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Internet of Things – potential for libraries

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Abstract

Purpose – The purpose of this paper is to subject the potential of Internet of Things (IoT) technology for libraries in terms of the possible scope and usage forms of this technology in public and academic library services.

Design/methodology/approach – Based on analysis of the subject literature, the main areas of IoT applications in commercial institutions were identified, then an analysis of Library and Information Science English-language literature from the years 2010 to 2015 was conducted in order to create a profile of modern library services. The range of activities of commercial and non-commercial institutions were compared to ascertain if areas in which commercial entities using or planning to use IoT could also be an inspiration for libraries. In this way, a theoretical model of IoT use in library activities was developed.

Findings – The research showed that IoT technology might have the potential to be used in library services and other activities, similar to how it is implemented in the commercial sector.

Research limitations/implications – The aim of the paper is to determine the possible, not the actual, scope and forms of using this technology in public and academic libraries' services.

Practical implications – The results can be widely used in libraries as an inspiration for the use of IoT technology in modern library services.

Social implications – The use of new technologies in libraries can help to improve the image of these institutions in the eyes of users, especially the younger generation.

Originality/value – The use of IoT in libraries is a new issue that has not been studied much yet. The issue of using the potential of this technology for the needs of libraries has, in recent years, been raised at international conferences, become a subject of interest to librarian associations, and been widely discussed in the blogosphere, thus proving that this topic is important to practitioners. It is difficult, however, to find any scientific, comprehensive studies of this topic.

Keywords Academic libraries, Library services, Public libraries, Internet of Things, Information technologies, Services

Paper type Viewpoint

Introduction

The development of information and communication technologies is currently rapid, and the consequences of this phenomenon have an impact on libraries (Pellen and Miller, 2012; Aharony, 2014; Boateng and Liu, 2014). After a period of intensive computerization of libraries (Kilgour, 2013), the beginning of the twenty-first century has been a time of great interest in social media issues (Anttiroiko and Savolainen, 2011; Buigues-García and Giménez-Chornet, 2012; Charnigo and Barnett-Ellis, 2013) and mobile technologies (Nowlan, 2013; Ong *et al.*, 2014), but new challenges are constantly being faced by libraries. New technologies such as augmented reality, wearable computing and 3D printing are slowly becoming relevant to library services, forcing continuous development and the need to tailor libraries' offerings to changing conditions and evolving customer habits (Prince, 2014; Wójcik, 2015). One of the most

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interesting concepts of recent years, which could potentially be a big challenge for libraries, is the Internet of Things (IoT).

The issue of using the potential of this technology for the needs of libraries has, in recent years, been raised at international conferences (Obodovski, 2014), become a subject of interest to librarian associations (ALA, 2015; OCLC, 2015), and been widely discussed in the blogosphere (Mylee, 2011; Potter, 2014), thus proving that this topic is important to practitioners. It is difficult, however, to find any scientific, comprehensive studies of this topic, which is why author decided to address this issue in the hope that this paper will contribute to wider discussion.

The subject of this paper is the potential of IoT technology for libraries. The aim is to determine the possible scope and forms of the use this technology in public and academic library services. The specific objectives include:

- define the form of modern library services;
- determine the potential of the IoT for the improvement of library services;
- describe examples of IoT applications in libraries; and
- formulate prospects for the use of the IoT in libraries.

Description of IoT

IoT is a concept that has been described extensively since the late 1990s. Many definitions emphasize the different aspects of this issue. According to L. Atzori, A. Iera and G. Morabito it can be described as a "novel paradigm that is rapidly gaining ground in the scenario of modern wireless telecommunications" (Atzori *et al.*, 2010). These authors explained that "the basic idea of this concept is the pervasive presence around us of a variety of things or objects such as Radio-Frequency Identification (RFID) tags, sensors, actuators, mobile phones, etc. which, through unique addressing schemes, are able to interact with each other and cooperate with their neighbors to reach common goals" (Atzori *et al.*, 2010). According to another similar definition: "IoT refers to the networked interconnection of everyday objects, which are often equipped with ubiquitous intelligence" (Xia *et al.*, 2012). The IoT is also considered to be a part of the so-called Future Internet, defined as a "dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols where physical and virtual 'things' have identities, physical attributes, virtual personalities, use intelligent interfaces, and are seamlessly integrated into the information network" (Vermesan *et al.*, 2011).

In summary, it appears that the main idea of the IoT is based on the assumption that everyday objects equipped with appropriate sensors and network access can communicate to fulfill certain tasks. This bold statement raises as much hope as controversy. Enthusiasts of this technology point out the revolutionary nature of the concept and the possibility of its use in almost all areas of life (Guerra, 2012; Suraki and Jahanshahi, 2013). Opponents draw attention to the risks associated with the loss of data privacy, legal problems, and finally the risk of devolving too much control to the devices (Yang *et al.*, 2011; Ziegeldorf *et al.*, 2014). Most researchers and practitioners, regardless of their professed views, are however agreed that IoT is the technology of the future; therefore, the pros and cons of it must be thoroughly recognized, as it will become more and ubiquitous.

Literature review

To establish the state of research, scientific resources were sourced using Google Scholar. For this author, it was important to comprehensively search for papers that

represent different authors, publishers and research perspectives. Only articles, books and research reports published between 2010 and 2015 in English were sought. Papers from the same chronological range that were included in the key librarianship databases such as LISTA were also complementarily taken into account, as well as publications, mainly reports, provided by key technology companies from the IoT field, such as CISCO, IBM and Bosch. Based on both full papers and abstracts, the main directions of IoT research were established. These were found to include: general elaboration about the idea of IoT (Weber and Weber, 2010; Kopetz, 2011, Miorandi *et al.*, 2012, Gubbi *et al.*, 2013); forecasts for the development of IoT (Sarma and Girão, 2009; Zorzi *et al.*, 2010; Tan and Wang, 2013); empirical surveys on the use IoT (Atzori *et al.*, 2010; Gluhak *et al.*, 2011; Sheng *et al.*, 2013; Perera *et al.*, 2014); and descriptions of IoT usage in various areas of applications (Tianbo, 2012; Jara *et al.*, 2014; Pang *et al.*, 2014).

In general, the topic of IoT use in various scientific disciplines and branches of practical activity is popular. However, there are insufficient papers that approach this issue from the perspective of Library and Information Science (LIS). The following works seem most relevant in the context of this paper: "Ambient findability: libraries, serials, and the internet of things" (Morville and Sullenger, 2010); "Construction of the personalized service system of university libraries in the environment of the internet of things" (Hongbing, 2011); "Smart library and the construction of its service model" (En, 2012); "The new directions of expanding service in colleges and universities libraries under internet of things environment" (Li and Lin, 2013); "An analysis of the conditions for construction of smart library" (Zhuanqin, 2013); "On the construction of Wisdom Libraries in university library" (Fang, 2014); "A framework for citizen participation in the internet of things" (Moreno *et al.*, 2014); "The 'Internet of Things': what it is and what it means for libraries" (Hoy, 2015); "Internet of Things and libraries" (Pujar and Satyanarayana, 2015). Unfortunately, many papers related to IoT use in libraries were published in conference proceedings and local journals, thus limiting their accessibility. There are few internationally published articles in major journals in the field of information and library science that are available to the public.

Methodology

The conducted analysis consisted of several stages (Figure 1). In the first stage, the main types of IoT applications developed by commercial companies were identified, based on analysis of the subject literature and reports provided by key companies in the field. As a result, a little over 50 of the most relevant abstracts or full texts of English-language papers published in 2010-2015 were analyzed. The collected material was subjected to categorization. In the second stage of the study, an analysis of LIS English-language literature from 2010 to 2015 was conducted in order to create a profile of modern library services. A little over 50 articles relating most to the characteristics and forms of modern library services were analyzed. Subsequently, the ranges of activities of commercial and non-commercial institutions were compared. The aim was to ascertain if areas in which commercial institutions using or planning to use IoT might also be inspiration for libraries. Thus, a theoretical model of IoT usage in library activities was developed. In the last stage of the research, both subject literature and network resources were searched to find examples of actual attempts to implement the IoT in libraries. Finally, conclusions about the prospects for the future use of IoT in libraries were formulated. The developed model relates to the potential use of IoT in library services. The author realizes that such considerations always carry a risk of speculation, but believes that a starting point for discussion is needed as this could lead to more research in this area by this and other authors.

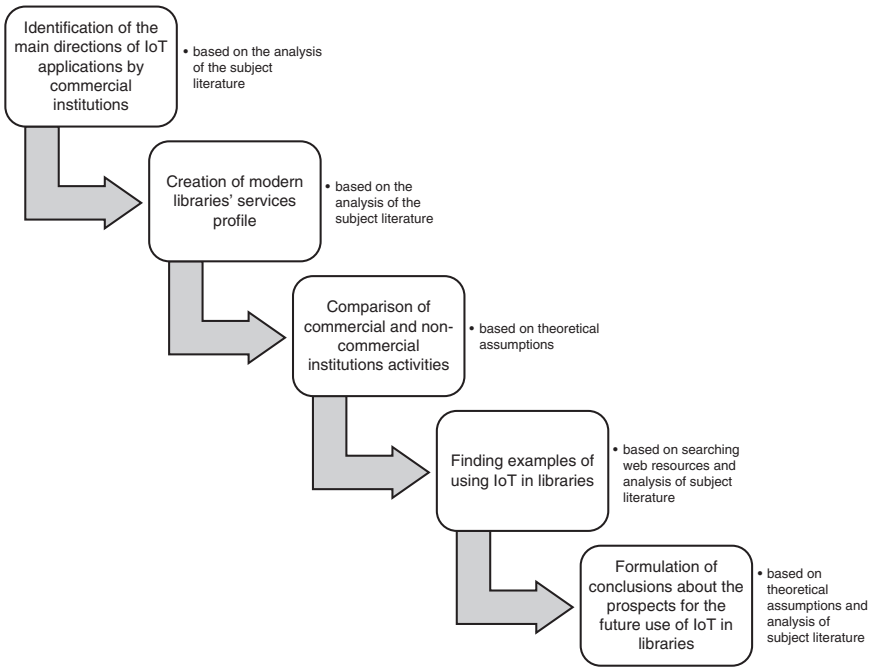

Figure 1. Research methodology

IoT in commercial services

In many areas, parallels can be found between the activities carried out by commercial and non-commercial institutions. The LIS area is a good example of this statement. The main mission of libraries – to mediate in communication – is implemented by a number of commercial entities from various industries, often in very interesting and innovative ways. Commercial institutions, defined here as entities whose primary aim is the pursuit of profit by satisfying consumers' needs, often have financial and technical resources that enable them to deploy new solutions faster than non-commercial institutions. Therefore, it is worth looking into the ideas and experience of commercial entities that could be beneficial to non-profit institutions when conditions are conducive.

The analysis of subject literature dedicated to the implementation of the IoT in business, primarily in industries such as communications, management, consulting transport and logistics, make it possible to distinguish several key application areas for this technology. Of course, the diversity of IoT usage ideas is large, but the goal was not to describe it in detail, only to extract some general trends. The summary of this analysis is shown in Figure 2.

The analysis showed that commercial institutions use the IoT to share contextual information about products and services. An example might be the trend to send so-called push notifications that display contextual information about products and services on mobile devices, e.g. when passing or staying in a particular place in a mall. This is still more a concept than a widely applicable solution, however, push notifications in their various guises are already part of the shopping experience of many smartphone users with appropriate applications (Pan *et al.*, 2015; Waracle, 2015). Similar solutions are also used in marketing as a part of a participative concept.

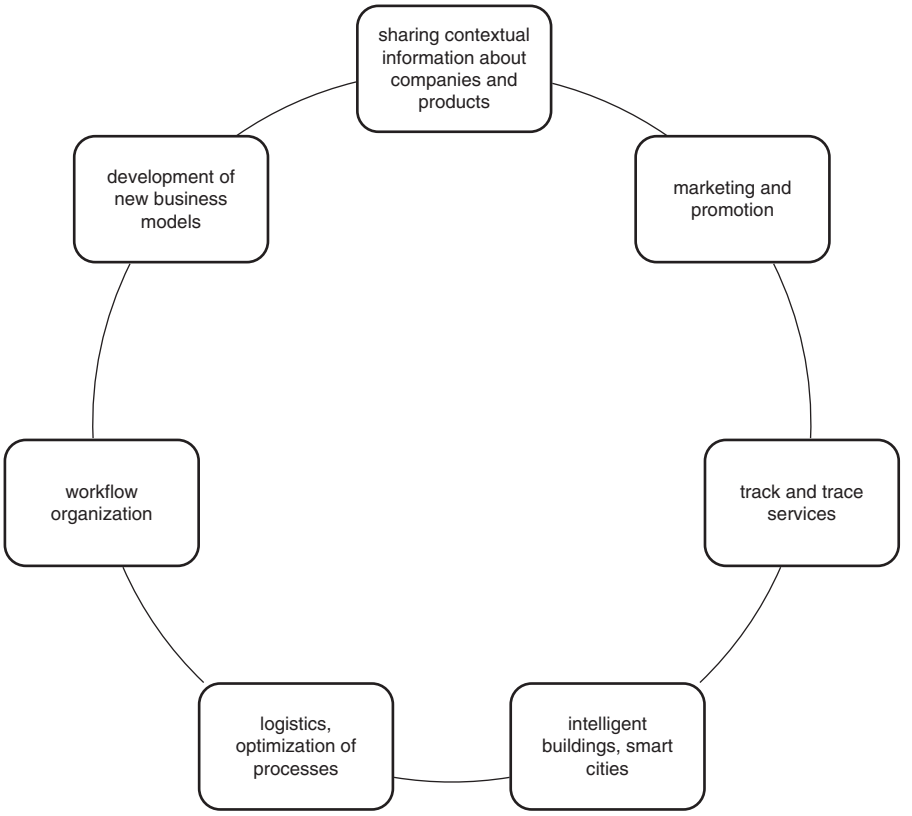

Figure 2.
The main areas of IoT use in the commercial sector

The idea is that customers – now called prosumers – can take to the next level the possibilities offered by social media and actively participate in marketing processes by rating and commenting on products or services on an ongoing basis. IoT technology can give them more tools and opportunities to be involved in sharing information and promoting favorite companies and products (Jara *et al.*, 2014).

The IoT is also often used in various contexts related to improved organization, management, and planning. Proof of this is the use of IoT technology in track and trace services, for example in airports, delivery companies and transportation. The possibilities offered by the communication between IoT objects make easier management of standard processes possible in many industries (Michahelles and Cvijikj, 2012; Lopez Research, 2013; CISCO, 2015a). On a larger scale, IoT solutions are used in so-called smart buildings and smart cities (CISCO, 2015b). The idea of smart cities is based on the assumption that the devices can personalize a user's environment based on information sent by mobile devices (GhaffarianHoseini *et al.*, 2013), offering many still difficult to predict opportunities. Nowadays, many processes implemented in buildings are already automated. Management of air conditioning, temperature or alarm systems is not a problem for modern architecture, but many IoT commentators predict not just smart, but truly intelligent buildings that have the characteristics of artificial intelligence and the ability to independently and accurately make decisions, but this is still in the future (Torres, 2015).

The IoT is used in logistics and process and workflow organization in various sectors. Using this technology can improve organization, both on the individual and the enterprise level (Giner *et al.*, 2010; Schmidt and Schief, 2010). The IoT allows real-time monitoring and optimizing of processes (Atzori *et al.*, 2010), whether they are related to production, services, trade, storage, transportation, or other business activities. In the subject literature, the IoT is also widely reported to create new business models (Bucherer and Uckelmann, 2011; Glova *et al.*, 2014; Fleisch *et al.*, 2014; Bosch, 2015). It is believed that the IoT can provide the technical and conceptual conditions for the development of new ideas for delivering products and services to clients. According to some authors (Perera *et al.*, 2014), using IoT technology fits well in the global trend of providing all goods as services. The full scope of the use of the IoT for the creation of business models is not yet known, but existing models of potential IoT applications in business are promising (Sun *et al.*, 2012).

Modern libraries' services

Moving on to discuss the specifics of modern library services, it can be concluded that despite the passage of time and technological changes, the core of library services is still essentially the mediation of access to information (Wojciechowski, 2014). Providing access to both traditional and online collections is still given in subject literature as the main area of library services. No less important is the area of advisory services and consulting. According to the Pew Report, borrowing books is a very important service for 80 percent of Americans, and another 80 percent claim that help from reference librarians is very important for their library experience (Zickuhr *et al.*, 2013). It is suggested that librarians' duties include sharing catalogue information, referring to sources of information, and providing facts, thereby actually being a source of information. In some papers, attention has been drawn to the fact that nowadays the role of librarians – especially in academic environments – is not limited to simple information sharing, but is also based on partnership and assisting users, be they researchers or students, in the whole process of obtaining and using data, starting from the point where the idea, need or concept appears, to the moment of publication (Tsang and Renaud, 2014). This approach is related to the idea of so-called embedded librarianship, which is a concept based on deep participation of librarians in the lives of users and providing services at a place and time convenient for them (Shumaker, 2009).

Library services are nowadays offered in various forms and with a variety of tools, such as chat, mail, social media, mobile applications, and others (Canuel and Crichton, 2011; Arif and Mahmood, 2012; Ong *et al.*, 2014), but when it comes to their basic nature, it seems that the core of library services can be split into groups (Figure 3). First, the sharing of information in the form of dates, names, facts, etc. Second, the provision of catalog and bibliographic information which assists users with navigating through library resources and searching for relevant sources of information. Third, the provision of access to traditional and online collections in terms of lending materials and making them available on-site or remotely. As was concluded earlier (Tsang and Renaud, 2014), in a modern library service model, providing factual or directory information and providing access to traditional and electronic resources often merge into one complex process which hopes to find a comprehensive solution for a user's problem. Another aspect of library service models is the provision of space and equipment, for instance library rooms, computers, scanners, information searching tools, etc. Pew Institute research showed that this aspect of library services – particularly providing free access to computers and the internet – is very important

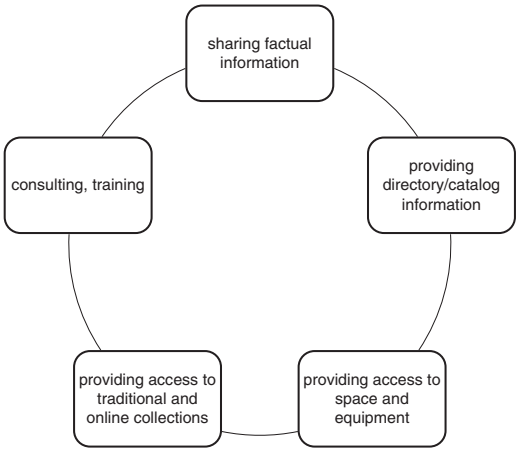

Figure 3.
The main modern library services

for 77 percent of Americans above 16 years old (Zickuhr *et al.*, 2013). The same research also showed that 35 percent of respondents would very likely make use of new electronic devices in libraries (Zickuhr *et al.*, 2013). Finally, there is complex consulting and training on the use of the library, its contents, and about information retrieval in general. In the modern world, libraries play an important role in educating competences in the field of information and media literacy. Providing education in the field of evaluating the quality of information is one of the most important library services (Katz, 2015).

It is worth noting that this list does not include the so-called external activities of libraries, such as cultural, local, and community events, etc. Other library processes, such as gathering, describing and storage of collections, were not included either. The developed scheme that covers the main aspects of library services may seem simple, but when the variety of activities undertaken by the libraries is considered it can be seen to be correct. Therefore, this will serve as a basis for further analysis.

The IoT in library services: a theoretical model

The actions described in this part of the paper are intended to create a theoretical model for areas of IoT application in library services. This idea is based on the assumption that the IoT is universally applicable and can be widely used regardless of the nature of the business profile of a company or institution. To test this hypothesis, the areas of IoT use in various commercial sectors were analyzed to select the most common fields of use, which were then divided into services and other activities. The results of this analysis were compared with a list of the main services and other activities provided by libraries in search of commonalities in terms of functions performed by commercial enterprises and libraries. The author assumed that if the functions/areas of activity of various industries and libraries are similar and commercial businesses use the IoT, then this is also theoretically possible for libraries. The results of this comparison are shown in Tables I and II.

The first comparison concerning services showed that the IoT could potentially be used in libraries for providing access to traditional and online collections and providing factual and directory information, as is the case in the commercial sector. For example, this technology could make it easier for librarians and users to locate physical objects

in the library and navigate through virtual resources. It could also be used to deliver contextual hints and information about resources connected with current user interests. The IoT could also be potentially useful in other areas of library services, such as consulting and training. In this context, the IoT could be used for downloading up-to-date information about users from their mobile devices, for instance their mood, daily schedule, etc., and personalizing training courses according to this data. The IoT could also be used for signaling the availability of facilities and resources, thus preventing user frustration due to lack of space in the reading room or unavailability of workstations.

Comparison of other commercial IoT uses against other types of library activities also revealed interesting possibilities. It seems that although the IoT could potentially be frequently used in marketing and promotion, its usefulness is not limited to this area. It could also be used in process optimization, library workflow organization, and the development of innovative business models that make libraries more interesting for users and other stakeholders. Using innovative IoT-based marketing techniques to promote libraries and organize events could help build the image of the library as a modern institution that follows current trends. This technology could also be used to streamline internal library processes. For example, gathering, describing and analyzing resources, smart building technology, and the proper storage of resources.

To sum up, it can be concluded that the main potential areas of IoT use in library services are providing directory information and providing access to traditional and online collections. The IoT also has potential for consulting and training, track and trace services, and the sharing of information (Figure 4).

	Providing contextual information about companies and products	Track and trace services
Providing access to traditional and online collections	1	1
Consulting, training	1	0
Sharing factual information	1	0
Providing directory information	1	1
Providing access to space and equipment	0	1

Notes: 1 – there is a match; 0 – there is no match

Table I. Comparison of IoT's fields of use in services of commercial companies with the range of modern libraries' services

	Marketing and promotion	Logistics, optimization of processes	Workflow organization	Development of new business models	Constructing smart buildings
Gathering	0	1	1	0	0
Description	0	1	1	0	0
Storage	0	1	1	0	1
Analysis and selection of collection	0	1	1	0	0
Marketing and promotion	1	1	1	1	0
Beyond services offer	1	1	1	1	0

Notes: 1 – match exists; 0 – no match

Table II. Comparison of other fields of IoT use in commercial companies with non-service library activities

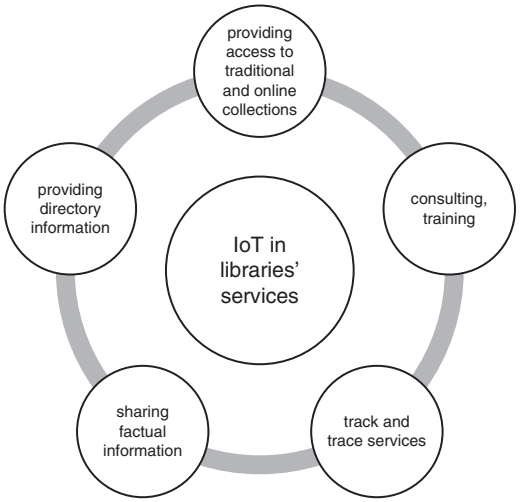

Figure 4.
The main areas of potential IoT use in library services

In terms of IoT use in other library activities, the most promising areas seem to be marketing, promotion, storage, and cultural activities and events. IoT can also be used in gathering, description and analysis/selection of collections (Figure 5).

Overall, it seems that the IoT can theoretically be successfully used in almost every area of library work, including both services and other activities.

The IoT in libraries – examples of implementation

There are not many existing descriptions of IoT use in libraries, however literature analysis and a search of network resources revealed some interesting initiatives.

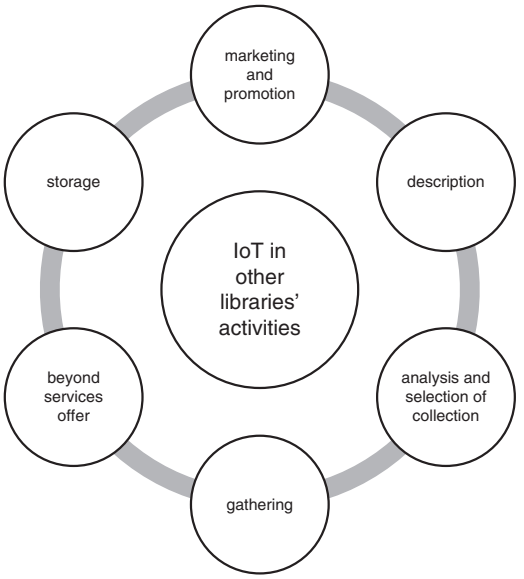

Figure 5.
The main areas of potential IoT use in other library activities

The first is the BluuBeam application implemented by Orlando Public Library. This application is based on the iBeacon technology that is usually used in augmented reality initiatives. BluuBeam sends location-triggered information to mobile devices that helps users search for resources and expand their interests with contextual hints (Sarmah, 2015). According to the assistant director of the Orange County Library System, this application is like a "virtual tap on the shoulder" (Sarmah, 2015), a little reminder and a hint for users. The distinguishing feature of this product is the simplicity of the concept, which is easy to explain to users, and its high utility for contextual search. The BluuBeam technology used by Orlando Public Library is also used – according to the company's founder – by approximately 30 other libraries in the USA. Unfortunately, other instances of BluuBeam use in libraries are not well described (Swedberg, 2014).

Capira Technologies has a rival idea for IoT use in libraries. The solutions offered by this company allow the integration of mobile applications with existing library systems. The application can be tailored to the individual needs of a library and gives broad possibilities: users can receive notifications about the status of their account, can be informed about library events, search through catalogs, or receive personalized and contextual notifications from librarians that are related to their current interests. According to one of Capira's co-founders, this application is widely used in over 100 libraries (Swedberg, 2014). Examples are Somerset County Library and Half Hollow Hills Community Library (Swedberg, 2014).

Conclusions

Despite several successful initiatives, the IoT in libraries is still more a concept than reality. It remains to be seen what will happen in the future. In the subject literature, in the blogosphere, and in the public discourse a belief seems to be prevalent about the rapid and inevitable development of IoT technologies (Gubbi *et al.*, 2013; Xu *et al.*, 2014; Roy, 2015). According to some authors: "The Internet-of-Things may represent the next big leap ahead in the ICT sector" (Miorandi *et al.*, 2012).

The potential scope of IoT applications in business, science, entertainment and everyday life is huge. In the literature and in the media, different visions of the development of the IoT and the various applications of this technology can be found, some based on existing projects, others still bordering on science fiction. According to Daniel Obodovski, author of *The Silent Intelligence: The Internet of Things* book and keynote speaker at an American Library Association (ALA) conference: "the Internet of Things is happening, and it is happening now" (Obodovski, 2014). This suggests that although the predicted IoT boom has yet to come, the first signs of this technology are already clearly visible. It seems logical that in this context, libraries will include IoT in their service range to follow global trends and better meet users' needs.

Based on observation of the commercial sector, this paper presents one vision of the potential of IoT for libraries and attempts to identify areas of library activities in which this technology could perform well. Analysis showed that some commercial activities overlap with library services. Therefore, libraries can theoretically use the IoT in a similar way to commercial institutions. The obstacles to the use of IoT in the library services are, of course, financial and organizational, but the potential is clearly visible. In the area of library services, the greatest potential of IoT technology can be seen in process of providing access to traditional and online collections and providing directory information. IoT technology can also be useful for sharing information, conducting consulting or training, and providing access to spaces and equipment.

IoT technology may also be useful in other non-service library activities such as gathering, description, storage, analysis and selection of collections, marketing and promotion, and event organization.

The presented findings are largely consistent with the assumptions presented by other authors and practitioners. Results of the online survey conducted among librarians in 2014 by the Online Computer Library Center showed, for instance, that from the point of view of practitioners, the IoT is a promising technology that can be used in areas such as inventory control, access and authentication, and monitoring of collection storage (OCLC, 2015). Of course, there are some concerns too, mostly related to data privacy and security issues, but they do not outweigh the potential benefits (OCLC, 2015). A similar opinion is presented in a trend analysis prepared by ALA. According to the ALA's Center for the Future of Libraries, development of the IoT will be rapid: "Estimates of the size of the Internet of Things range from 25 billion to 50 billion objects connected by 2025" (ALA) and it will definitely be one of rising trends important for the future of libraries. Among concerns related to introducing the IoT to the public on a large scale, the ALA listed problems with a lack of standards for data collection, storage and transmission. Another potentially dangerous factor is the threat of a digital divide developing between users and non-users of this technology (ALA).

As Potter predicts on his blog, "The Internet of Things will, hopefully, be a big deal in libraries" (Potter, 2014). Among potential areas of IoT use, the author listed: tracking books; organizing self-guided tours; making exhibits in special collections more interesting; providing options for contactless payments; checking availability of equipment; and providing more detailed information about collections (Potter, 2014). A similar conclusion is reached by Engard, according to whom the possibilities of IoT use in libraries are almost endless and depends mostly on the imagination of librarians (Engard, 2015). Among examples of IoT use in libraries, the author listed: using RIFD technology for self-checkout; using floor pressure pads and iBeacons to track users' movements and provide them with contextual information; using wristbands as library cards, and many others (Engard, 2015). In summary, it seems that IoT technology can be used in libraries to support both back-office processes and services for users.

New technologies such as IoT usually bring some potential challenges alongside the benefits and opportunities they offer (Figure 6). The IoT has the potential to improve library services by providing users with tools that allow easy use of libraries, constant contextual help, and personalization processes. The IoT may also make it easier for librarians to perform their jobs through extensive automation of routine tasks. The IoT may be a good tool for building the positive image of libraries as modern and constantly developing institutions. On the other hand, questions arise about privacy and data security issues, especially the ethical and legal aspects of data collection and processing and the safety and privacy of users' data. Careful consideration is required of whether libraries have the financial and technical means to ensure data security and are ready to bear the legal and moral consequences of any failure in this regard. There are also some financial and organizational barriers. Implementation of the IoT requires a lot of financial, technological and organizational expenditure, which may be beyond the capabilities of libraries. Librarians should think about the funding of such initiatives and make accurate business analysis of the profitability of the IoT introduction in libraries. However, the consequences of implementing any technology are often difficult to predict, especially because in the

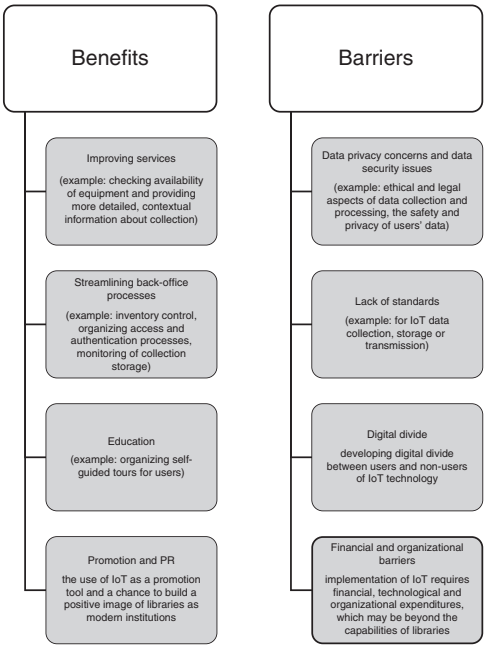

Figure 6.
IoT in libraries – benefits and barriers (summary)

case of libraries the issue is not about financial return, but more about benefits to the community. Another barrier may be the lack of IoT data collection, storage and transmission standards. This is new, unknown territory which librarians will have to investigate and work out new solutions for from scratch. It can be assumed that this will not be an easy process. Finally yet importantly is the problem of the digital divide. For many library clients the new technology is attractive and beneficial, but there are also users who may feel excluded and lost, such as the elderly or the less technically competent. The priority for libraries should be to develop solutions that help tame new the technologies and overcome the concerns of users, before offering new solutions.

Overall, it seems that introducing the IoT in libraries is an imminent and inevitable prospect that brings both great prospects and challenges. Therefore, it is particularly worth immediately discussing the pros and cons of this issue in order to be prepared for the future and efficiently prevent problems in order to gain the most benefits from the development of this technology.

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Further reading

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