetrate and go beyond the traditional boundaries devices. The changing nature of the products resulting in disruption of existing value chains and forcing companies to rethink

and reorganize almost all internal operations. These new types of products modify the structure of the industry and the nature of the competition, opening new market opportunities companies and exposing them to new threats. It also move the boundaries between industries and create entirely new sectors of the economy [5,6].

Product intelligence is referred as an automated system for gathering and analyzing data about the performance of a product being designed and manufactured in such way that this data is automatically sent back to the product managers and engineers designing the product. It enables to assist them in the development of the next version of that product. The aim of product intelligence is to raise the rate of product innovation, by making the product and its owners more competitive. Product intelligence is usually applied to electronic products, but it is not limited to electronic products only.

Product intelligence is focus on the gathering of product performance, quality and test data. It can have also two additional functions. Firstly, an automated process for synchronizing all manufacturing locations involved in producing the product, so that production of the new version can begin immediately. This is typically accomplished by push product production and test specification software to all the test stations in the manufacturing pipeline over a network or web connection. This accelerates the product's time-to-market. Secondly, the automatic enforcement of quality manufacturing processes to ensure that products are manufactured correctly, according to the specifications of the product designers. This ensures quality and consistency across many manufacturing sites.
The true challenge for today's enterprise lies in harnessing the power of IoT to create smarter products and a smarter future. To create smart products, its needs intelligent tools. These tools will require built-in RFID devices, sensors, GPS features, storage and many more. And these devices will require local applications and performance management alerts that will connect to data via the Internet, cloud or Wi-Fi. Smart products require data, computational power and analytical ability to provide information and create key insights. Most importantly, these smart products will bring about new business models. To compete, today's organization must accurately assess the challenge and opportunities creating smart products can herald.

To create smart products, today's enterprise must move production to a new era of "smart manufacturing" by using intelligent tools and processes to maximize product potential, improve production and design engineering processes. Create connected products via embedded intelligence that can help organization create more useful and more personalized products and services. Gather data to create more intelligent value chains utilize data from smart manufacturing, inventory and logistics, to create real-time updates, better products and ultimately spur innovation [7].

Information technology is revolutionizing products. Once composed solely of mechanical and electrical parts, products have become complex systems that combine hardware, sensors, data storage, software, microprocessors and connectivity in myriad ways. These "smart, connected products" made possible by enormous improvements in processing power and device miniaturization and by the network benefits of ubiquitous wireless connectivity have unleashed a new era of competition.

Smart, connected products have three main core elements: physical components, "smart" components, and connectivity components. Smart components strengthen the capabilities and value of the physical components, while connectivity amplifies the capabilities and value of the smart components and enables some of them to exist outside the physical product itself. The result is a virtuous cycle of value improvement. Physical components comprise the product's electrical and mechanical parts.. Smart components

comprise the sensors, microprocessors, data storage, controls, software, and, typically, an embedded operating system and enhanced user interface.

In many products, software replaces some hardware components and enables a single physical device to perform at a variety of levels. Connectivity components comprise the ports and protocols enabling wired or wireless connections with the product. Connectivity takes three forms, which can be present together [8]:

- One-to-one: An individual product connects to the manufacturer, the users or another product through a port or other interface,
- One-to-many: A central system is continuously connected to many products simultaneously.

4. Benefits and possible threats connected with intelligent product application

P. Kotler and J. E. Heppelmann include Internet Things to third wave related to the development of new technologies, which appeared in the last 50 years. The first of these has automated manual activity and lead to the computer-supported automation. The second stage began at the time of usage of the Internet and led to advanced coordination and integration of activities at the global level. The current wave caused that technology has become an integral part of the products themselves and turning them into computers, which gave four main areas of benefits [9]:

- monitoring – the product is able to inform about its condition and about external conditions,
- optimization – intelligent product based on the algorithms and collected data in real time, by putting them together with historical data is able to increase their efficiency and lead diagnostics, maintenance and service,
- autonomy – the product recognize the needs, connect with other peripheral devices and even auto-diagnostic and repair itself,
- control – the product can be monitored by using sent commands or learn himself about user's needs using a built- in algorithms.

The challenges of intelligent products should include five main areas, which need to be counted during prototyping and implementation of each product separately [10,11]:

- design – standardization of the software, personalization and updating of the proposed solution. Smart products require a whole set of new design rules, such as designs that achieve hardware standardization through software-based customization, designs that enable personalization, designs the ability to support ongoing product upgrades and enable predictive, enhanced service. Expertise in agile software development and in systems engineering is essential to integrate a product’s hardware, electronics, software, operating system and connectivity components expertise.. Product development processes will also need to accommodate more late-stage and post purchase design changes quickly and efficiently,
- service – collecting and analyzing data, reorganization of the service-points and delivery terms. Intelligent products offer major improvements in maintenance and service productivity. New service organizational structures and delivery processes are required to take advantage of product data that can reveal existing and future problems and enable companies to make timely and if possible remote repairs. Real-time product usage and performance data allows substantial reductions in field-service dispatch costs and major efficiencies in spare-parts inventory control. Early

warnings about impending failure of parts or components can reduce breakdowns and allow more efficient service. Data on product usage and performance can feed insights back to product design, so that companies can reduce future product failures and associated service required,

- marketing – to take full advantage of the opportunity to build relationships with consumers through value-added services, it is necessary to data collection and its processing and personalization. It needs creativity in feasibility of using them in the future and require new marketing practices and skill sets. While companies analyze product usage data, they could gain new insights into how products create value for customers, allowing better positioning of offers and more effective communication of product value to customers. Using data analytics tools, companies can segment their markets in more-sophisticated ways, tailor-made product and service bundles that deliver greater value to each segment,
- human resources – the need to expand personnel with new skills related to software and analytics of acquired data. The engineering departments, traditionally staffed with mechanical engineers, must add talent in software development, systems engineering, product clouds, big data analytics, and other areas.
- safety – data protection, concerning both product and its users. Intelligent products create the need for robust security management to protect the data flow. It needs to protect the communication process to-from and between products, protect products against unauthorized use. It has to secure access between the product technology stack and other corporate systems. This will require new authentication processes, secured storage of products data, protections against hackers for both product data and customer data and protections for products themselves from hackers and unauthorized use.

5. A few words about racquet sports

In the European market, however, there is no IT system to provide comprehensive service of racket sports and the need for its creation was confirmed repeatedly and emphatically by focus market (players, coaches, referees and club owners).

Thinking about the idea of a modern intelligent system for racket games it has to be taken into account the very rapid development of those sports disciplines worldwide. According to World Squash Federation, the dynamics of the development of squash (one of the most popular racket sport in the world) expands very quickly, from the first squash court in 1830 to over 50 000 squash clubs worldwide, while in Poland from the first court in the 1976's to more than 500 squash courts in 2015and this numbers still raising [12].

The dynamics of the development the rest of the racket sports also looks very promising. The number of players and clubs in badminton, table tennis and squash are presented on the Figure 2.

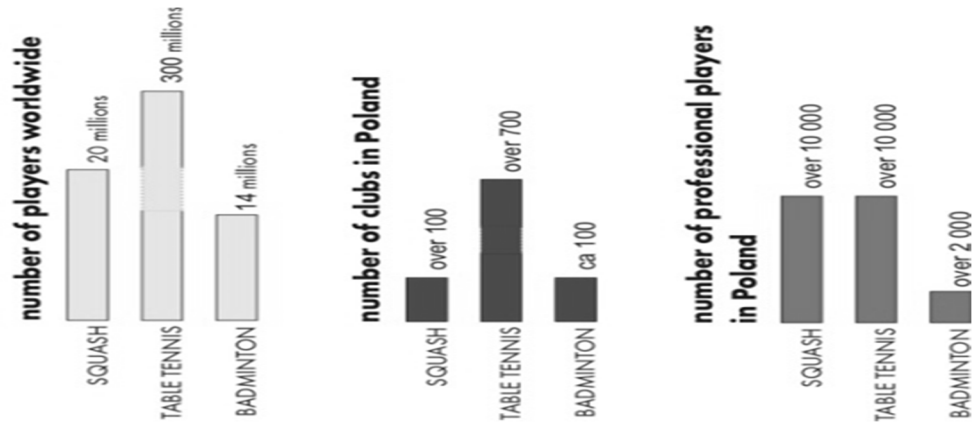

Figure 2. Number of players in different racket sports worldwide
Source: Own elaboration based on WSF analysis

As we see on figure 2, the number of players in the world when it comes to racket sports significantly exceeds 300 millions. The number of squash clubs in Poland is over 100, and it is pointed out the number of professional players is very similar as for table tennis. We can also see that squash has a greater interest than badminton, which is an Olympic sport.

6. Company and product description

The company e2 SYSTEM sp. z o. o. was established as a special purpose company for the design and implementation of the described product. The company has full copyrights to the proposed solution. The company operates in the field of sport and specialized in selling solutions dedicated to racket sports.

The e2 SYSTEM is a hardware and software package integrated in the racket sports courts (squash, badminton, table tennis). The system provides the users a number of features to increase the usage of the courts. e2 SYSTEM is an innovative electronic, completely revolutionary system of refereeing and conducting sports competitions in racket games.

So far, the players playing recreationally, without the help of a judge, conducted scores of game memorized, which repeatedly led to conflict – during a thrilling match memory is sometimes unreliable and sometimes ambitions prevail over the principles of fair play. In the case of judged matches and tournaments, recording the results was done by ballot. Registering and carrying the whole complicated process of tournament organizing relied on writing up a lot of pages, rewriting their content on bigger cards, up to large sheets.

e2SYSTEM combines the controlling peripheral elements (touchpads installed on the sidewalls of the court and operated by the players themselves and the referee remote control replacing touchpads in case of matches judged from the outside of the court by the referee) and the scoreboard consisting of a matte LED LCD matrix with commonly used resolution 16:9 Full HD technology and a fully functional quad-core single-board computer, also mounted on the court, on its front wall below the tin-line. Innovation is also the method of placing devices on the court.

Groundbreaking innovativeness of this solution is confirmed by the analysis of "freedom to operate" carried out by the Polish Patent Office, which confirmed the possibility of reservations, after submitting the application for patent.

7. Main hardware components of the product

The main hardware components of the e2 SYSTEM are:

- the scoreboard (Figure 3) – LED screen with an integrated computer, mounted on the front wall of the court in the tin-board, size of the screen: 24'' (integrated in the tin-line), which displays and announces: random selection of the player who starts the game, the duration of the warm-up or break time between gems, the current state of the game, including the number of gems won by a player and field from which side will be executed next serve, and by which player, all commands referee announced during the game (stroke, yes let, not up, no let, down, fault, stop) and additional commands such as "handout", "game ball",

Figure 3. e2 SYSTEM scoreboard presentation

- touchpads (Figure 4) installed on both sides of the court, at the height of service box, designed to scoring for match without the referee. They allow players choice of which side they intend to serve. Players themselves admit individual points during the game by touching the corresponding buttons of the e2 SYSTEM touchpad (blue/red). This allows the control of the competition status and the choice from which side will be executed next serve by players. Players using touchpads have the opportunity to: random selection of the player who starts the game, scoring gameplay, display and announce its status, precise counting of the time interval between matches and warm-up time, selection and display from which side will be executed next serve,

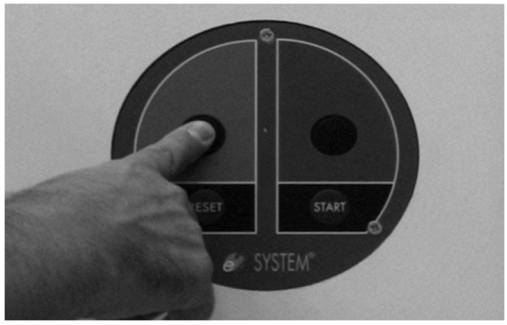

Figure 4. e2 SYSTEM touchpad presentation

– referee remote control – tablet (Figure 5), which facilitates for the single-match, as well as the whole tournaments with the participation of the referee. His commands are issued and announced by using the referee remote control. Applications created on the tablet are intuitive and does not require looking at the device during use, making refereeing easier,

Figure 5. e2 SYSTEM tablet application presentation

– server with innovative Tournament Software designed to organize tournaments and handle all courts in the club having installed e2 SYSTEM. It is installed one in each facility. The server is Hi-tech solution, connected via Internet channel with the IT Back Office, which enables full-control of the whole system.

The e2 SYSTEM devices placement on the squash court is presented on the Figure 6.

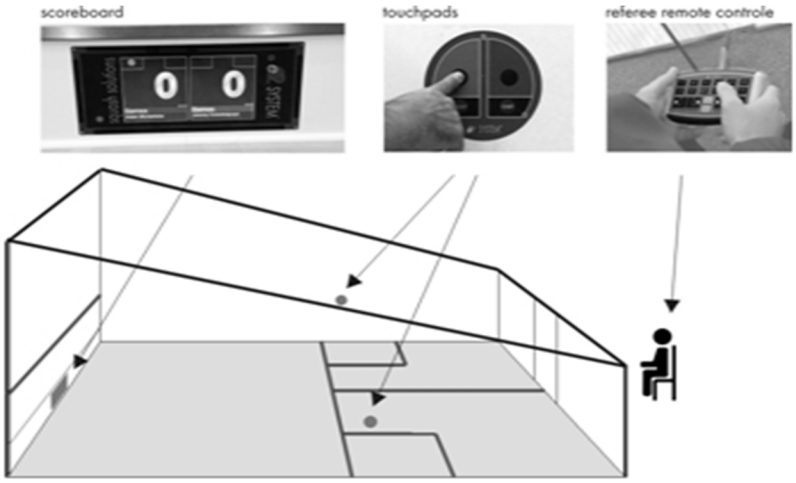

Figure 6. e2 SYSTEM product placement on the squash court

8. Main functions of the e2 SYSTEM product

The main functions of e2SYSTEM product are: the possibility of carrying out the scoring by players and automatic refereeing the game; displaying the scoring of sets and matches on the screen; the possibility of refereeing the match by the referee using the remote control; announcing the judges' scoring and commands using the speaker system, built in scoreboard. The Tournament Software enables:

- automatic drawing players in accordance with the ranking and drawing players into pools at random for different types of tournaments and leagues. The ability to conduct a variety of tournaments and competitions,
- automatic placing competitors according to the ranking of the relevant federation,
- automatic generating player's classification draw and schedule of the tournament,
- real-time tournament controlling – all matches in the tournament are visible on the one monitor. Ability to conduct several tournaments in the same time. The possibility to queuing matches of the tournament on the specific courts,
- visibility for players – the possibility to sending players into specific courts, their names are visible on the courts,
- full documentation of the tournament – automatically generate all score sheet after the each match and the current tournament ladder. All documents are available in the pdf format,
- presentation of the results – showing in the real-time championship's final draw which is automatically up-to date after each match for the audience on any (big) monitor. Access to full statistics of both the tournament and the individual player separately,
- the ability to create sparring matches and mini-tournaments during recreational play, from which are generated and sent to each of the players individually complete statistics of finished sparring with the graph of shape during the meeting,
- real time controlling of the courts, by the ability to displaying advertising on each court separately - slides, videos, audios, etc. or permanent screensaver e.g. the logo of the club when court is not used.

9. Justification of Product Intelligence implementation in e2SYSTEM product

Intelligence and connectivity enable an entirely new set of product functions and capabilities, which can be grouped into four areas: monitoring, control, optimization and autonomy. Within the e2 SYSTEM product there are implemented all four product intelligences areas.

Monitoring. Smart, connected products enable the comprehensive monitoring of a product's condition, operation, and external environment through sensors and external data sources. The e2 SYSTEM server is connect via Internet with the software developers in the IT back office. It enables a 24/7 maintenance of the whole system including the installation of future updates. In case of any system anomalies, the IT team automatically receives a message from the system. Therefore, they can fix the problem before somebody will even realize it. By using data, a product can alert users or others to changes in circumstances or performance. By sending systematically reports about each installed product's condition and the external environment, the product's operation and usage allows company and customers to track a product's operating characteristics and to better understand how the product is actually used. Permanent check of temperature and humidity to provide the players the optimum playing conditions according to scientific sport analytics. This data has important implications for design (by reducing over-engineering, for example), market segmentation (through the analysis of usage patterns by the players), and after-sale service, by allowing the dispatch of the right technician with the right part, thus improving the first-time fix rate. Monitoring data reveal warranty compliance issues as well as new sales opportunities, such as the need for additional product capacity because of high utilization.

Control. Intelligent products can be controlled through remote commands or algorithms that are built into the device or reside in the product cloud. Algorithms are rules that direct the product to respond to specified changes in its condition or environment.

e2 SYSTEM provides the dedicated application for the players, which enables using their devices as a referee remote control. They creates QR codes that are available at the front desk of the club for the players, so they can download the application directly from the server and use it in their daily games on their phones. Users can also use their smartwatches as a referee remote control for example on badminton courts where touchpads are not installed. This functionality allows the use of wearable devices as a replacement for the touchpads making playing racket sports more interesting for the players. Smartwatches equipped with speed sensor, gyroscope, accelerometer gives more and more measurement and analyzing capabilities of sporting activities. The e2 SYSTEM solution gives also the ability to display different type of ads, videos or logos on the screen installed in the each court in the club between matches or when the system is not used by the club's owner, making the product more personalized. By using hemispheric IP camera installed inside the e2 SYSTEM product, it is possible to record entire matches and their life streaming on the Internet in the real-time. The player before entering the court manually start recording on its own device and manually stops recording after the game. By watching the important sequences of the last game session, the player can easily find his/her mistakes during the play. This method increases the effectiveness of coaching. It does not only provide ideal training conditions, but also becomes a stage for the world's major tournaments due to the fact that tournaments can be recorded and published on the homepage of the club or shown via live streaming in real time distributed worldwide via the Internet. Another, intelligent option implemented into the product is interactive coaching application. By using the remote control there is a possibility to choose one from several short (5-60 minutes) training programs with the world's most renowned racket sports coaches displayed on the installed screen. The training programs are divided into the several categories (advanced level of the players, time, type of the training) and add another, educational value on the court. e2 SYSTEM prepared also the portal for the players, which consists information about upcoming tournaments and all information about the tournaments played with the results and statistics - rankings of all players (the time on the court, points etc.). The player's profile is divided into amateur sparring matches when renting court and tournament information. Player should has statistics from matches and have synchronized profile with the appropriate federation ranking. The logged user is able to create sparring matches - the player chooses a partner from a list of system users. He is also be able to "seeking" partner to different racket plays, by sending an invitation to play in the club, in a particular time to his friends (e.g. chat, message options).The user have the ability to track the chart of his shape, divided into different periods of time. This option enables users to control and personalize their interaction with the product in many new ways. Control through software embedded in the product allows the customization of product performance to a degree that previously was not possible.

Optimization. The rich flow of monitoring data from installed in the clubs smart servers, coupled with the capacity to control product operation, allows company to optimize product performance in numerous ways, many of which have not been previously possible. Product can apply algorithms and analytics to in-use or historical data to dramatically improve output, utilization and efficiency. Real-time monitoring data on product condition and product control capability enables company to optimize service by performing preventative maintenance when failure is imminent and accomplishing repairs remotely,

thereby reducing product down- time and the need to dispatch repair personnel. Even when on-site repair is required, advance information about what is broken, what parts are needed, and how to accomplish the fix reduces service costs and improves first-time fix rates. For early signs of trouble, after assessing any problems or threats the server is repaired remotely if possible, or the company deploys a technician who has been given a detailed diagnosis of the problem, a recommended repair process, and, often, the needed parts.

Autonomy. Monitoring, control, and optimization capabilities combine to allow smart products to achieve a previously unattainable level of autonomy. It allows autonomous product operation, self-coordination of operation with other products like smartwatches, tablets and smartphones used commonly by the players. It enables also autonomous product enhancement, customization and self-diagnosis and service. The security advantages of the proposed solution is the possibility of trouble-free usage of the system and all its functions without being connected to the Internet, only on the local network.

E2 SYSTEM also provide intelligence by **learning algorithms**. The server by collecting regular information (at 1 min.) about the state of the whole system (i.e. all the tennis club fitted with scoreboard) stores, analyzes and reports all existing anomalies in the functioning. This allows for the continuous improvement of the software in order to avoid any potential problems and errors. The server software and algorithms have been applied scoreboards auto-repair. The system will "know" when it needs a service "reboot" or require service activities, by recording and analyzing the situation scripts that have already taken place. When it comes to dedicated software also learns customer behavior, giving us information about the most frequently used functionalities allowing us the opportunity to personalize solutions for each client individually (control through software embedded in the product allows the customization of product performance).

10. Conclusions

The Internet of Things has the potential to deliver greater value to customers, create new services, spur innovation and help tear down the traditional walls on making new products. The evolution of products into intelligent, connected devices, which are increasingly embedded in broader systems is radically reshaping companies and competition [13]. The key conclusions, which flow from the above analysis are huge potential of IoT within sport appliance, which results with a high degree of resilience and high demand for that kind of solutions nowadays. On the other hand, the need to resolve the fears of the data protections and highlight the benefits of this ecosystem for users. In addition, to significant technological and legal solutions, concerning the processing of data from monitoring behaviour and their profiling, it is important to offer real benefits, which may be an important factor determining purchase this type of solutions and products.

e2 SYSTEM fits as an example of the intelligent product scheme as a completely revolutionary system of refereeing and conducting sports competitions and facilitate the courts in racket games. Till now, there hasn't been created any system with such wide application, responding to all the "new" needs of both players, club owners, fans and sports federations. e2 SYSTEM in an unprecedented way revolutionizing the judging system and conducting competitions in the area of one of the most popular sports. Company offer to the people, who currently follow the technical innovations and IT gadgets, a combination of physical activity with access to ultramodern system that they can use by themselves, benefitting from its features. This is combination of greater satisfaction from the game with more attractiveness for fans, makes playing racket sports more intelligent and up-to date.

Intellectual property rights held by the company e2 System Sp. z o. o. Co-founder of the functionality of the system is one of the authors – Małgorzata Ejzert. Preliminary analysis of the "freedom to operate" was conducted by the Patent Office in which the application for a patent was filed on 05.08.2014. The name of an invention "Tennis squash and a team of recorders course of the game" – No. P.409112.

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