INTERNET OF THINGS (IOT) AND ITS EFFECTS ON LIFE STANDARDS OF DISABLED PEOPLE

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Abstract

In recent years, with the rapid development of network science applications as well as the increasing number and variety of devices that connect to networks, the "Internet of Things" has been more expansive in our lives. While it has inspired new entrepreneurial ventures thanks to the increased use of devices that connect to the Internet, the "Internet of Things" also provides us with practical everyday solutions and applications. The goal of this study is to analyze this technology's content, history, working principles, challenges and limits, fields of application, as well as its implications on the life standards of people with disabilities.

Keywords: IoT, Network Science, Smart Objects, Smart Automation Systems, Living Conditions of People with Disabilities

Nesnelerin İnterneti ve Engelli İnsanların Yaşam Standartları Üzerindeki Etkileri

Özet

Son yıllarda hızla gelişmekte olan ağ bilimi uygulamaları ve bu ağlara bağlanabilen cihazların çeşit ve sayılarının artmasıyla giderek daha çok dikkat çeken "Nesnelerin İnterneti" konusu hayatımıza süratle girmekte. İnternete bağlanan cihazların kullanım sıklığının artması sebebi ile pek çok yeni iş fikrini de doğuran "Nesnelerin İnterneti" ayrıca hayatı kolaylaştıran çözümleri ve uygulamaları da bize sunmaktadır. Çalışmanın amacı teknolojinin içeriği, tarihi, çalışma prensipleri, karşılaştığı engeller ve kullanım alanlarının yanı sıra engelli insanların yaşam standartları üzerine etkilerini incelemektir.

Anahtar Kelimeler: Nesnelerin İnterneti, Ağ Bilimi, Akıllı Nesneler, Akıllı Otomasyon Sistemleri, Engelli İnsanların Yaşam Standartları

1. INTRODUCTION

The concept of network science, which has greatly gained in importance together with the invention of the Internet, continues to grow at a great pace even today with many different disciplines it hosts. The increasing popularity of smartphones, in particular, makes it easier for more people in the world to access the internet, and the number of objects with internet access increases day by day.

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The Internet of Things (Iot) is one of the great innovations of our age in the field of digital communication. It denotes that each object is connected with each other within a world of connected objects. And with this innovation new ways and forms of communication have been discovered (ITU Internet Reports, 2005). It is an undeniable fact that technology, which encompasses the communication that people make through the Internet and the digital communication between the objects themselves, is chronologically yet in its early days, but it indicates significant changes for both our working and everyday lives (Tan and Wang, 2010).

When the results of the census (6.9 billion) in 2010 and the World Health Survey and Global Burden of Disease are compared, it is seen that 15% of the world population is composed of people with disabilities (World Health Organization (WHO), 2011). In this study, principles and benefits of "Internet of Things" will be emphasized and what opportunities of this technology can offer to people with disabilities, will be put forth.

1.1. The Internet of Things (IoT)

The concept of Internet of Things (IoT) was first used by Kevin Ashton in 1999. It has been adopted by the Auto-ID research group which works on the concept of RFID and similar technologies, and then it has spread worldwide. However, definitions of the concept have been formed within the next 10 years (van Kranenburg and Bassi, 2012).

Novelty of concept and the technology's evolving nature bring many different definitions about IoT such as "A world-wide global infrastructure that links physical and virtual objects together and enables them to produce and share data", "A system of networks that integrates with physical objects and enables them to contribute data creation and business processes".

Starting from the aforementioned definitions, the Internet of Things is a communication network in which physical objects are interconnected with each other or with larger systems through technologies such as RFID, bluetooth, wi-fi. Objects within this network include and / or reflect gathered data to the process, either received on their own or through other objects connected to this network via the Internet Technology allows to see bigger results from the sum of small pieces, and accordingly has the potential to fill Big Data to a great extent.

1.1.1 A Brief History of Internet of Things

The concept of Internet of Things has emerged thanks to many different technologies which were discovered before it and deeply affected the world industry and finance. The first and most important of these is the concept of "INTERNET", which came in our lives through ARPA.net, and has a profound impact on our lifestyles ever since. Another one is Radio Frequency Identification (RFID) technology, which plays a key role in enabling mobile phones to be used by everyone at this frequency. The sensor technology, which is the most important factor in this platform, collects the transferable data for the concept and directs them to the defined addresses. The combination of these technologies in a
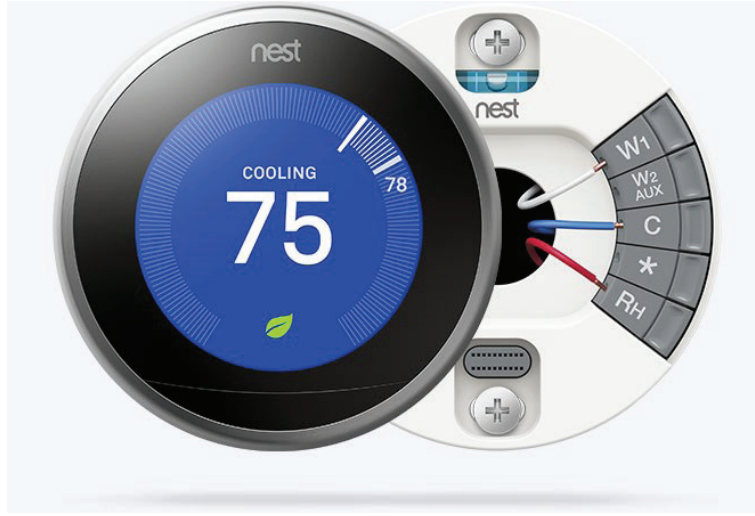
logical plane forms the concept of the Internet of Things. It can be mentioned that among other historical developments which have paved the way for this technology are Baron Schilling von Canstatt's invention of electromagnetic telegraph in 1832, the discovery of Samuel Morse's Morse alphabet in 1844, and Tesla's words in interview with Colliers Magazine in 1926, which underline that wireless receiver apparatus can become more accessible(Collier's Magazine, 1926). Also there are other technologies that can be considered as milestones of this concept, which are the discovery of two-way radio in early 1920's, Norman Joseph Woodland and Bernard Silver's invention of linear barcode in 1952, Morton Heilig's product which is widely accepted as a pioneer of virtual reality in 1960, ARPA. net's sending of the first message through internet in 1969, Mario Cardullo's invention which can read and write radio frequencies in 1973 and Tim Berners-Lee's presentation of World Wide Web to the whole world in 1989.

After this point, the "web" has become more interactive by getting rid of its static state. The sale of the products that are presented to the market through the Internet has gone beyond the imagination and the applications such as "eBay" and "Amazon" have started to increase rapidly after this period. Then in 1990 Olivetti Research Laboratories introduced a product that could detect someone's location with infrared signals. In the same year, John Romkey and Simon Hackett introduced the world's first "connected object" (a toaster attached to a computer, taking orders from the it). In 1994, Mik Lamming and Mike Flynn's wearable product, named Forget-Me-Not, was able to interact with people and objects around, and to collect data as a result of these interactions. In addition, the development of the first GSM data modules by Siemens in 1995 and then the emergence of the Bluetooth concept for the first time in 1998 were the evolutions that triggered the concept of "Internet of Things".

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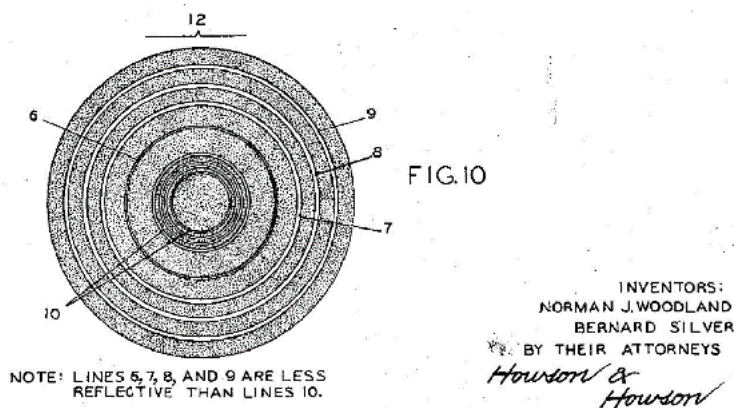
Figure 1. Norman Joseph Woodland and Bernard Silver's Linear Barcode's patent

In 1999, the emergence of the IoT concept is followed by the introduction of the first M2M (Machine to Machine) protocol for interconnected devices. In 2008, the IPSO Alliance introduced the technology that can make IP-to-IP connections, meanwhile giant technology companies such as Samsung, LG, and Google have already started to develop products based on this concept.

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Figure 2. Smart thermostat designed by NEST

### 1.1.2 Working Principle of IoT

As mentioned earlier, the ability of the concept to function properly is only possible if the sub-technologies work in a correlative way. This tells us that the concept's working principle has an architecture. It should be noted that the Internet of Things technology can be processed by the execution of three main factors together. Devices, are foremost among these factors, and perform the tasks of "perceiving objects" and "collecting data of objects" in the process. These devices have begun to enter everyday life more comfortably with the size of the sensors becoming more and more smaller. Due to the development of micro-electro-mechanical systems, micro-sensors, micro-processors, micro-electronics and micro-structures have become easier and cheaper to access. The main task of these devices in the process is to collect data to be transferred. During the identification and recognition phase of the process, RFID technology elements such as NFC (Near Field Communication), barcodes (barcode reader, barcode printer and barcode scanner), QR (Quick Response) codes and digital watermarks are used. Collecting data about the object is provided by sensors (heat sensors, magnetic sensors, pressure sensors, optical sensors, sound sensors etc.). In some specific applications, transducers, triggers, and filters can be used alongside sensors to filter received data or convert it to a different kind of signal (Çeltek, Hacıbeyoğlu and Soy, 2015).

Network connection is the second step of the process where the data is transformed and processed. Especially with the widespread use of broadband internet, it has become more functional. In the process, information gathered with technologies such as radio signals, wireless connectivity, bluetooth technology can be transmitted to other objects through the same path, or it can be collected and processed in other devices to join another object's information network. Assigning an IP address to every object is a must for IoT technology. Passing from IPv4 to IPv6 has created the proper infrasturcture for IOT, therefore there are enough IP addresses, as it were, to tag every sand partical on earth (Mulligan, 2009).

Applications' segment, which is the third major element of the process, has the fastest growth rate and is intertwined with finance market. One of its main purposes is to create an interface between technology and people to provide a more ergonomic method for users who are unfamiliar with the technology while using connected objects. Especially with the emergence of smartphones, application market has grown remarkably, and today it has a $61 Billion budget. Furthermore, the estimated budget of application market on 2019 is $490 Billion (Global Initiative for Inclusive Technologies Publications and Reports, 2015).

1.1.3 Areas of Use of IoT and the Current Samples

Having been a significant part of our life, the internet soon has held a critical place in business world as well. Growing industries are faced with difficult data flows and information storage problems. The solutions of these problems, which naturally point to the internet, made the IoT a target for the sectors which will be explained in the following passages. In business and manufacturing sector, real-time tracking and analysing of supply chain and equipments and controlling robotic machines; in health sector, portable health monitoring systems, keeping electronic records, pharmaceutical protection; in retail sector, inventory tracking, smartphone shopping, anonymous consumer preference analysis; in security sector, biometric and face recognition locks, remote sensors, and finally in transportation sector, self parking vehicles, GPS location finders, performance tracking are the fields that IoT presents innovative solutions. In addition, IoT has the the biggest share in the health, management and production sectors.
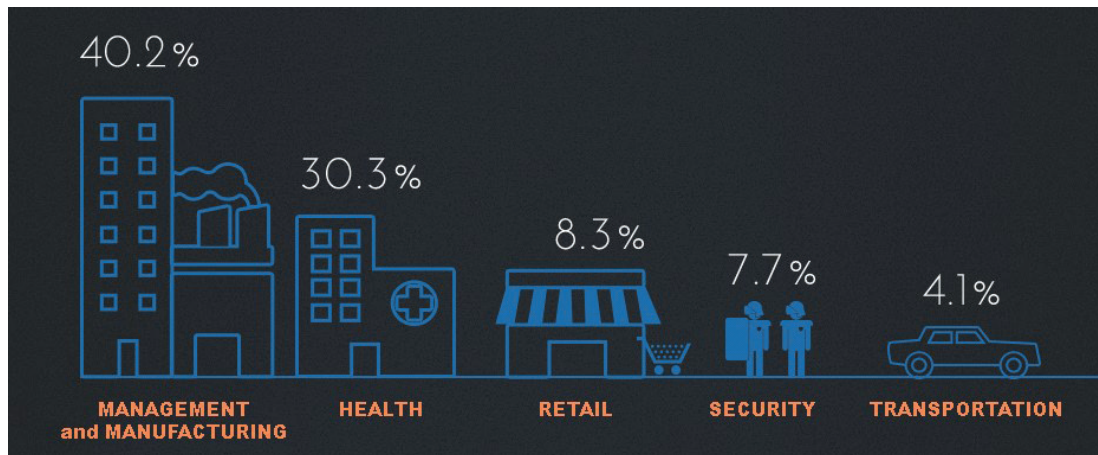
Figure 3. Distribution percentage of Internet technology by sectors

Among the latest successful products which use IoT, are Tesla's car with smart parking feature, Medtronic's continuous glucose meter device, Google's Self-Drive car, iRobot's Roomba smart vacuum cleaner, Philips's smart lighting product Hue Light Bulbs and Bridge, John Deere's intelligent planting/harvesting application Farmsight, Ralph Lauren's wearable smart product Polo Tech Shirt, June Company's smart oven, ShotSpotter company's Gunshot Detection and Location System application.

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Figure 4. Philips Hue Light Bulbs and Bridge

2. HOW TO USE IoT FOR CHANGING DISABILITIES TO ABILITIES

The applications provided by the IoT technology are convenient, easy and secure in terms of applicability. People interact with this technology through interfaces such as smartphones. These applications allow people to control the thermostats, lights and even key positions of their doors from where they are located (Stefanov, Bien and Bang, 2004). All this opportunity means a lot for all kind of users, especially for people with disabilities during their daily lives.

The developments in the accessibility and simplification make interfaces more ergonomic, thus disabled users use their smartphones more actively than ever before. The concept of "intelligent" is now being used in conjunction with more complex structures such as cities and transportation, and these definitions open new doors to people with disabilities in their ability to transform their own daily lives as well as their economic and social environments.

2.1 Benefits of IoT According to Types of Disabilities

Internet of Things can serve different needs in terms of purpose and method of application, thus it may make the restricted environment due to the user's obstacle more accessible to them. Technology offers solutions to people with disabilities, according to the types of their handicaps, in areas such as access, transportation, information and communication. If we look at the applications of technology according to the types of handicaps:

• The main problems of **people with physical disabilities** are related with accessibility and transportation. The technology will allow to easily access the troublesome points of their living environments with

speech activated devices to help and support them at house. In addition, automated accessibility functions in public spaces can allow them to live their daily lives more efficiently.

• It is one of the most important issues for a **visually impaired** person to be able to perform his / her individual activities without the need of someone's help (Lanigan et al., 2007). In this context, systems that define the user environment to find directions, automations of surroundings and voice communication with speech activated devices may assist them in fulfilling their requests.

• Because **hearing-impaired** people lack the sound stimuli, they have to maintain their daily lives being unaware of the sounds around them. In particular, the problems that hearing-impaired people face, such as security, can be solved by the Internet of Things technology. On their mobile devices, they can capture visual cues about the state of the objects in the house, and can be alerted by sensors in case of an unfamiliar sound in the house. At the same time, since sound means communication, a smart pair of glasses that transmit the perceived speech to the person in subtitles can offer a striking solution for communication problems.

• Integration of automation and reminders can be possible with technology for **people with cognitive disabilities** in order to sustain their daily lives. The localization and orientation of the environment they live in, as well as intelligent reminders positioned at convenient locations and programmable security processes can make their living spaces safer, and will provide great convenience to them.

2.1.1 Integration of IoT Technology to the Environment

In daily life, people go out to markets for shopping, to work places for working, to schools for education, to hospitals for dealing with health problems, to cafes for socializing etc. In other words, they could be located in more than one place at different times during the day. Therefore, they face multiple environmental factors. For a normal person, all of these are normal routines of everyday life, but for people with disabilities, each can turn into a problem on its own. The IoT concept may become a module that facilitates the daily lives of people with disabilities by placing the technology in environmental elements at this point. It can function as an instrument that guides disabled people in the form of intelligent automation systems in environments such as homes, schools, markets and even in the usage process of their wheelchairs.

2.1.2 Intelligent Home Automation Systems

Houses, where a great part of life passes, are one of the most important environments that technology is practiced. The primary task of the technology is to establish an interactive link between the user and the living space. It needs cameras and sensor systems deployed in the house to make this connection. Interactive devices such as smartphones can provide necessary automations such as heating, temperature adjustment and security at home.

Among the possible in-house applications of the technology according to the obstacle type are the possibility to control home appliances and thermostat with a single touch from smartphones for visually impaired people;

the ability to control devices, such as lights, door locks, security systems, that require access in difficult places in house with minimal effort for people with physical disabilities; the ability to alert the hearing-impaired people via their devices when a stranger enters their living area, and the ability to send warnings to caretakers and / or relatives through systems that control the body rhythm or activities of people in need of nursing. "Digital Life", which is a group of products manufactured by AT & T with an eye to needs of elderly and disabled people, provides a safer and more independent living environment by offering automation possibilities to its users.

Figure 5. AT&T Digital Life Products and Applications

The applications of Digital Life can be incorporated into the user's life in various ways. For example, the sensors placed on the foot of the bed create a notification when the person leaves the bed, the sensors that placed on the fridge or covers of the medicine box can generate notifications by counting how many times it has been used, the sensors that detect the accumulation of excess water in a sink or tub may block water flow without the need of intervention of a person, and thus preventing a possible overflow.

2.1.3 Intel Connected Wheelchair Project

The "Connected Wheelchair" product, developed by Intel's IoT department, is a unique example of product and user experience design. The progenitor of the idea is a 20 years old intern of Intel, Tim Balz, who is a student at Rose-Hulman Institute of Technology (BBC.com, 2014). Using the user's biometric and physical data analysis from the wheelchair, the product basically offers a more accessible life opportunity for disabled users. The interface screen displays information about the condition and functions of the wheelchair to the user. Additionally, the product has a function that measures vital functions of user, such as blood and body temperature, heart rhythm, and alert their doctor or call emergency services in dangerous situations.

With the phone application, designed by the same department, to make the product experience more interactive and shared, users can be informed by giving access points on the map to each other and

commenting on the the points without having to leave their home (TechTimes.com, 2015). In addition, the department states that more applications can be designed by different people, because of its open-based structure.

Figure 6. Intel Connected Wheelchair

2.2. Limitations of IoT Technology

Despite that IoT has numerous benefits and possibilities, there are some limitations that need to be overcome before becoming widespread and being used frequently.

• **Accessibility:** In order to make users with disabilities access the concept as simple as possible, the firms that produce products or applications must take into consideration the accessibility, which is one of the most important issues . Companies in IoT-related bussiness, such as manufactarers, network and application vendors that want to offer products for anyone, should better analyze and apply the concept of accessibility for every step of the product development process. In this context, it is an important factor that products must conform to the principles of universal design.

• **Network Access and Compliance:** It's previously mentioned that the objects in the concept of IoT must be connected to the Internet and have an access to a network. Although usage of Internet in today's world is more widespread than ever, researches show that only 46% of the world's population use Internet (InternetWorldStats.com, 2015). It can be inferred that people, who do not use Internet technology, have problems with accessing to IoT, such as compatibility issues arising from unawareness of the concept or lack of financial means. However, the concept is developing, becoming widespreadand

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getting more accessible because of its own nature, and thus will allow more people to reach the technology in near future.

• **Standardization:** While the Internet of Things spreads rapidly and continues to develop, an important question remains, which is, because of its layered structure collecting and processing information with different techniques, how and through which common language those products and applications will be connected to each other. (Atzori, Iera and Morabita, 2010) Multiple work groups are involved in creating a common language within the context of the Internet of Things. One of these, the IEEE Standards Association (IEEESA), has 80 standards that are published and accepted, which also include Bluetooth and wi-fi technologies. On international scale, many other standard development organizations are striving to develop IOT-based standards. For example, the standard edition of the Consumer Electronics Association's (CEA) ANSI/CEA-2045 contains extensive work to include energy-based equipments, such as sensors, thermostats, appliances, energy management control units (Schneiderman, 2015). CEA has also developed a standard for more efficient energy consumption. This diversity on work of standard offers us a positive insight into the future for finding a common standard language.

• **Privacy:** By definition, the applications of the Internet of Things, gather informations of the people's movements in their daily lives. For example, in a smart home automation system, applications at home collect informations as to where the user is in the house during the day, how many times he/she opens the closet, and which faucet he/she uses more. At this point, an application which collects so much individual information from private lives, raises the issue of personal privacy. At this stage of technology, training of the user as to what kind of data are gathered from their daily lives, and what they can do with these data, provides guidance to the user at certain points and make it possible for him/her to make logical choices is an important step in the resolution of privacy problems.

• **Security:** Because a huge amount of data is collected and stored from the users of the technology, and the reuse of these when the need arises, it has become a serious problem that how the security of these collected and stored data will be ensured. Also, this subject is yet to be explored in the fields of ethics and pychology in order to be understood by the corporations and the states.

3. CONCLUSIONS

IoT is a technology that has a great potential but it is still in infancy today and needs time to fulfill what it promised. There are some steps that still need to be overcome in order that technology can actively take role -especially for people with disabilities- in daily life. The concept must evolve at many points such as standardization, compatibility, network access, protection of personal privacy, security and accessibility of collected data. Besides these, the great convenience and innovations that IoT can offer to humanity can not be denied. If the leading companies of the developing industry are aware of the universal design criterias and the needs of people with disabilities, it seems reasonable that IoT is the herald of a more independent, more mobile and more flexible life. It's a a fact that today's technology, which plays an increasingly important role in people's business and education lives with portable and wearable technologies, will rapidly complete its own evolution and become more feasible. In addition, all of these developments will help us discover new horizons.

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Figure 1., 2015. Norman Joseph Woodland and Bernard Silver's Linear Barcode's patent available in http://www.thetimes.co.uk/tto/multimedia/archive/00365/Woodland2_365353c.jpg

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