Adoption of Internet of Things Technologies in Enterprises

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The Internet of Things (IoT) pervades any device that has or that can be upgraded with an Internet connection capability. IoT has become a key concept linking uniquely identifiable things to their virtual representations over the Internet. Currently, this approach has spread widely throughout most of areas, enterprises or groups of people, on the thriving express lane provided by IPv6 protocol. This newer version of IP has more than enough addresses, about 3.4×10^{38} addresses to serve all IP networking needs for the foreseeable future when more than twenty-four billion smart things will be connected by 2020. As we move from www (static pages web) to web2 (social networking web) to web3 (ubiquitous computing web), the need for data-on-demand using sophisticated intuitive queries increases significantly.
Keywords: *Internet of Things, Wireless Sensor Networks, ubiquitous sensing, open innovation, pervasive information, smart things, smart environments, business model innovation*

1 Introduction

The *Internet of Things* (IoT) architecture arouses the premises of an organic approach that extends the actual extreme frontier in Internet communications.

As identified by Atzori [1], *Internet of Things* can be realized in three paradigms – internet-oriented (middleware), things oriented (sensors) and semantic-oriented (knowledge).

Although this type of delineation is required due to the interdisciplinary nature of the subject, the usefulness of IoT can be unleashed only in an application domain where the three paradigms intersect.

According to the experts, this next revolution in digital technology is a global, immersive, pervasive, ambient networked computing environment built through the continued proliferation of smart sensors, cameras, software, databases, and massive data centres in a world-spanning information fabric known as the Internet of Things.

At present, we illustrated in **Fig. 1.** that IoT creates a connectivity [2] between six elements:

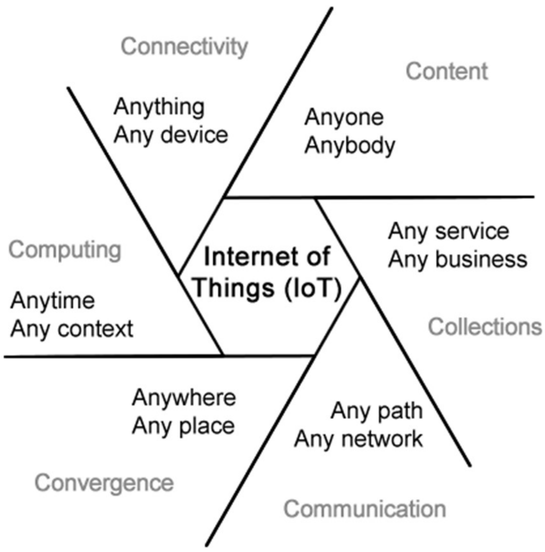

Fig. 1. Connectivity of IoT

- *Anything*, any device that we already use (desktops, notebooks, tablets, smartphones), devices using connectivity in new ways (household appliances like smart TVs or smart sensors and actuators), devices previously inactive, but now intelligent (smart bulbs, watches or vehicles) or completely new devices (virtual reality headsets and other gadgets);

- *Anytime*, any context enables the real-time computing, monitoring, control and continuous optimization of even a large number of devices, easily, from a single centralized control point; moreover, the computing capability of the device enables all kinds of logic to be written and executed: *if*, *then*, *and*, *or*, *else*, *nor*, and so on depending on self or other devices;
- *Anywhere*, any place the remote devices are situated, they all point towards their manufacturer/owner who is updated at certain intervals or real-time data or parameters settings that he is designed to provide;
- *Any network*, any path the IoT device can connect to a gateway using any communication method like GPRS/2G/3G/4G, Bluetooth, ZigBee, Serial/USB, Ethernet, VPN, Wi-Fi access point, MQTT etc.; because the vast majority of IoT end devices are engineered to operate independently of network connectivity, *individual* data messages are completely *uncritical*;
- *Any service*, any business process can be exposed and called to retrieve information or to activate a certain action; moreover, IoT is more than a business tool for managing business processes more efficiently and more effectively – it also enables a more convenient way of life [3];
- *Anybody*, anyone who is interested or has access to the device or service.

'Things' are active participants in business, information and social processes where they are enabled to interact and communicate among themselves and with the environment by exchanging data and information sensed about the environment, while reacting autonomously to the real/physical world events and influencing it by running processes that trigger actions and create services with or without direct human intervention.

The popularity of different paradigms varies with time. The web search popularity, as measured by the Google search trends during the last 14 years for the terms *Internet of Things*, *Wireless Sensor Networks* and *Ubiquitous Computing* are shown in **Fig. 2.** [4].

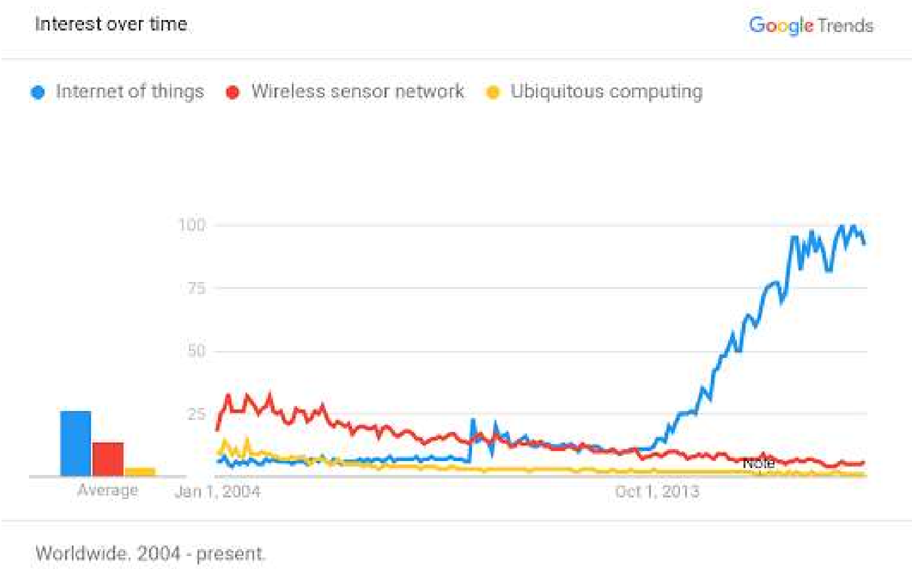

Fig. 2. Google search trends since 2004:
■ Internet of Things, ■ Wireless Sensor Networks, ■ Ubiquitous Computing.

As it can be seen, since IoT has come into existence, search volume is consistently increasing with the falling trend for Wireless Sensor Networks. Between August 2009 and August 2013, the concurrence terms Internet of Things and Wireless Sensor Networks is tight, but ascending trend of IoT continues for the next years as other enabling technologies converge to form a genuine Internet of Things.

Internet of Things has started gaining popularity and overpassed Wireless Sensor Networks and Ubiquitous Computing since August 2013. In fact, this reflects the social acceptability of the technology as consumers look for more data about various topics of interest.

IoT involves the integration of various technologies and domain knowledge across industries. Without cross-industry collaboration, the development of IoT applications will be limited in its scope and reach [5]. Therefore, breaking through the limitations and stalled situation requires an open collaborative approach whereby people together could innovate through the power of open innovation, promoting self-development and seeding the growth of IoT implementation

One of the most popular industry models for IoT implementation today is to combine *cloud computing* and *big data* analytics technology to develop application-specific solutions.

2 Communication requirements

Anything can be an IoT device if it can send or receive data from the cloud and is designed to process a unique task using cloud recommendations.

IoT grants "smart objects" to be active participants in business, information and social processes where they are enabled to interact and communicate among themselves and with the environment by exchanging data and information "sensed" from the environment, while reacting autonomously to the "real world" events and influencing it by running processes that trigger actions and create services with or without direct human intervention.

Ubiquitous services enable interaction with these "smart things" using standard interfaces that provide the necessary link via the Internet, to query and change their state and retrieve any pervasive information associated with them, taking into account security and privacy issues.

The architecture of the original Internet was created long before communicating with billions of very simple devices such as sensors and appliances was ever envisioned.

The present explosion of these much simpler devices creates tremendous challenges for the current networking paradigm in terms of the number of devices, unprecedented demands for low-cost connectivity, and the impossibility of managing remote and diverse equipment.

From a high-level perspective, there are three IoT components [6] which enables seamless ubicomp:

1. Hardware - made up of sensors, actuators, and embedded communication hardware
2. Middleware – on-demand storage and computing tools for data analytics and
3. Presentation - novel easy to understand visualization and interpretation tools which can be widely accessed on different platforms and which can be designed for different applications [7].

A radical evolution of the current Internet into a Network of interconnected objects that not only harvests information from the environment (sensing) and interacts with the physical world (actuation/ command/control) but also uses existing Internet standards to provide services for information transfer, analytics, applications and communications.

Fueled by the prevalence of devices enabled by open wireless technology such as Bluetooth, radio frequency identification (RFID), Wi-Fi and telephonic data services as well as embedded sensor and actuator nodes, IoT has stepped out of its infancy and is on the verge of transforming the current static Internet into a fully integrated Future Internet [8]. Internet revolution led to the interconnection between people at an unprecedented scale and pace. The next revolution will be the interconnection between objects to create a smart environment. Only in 2011, the number of interconnected devices on the planet overtook the actual number of people.

Smart connectivity with existing networks and context-aware computation using network resources is an indispensable part of IoT. With the growing presence of Wi-Fi and 4G-LTE wireless Internet access, the evolution toward ubiquitous information and communication networks is already evident. However, for the Internet of Things vision to successfully emerge, the computing criterion will need to go beyond traditional mobile computing scenarios that use smartphones and evolve into connecting everyday existing objects and embedding intelligence into our environment. For technology to disappear from the consciousness of the user, the Internet of Things demands:

1. a shared understanding of the situation of its users and their appliances,
2. software architectures and pervasive communication networks to process and convey the contextual information to where it is relevant, and
3. the analytics tools in the Internet of Things that aim for autonomous and smart behavior.

With these three fundamental grounds in place, smart connectivity and context-aware computation can be accomplished.

The first direct consequence of the IoT is the generation of huge quantities of data, where every physical or virtual object connected to the IoT may have a digital twin in the cloud, which could be generating regular updates.

IoT developments show that we will have about twenty-four billion connected devices by the year 2020 [9], which will average out to nine devices per person on earth and to many more per person in digital societies.

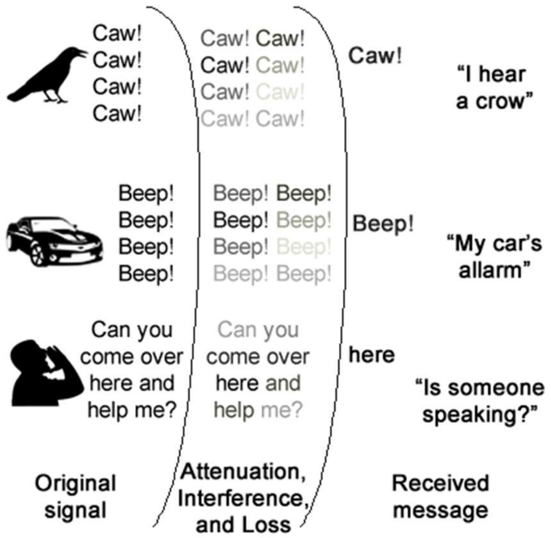

Fig. 3. The results of a lossy connection at an endpoint

Although these challenges are becoming evident now, they will pose a greater, more severe problem as this revolution accelerates.

This paper aims to define a new paradigm for the Internet of Things to be adopted both by individuals and organizations; but first, the need of an IoT architecture much more organic approach compared with traditional networking because it represents an extreme frontier in communications.

The scope and diversity of the devices to be connected are huge, and the connections to the edges of the network where these devices will be arrayed will be "low fidelity": low-speed, lossy (where attenuation and interference may cause lost but generally insignificant data), and intermittent, as shown in **Fig. 3**. At the same time, much of the communication will be machine-to-machine and in tiny snatches of data, which is completely the opposite of networks such as the traditional Internet.

3 Appearance of ubiquitous computing

In the late 1980s researchers tried to create human-to-human interface through technology, but their effort resulted in the creation of the *ubiquitous computing* discipline, whose objective is to embed technology into the background of everyday life. Currently, we are in the post-PC era where smartphones and other handheld devices are changing our environment by making it more interactive as well as informative.

Mark Weiser, the forefather of Ubiquitous Computing (*ubicomp*), defined a smart environment [10] as – the physical world that is richly and invisibly interwoven with sensors, actuators, displays, and computational elements, embedded seamlessly in the everyday objects of our lives, and connected through a continuous network.

The appearance of the Internet has marked a foremost milestone towards achieving ubicomp‘s vision which enables individual devices to communicate with any other device in the world. The inter-networking reveals the potential of a seemingly endless amount of distributed computing resources and storage owned by various owners.

In contrast to Weiser’s calm computing approach, Rogers proposes a human-centric ubicomp which makes use of human creativity in exploiting the environment and extending their capabilities [11]. He proposes a domain-specific ubicomp solution when he says: “In terms of who should benefit, it is useful to think of how ubicomp technologies can be developed not for the Sal’s of the world, but for particular domains that can be set up and customized by an individual firm or organization, such as for agriculture production, environmental restoration or retailing.”

Caceres and Friday [12] discuss the progress, opportunities, and challenges during the 20-year anniversary of ubicomp. They suggest the building blocks of ubicomp and the characteristics of the system to adapt to the changing world. More importantly, they identify two critical technologies for growing the ubicomp infrastructure - *Cloud Computing* and the *Internet of Things*.

The advancements and convergence of micro-electro-mechanical systems (MEMS) technology, wireless communications, and digital electronics have resulted in the development of miniature devices having the ability to sense, compute and communicate wirelessly in short distances. These miniature devices called nodes interconnect to form a *Wireless Sensor Networks* (WSN) and find wide application in environmental monitoring, infrastructure monitoring, traffic monitoring, retail, etc. [13]. This has the ability to provide ubiquitous sensing capability which is critical in realizing the overall vision of ubicomp as outlined by Weiser [10].

In order to build a complete IoT vision, an efficient, secure, scalable and market-oriented computing and storage resourcing are essential. Cloud computing [14] is the most recent paradigm to emerge which promises reliable services delivered through next-generation data centers that are based on virtualized storage technologies. This platform acts as a receiver of data from the ubiquitous sensors; as a computer to analyze and interpret the data; as well as providing the user with easy to understand web-based visualization. The ubiquitous sensing and processing works in the background, *hidden* from the user, and provides him pervasive information.

This new integrated Sensor-Actuator-Internet framework is the core technology around which a smart environment will be shaped: information generated will be shared across diverse platforms and applications, to develop a common operating picture of an open innovation smart environment, where control of certain unrestricted ‘Things’ are made possible. As we shifted from www (static pages web) to web2 (social networking web) to web3 (ubiquitous computing web), the need for data-on-demand using complex intuitive queries increases. To take full advantage of the available Internet technology, there is a need to deploy large-scale, platform-independent, wireless sensor network infrastructure that includes data management and processing, actuation and analytics. *Cloud computing* promises high reliability, scalability, and autonomy to provide ubiquitous access, dynamic resource discovery and composability required for the next-generation Internet of Things applications. Consumers will be able to choose the service level by changing the Quality of Service parameters.

4 Smart environments and ‘things’ uniquely identification

According to Forrester Research [15], a smart environment uses information and communications technologies to make the critical infrastructure components and services of a city’s administration, education, healthcare, public safety, real estate, transportation and utilities more aware, interactive and efficient.

If we give this definition a more user-centric approach and do not restrict it to any standard communication protocol, it will allow long-lasting applications to be developed and deployed using the available state-of-the-art protocols at any given point in time.

Open standards are required to use and extend its functionality. It will be a huge network, considering that every object has its virtual representation. Open innovation clusters have a great contribution to the definition and development of the present and future versions of the Internet of Things.

Therefore, in IoT scalability is required. The Internet of Things will need to be flexible enough to adapt to changing requirements and technological developments. Its development can be accelerated through the availability of open source software that allows anyone to implement and test new functionalities. Another opportunity to experiment and test new functionalities are living lab initiatives, where service providers and users participate in a collaborative environment.

The Internet of Things requires a more holistic architecture that includes layering of standards, separation of data models and interfaces, provision of extension mechanisms, specification of data models and interfaces, initially in a neutral abstract manner (e.g., using UML), then with provision of specific transport bindings (e.g., web services) and schema bindings (e.g., XML).

This holistic architecture is possible using open innovation to build a cloud-based open community environment in which participants with different expertise and vertical industry knowledge can share resources and leverage the different development tools from each other. Innovators could come together in the community and exchange innovative ideas and creative knowledge to effectively find appropriate products or solutions that fill the gaps of each other’s shortcomings [5].

A future Internet of Things has to integrate stakeholders who will be affected by the Internet of Things, such as citizens, small and medium enterprises, governmental institutions and policymakers, to meet and match key societal and economic needs. Applications that recognize and improve the fundamental qualities of life for users, businesses, society and the environment are needed [8].

Finally, it needs a sustainable infrastructure to provide a basis for the necessary investments.

Still, one of the greatest challenges of IoT, critical for its success is the unique identification of billions of devices but also to control remote devices through the Internet. The few most critical features of creating a unique address are: uniqueness, reliability, persistence and scalability.

Every element that is already connected and those that are going to be connected must be identified by their unique identification, location, and functionalities.

The current IPv4 may support to an extent where a group of cohabiting sensor devices can be identified geographically, but not individually. The Internet Mobility attributes in the IPV6 may alleviate some of the device identification problems; however, the heterogeneous nature of wireless nodes, variable data types, concurrent operations and the confluence of data from devices exacerbates the problem further [16].

Persistent network channel data traffic ubiquitously and. Although the TCP/IP takes care of this mechanism by routing in a more reliable and efficient way, from source to destination, the IoT faces a bottleneck at the interface between the gateway and wireless sensor devices. Furthermore, the scalability of the device address of the existing network must be sustainable. The addition of networks and devices must not hamper the performance of the network, the functioning of the devices, the reliability of the data over the network or the effective use of the devices from the user interface.

To solve these issues, the Uniform Resource Name (URN) system is considered fundamental for the development of IoT. URN creates replicas of the resources that can be accessed through the URL. With large amounts of spatial data being gathered, it is often quite important to take advantage of the benefits of metadata for transferring the information from a database to the user via the Internet [17]. IPv6 also gives a very good option to access the resources uniquely and remotely. Another critical development in addressing is the development of a lightweight IPv6 that will enable addressing home appliances uniquely.

Wireless sensor networks (considering them as building blocks of IoT), which run on a different stack compared to the Internet, cannot possess IPv6 stack to address individually and hence a subnet with a gateway having a URN will be required. With this in mind, we then need a layer for addressing sensor devices by the relevant gateway. At the subnet level, the URN for the sensor devices could be the unique IDs rather than human-friendly names as in the www, and a lookup table at the gateway to address this device. Further, at the node level, each sensor will have a URN (as numbers) for sensors to be addressed by the gateway [18]. The entire network now forms a web of connectivity from users (high-level) to sensors (low-level) that is addressable (through URN), accessible (through URL) and controllable (through URC).

5 Data storage and analytics

One of the most important outcomes is the creation of an unprecedented amount of data. Storage, ownership, and expiry of the data become critical issues. The internet consumes up to 5% of the total energy generated today and with these types of demands, it is sure to go up even further.

Machine-to-machine communications require minimal packaging and presentation overhead. For example, a moisture sensor in a farmer's field may have only a single value to send of volumetric water content. It can be communicated in a few characters of data, perhaps with the addition of a location/identification tag. This value might change slowly throughout the day, but the frequency of meaningful updates will be low. Similar terse communication forms can be imagined for millions of other types of IoT sensors and devices. Many of these IoT devices may be simplex or nearly simplex in data flows, simply broadcasting a state or reading over and over while switched on without even the capacity to "listen" for a reply.

This raises another aspect of the typical IoT message: it's individually unimportant. For simple sensors and state machines, the variations in conditions over time may be small. Thus, any individual transmission from the majority of IoT devices is likely completely uncritical. These messages are being collected and interpreted elsewhere in the network, and a gap in data will simply be ignored or extrapolated (see **Fig. 4**).

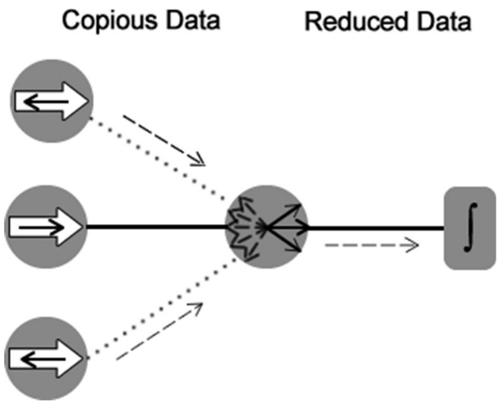

Fig. 4. Multiple identical messages may be received; some are discarded

Even more complex devices, such as a remotely monitored diesel generator, should generate little more traffic, again in terse formats unintelligible to humans, but gathered and interpreted by other devices in the IoT. Overall, the meaningful amount of data generated from each IoT device is vanishingly small—nearly exactly the opposite of the trends seen in the traditional Internet.

Today's traditional Internet is extremely reliable, even if labeled "best effort." Overprovisioning of bandwidth (for normal situations) and backbone routing diversity have created an expectation of high service levels among Internet users. "Cloud" architectures and the structure of modern business organizations are built on this expectation of Internet quality and reliability.

But at the extreme edges of the network that will make up the vast statistical majority of the IoT, connections may often be intermittent and inconsistent in quality.

Traditional protocols such as TCP/IP are designed to deal with lossy and inconsistent connections by resending data. Even though the data flowing to or from any individual IoT device may be exceedingly small, it will grow quite large in aggregate IoT traffic. The inefficiencies of resending vast quantities of *mostly individually unimportant* data are clearly an unnecessary redundancy.

Data must be stored and used intelligently for smart monitoring and actuation. It is important to develop artificial intelligence algorithms which could be centralized or distributed based on the need. Novel fusion algorithms need to be developed to make sense of the data collected. State-of-the-art non-linear, temporal machine learning methods based on evolutionary algorithms, genetic algorithms, neural networks, and other artificial intelligence techniques are necessary to achieve automated decision making [19].

Visualization is critical for an IoT application as this allows the interaction of the user with the environment. With recent advances in touchscreen technologies, use of smart tablets and phones has become very intuitive. For an average person to fully benefit from the IoT revolution, attractive and easy to understand visualization has to be created. This will also enable policymakers to convert data into knowledge, which is critical in fast decision making. Extraction of meaningful information from raw data is non-trivial. This encompasses both event detection and visualization of the associated raw and modeled data, with information represented according to the needs of the end-user

6 Enterprises

We refer to the 'Network of Things' within a work environment as an enterprise-based application. Information collected from such networks are used only by the owners and the data may be released selectively.

Environmental monitoring is the first common application which is implemented to keep track of the number of occupants and manage the utilities within the building (e.g., HVAC – heating, ventilation, and air conditioning, or lighting).

Sensors have always been an integral part of the factory setup for security, automation, climate control, etc. This will eventually be replaced by a wireless

system giving the flexibility to make changes to the setup whenever required. This is nothing but an IoT subnet dedicated to factory maintenance.
One of the major IoT application areas that are already drawing attention is Smart Environment IoT [20]. There are several testbeds being implemented and many more planned in the coming years. The smart environment includes subsystems as shown in **Table 1.** and the characteristics from a technological perspective are listed briefly. It should be noted that each of the subdomains covers many focus groups and the data will be shared [8].

Table 1. Smart environment application domains

	Smart home/ office	**Smart retail**	**Smart city**	**Smart agriculture/ forest**	**Smart water**	**Smart transport-tation**
Network size	Small	Small	Medium	Medium/large	Large	Large
Users	Very few, family members	Few, community level	Many, policy makers, general public	Few, landowners, Policy makers	Few, government	Large, general public
Energy	Rechargeable battery	Rechargeable battery	Rechargeable battery, Energy harvesting	Energy harvesting	Energy harvesting	Rechargeabl e battery, energy harvesting
Internet connectivity	Wifi, 3G, 4G LTE backbone	Wifi, 3G, 4G LTE backbone	Wifi, 3G, 4G LTE backbone	Wi-Fi, satellite communica-tion	Satellite communica -tion, microwave links	Wi-Fi, satellite communica-tion
Data management	Local server	Local server	Shared server	Local server, shared server	Shared server	Shared server
IoT devices	RFID, WSN	RFID, WSN	RFID, WSN	WSN	Single sensors	RFID, WSN, single sensors
Bandwidth requirement	Small	Small	Large	Medium	Medium	Medium/ large

The applications or use-cases within the urban environment that can benefit from the realization of a smart city WSN capability are shown in **Table 2.**
These applications are grouped according to their impact areas.

Table 2. Potential IoT applications identified by different focus groups of the city of Bucharest

Citizens	
Healthcare	Triage, patient monitoring, personnel monitoring, disease spread modeling and containment—real-time health status and predictive information to assist practitioners in the field, or policy decisions in pandemic scenarios
Emergency services, defense	Remote personnel monitoring (health, location); resource management and distribution, response planning; sensors built into building infrastructure to guide first responders in emergencies or disaster scenarios
Crowd monitoring	Crowd flow monitoring for emergency management; efficient use of public and retail spaces; workflow in commercial environments
Transport	
Traffic management	Intelligent transportation through real-time traffic information and path optimization
Infrastructure	Sensors built into infrastructure to monitor structural fatigue and other maintenance;

monitoring	accident monitoring for incident management and emergency response coordination
Services	
Water	Water quality, leakage, usage, distribution, waste management
Building management	Temperature, humidity control, activity monitoring for energy usage management, Ventilation and Air Conditioning (HVAC)
Environment	Air pollution, noise monitoring, waterways, industry monitoring

This includes the effect on citizens considering health and wellbeing issues; transport in light of its impact on mobility, productivity, pollution; and services in terms of critical community services managed and provided by local government to city inhabitants.

7 Conclusions

The Internet of Things is essentially about how data is retrieved from sensors and chips to drive various business processes, automate them, enable new applications and service customers in entirely new approaches.

The evolution of the next-generation mobile systems will depend on the creativity of the users in designing new applications. IoT is an ideal emerging technology to influence this domain by providing new evolving data and the required computational resources for creating innovative applications.

8 Acknowledgment

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References

[1] L. Atzori, A. Iera, G. Morabito, The Internet of Things: A survey, *Computer Networks*, Volume 54, pp. 2787–2805, 2010.

[2] O. Vermesan, P. Friess, P. Guillemin, S. Gusmeroli, H. Sundmaeker, A. Bassi, I. S. Jubert, M. Mazura, M. Harrison, M. Eisenhauer, P. Doody, “Internet of things strategic research roadmap.”, *Internet of Things-Global Technological and Societal Trends*, *1*, ISBN 978-8-792-32967-7, pp. 9-52, 2011.

[3] D. Uckelmann, M. Harrison, F. Michahelles, “An Architectural Approach Towards the Future Internet of Things”, *Architecting the Internet of Things*, ISBN: 978-3-642-19156-5, pp. 1-22, Springer-Verlag Berlin Heidelberg, 2011.

[4] Google Trends, *Google*. https://trends.google.com/trends/explore?date=all&q=%2Fm%2F02vnd10,%2Fm%2F043x2v,%2Fm%2F07v58

[5] A. Perng, “IoT Development Enters the Open Innovation Craze” - White Paper, NEXCOM, 2016.

[6] S. Tilak, N. Abu-Ghazaleh, W. Heinzelman, A taxonomy of wireless micro-sensor network models, Acm Mobile Computing and Communications Review. 6, pp. 28–36, 2002.

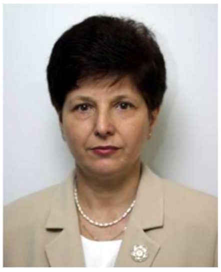
[7] M. Tory, T. Moller, Rethinking Visualization: A High-Level Taxonomy, Information Visualiza-tion, INFOVIS 2004. Symposium on. IEEE, pp. 151–158, 2004.

[8] J Gubbi, R Buyya, S Marusic, M Palaniswami “Internet of Things (IoT): A vision, architectural elements, and future directions”, *Elsevier. Future Generation Computer Systems*. Volume 29, Issue 7, pp. 1645-1660, 2013.

[9] Routledge, The Internet of Things: From RFID to the Next-Generation Pervasive Networked Systems (Hardback) – Routledge, 2008.

[10] Weiser M., Gold R., The origins of ubiquitous computing research at

PARC in the late 1980s, *IBM Systems Journal*. 1999.
[11] Y. Rogers, “Moving on from weiser‘s vision of calm computing: Engaging ubicomp experiences”, UbiComp, *Ubiquitous Computing*, 2006.
[12] R. Caceres, A. Friday, “Ubicomp Systems at 20: Progress, Opportunities, and Challenges”, *IEEE Pervasive Computing* vol. 11, pp. 14–21, 2012.
[13] I.F. Akyildiz, W. Su, Y. Sankarasubramaniam, E. Cayirci, “Wireless Sensor Networks: A Survey”, *Computing Networks*, pp. 38 393–422, 2002.
[14] R. Buyya, C.S. Yeo, S. Venugopal, J. Broberg, I. Brandic, “Cloud computing and emerging IT platforms: Vision, hype, and reality for delivering computing as the 5th utility”, *Future Generation Computer Systems*, vol. 25, pp. 599–616, 2009.
[15] J. Belissent, “Getting clever about smart cities: new opportunities require new business models”, *Forrester Research*, 2010.
[16] M. Zorzi, A. Gluhak, S. Lange, A. Bassi, From today’s Intranet of Things to a future Internet of Things: a wireless- and mobility-related view, IEEE Wireless Communications 17, pp. 43–51, 2010.
[17] N. Honle, U.P. Kappeler, D. Nicklas, T. Schwarz, M. Grossmann, Benefits of integrating meta data into a context model, pp. 25–29, 2005.
[18] A. Gluhak, S. Krco, M. Nati, D. Pfisterer, N. Mitton, T. Razafindralambo, A survey on facilities for experimental Internet of Things research, IEEE Communications Magazine 49, pp. 58–67, 2011.
[19] A. Ghosh, S.K. Das, Coverage and connectivity issues in wireless sensor networks: a survey, *Pervasive and Mobile Computing* 4, pp. 303–334, 2008.
[20] A. Gluhak, S. Krco, M. Nati, D. Pfisterer, N. Mitton, T. Razafindralambo, A survey on facilities for experimental Internet of Things research, “IEEE Communications Magazine” vol. 49, pp. 58–67, 2011.



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