# User Perceptions of Internet of Things (IoT) Systems

Anastasios A. Economides(✉)

University of Macedonia, Thessaloniki, Greece
economid@uom.gr
http://conta.uom.gr

**Abstract.** This chapter proposes a user perceptions model regarding an IoT system that is based on the user's beliefs about important factors of this IoT system. Initially, the chapter classifies the IoT applications and services in twelve (12) sectors across the personal, business and public domains. It also outlines the technological, societal, business and human challenges. Then, it defines the IoT User Perceptions Model (IoT-UPM) which is composed from thirty-three (33) fundamental factors. Also, it formally defines these thirty-three (33) factors in order to establish a universally accepted model regarding user perceptions of a particular IoT system.

**Keywords:** Easy-of-use · Effectiveness · Efficiency · Internet of Things · Interoperability · IoT · IoT-UPM · Personalization · Satisfaction · Security · Technology Acceptance Model · Ubiquity · Usefulness · User control · User experience · User perceptions · Value-for-money

## 1 Introduction

IoT is the worldwide digital infrastructure that supports ubiquitous services among interacting humans, things, data and applications. A thing carries sensors which sense, measure and collect data. It may process and analyze these data either locally or transmit them to other systems. Subsequently, these systems make recommendations to people or order actuators to act appropriately. Thus, a thing may carry one or more sensors and/or actuators and be able to communicate with other things. It is forecasted that there will exist around 30 billion connected devices by 2021 [21, 23, 24]. Correspondingly, the IoT economic impact is expected to be around $1 trillion by 2022 [36]. Major IoT applications sectors include smart cities, smart transportation and logistics, smart industry, and smart home. It is expected that the market in emerging sectors will exceed $100 billion per sector by 2021 [2, 25, 36, 45, 46].

IoT has the potential to transform not only businesses but also society and everyday life [3, 5, 19, 47, 48, 53]. It will bring together people, things, data, applications and services. It will empower people to achieve their objectives (regarding health, education, enjoyment, family, work etc.), companies to accomplish their purpose and governments to serve their citizen. It will change the ways people, businesses, and governments interact among themselves. All the following interaction types would co-exist in IoT: Person-to-Person (P2P), Person-to-System (P2S), Person-to-Business


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(P2B), Person-to-Government (P2G), Person-to-Environment (P2E), Business-to-Person (B2P), Business-to-System (B2S), Business-to-Business (B2B), Business-to-Government (B2G), Business-to-Environment (B2E), Government-to-Person (G2P), Government-to-System (G2S), Government-to-Business (G2B), Government-to-Government (G2G), Government-to-Environment (G2E). Each actor (Person, Business, or Government) could be a single or a group of actors.

The proliferation of connected things, connected people, connected devices, connected networks, connected data and connected processes would create revolutionary opportunities in economy, society, business, and personal life. For example, an IoT system might continuously monitor elderly health and instantaneously alert emergency services in case of abnormal conditions. A carry-on IoT system might interact with Facebook and inform the user when someone of his friend is close to him. Food would be continuously monitored to guarantee that its ingredients, cooking, storage, and transportation adhere to hygiene standards. City officials would control traffic, parking, lighting, park irrigation and waste management. Government would monitor and maintain bridges, tunnels and other infrastructure conditions.

Currently, there are available sensors to collect temperature, location, motion, velocity, acceleration, force, pressure, flow, humidity, light, acoustic, magnetic, seismic, imaging, luminosity, chemical, radiation and body measurements. These measurements would be used by connected applications and services to better serve people, society and businesses.

Various organizations and international projects are actively developing the IoT ecosystem. Major players include European Smart Anything Everywhere (SAE) Initiative, Alliance for the Internet of Things Innovation (AIOTI), Internet of Things (IoT) Global Standards Initiative (GSI), W3C - Web of Things Community, ISO/IEC JTC 1/SWG 5 IoT; INCITS 5G on IoT, One M2M, AllSeen Alliance, Open Interconnect Consortium, Industrial Internet Consortium (IIC), Eclipse IoT, among others. Also, major companies (Intel, Qualcomm, IBM, MS, Cisco, Samsung, Amazon, Google, Apple, HP, SAP, Huawei, etc.) are intensively participating in this evolution.

However, while much attention has been given to the technology needed to develop IoT; little attention has been given to the end user. Even if the technology and the applications are available, it is not guaranteed that the users will accept and use them. In this chapter, we propose a model that considers the major factors that affect the IoT acceptance by users. These concepts have been presented initially in two keynote speeches given by the author [16, 17].

In the next Sect. 2, we outline the IoT services and applications across the various sectors. Then in Sect. 3, we describe the challenges. In Sect. 4 we describe the proposed model and that factors that compose it. Finally, we conclude in Sect. 5 and suggest directions for future research.

## 2 IoT Services and Applications

The increasing connectivity among people, things and data enable great opportunities for developing applications in almost any sector of society, economy or personal life (e.g. [38]). After classifying the various sectors in three main domains (i.e. personal domain, business domain, and public domain), we outline various services and applications in every sector (Diagram 1).

***Personal Domain***

In this domain, we consider IoT applications sectors that would improve the quality of personal life using IoT. The Personal domain includes the following sectors: Smart Healthcare and Wellbeing, Smart Education, and Smart Home.

**Smart Healthcare and Wellbeing**

A user would wear smart clothes and carry wearable devices (e.g. smart clothes, glass, watch, telephone) while he is exercising, eating, working, studying, having fun, sleeping. An IoT system would monitor a person's health (physical, mental, emotional), analyze health state (e.g. diagnostics), notify appropriate agencies (e.g. doctors, family, emergency units), make recommendations (e.g. a special diet) or even take appropriate actions (e.g. in case of user's inability). For example, it would encourage exercising or alert him when it is time to take his medicine. Special assistance would be given to infant, elderly, patient, or persons with special needs (e.g. [1, 11, 26]). Also, doctors would study the effect of a therapy or medication. Hospitals would use IoT systems to monitor connected devices, instruments, equipment, pharmaceuticals, drugs, etc.

**Smart Education**

An IoT system continuously monitors the learner and encourages him (e.g. [15, 37]), recommends to him educational material to study or next appropriate question during exams according to his progress and his emotional state (e.g. [12, 14, 42]).

Correspondingly, it may notify the teacher, the school administration and other interested parties about the learner's progress. For example, an adviser gets an alert when a student is at risk of dropping out. Also, group of students and teachers may interact and collaborate among themselves using IoT systems to monitor the environment (i.e. plants, water, and air) and accomplish an educational activity.

**Smart Home**

An IoT system would continuously monitor home's safety (e.g. smoke, gas, motion detection), environment (e.g. heat, air, light), appliances, equipment, consumption (e.g. electricity, gas, water), security and surveillance, make recommendations, adjust systems to prescribed state (e.g. adjust temperature) or take appropriate actions (e.g. extinguish fire) (e.g. [20, 49]). A user would monitor infant, elderly and patients. Also, a user would control and manage home appliances, entertainment devices, and eventually the whole home.

***Business Domain***

In this domain, we consider IoT applications sectors that enable business to accomplish their purpose and benefit from IoT. The Business domain includes the following sectors: Smart Building, Smart Industry, Smart Services, Smart Retailing and Logistics, and Smart Transportation and Smart Vehicle, Smart Agriculture and Livestock (Animal Farming).

**Smart Building**

IoT systems would monitor and control the building's (e.g. offices, hotel, museum) access, lighting, heating/air-conditioning, equipment and resources' usage etc. (e.g. [40]). IoT systems would be used for smart metering to control energy consumption in order to reduce cost. Also, IoT systems would be used for security and surveillance, alarm in case of emergency (e.g. fire, intruders) or take appropriate actions (e.g. improve air quality, close lights if no one is around).

**Smart Industry**
Connected machines and robots would be used in smart factory, manufacturing, mining, construction to improve production (e.g. customized, on-time, on-demand production) (e.g. [31, 34, 43]).

**Smart Services**
IoT systems would be used in the financial, banking, insurance (health, building, car, etc.) services to monitor people, data and resources in order to improve their offered services (e.g. [10]). For example in tourism, IoT systems would track visitors and recommend destinations, sites, tours, hotels, driving routes, hiking paths, and other activities based on the tourists' characteristics.

**Smart Retailing and Logistics**
IoT systems would be used to track products, monitor cargo and warehouses in order to optimize inventory and stock levels, reduce theft, and maintain product quality (e.g. [4]). An IoT system would monitor the state of products in storage and during transport, make recommendation and alert when the products are not stored according to requirements, when the product's expiration date approaches or when unauthorized access happens.

**Smart Transportation and Smart Vehicle**
IoT systems would be used to monitor passengers (e.g. mobile tickets), luggage's, vehicles (e.g. cars, buses, airplanes, ships), containers, infrastructure conditions (e.g. roads, airports, railways, harbors, bridges, tunnels, tolls) to optimize transportation via land, air, or water, or schedule predictive maintenance. For example, sensors could monitor the traffic and appropriately control the lighting in tunnels [41].

Connected cars and smart vehicles would interact to avoid accidents, enhance infotainment, and reduce traffic congestion, power consumption, pollution, and time waste. Smart fleet management would reduce cost, delivery time, wasted empty space in tracks etc. (e.g. [22, 32]). Finally, transportation of hazardous material (e.g. corrosives, flammables, toxic, explosives) would be improved.

**Smart Agriculture and Livestock**
IoT systems would monitor a farm, crop, vineyard, green house, livestock, animals, farm equipment and machinery (tractors, fertilizer distribution), make recommendations or take appropriate actions (e.g. irrigation, feeding) to enhance the production quality and quantity (e.g. [33]).

***Public Domain***
In this domain, we consider IoT applications sectors that enable the public sector to better serve the citizens using IoT. The Public domain includes the following sectors: Smart City/Community, Smart Utilities, and Smart Environment.

**Smart City and Community**
IoT systems would monitor streets for security reasons and alarm police in case of crime or violence. Similarly, they would monitor the city's environment and alarm

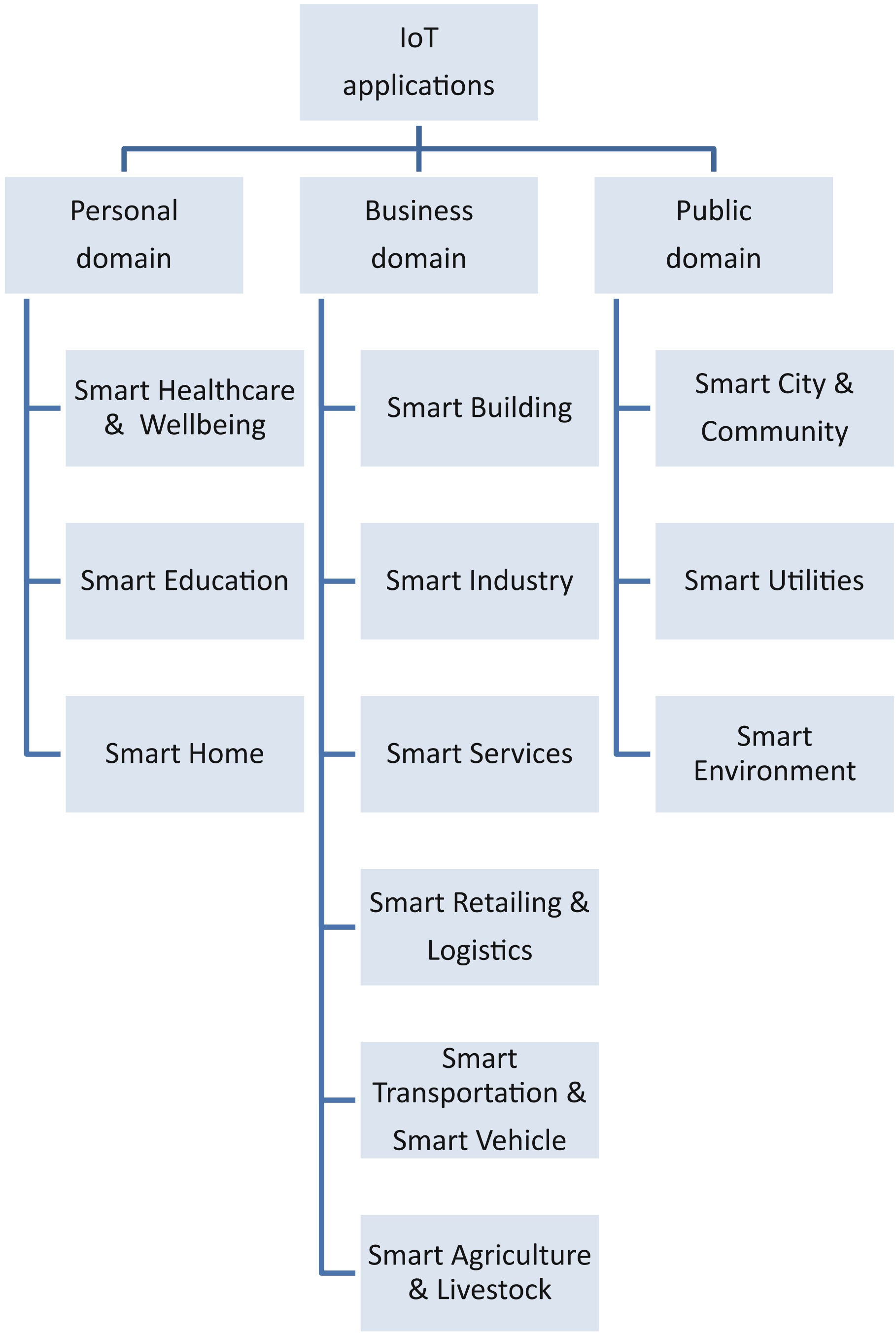


**Diagram 1.** IoT applications.

citizen and appropriate authorities in case of emergency (e.g. fire, chemical leakage, air-pollution) or congestion instances (e.g. accidents, demonstrations, crowding). IoT systems would control and manage traffic lights, parking spaces, public transportation (e.g. cars, buses, metro), smart ticketing, and bike sharing (e.g. [6, 7, 54]). IoT systems would manage street lights for energy saving, park irrigation for water conservation, waste disposal, recycling, etc. IoT systems would notify citizen and tourists for events (e.g. concerts, celebrations, festivities, artistic happenings, open education lectures) near their current location.

**Smart Utilities**
IoT systems would be used for smart metering, maintenance (e.g. leakage detection) and billing of utilities (e.g. electricity, water, gas) (e.g. [44]). Smart grid would optimize power generation, distribution, storage, trading, and pricing.

**Smart Environment**
IoT systems would monitor the environment and warn people regarding pollution, radiation, weather extreme conditions, natural disasters, forest fires, tsunami, volcano explosions, earthquakes, avalanches, etc. (e.g. [35]). Rescuers would also use IoT systems in their efforts to rescue people in danger. Finally, IoT systems would be exploited for territorial monitoring, surveillance and boarder guard. Dropping sensors from a helicopter or airplane would monitor for forest fire, snow avalanche or oil slicks at sea.

## 3 Challenges

IoT opportunities are not coming without any challenges. We classify these challenges across four dimensions: Technological Challenges, Societal Challenges, Business Challenges, and Human Challenges.

### 3.1 Technological Challenges

Although much work has been done on advancing technology, it is never enough for supporting greedy applications and users. There is an everlasting need to develop advanced technologies on the following areas: Devices (Sensors, Actuators, etc.), Networking and Communications, Computing and Storage, Platforms, Data Management and Analytics, Decision Making Systems, Applications and Services, etc. Furthermore, cross-disciplinary challenges include the following: Security and Privacy, Interoperability and Standards, Seamless Integration, Scalability, Energy efficiency, among others.

### 3.2 Societal Challenges

Advancing technology creates various questions to be answered by Society. We classify the societal challenges in the following areas:

Education: how to educate specialists and the general public on IoT? How to use IoT to enhance education?

Democracy and Participation: how democracy and citizen participation will be affected by IoT? How to use IoT to enhance democracy and citizen participation?
Legislation: what legislation is needed in the IoT era? How to use IoT to enhance legislation?
Economics: how the global economy will affect IoT? How to use IoT to develop the economy?
Security and Privacy: how security and privacy will be affected by IoT? How to use IoT to enhance security and privacy?
Universal Access, Inclusion and Non- Discrimination, etc.: how Universal Access, Inclusion and Non- Discrimination will be affected by IoT? How to use IoT to enhance Universal Access, Inclusion and Non- Discrimination?

Finally, other major societal challenges include Ethics, Sustainability, and Environmental Protection, among others.

### 3.3 Business Challenges

Businesses that develop and sell IoT systems or businesses that buy and use IoT systems should be adapted to these new advances and changes. They should change not only their working practices but also their thinking and limits. For example, to cope with these radical and rapid changes companies should cooperate and collaborate with other private and public organizations, even with competing companies.

They should adapt their Strategies, Alliances, Partnerships, as well as Business Models, Marketing, Products and Services taking into consideration the evolving technology, laws, regulations, taxation, customer requirements, worldwide economy and competition among others.

### 3.4 Human Challenges

In order this new revolution happens, users should accept the offered IoT systems. So, it is extremely important to understand what users need, want, and expect? What drives them to buy and use the offered IoT systems? What prevents them of using the offered IoT systems? How much are they willing to pay? etc.

In the next section, we identify the factors that would affect the users' acceptance of IoT systems. Companies that built IoT systems should seriously take into consideration the users perceptions regarding these IoT systems.

## 4 IoT User Perceptions Model (IoT- UPM)

The acceptance of a particular IoT system by the user as well the intention to use it and the actual usage of it depend on a variety of factors. We would classify these factors to factors related to the characteristics (features, attributes) of the User, of this IoT System itself, of this IoT system Producer, and of the Environment where these stakeholders act (Diagram 2). Actually, all these characteristics describe the context [13, 14]. For example, User's characteristics include age, gender, education, experience (with computers, mobiles, specific devices etc.), personality, emotions, preferences, interests, abilities, competencies, etc. IoT System's characteristics include usability, functionalities, performance, reliability, security, interoperability etc. IoT system Producer's characteristics include brand name, industry sector, size, customer support, etc. Environment's characteristics include other users, other IoT systems, other producers, society state, economy state, market, companies, competition, public policies, ethics, etc.

The characteristics of the User interact among themselves as well with the characteristics of the IoT System, of the IoT system Producer, and of the Environment. Similarly, the characteristics of the IoT System interact among themselves as well with the characteristics of the User, of the IoT system Producer, and of the Environment. The characteristics of the IoT system Producer interact among themselves as well with the characteristics of the User, of the IoT System, and of the Environment. The characteristics of the Environment interact among themselves as well with the characteristics of the User, of the IoT System, and of the IoT system Producer. Finally, all these characteristics interact with the user's attitude, acceptance, adoption, intention to use, actual use, and continuance intention to use the IoT System (Diagram 3).

Although it is desirable to be able to measure these characteristics, it is not always easy or even possible to quantify and accurately measure them. In other words, we want like to have accurate and current measurements of the actual characteristics of the User, of the IoT System itself, of the IoT system Producer and of the Environment. However, we may content to perceptions about the User, the IoT System itself, the IoT system Producer and the Environment. So, there is the "Real Context" and the "Perceived Context".

In this chapter, we are further investigating the factors that are related to the IoT System. In a future paper, we will describe the factors associated with the User, the Producer and the Environment. The IoT System has some characteristics that can be either measurable or not. However, even if some IoT System characteristics could be measured it would be difficult for the User to really measure them with accuracy and reliability. Furthermore, it may not be easy, convenient, and comfortable for him to measure these characteristics. So, eventually what it matters to him is his perceptions about these IoT System characteristics. So, in this chapter we explicitly define the important IoT System factors from the User's perspective to decide if he will accept and use a particular IoT System. A User needs some features to be offered by an IoT System in order to achieve his objectives and goals. He expects that using the particular IoT System he would fully achieve his desired outcomes and results. The IoT system Producer would promote the corresponding IoT System's characteristics (features, attributes) to influence the User's attitude towards his IoT System. For example, a User would like to be able to use an IoT System (e.g. an e-health equipment) anytime, anywhere, via any device and any network. Thus, the Producer would try to provide this ability to the IoT System.

In this section, we propose the IoT User Perceptions Model (IoT- UPM) that was inspired by previous models such as the Technology Acceptance Model (TAM) (e.g. [8, 9, 50–52]), ISO Quality models (e.g. [27–30]) as well quality frameworks for evaluating mobile devices (e.g. [18]) or websites (e.g. [39, 55]) that were proposed in different from IoT contexts.

The IoT-UPM is composed from thirty-three (33) factors categorized in 3 dimensions: (i) User- IoT System Interaction, (ii) IoT System Operation, and (iii) IoT System Results (Diagram 4). These factors affect the attitude of a user towards using, the intention to use, the acceptance, the actual use, and the continuance intention to use a particular IoT system. The producer of a particular IoT system could try to improve the IoT system's characteristics that correspond to these factors in order to develop favorable user perceptions towards his IoT system.

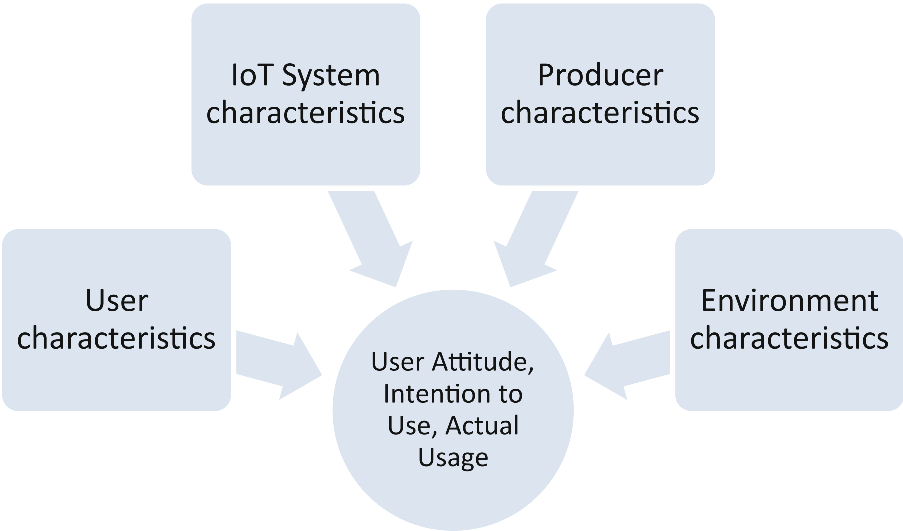


**Diagram 2.** Factors that influence the User's Attitude toward Using, Intention to Use, Actual Use, and Continuance Intention to Use the IoT System.

Next, we define "resource" to be any of the following: space, energy, money, processing and computations, storage and memory, communications and bandwidth, software, etc.

### 4.1 User - IoT System Interaction

- Perceived Ease-of-Use is defined as the degree to which a user believes that using a particular IoT system would be easy (simple, clear, intuitive, comfortable) and without much effort (mental, emotional and/or physical effort, time spent) to carry it, to install it, to initiate it, to understand its usage, to learn its usage, to remember its usage, as well as to actually access, use (operate), control (manage, manipulate), maintain, pay and terminate (shut down, retire, withdraw) it. It includes Simplicity, Clarity, Convenience, Comfort, Manageable size, weight, noise, etc.
- Perceived Accessibility (Universality and Non-discrimination) is defined as the degree to which a user of a particular IoT system believes that it could efficiently be

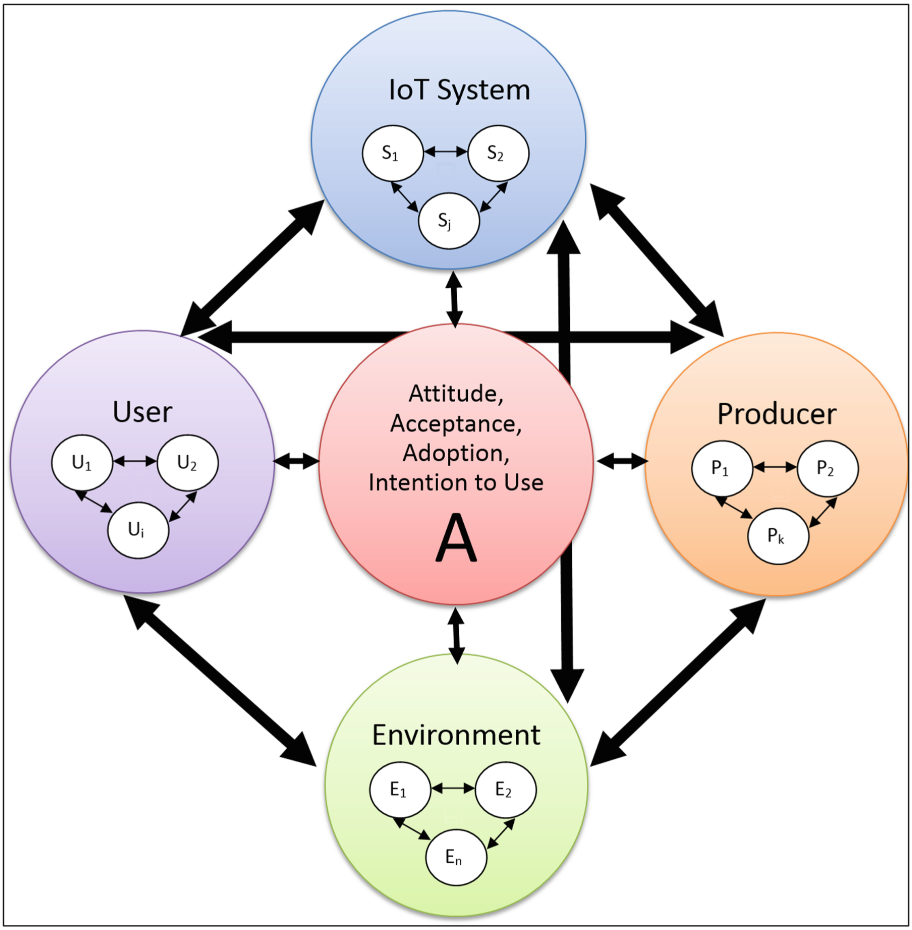


**Diagram 3.** Interaction among all factors, where U_i: User's characteristics #i, S_j: IoT System's characteristic # j, P_k: IoT system Producer's characteristic #k, E_n: Environment's characteristics #n, A: user's attitude, acceptance, adoption, intention to use, actual use, and continuance intention to use the IoT system.

used by various users with diverse characteristics (e.g. language, gender, age, education, religion), skills, capabilities and disabilities (e.g. vision or hearing impairments) to achieve a specified goal.

- Perceived Awareness (Visibility and Observability) is defined as the degree to which a user believes that using a particular IoT system he would know with accuracy, clarity and real time the system's resources usage, billing costs, actions and communications with other systems to accomplish his objective. For example, he might know who is monitoring the user, what operations are being executed, what information is processed, stored and communicated, when, how long, why (for what purpose), where, to whom (which entities are informed), what cost is charged for every activity every moment, what is the response time of an activity, to what networks it is connected, etc.

- Perceived Aesthetics (Appeal) is defined as the degree to which a user of a particular IoT system believes that it would be attractive and beautiful with respect to visual, auditory, haptic, olfactory senses.
- Perceived Support (Help and Assistance) is defined as the degree to which a user of a particular IoT system believes that he would be supported by the system itself and/or by the providing company (e.g. helpdesk, documentation, interactive tutorials, troubleshooting) continuously, real-time, anytime, anywhere, on-time accurately, completely on how to install, use, maintain, recover from failure, adapt, extend the system.
- Perceived Ubiquity (Seamlessness, Invisibility, Unobtrusiveness) is defined as the degree to which a user of a particular IoT system believes that he would be able to access and use the system continuously, without any interruption or disturbance anytime and anywhere as he moves from one environment (hardware, software, network) to another.
- Perceived Personalization is defined as the degree to which a user of a particular IoT system believes that its interface, appearance, functionalities and operations could be tailored to his personal characteristics such as preferences, interests, abilities, competencies, gender, age, language, measurement units, currency, culture, etc.
- Perceived Control is defined as the degree to which a user of a particular IoT system believes that he could control its resources, data and operations during usage in order to achieve his objective. It includes the ability of the user to also control and correct any information about himself.

## 4.2 IoT System Operation

- Perceived Efficiency is defined as the degree to which a user believes that using a particular IoT system he would achieve a specified level of performance and outcomes utilizing the minimum amount of resources (time, effort, cost, processing, storage, energy, bandwidth, etc.).
- Perceived Functionality is defined as the degree to which a user of a particular IoT system believes that the system would provide the necessary functions to achieve his objective.
- Perceived Performance is defined as the degree to which a user of a particular IoT system believes that the speed, response times, task completion times and throughput rates of the IoT system would meet his requirements.
- Perceived Reliability is defined as the degree to which a user of a particular IoT system believes that using the system there will be no interruptions since the system will prevent, reduce, handle (deal with) and recover from failures, faults, errors, downtime or breaks for a specified period of time usage.
- Availability is defined as the degree to which a user of a particular IoT system believes that he would be able to continue using it even in case of external factors failure (e.g. electricity shutdown/interruption/pause, network disconnection) or internal factors failure (e.g. not enough memory).

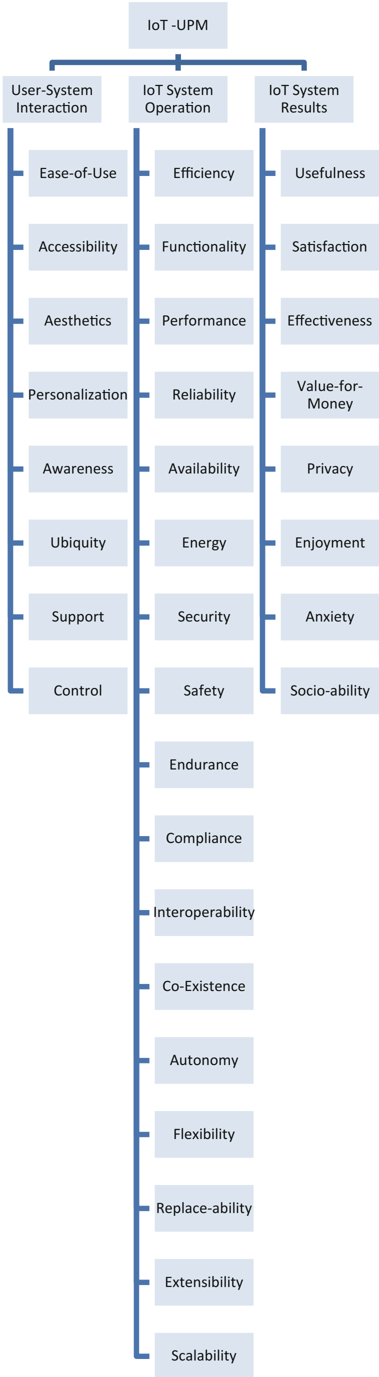


**Diagram 4.** IoT user perceptions model

- Perceived Energy Efficiency is defined as the degree to which a user of a particular IoT system believes that the system would efficiently operate powered by its energy sources for the specified time duration exploiting any energy conserving techniques (e.g. sleeping mode, solar panels).
- Perceived Security is defined as the degree to which a user of a particular IoT system believes that he would be protected from unauthorized access to, use, modification, destruction, or disclosure of either its resources or the user's personal information during processing, storage and transmission of data.
- Perceived Safety is defined as the degree to which a user believes that using a particular IoT system he would be free from possible dangers (health, physical, mental, financial, social, environmental, etc.), risks, losses, negative outcomes that can be caused from its usage.
- Perceived Endurance (Sustainability) is defined as the degree to which a user of a particular IoT system believes that he would use it for long time and it would not become obsolete soon.
- Perceived Flexibility (Versatility, Portability, Transferability, Modifiability, Reusability) is defined as the degree to which a user of a particular IoT system believes that he could efficiently use it (as it is or by easily and/or slightly modifying it) in many diverse environments or in building other systems or for achieving different objectives beyond those initially specified in the requirements. The least effort needed the most flexible it is. The more environments can be used in the more portable it is.
- Perceived Compliance (Conformance, Openness) is defined as the degree to which a user of a particular IoT system believes that it would follow/adhere to standards, laws, regulations etc.
- Perceived Interoperability (Compatibility) is defined as the degree to which a user of a particular IoT system believes that it could efficiently interact, communicate and collaborate with various other systems.
- Perceived Co-existence (Smooth Integration) is defined as the degree to which a user of a particular IoT system believes that it could perform its required functions efficiently while sharing a common environment, infrastructure and resources with other systems, without damaging impact on any other system.
- Perceived Autonomy is defined as the degree to which a user of a particular IoT system believes that he would use it with minimum extra (additional) required resources (e.g. additives, complements, accessories, extra hardware, extra software, extra networking, extra energy).
- Perceived Replace-ability is defined as the degree to which a user of a particular IoT system believes that he would replace this system with (switch to) another one without substantial switching costs (e.g. financial, time, learning, cognitive and emotional costs).
- Perceived Extensibility (Expandability) is defined as the degree to which a user of a particular IoT system believes that he could easily extend (upgrade) it with new functionalities and abilities to address new requirements.

- Perceived Scalability is defined as the degree to which a user of a particular IoT system believes that he could increase his performance and outcomes (in quantity) or accommodate extra demands by adding extra resources to the system.

### 4.3 IoT System Results

- Perceived Usefulness is defined as the degree to which a user believes that using a particular IoT system he would achieve results and outcomes that he considers useful, such as solving a problem, achieving an objective, producing a desired outcome (result, accomplishment), enhancing his performance (productivity, abilities, skills, etc.), decreasing his weaknesses (disabilities, shortcomings, deficiencies, risks, etc.).
- Perceived Satisfaction is defined as the degree to which a user believes that using a particular IoT system he would satisfy (fulfill, meet) his requirements, needs, expectations, desires, goals, and objectives.
- Perceived Effectiveness is defined as the degree to which a user believes that using a particular IoT system he could fully and accurately achieve the expected results and outcomes.
- Perceived Value for Money is defined as the degree to which a user believes that using a particular IoT system he would receive benefits (positive results, outcomes, accomplishments) in comparison to the cost for buying, learning, using, operating, maintaining and retiring it cost efficiency. The benefits would be financial, educational, health (physical, mental, emotional), amusement, time-saving etc.
- Perceived Privacy is defined as the degree to which a user believes that using a particular IoT system he could control (or give his consensus) when, how and what information related to him (private information, e.g. financial, health, gender, age, religion, geo-location, etc.) may be accessed, collected, stored, used, manipulated (altered) and communicated by whom, and to whom that information may be disclosed.
- Perceived Enjoyment is defined as the degree to which a user believes that using a particular IoT system would be enjoyable, fun and pleasant.
- Perceived Anxiety (Stress) is defined as the degree to which a user believes that using a particular IoT system would cause him anxiety and stress.
- Perceived Sociability is defined as the degree to which a user believes that using a particular IoT system he would be able to connect, relate, communicate, collaborate, interact and play with many other people using corresponding systems, as well as he would enhance his reputation (fame, prestige, esteem, "image") since others find it smart, worthy, remarkable and trendy.

## 5 Conclusions and Future Research

In this chapter we classified the IoT systems, applications and services in twelve (12) sectors across the personal, business and public domains. We also outlined the technological, societal, business and human challenges regarding the IoT revolution.

Then, we argued that there are various important factors that affect the user' attitude towards using, acceptance, intention to use, actual use, and the continuance intention to use such IoT systems. We classified these factors to those related to the IoT system itself, to the user, to the producer as well to the environment. It would be desirable that the user knows with accuracy and reliability the real characteristics of a particular IoT system. However, this is not the usual case. Usually, the user has only perceptions about the IoT system characteristics. So, we defined the IoT User Perceptions Model (IoT-UPM) which is composed from 33 fundamental factors that describe the user's perceptions about the IoT system. Also, we formally defined these 33 factors in order to establish a universally accepted model regarding user perceptions about IoT systems. Thus, an IoT system producer would try to enhance the IoT system parameters that correspond to these factors in order to influence the users' attitude towards using, intention to use, actual use, and the continuance intention to use this particular IoT system.

In a future paper, we will examine the interrelationships among these IoT-UPM factors as well the factors that are related to the User's characteristics, the Producer's characteristics and the Environment's characteristics.

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