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Technical Foresight Report

Crowd-based Services for Digital Cities

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Technical Foresight Report on Crowd-based Services for Digital Cities

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"The 19th century was a century of empires. The 20th century was a century of nation states. The 21st century will be a century of cities."

--- Wellington E. Webb, former mayor of Denver

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Executive summary

This report aims to identify trends, challenges, and recommendations in regard of Crowd-based Services for Digital Cities of the Future. This foresight will help expose future themes with high innovation and business potential, based on a timeframe roughly 15 years ahead, or 2030! The purpose is to create a common outlook on the future of ICT and to establish a strong community across EIT ICT Labs nodes and partner organizations.

Trends

1. Emergence of a new consumer type: the working consumer [10]. Contrary to the conventional role of passive kings to be waited upon, consumers are now becoming more like co-workers who take over specific parts of a production process, whereby this process ultimately remains under the control of an organization [11] (e.g. retail loyalty schemes).
2. Emergence of a new model of computation named crowdsourcing, which harnesses human computation - *"wisdom of the crowd"*.
3. Although there may be challenges in defining the crowd concept, that is, crowdsourcing or crowd-based services, the trend is toward *"everyone as a service"* [2].
4. Emergence of distributed sensing, using mobile phones, where the sophisticated sensing, processing, and communication capabilities of millions of smartphone users can be harnessed towards a common sensing goal [12]. Distributed data collection from mobile phones and other devices will produce an essential part of the *big data* trend.
5. The rise of social media platforms has shown that people want to create and share their content with others [13]. In the future, this will be included in the future *Internet of Things* as part of social media.
6. Public organizations will provide *open data* for creation of new services for smart cities. Cities and public authorities allow generation of open data emerging from crowd behavior in cities. This enables rethinking of *smart cities* of data as *learning cities*, with history and future planning.
7. Big data, including IoT, and open data trends will enable digital service mash-ups together with crowd-based data, that is, people producing new information. For instance, energy and traffic data appears in new forms, while the ICT gluing these together can be used to create new service business models.

Challenges

1. Identifying and defining a new type of digital service for the user. *"You just can't ask customers what they want and then try to give them that. By the time you get it built, they'll want something new."* (Steve Jobs, CEO of Apple)

2. Building the ecosystem for crowd-based solutions. Is it intentional and goal oriented or does the market decide what happens? The crowd concept must be revisited and redefined when big data opportunities become clearer. Passive crowd data collected from users' devices, or active user behavior, given explicitly by users, are examples of categories that delineate crowd-based services from crowd perspective.
3. The participation of the crowd in the crowdsourcing initiative is needed for its success - the contribution of a wide network of people is required for the initiative to reach a substantial scale.
4. The real issue is not acquiring large amounts of data, but what we do with the big data that matters - with huge data sets and fine-grained measurement, there is an increased risk of false discoveries.
5. Successful open data initiatives involve more than just putting datasets online; they work to make data more accessible and re-useable.
6. The success of the Internet of Things will not so much depend on the development of new technologies, but more on connecting and integrating existing resources.
7. Current IoT solutions are fragmented and target specific vertical domains and/or specific types of applications – the need for common/dominant standards, platforms, and interfaces.
8. European cities need to secure high living standards through the innovation economy - smart cities must enable new ways to enhance local innovation ecosystems and the knowledge economy overall.
9. Innovation ecosystems for smart cities have to be defined, to help cities to identify revenue streams, broker public-private partnerships, and open public data up to developers and user communities.
10. How to design intentional and directional learning cities from smart city data.

Recommendations

1. Look for creative ways to use crowdsourcing beyond idea generation and to source the challenge to the "crowd" - this applies to new digital ecosystem creation as well, where the challenge can be a deployment of a new application. Identify and nourish suitable test-beds for industry.
2. Find ways of providing mutual benefit - people sharing information also benefit from that and take into account the privacy and security implications. This means work on European-level regulations.
3. Focus on interoperability of the services - dominant standards, platforms, and interfaces that match the requirements of the specific IoT domains. Encourage standardization of technologies in research projects.
4. Assess business models – identify new value exchange and the flow of revenues already in research projects. Identify new ecosystems and roadmaps early, and actively build on them – (how) can we influence the transformation of them in Europe, for example with new kinds of investor relationships?

Summary

First, places were connected; next, people were connected; and now – we are in the early stages of the next major inflection point for our industry – the connection of a vast array of "things". Cities and urban areas are emerging as innovation ecosystems empowering collective intelligence and co-creation capabilities of user/citizen communities. Cities are becoming "smarter," as governments, businesses, and communities increasingly rely on technology to overcome the challenges from rapid urbanization.

There is vast potential that we can realize by integrating computation with human intellectual power; we can now harness "human computation" - *"wisdom of the crowd"*. The first crowd trend is "from Internet-of-Things to *things of meaning*'', because people and the use context make the meaning for the systems of things. *Mobile crowdsourcing* is an increasingly popular mechanism to realize applications that harness a large volume of real-time data to improve daily life.

Although there may be challenges in defining the crowd concept, or crowdsourcing or crowd-based services, the trend is toward Petrie's [2] prediction of *"everyone as a service"*. This valuable resource can only grow with time, as more people worldwide become connected and the digital divide narrows. More importantly, it can assist us in tapping into the vast, unused capacity in the deep recesses of the collective human brain, for societal benefit [1].

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1 Introduction

This technical report is part of the EIT ICT Labs Foresight Study and Innovation Radar within the thematic action line of Digital Cities of the Future (TDCT).

The report aims to identify key scenarios, trends, challenges, and recommendations in regard of Crowd-based Services for Digital Cities of the Future. This foresight will help expose future themes with high innovation and business potential, based on a timeframe at least 15 years ahead, or 2030! The purpose is to create a common outlook on the future of ICT and to establish a strong community across EIT ICT Labs nodes and partner organizations.

1.1 Outline

Chapter 2 overviews the technology trends of the future that have an impact **on how to reach crowds**, a multitude of users, and their use context, with the predictions made of the technology evolution and Internet usage characteristics of future citizens. Especially, we consider the emergence of the **Internet of Things,** and **smart cities**, which are producers of **big data**.

We point out rapid urbanization as a trend and discuss more deeply the emergence and promise of **smart cities**, ending up with a remark on **learning cities** as an opportunity**.**

Then we discuss how crowdsourcing harnesses the power of the individual for a purpose, but add perspectives on IoT and big data that will create new opportunities for digital services. Finally, viewpoints on **crowd-based services** scenarios are delineated.

Chapter 3 gives background information on **crowdsourcing**, **open data**, and **IoT**, with examples of current **initiatives**; and considers **challenges** relevant to the previously introduced technological developments, focusing on the diversified definition of the term **crowd**, then on getting the **crowd to contribute**, and the related **interoperability**, **privacy**, and **security** issues.

Chapter 4 presents trends, implications, and recommendations, with a 2030 baseline in mind.

Chapter 5 draws conclusions for future EIT ICT Labs activities.

2 Trends

"Technology does not drive change – it enables change"

2.1 Technology Evolution

"More devices, more connections"

We are finally reaching the point when people are equipped with fast-speed, and (almost) any-time and any-place information and communication solutions, allowing them to be connected with each other, and to interact with and through the rich world of Internet-enabled applications and services [26].

Mobile telephony was a first inflection point for the growth in connections. First, places were connected; next, people were connected; and now – we are in the early stages of the next major inflection point for our industry – the connection of a vast array of "things". On top of this are the connected tags, such as paper tags, electronic tags, and virtual tags. For example, according to IBM Chief Scientist Jeff Jonas, "mobile devices in America are generating something like 600 billion geo-spatially tagged transactions per day. Every call, text message, email and data transfer handled by your mobile device creates a transaction with your space-time coordinate, whether you have GPS or not. [57]"

There is already now a tremendous growth in mobile connected devices and the traffic generated by them. Forecasts predict almost 50 yearly exabytes (equal to one quintillion bytes [20]) of subscriber data traffic in mobile access networks around year 2015 (Figure 1). There is also a huge growth in non-phone and non-laptop devices. One prediction is that there will be as many other devices as phones by 2014, with the specific number being 14 billion. A more long-term statement is that there will be 50 billion intelligent connected devices by the year 2020 [e.g. 21].

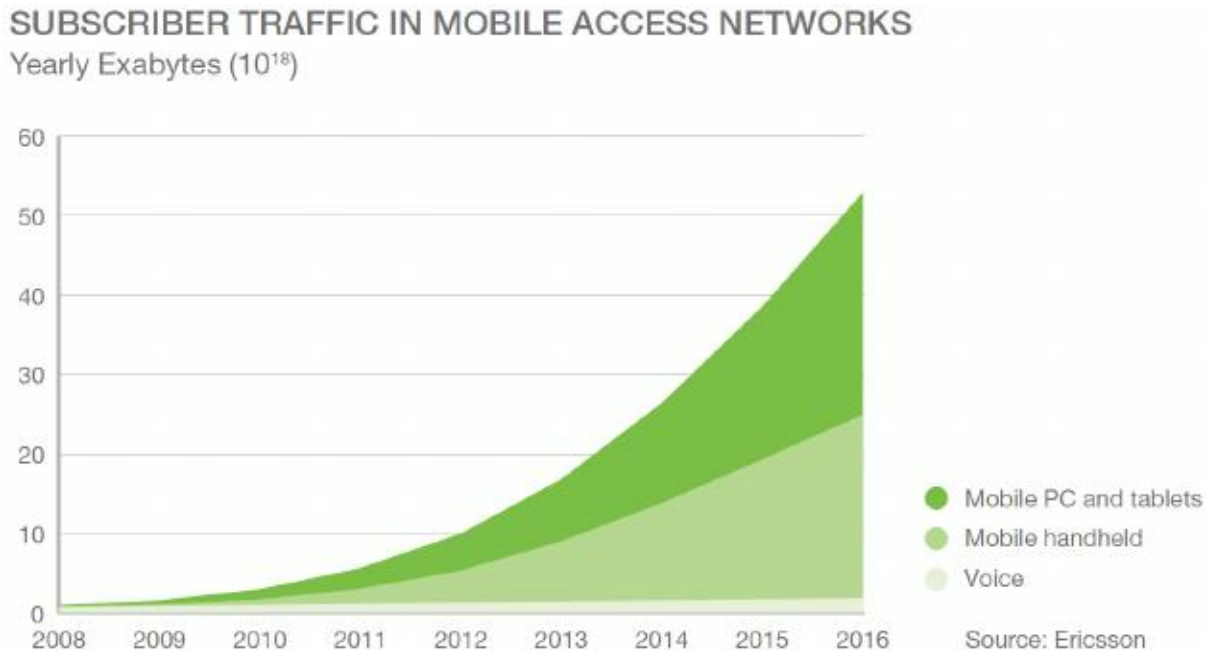


Figure 1. Subscriber data in a mobile access network

Another prediction given by GSMA [35] asserts that the number of connected devices is expected to grow from 9 billion in 2011 to 24 billion in 2020. As shown in Figure 2 below, this will be dominated by the growth in machine-to-machine connections, increasing from two billion at the end of 2011 to 12 billion at the end of 2020 [35]. Cellular technologies are expected to get a 19% share (2.3 billion) of connections by 2020 [35].

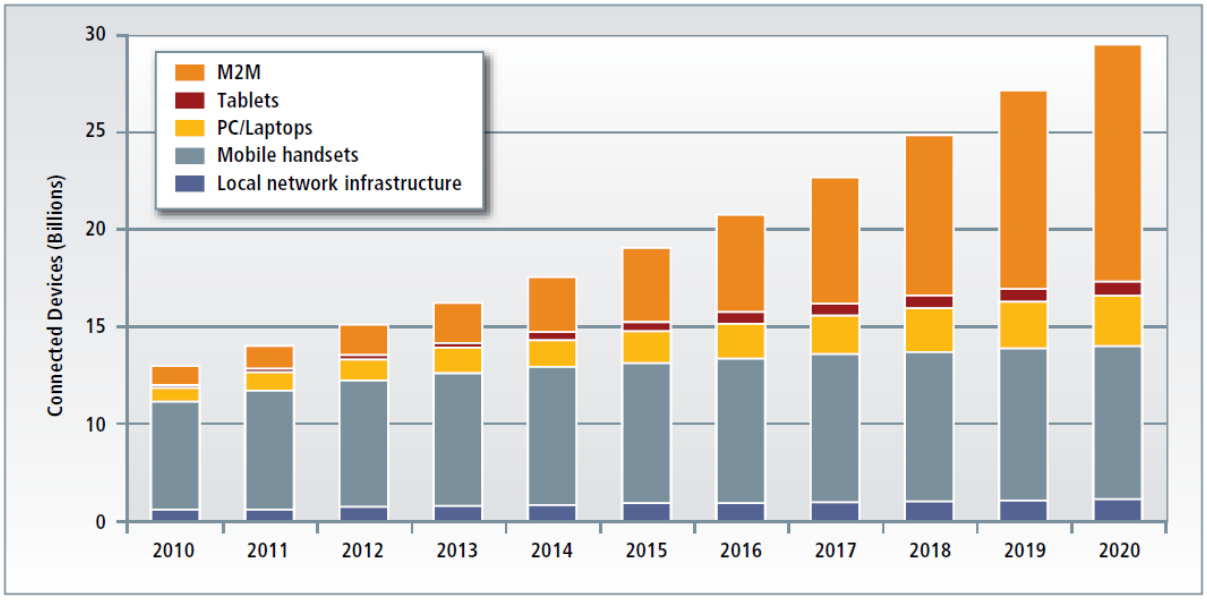


Figure 2. Growth in the number of connected devices [35]

The total revenue generated by connected devices will also grow significantly – according to some estimates, from EUR 420 billion in 2010, it will reach EUR 1.3 trillion in 2020, excluding mobile handset revenues [35].

2.1.1 Big Data

"And the result is: more data"

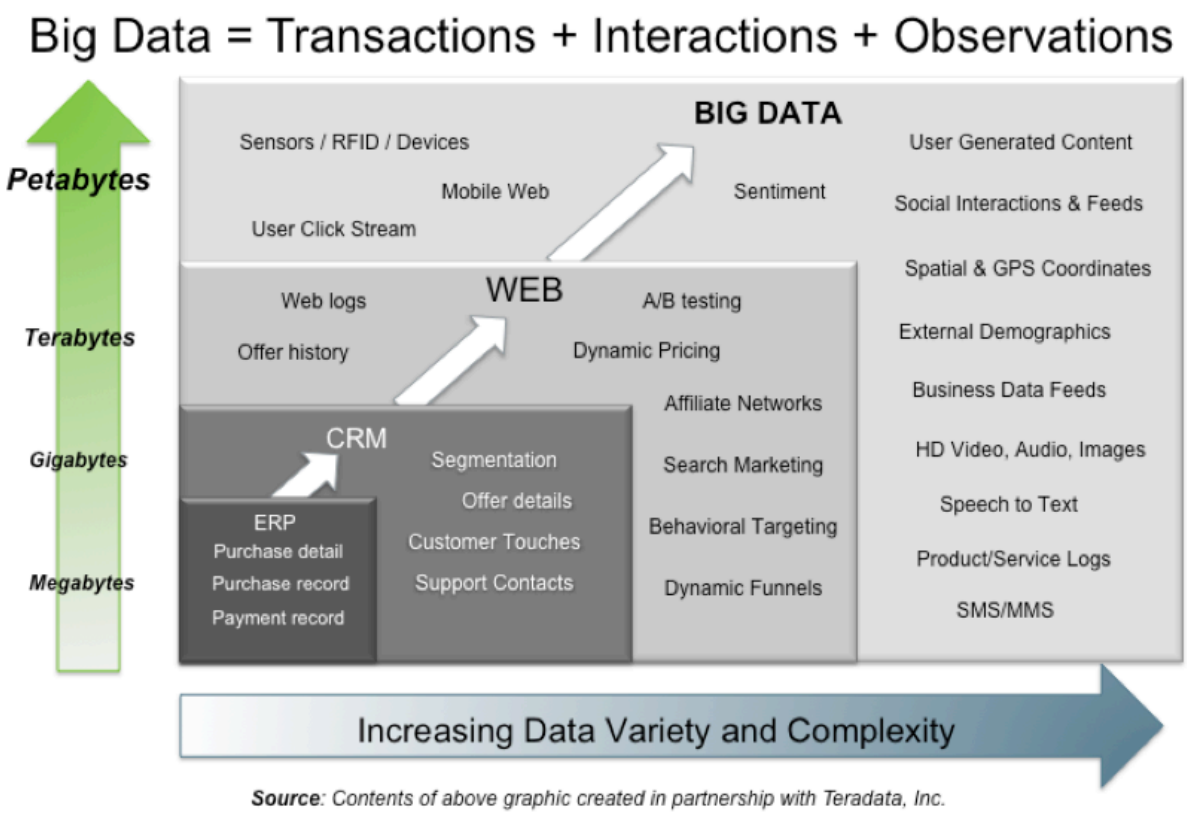
As of 2012, about 2.5 exabytes of data are created every day, an amount that doubles every 40 months or so. Today, we create so much data every day, that 90% of the data in the world today has been created in the last two years alone [30]. This data comes from everywhere: there are now countless digital sensors worldwide, such as sensors used to gather climate information, posts to social media sites, digital pictures and videos, purchase transaction records, and cell phone GPS signals, to name a few. It is not just more streams of data, but entirely new ones. This data is **big data** [30]. A meme and a marketing term, for sure, but also shorthand for advancing trends in technology that open the door to a new approach to understanding the world and making decisions [31].

More data crosses the internet every second than was stored on the entire Internet just 20 years ago. Thus, we are clearly in the era of big data. Companies have the opportunity to work with many petabytes of data in a single data set – not just from the Internet. For example, Walmart collects more than 2.5 petabytes of data every hour from its customer transactions; 340 million tweets are sent per day, which is nearly 4,000 tweets per second; 10,000 payment card transactions are made every second around the world. A petabyte is one quadrillion bytes, or the equivalent of 20 million filing cabinets worth of text. An exabyte is 1,000 times that amount, or one billion gigabytes [36].

Looking forward to 10 years from now, if the Internet and data expand at the same rate, the daily amount of new data will be 10 exabytes. If the doubling rate continues, in 20 years from now, we reach 80 exabytes daily. Considering systems created for *smart cities*, this may well be true number or even bigger. Apparently, there is a need to revise our set of thinking to understand the world in a new way.

Most considerations of big data focus on the unforeseeable amounts of data exceeding the normal processing capabilities, with new levels of "*volume, velocity, variety, and complexity*". At the same time, for example, Connolly [32] has approached big data with the equation:

Big Data = *Transactions* + *Interactions* + *Observations* (see Figure 3).



***Source**: Contents of above graphic created in partnership with Teradata, Inc.*

Figure 3. Big data [32]

The real issue is not that we are acquiring large amounts of data, but it is what we do with your big data that matters. The expected vision for big data is that we will be able to harness relevant data and use it to make the best decisions. Link these communicating sensors to computing intelligence, and you see the rise of what is called the *Internet of Things*. The wealth of new data, in turn, accelerates advances in computing — a virtuous circle of big data [31]. Improved access to information is also fueling the big data trend; data is not only becoming more available, but also more understandable to computers [31].

Big data has great impacts on decision making, so that decisions will be based on data and analysis rather than on experience and intuition [31]. The predictive power of big data also appears promising in fields like public health, economic development, and economic forecasting [31]. Big data is also leveraged for global development by a new initiative by the United Nations. In addition, it is transforming the study of how social networks function, helping, for example, to identify patterns of influence and peaks in communication on a subject, and to understand collective behavior [31].

However, big data also has risks. With huge data sets and fine-grained measurement, there is an increased risk of false discoveries.

2.1.2 Internet of Things (IoT)

"Internet of things – and the data will explode"

In the forthcoming years, the Internet will undergo evolutions that can be expected to add billions of new connections; these include many new users from emergent countries and a vast array of objects of all kinds. The Internet is expected to ultimately interconnect billions of people and trillions of devices (see Figure 4). For several years, "Internet of Things" initiatives have emerged primarily aimed at device-to-device interactions using standard communications protocols. As yet, their rate of adoption in commercial products and services is fairly low. The Internet of Things, also known as the *Internet of Objects* or the *Web of Objects*, refers to the networked interconnection of everyday objects and is described as a self-configuring wireless network of distributed sensors, the purpose of which would be to interconnect all things.

Sensors and actuators will be seamlessly connected with each other and with different types of smart spaces. Mobile devices will assist users in managing their everyday tasks. New breeds of smart services will emerge, such as context sharing between family members, adapting residential facilities to the needs of new tenants, and interactions with and between home devices optimizing home energy consumption. Intelligent buildings and smart grids will provide the enabling technologies required for *smart cities*.

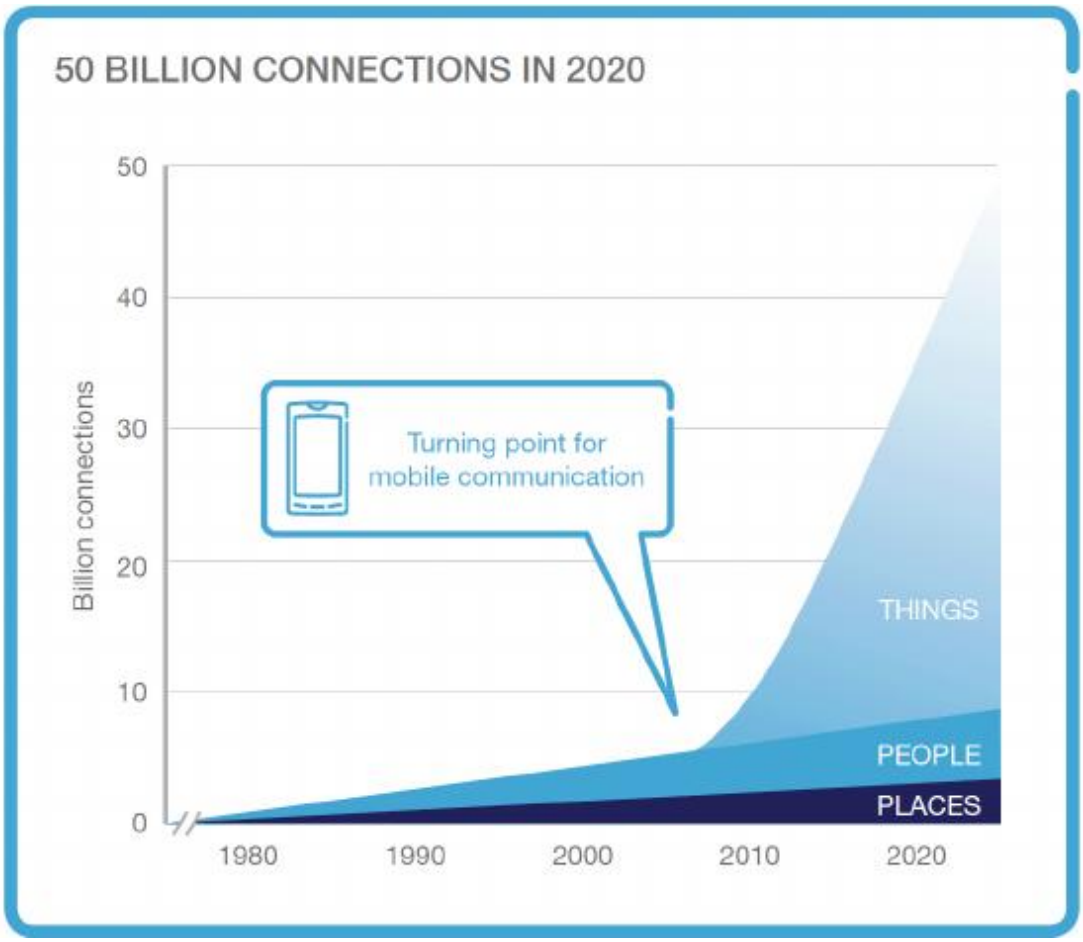


Figure 4. Connection numbers (Source: Ericsson)

The Internet of Things is all about convergence, from connected computing using RFID, NFC (Near Field Communication), and sensor technology, to digital content and context-aware services. The success of the Internet of Things will not so much depend on the development of new technologies, but more so on connecting and integrating existing resources, ranging from small-scale objects, such as RFID tags, to large-scale software systems that serve thousands of clients at a time.

Some analysts estimate that the added-value services using the Internet of Things could reach as much as $200 billion/year, 15 billion devices by 2015, and could deliver the next wave of growth of the Internet, with new business models, applications, and services in most sectors of the economy. Such demand could also spur innovation and growth in the value chain of components, devices, wireless connectivity, middleware, decision support tools, and so on.

The M2M market is expected to be the largest submarket within the IoT market: the total revenue generated by the connected devices will grow from EUR 420 billion in 2010 to EUR 1.3 trillion in 2020; and M2M is expected to account for the largest proportion of the so-called “connected life” revenue, overall generating EUR 714 billion in 2020 [37]. Within the M2M submarket, GSMA [35] expects the main vertical sectors to be:

- Automotive (revenue opportunity $202 billion)
- Healthcare (revenue opportunity $97 billion)
- Consumer electronics (revenue opportunity $445 billion)
- Utilities (revenue opportunity $36 billion)

This is also visible in Figure 5, which portrays the expected revenue growth in different M2M vertical segments. As can be seen, the consumer electronics, automotive, and healthcare, as well as intelligent buildings and utilities, are the most promising, in terms of both revenues and growth rates.

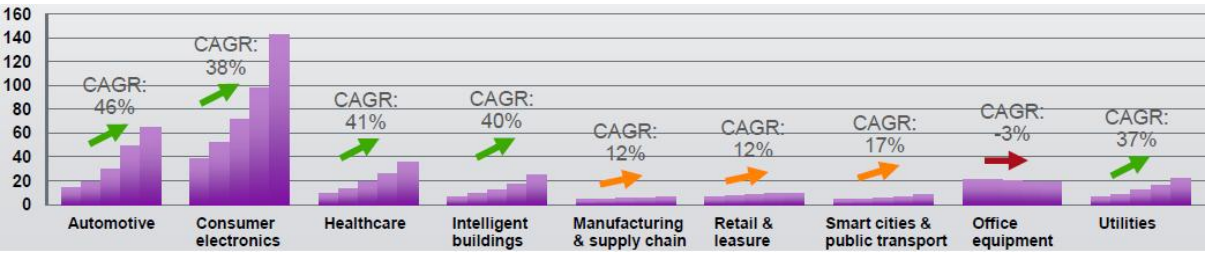


Figure 5. M2M global revenue forecast 2011-2015 (millions)*

2.2 Rapid Urbanization

"Cities are systems of people with more need to connect"

We are passing through a revolutionary period. The United Nations estimates that, at some time between 2008 and 2009, the world's urban and rural populations became equal [15]. And by the beginning of 2019, it is expected that more people will live in cities than in rural areas. The rapid growth in population poses new challenges for city services and infrastructure, but at the same time, it creates new economic opportunities and social benefits for people [14]. The future *smart city* (discussed in the next section) promises to capitalize on its economic opportunities and social benefits, while alleviating the pains of urbanization, which include:

- Scarcity of resources
- Inadequate and deteriorating infrastructure
- Energy shortages and price instability
- Global environment "weirding" and human health concerns
- Demand for better economic opportunities and social benefits

2.2.1 Smart Cities

Cities nowadays face complex challenges to meet objectives regarding socio-economic development and quality of life [18]. The concept of "*smart cities*" is a response to these challenges [18], and the vision for smart cities originated as a natural evolution of research in smart homes and other smaller-scale smart spaces [16]. Cities are becoming "smarter" as governments, businesses, and communities increasingly rely on technology to overcome the challenges of rapid urbanization.

Until now the role of cities and regions in ICT-based innovation mostly focused on deploying broadband infrastructure, the stimulation of ICT-based applications enhancing citizens' quality of life is now becoming a key priority [18]. As a next step, the potential role of cities as innovation environments is gaining recognition, as cities and urban areas are considered not only as the object of innovation but also as innovation ecosystems that empower the collective intelligence and co-creation capabilities of user/citizen communities for designing innovative living and working scenarios [18].

The research on smart cities has brought together a diverse group of participants, including governments, urban planners, sociologists, and traditional ubiquitous-computing researchers. Several governments have already undertaken ambitious programs to build smart cities by augmenting existing city infrastructure with embedded sensing, as well as communication and interaction technologies [16].

According to Forrester [14], the smart city is a collection of smart computing technologies applied to the seven critical infrastructure components and services: city administration, education, health care, public safety, real estate, transportation, and utilities (see Figure 6).

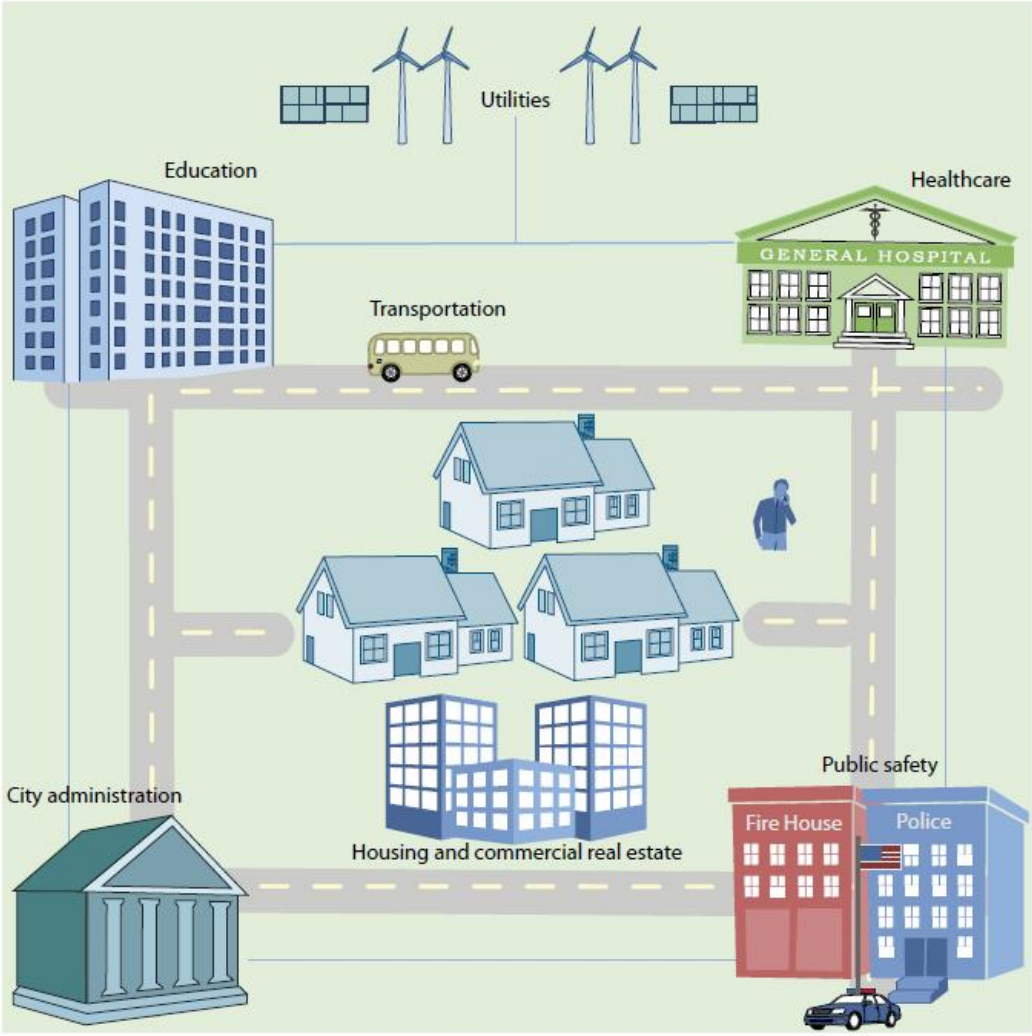


Figure 6. Smart city blueprint [14]

Across the globe, existing cities are revamping their critical infrastructure and services, and prioritizing projects in a staggered fashion — but there are newer cities that have incorporated the smart city vision in its entirety from scratch [14].

The positive impact of available smart city solutions on European cities has not yet been demonstrated, nor have the necessary funding mechanisms and business models for their sustainability been developed [18]. Creating the market constitutes the first priority. Innovation ecosystems for smart cities have to be defined in terms of applications, services, financial engineering, and partnerships. This will help cities to secure funding, identify revenue streams, broker public-private partnerships, and open public data up to developers and user communities. As the major challenge facing European cities is to secure high living standards through the innovation economy, smart cities must enable new ways of enhancing local innovation ecosystems and the knowledge economy overall.

2.2.2 Learning Cities

"Intentional organization of cities"

In the future, we will have to revise our conceptualization of how we look at the world, due to new sources of data and big data. The very well-known contemporary concept of smart cities, for instance, could be revisited. In a vague definition, it means any systems that make cities' and citizens' activities somehow smarter. A system can be broadly understood to consist of people and ICT systems. What is the essence of smartness? It is the idea that the cities have some goals as systems that bring benefits to themselves: sustainability, savings, and better user experience.

For the first time in history, it will be possible to collect data from such systems in a manner that can give not only a single benefit, but that can let us understand the behavior of the masses, or understand what the development opportunities are in cities via, for example, simulations based on the data. What is more, it is possible to affect the behavior through city planning and predictions, and to alleviate problems arising from urbanization. In fact, this is a must, when thinking of sustainability.

2.3 Harnessing Human Intellectual Power and More

"Wisdom of the Crowd"

The vast potential we can realize by integrating computation with human intellectual power has been recognized from the earliest days of computing [1]. There are many ways that crowds can help businesses achieve their objectives [9]. There are increasingly more entire business models that are fundamentally based on tapping contributions from crowds, where a primary source of value creation is from the crowd [9]. But we are early in what will prove to be a long-term rise in the prominence and success of crowd business models [9].

According to [5], due to the global growth in Internet connectivity and bandwidth, we can now harness "human computation" in near real time from a vast and ever-growing distributed population of online Internet users. While many businesses will see this simply as finding more effective and efficient ways to perform existing business functions, an increasing proportion of companies will start basing their core business model on crowds [9]. By using *"wisdom of the crowd"* aggregation strategies which combine information from multiple annotators to provide the potential to reduce bias and improve accuracy versus traditional assessment practices using in-house annotators [5]. As more people interact on the social web, providing frequent updates on their location and activities, *crowdsourcing* all types of status information — mixed with context information — becomes practical [6].

According to the priority matrix and hype cycle (Figure 7) for social software (September 2011), the benefit of crowdsourcing is **high**, market penetration is **1% to 5% of target audience**, maturity is **adolescent**, and time to mainstream adoption is **5-10 years** [6].

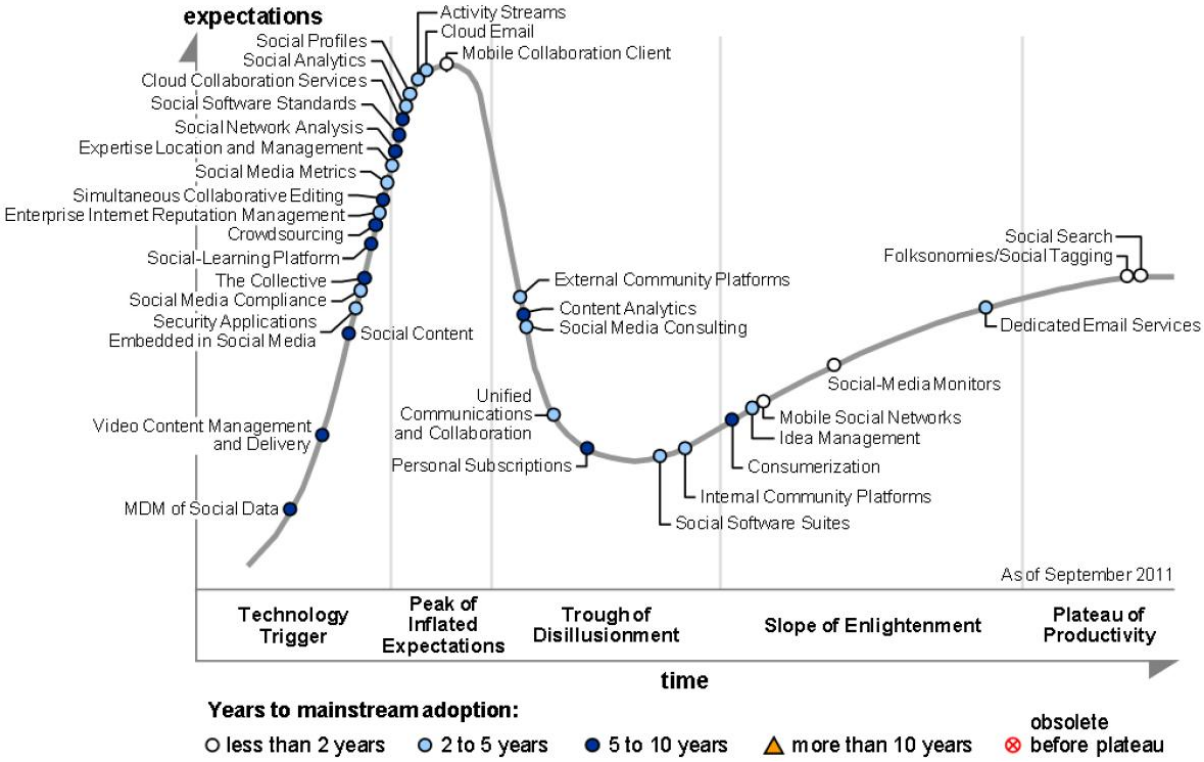


Figure 7. Hype cycle for social software, 2011 [6]

Crowdsourcing has been applied in a range of areas in government and private-sector organizations for nearly a decade, with rapid acceleration in its use during the past two to three years for idea generation in organizational innovation programs [6]. Innovation activities where customers or the collective create and rank ideas or design marketing campaigns are the most popular areas. Crowdsourcing has also introduced intriguing novel possibilities for integrating human computation with automated systems [5].

There is a large, untapped potential in applying crowdsourcing to a much broader range of tasks and goals, but there is still more to be learned and experienced regarding where the practice is most effective compared with other approaches. For this reason, Gartner [6] has changed the estimated "time to plateau" from two to five years, back to five to ten years. According to Gartner [6], crowdsourcing offers the ability to dramatically *increase the available human resources* that can be applied to a task or challenge — well-designed crowdsourcing efforts will attract interest and creativity to a task.

Crowdsourcing is used primarily for developing initial ideas for innovation (33% of all respondents; 18% for B-to-C companies), secondly for concept testing and development (24%; 6%), thirdly for idea screening (16%; 13%), and fourthly for launching products (9%; 6%) [8].

Respondents in B-to-C companies employ specialized vendors for crowdsourcing (88%), customer surveys, workshops and focus groups (25%), formal networks (13%), and social media (6%) [8].

"IoT enables new and exciting social and crowd services."

The *big data* that is created by IoT enablers will have value for a new set of uses and users. While many of the smart space technologies, such as sensors and actuators, are already known, their impact in social interaction is not addressed. What happens when things become social? Thinking of this, it becomes quickly clear that there is a huge potential for applications that can emerge when the smart space architecture is in place. The interplay between things and people allows data gathering, control, business opportunities with crowd-based big data, or new opportunities in user identification.

2.3.1 Crowd-based Services Scenarios

"Things of meaning for people who have intention"

The first crowd trend is "from the Internet of Things to '*things of meaning*''', because people and the use context make the meaning for the systems of things. In addition, although there may be challenges in defining the crowd concept, that is, crowdsourcing or crowd-based services, the trend is toward "everyone as a service" (cf. Petrie's [2]).

The opportunity is huge. Example domains include social energy production and consumption, consumers in socially and crowd-oriented food production, education connected with the physical environment and social behavior, and user-implemented service desks, to name a few. People may become automatic sources of activity information due to sensors in mobile phones; consequently this information induces crowd behavior and understanding of activities. In turn, such information can produce proactive activities by service producers; for example, a city can plan for maintenance activities in an area precisely identified by crowd behavior.

3 Background

The potential of tapping the power of crowds is becoming more apparent [9]. We propose that the trend is toward everyone as a service, as in Petrie [2], but we also add that this happens in every interaction of the individual with the crowd-based service. In this chapter, we first delineate the background of crowdsourcing, and then go to mobile crowdsourcing, crowdservicing, open data, and the Internet of things. These all are steps that elaborate the link between the crowd and big data. A system of people, or a crowd, becomes interlinked with other systemic data, that is, open data and the Internet of things.

3.1 Crowdsourcing

"Crowdsourcing is an umbrella term"

The term crowdsourcing is being debated; the term often seems to refer to one-way interaction whereby individuals submit information or ideas to a specific task [4]. Generally, crowdsourcing can be defined by the following two elements: 1) *an open call*, and 2) *a crowd* [38].

In its broadest sense, crowdsourcing could be viewed as synonymous with *collective intelligence* (that is, web-mediated mass collaboration such as Wikipedia or open source), but it is more often used to refer to a focused effort by a company or organization to achieve a specific task, or identify opportunities, by drawing on contributors outside the immediate control of its management or contractual structures [6].

Crowdsourcing as a concept, as well as a practice, refers to the idea that the web can facilitate the aggregation or selection of useful information from a potentially large number of people connected to the Internet [1]. Wikipedia is a good example of this distributed knowledge gathering and organization in action [1]. Crowdsourcing typically includes mechanisms to attract the desired participants, stimulate relevant contributions, and select the winning ideas or solutions [6].

Crowdsourcing is popular, easy, and a good fit for many innovation programs, simply because everyone is a consumer or constituent. Crowdsourcing can be a more robust alternative to using in-house teams of experts or a chosen group of contributors for a wide array of problems [1]. Everyone has ideas about how to improve the products or services they use, how to simplify processes, or how to reduce costs. Crowdsourcing potentially appears to significantly contribute to innovation [4]. The basic assumption is that the crowd can bring interesting, non-trivial, and non-overlapping information, insights, or skills, which, when harnessed through appropriate aggregation and selection mechanisms, can add to the quality of the solutions [1].

We can distinguish between internal, firm-developed crowdsourcing initiatives to leverage the knowledge within a company, as opposed to crowdsourcing with external collaborators [4]. External collaboration can be implemented in companies' virtual communication environments (VCEs). Alternatively, collaboration can be

outsourced to specialist service vendors, which other firms can also use. These intermediaries offer the co-creation process either for anybody or for a pre-defined group of participants. Furthermore, crowdsourcing efforts can happen in either temporary innovation challenges or more permanent and ongoing VCE settings.

Crowdsourcing is frequently aimed outside an enterprise to engage customers, business partners, or the public. Individuals or groups may be invited to participate based on their expertise. Others may discover the challenge and participate on their own just because they are interested. The bottom line is that crowdsourcing is intuitive to use, a creative outlet, often a social activity, and, sometimes, just fun. It is usually easy to get involved — for the innovator and the participant [7].

For example, government organizations are in a good position to take advantage of crowdsourcing, because citizens are willing to help out in areas that affect them, their citizen services or rights, their environment, or their personal interests. Crowdsourcing also has the potential to dramatically increase available human thought, insight, competence, and expertise that enterprises need to resolve a problem or complete a task [7].

Crowdsourcing is often based on the framework of collective intelligence [39], the idea that knowledge is the most accurate when it consists of inputs from a distributed population – *"all of us together are smarter than any one of us individually"*. The concept of collective intelligence has been popularized as the wisdom of crowds [40], and crowdsourcing can be defined as a tool for gathering collective intelligence for certain tasks. Related concepts to crowdsourcing are co-creation [41], open innovation [42], and user innovation [43].

In [4], it is visualized how crowdsourcing relates to other concepts as shown in Figure 8. Here, crowdsourcing is a subset of user innovation, which in turn is a subset of open innovation. The notion of "co-creation" combines user innovation and crowdsourcing and is also a subset of the open innovation concept.

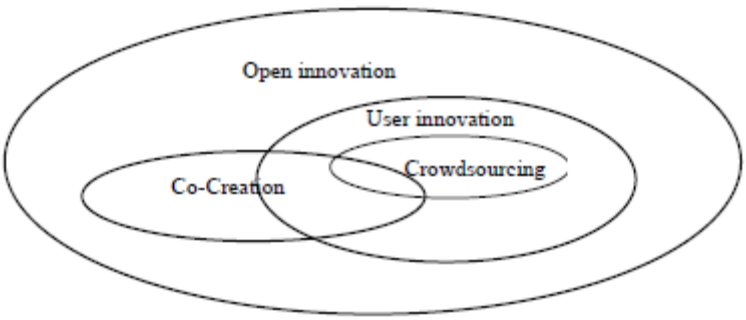


Figure 8. Crowdsourcing, open innovation, user innovation, and co-creation [4]

Schenk and Guittard [44] provide an alternative typology for crowdsourcing, distinguishing between integrative and selective crowdsourcing.

- *Integrative crowdsourcing* – the goal is to pool vast amounts of complementary information from a large number of users

- *Selective crowdsourcing* – the goal is to identify and select input from competing users

As suggested by Brabham [45], crowdsourcing could be positioned as one particular form of participatory social media. Crowdsourcing distinguishes itself by involving an organization-participant relationship, where the organization engages in a top-down, managed process to seek bottom-up, open input from users in an online community. Brabham [45] identifies four types of crowdsourcing:

1) *Knowledge discovery and management*
2) *Broadcast search*
3) *Peer-vetted creative production*
4) *Distributed human intelligence tasking*

In a related framework, Howe [46] argues that *"crowdsourcing isn't a single strategy. It is an umbrella term for a highly varied group of approaches that share one obvious attribute in common: they all depend on some contribution from the crowd"*. Howe [46] also presents a taxonomy that focuses attention on:

1) *Crowd wisdom* (similar to broadcast search above)
2) *Crowd creation* (similar to peer-vetted creative production)
3) *Crowd voting* (including prediction markets)
4) *Crowd funding* (including crowd-based micro-lending institutions)

An important question is whether to make use of 1) *collaborative communities* or 2) *competitive markets*, a topic addressed by Boudreau and Lakhani [47]. They find that communities are especially useful when an innovation problem is based on cumulative knowledge, that is, when it continually builds on past advances. On one hand, markets are more appropriate when an innovation problem is best addressed by broad experimentation. Furthermore, communities are more focused on intrinsic motivations of external innovators (e.g. the desire to be a part of a larger cause). On the other hand, markets usually reward extrinsic motivations (such as with financial compensation). According to [4], it seems that extrinsic motivators rarely work in isolation – intrinsic ones are essential and can be enhanced by extrinsic ones. An additional source of motivation for collective intelligence participation is "glory", as suggested by Malone et al. [48]. This is the case when individuals respond to the opportunities to be recognized by peers in a community.

A study by Poetz and Schreier [49] convincingly demonstrates the potential value of crowdsourcing in a real-world setting. The authors compare the quality of ideas generated by users to those of professionals (e.g. marketers, engineers, designers). The quality of ideas was measured in terms of 1) novelty, 2) customer benefit, and 3) feasibility (technical and economic), and was evaluated by firm executives in a blind survey, so that the raters were not aware of the source of the ideas. The study finds that user-generated ideas score significantly higher than those generated by professionals. Interestingly, whereas user ideas scored somewhat lower in feasibility (but not so much that this was seen to constitute a barrier), they were more frequently rated as among the best in novelty and customer benefit.

3.1.1 Initiatives

According to [29], most of the best global brands (11 out of 12, including e.g. Coca-Cola, IBM, Google and Toyota) use creative crowdsourcing in marketing and innovation. In [29] is a comprehensive list and description of these initiatives, focusing on web-based, distributed problem-solving, where people are asked to contribute with creative output. The most common forms of such initiatives are innovation tournaments, idea contests, creative competitions, and branded web-platforms for idea generation.

Wikipedia and iStockPhoto are other great examples of the use of crowdsourcing to achieve business goals. In addition, a well-known and thoroughly analyzed crowdsourcing case is Threadless.com, which has a user community of 700,000 individuals who contribute t-shirt designs, give each other feedback, vote on the best designs, and eventually buy those that the company decides to produce (based on votes and staff opinions) [4]. The company gives cash prizes of $2,500 to the winners of weekly contests and does not retain IP rights to the produced designs, so designers are free to use their creations in other applications.

Victors & Spoils, launched in 2009, is an advertising agency based on crowdsourcing, and is described as “the world’s first creative ad agency built on crowdsourcing principles” [9]. The company has close to 500 people from 126 countries in its contributor pool, all attracted through the firm’s significant media and online visibility. The firm has built a reputation system to make it more efficient to find the best people for projects.

Other crowdsourcing initiatives include a case where participants in Philadelphia used a smartphone application to find, photograph, and map 1,429 AEDs (automated external defibrillator) in public places [27]. The results will be used to help bystanders and emergency service operators locate AEDs in an emergency. Challenge participants were given a custom smartphone application to use to photograph the AEDs and enter information about their location and accessibility. Participants received monetary prizes as incentives. Data submitted was verified by matching the phones’ GPS coordinates in the photographs presented with the GPS coordinates of the location.

UNESCO has been making use of online crowdsourcing to help achieve Education for All [28]. By enabling people with similar interests to collaborate, crowdsourcing initiatives offer an opportunity to help others, learn something, and gain recognition. With these practices, community-based projects become exercises in collective problem-solving [28]. A project on crowdsourcing girls’ education in Ethiopia and Tanzania, launched in July 2011 (funded by the Packard Foundation), took a community-based approach to lowering drop-out rates in secondary schools in those countries by encouraging girls and their communities to propose solutions to obstacles preventing girls from completing secondary education.

In numerous countries, initiatives for crowdsourcing crisis information and managing crisis responses have been implemented. Ushahidi is a mapping tool [50] that enables the public to communicate crisis information via SMS, e-mail, or web entry. Consequently, the data received from the public is time-stamped and geo-tagged to

create a crisis map to report incidents to multiple organizations engaged in crisis response.

Wakamiya et al. [33] analyze urban characteristics in terms of crowd behavior by utilizing crowd lifelogs in an urban area. In order to collect crowd behavioral data, they utilize Twitter and model crowd behavior on the social network sites as a feature that will be used to drive crowd-based urban characteristics and analyze significant crowd behavioral patterns using a large number of geo-tagged tweets found from Twitter in Japan.

3.2 Mobile Crowdsourcing

"Mobile crowdsourcing is a new trend"

A remarkable trend in crowdsourcing is the use of mobile devices: these break the time and space barriers between people and enable them to share information and knowledge [17]. With the popularity of mobile social networking and the emergence of ideas like participatory sensing, mobile crowdsourcing has the potential to help tackle an array of new problems that involve real-time data collection from and coordination among a large number of participants [17]. The unique benefits of mobile technology in ubiquity, media convergence, and global mass reach will continue to drive new, innovative crowd-based concepts over mobile [3].

Some innovative start-ups or projects include [3]:

- *Cooperative traffic*
- *Geo-social networking*
- *Product-testing*
- *User-generated content*
- *User experience optimization*
- *Leveraging mass reach*
- *Retail information and loyalty schemes*

Most of the above-mentioned service examples position themselves as a service platform or marketplace, rather than as content publishers, vendors, or mobile retailers. This is an important success factor, as it gives users a sense of ownership and incentivizes them to contribute information, content, or volume to the service [3].

Mobile crowdsourcing is an increasingly popular mechanism to realize applications that harness a large volume of real-time data to improve daily life. Most mobile crowdsourcing services are currently in a build-up phase and some may not yet have a clearly defined monetization model, especially if they represent a breakthrough concept (e.g. Twitter). Generally, the commercial model needs to take into account the service value proposition and there does not appear to be a one-size-fits-all model. In many cases, some services hope to first build up the user base before entering into monetization. If the service is to be fee-based, it is essential to clearly state the payment terms and schedule in order to avoid user confusion [3].

3.2.1 Initiatives

Yan et al. [12] have demonstrated "mCrowd", an iPhone-based mobile crowdsourcing platform, which enables mobile users to post and work on sensor-

related crowdsourcing tasks. mCrowd enables mobile users to fully utilize the rich sensors with which the iPhone is equipped to participate and accomplish crowdsourcing tasks with the most popular crowdsourcing services.

Väätäjä et al. [13] conducted two user studies to support the development of future mobile crowdsourcing processes and mobile tools for news reporting, when reader reporters are involved as crowd workers and conduct location-based assignments. The findings revealed that SMS messages were experienced as an easy and handy means for news assignments, whereas a customized mobile client prototype was preferred for the submission of multimedia content.

A mobile application called "txteagle" [34] is a system that enables people in Africa to earn small amounts of money by completing simple tasks (such as translation, transcription, and surveys) on their mobile phone for corporations who pay them in either airtime or mobile money.

Mobile crowdsourcing can also be harnessed to design smart parking solutions. Chen et al. [17] have investigated the use of information collected through crowdsourcing for parking guidance, which is integrated into a road navigation system (as a design alternative to lower the cost of installing and maintaining a dedicated infrastructure). The basic idea behind the design is to build a system that acquires possibly approximate or aggregate parking availability information through crowdsourcing: each participating driver helps with data acquisition. In return, either the system provides the aggregate parking availability map and users make uncoordinated decisions, or the system provides customized recommendations for parking locations and navigation to the participants, and thus attempts to coordinate their behavior.

3.3 Crowdservicing

"Everyone as a service"

The crowd-based model aims to incorporate the information, knowledge, and skills of the crowd. According to Davis [1], we are witnessing the transition from crowdsourcing to crowdservicing, which echoes Petrie's [2] prediction of *"everyone as a service"*.

Davis [1] states that the intuition driving crowdservicing is similar to the evolving vision of Web 3.0, which is based on the balanced integration of diverse services provided by human agents and machines over the World Wide Web. Crowdservicing therefore lets us create platforms on which we can build new applications and even enterprises. Davis [1] states that we must construe human agents as more than just creators, annotators, exposers, and consumers of content and services in order to realize the full potential of crowdservicing. In many situations, human agents can provide all or part of a badly needed service.

Davis [1] suggests that perhaps the most exciting prospect that crowdservicing offers is the possibility for radically altering the landscape of service delivery on a global scale. This is the scenario that Petrie [2] has developed, according to which "*every connected individual is or can potentially become a service provider*".

Davis's [1] prediction is that work done with crowdservicing will bear fruit in **less than five years**. The infrastructure's softer side comprises a potentially large number of human agents with Internet access, possessing diverse information, human-computation capabilities, and the willingness to contribute these in appropriate terms. Furthermore, this valuable resource can only grow with time, as more people worldwide become connected, and the digital divide narrows.

A survey of the cutting-edge research and entrepreneurial landscape suggests that an emerging convergence exists around this concept, even though consensual vocabulary and language have yet to congeal [1]. It is also an indication of the progress made on the long journey to devise better paradigms for complex problem solving.

According to Davis [1], crowdservicing has the potential to effectively harness the machine's enormous raw power and the crowd's genius. It can also spawn new business models and start-ups. More importantly, it can assist us in tapping into the vast, unused capacity in the deep recesses of the collective human brain for societal benefit [1].

3.4 Open Data

In recent years, open data initiatives have emerged, and are now available in several countries/cities. Such initiatives consist of opening and sharing the public data of a country/city. The genesis of these initiatives comes from the acknowledgement that cities or, more generally, public administrations store a large amount of data, which belongs indeed to citizens. This data is used to accomplish the missions of administrations. It was originally almost restricted to administration usage because it was on physical media stored in archive rooms. But with the help of new digital technologies, this limit is removed. Opening the public data to the web meets the requirements of transparency required by citizens; in addition, the latter can re-use this information to develop added-value services and applications. Thus, open data gives new opportunities to interconnect information in a digital city.

3.4.1 Initiatives

Davies [24] considers what an open data initiative is and what its building blocks are. Successful open data initiatives involve more than just putting datasets online; they work to make data more accessible and re-usable. Initiatives can have a range of goals: anything from promoting transparency and accountability to stimulating innovation and economic growth. Open data initiatives can be led by governments proactively releasing data they hold, or they may be led by private actors or civil societies, who collate relevant public data in ways that make it more accessible. Initiatives can focus on a specific topic, collating data from across multiple authorities, or initiatives might be centered on a particular geographical area or institution, seeking to increase access to all the datasets relating to a particular region, state, or government body.

There are many potential gains from open data initiatives [22]. Open data enables accountability, since it is difficult to hide something if the facts are visible for everyone. Open data empowers communities through the shared truth about crime

rates, educational achievement, social services, and so on is laid bare. Open data drives economic growth as more small companies spring up that extract useful information from data. Open data may lead to more accurate conclusions and better decisions, as a wider variety of interested parties have the opportunity to examine the facts [22].

Many city governments are looking for new ways to share civic data and use it to serve city residents via web and mobile applications. Cities are releasing their data sets in several areas: geo-spatial (roadways, rivers, etc.), transit (train, bus, etc.), recreation facilities, regional crime, infrastructure, city operational data (trash pickup, street light repair, snow removal, etc.), and so on.

Crime maps are one example of the open data initiatives. As an example, the "How Safe Is Your Suburb?" application [23] mashes data from the NSW Bureau of Crime Statistics and Research and the Australian Bureau of Statistics. It can be used by residents, local governments, state and federal government, researchers, non-government agencies, and crime and policy makers to better understand the meaning of the statistics.

However, crime maps illustrate the sort of problems that can arise from the open data initiative [22]. The creation of online crime maps has been a clear public benefit, showing the police where resources should be concentrated and helping them to improve their tactics, while the public can identify risky areas to avoid and demand more police action if necessary. But there have been problems; for example, respondents have been found to have seen a crime but not reported an incident because they feared it would make it more difficult to rent or sell their house.

Thus, the very act of publishing the data influences the quality of future data.

3.5 Internet of Things

Relying on sophisticated architectures in which intelligent devices (Internet of Things) are seamlessly integrated into the Internet of Services creates a whole new and innovative market for new services for sensing and reacting to the physical world (medical, agricultural, environmental, energy-related, etc.), and the web-based service industry will leverage the Future Internet in providing a new service experience to the users. Everything gets connected based on three different drivers: people, businesses, and societies drive this ongoing development of the world.

From the *people*'s perspective, end-users are continuously looking for new things. Their hectic lifestyles are impacted by digital technologies. Networking, personalization, and mobility will support transformation of user patterns. New applications will enable the lifestyle of the future. Safety, convenience, and applications related to personal health – these are the drivers for these new consumer applications.

From a *business* perspective, enterprises are continuously looking for solutions that improve productivity and efficiency, and ICT will be critical for sustainable competitiveness. New applications will support industrial and business processes, and help the businesses manage their assets.

From *society*'s perspective, the role of new technologies, connected intelligent devices, and new information highways is becoming very strong in the notion of the development of a sustainable society. Sustainability will be at the top of political and business agendas.

An underlying fundamental enabler that supports this development is the technology evolution. There are two very important factors: broadband is everywhere and the cost of connectivity in a device is coming down dramatically. This means that if there is a benefit in connecting a device from a usage or business perspective, it will be connected!

At present, the IoT market is in a very early stage, with fragmented solutions targeting specific vertical domains and/or specific types of applications [26]. The current solutions are also characterized by a variety of proprietary platforms, protocols, and interfaces, making the components of solutions by different vendors barely compatible, while keeping the prices of the components high. Standard protocols and interfaces are also either available or being developed, but no single dominating set of standard protocols, interfaces, or platforms has emerged yet. The lack of a generally accepted dominant design and the resulting high costs of the solutions, along with the lack of reference architectures and the lack of vendor-independent guidelines on how to choose the solutions or their components, inhibit the wider adoption of the IoT technologies [51].

3.5.1 Initiatives

The variety of IoT technologies can be conventionally categorized into tagging things, sensing things, and embedded things [52]. *Tagging things* provide seamless and cost-efficient item identification, allowing the things to be connected to their records in databases. *Sensing things* give the possibility to measure the physical status of our environment and detect a change therein. *Embedded things* make available the information about the internal status of the embedding object. Over the last decade, these technologies have been developed rapidly, often focusing on a specific application domain, such as the radio-frequency identification (RFID) solutions in retail, mobile machine-to-machine (M2M) communication, and machine-type communication (MTC) in remote automated meter reading, wireless sensor and actuator networks (WSAN), ubiquitous computing, web of things (WoT), and ZigBee communications in a smart home, among others [26, 53].

Most common scenarios for IoT domains are often related to the **digital home domain**, including building and home automation [26]. The vision is that all electrical devices in a household are integrated and controlled through a network, with the purpose of offering enhanced energy saving, comfort, and so on. Other domains expected to bear the greatest potential within the IoT market [26] are **automotive/transportation applications**, including information sharing about road condition and traffic density, and **healthcare solutions**, including monitoring solutions supporting wellness, prevention, diagnostics, and treatment services.

According to some estimates, the service-enabling IoT firms – that is, the firms providing IoT platforms – will eventually be able to receive the biggest share of the total IoT revenues in the ecosystem [54]. At present, these ecosystems are mainly in

the formation stage, where both incumbent firms and the new entrants are cooperating and competing in the same market, and where no single firm could be identified as the leader, playing the role of a keystone or a dominator in the ecosystem [55].

The business models of the IoT firms depend on whether IoT is the main market for the firm (e.g. for a start-up focusing on smart home products) or whether the IoT is an extension of the business for an incumbent company [55]: the incumbents leverage the economies of scope by offering their customers IoT-related products, while the new entrants focus on individual niches forming around their competence-destroying innovations. It is believed that the innovative business models (of new entrants) rather than the market power (of established vendors) are likely to induce the major changes in the IoT field [26].

3.6 Challenges

3.6.1 Defining the Crowd Concept

The crowd concept must be revisited and redefined when big data opportunities become clearer. Passive crowd data collected from users' devices, or active user behavior, given explicitly by users, are examples of categories that delineate crowd-based services from the crowd perspective. But even though there may be challenges in defining the crowd concept, as in crowdsourcing or crowd-based services, the trend is toward "everyone as a service".

3.6.2 Crowd Contribution

Crowdsourcing is directed towards the crowd, which emphasizes the need for the participation of the crowd in the crowdsourcing initiative for its success. In crowdsourcing, the participation is voluntary and the contribution of a wide network of people is required for the initiative to reach a substantial scale. Therefore, sufficient crowd participation is imperative for the success of a crowdsourcing initiative. Crowdsourcing brings several new issues that arise only in the context of participatory, peer-to-peer systems [17]:

First, a naive crowdsourcing implementation in a mobile environment can lead to 'herd' behavior rather than collective intelligence, since each participant only has a limited view of their surroundings and a global picture of the physical world is not realizable. To deal with this issue, Chen et al. [17] propose '*coordinated crowdsourcing*', in which a server integrates all the information from participants and encourages them to explore unknown areas.

Second, the participation rate is more important than the volume of information that each individual contributes. Chen et al. [17] show that when the membership rate of a crowdsourcing system passes a certain threshold, the outcomes remain stable regardless of how much information each individual contributes and its accuracy. However, if the participation rate is low, a sophisticated data collection mechanism becomes necessary to compensate for the lack of data sources.

Finally, a crowdsourcing-based application might continue to increase social welfare by tolerating free riders, as long as it can maintain a moderate level of contribution

among participants [17]. In the context of mobile crowdsourcing, free riders could reduce the quality of the crowdsourcing-based service, as they might benefit from the system and change the status of the physical environment without reporting new information. However, the aggregated social benefit for all participants could still rise significantly (at the cost of a slightly degraded service quality), as long as a certain percentage of the members keep contributing their data.

3.6.3 Interoperability Issues

Data divides have consequences, as information is anything but transparent to the majority of people, even if it is technically available, online, searchable, and mashable [25]. Massive open data sets are not sufficient; ordinary people, in addition to data sophisticates, need to know what information is available and they need to know how to use it. And if people are to have anything more than theoretical access to the information, it needs to be easy and cheap to use. Data quality issues need to be raised [22], as the ability to extract meaningful information from data requires considerable skill. Without it, there is a real danger that incorrect conclusions may be drawn.

Interoperability of the services may appear as a challenge. Connecting services requires semantic interoperability and standardization The IoT field is relatively young, and is still dominated by the silos of vertically integrated solutions based on incompatible technologies, each having a relatively limited marked penetration [51, 56]. The expected rapid growth of the IoT market is contingent on the emergence of common/dominant standards, platforms, and interfaces [26]. Their emergence, in turn, depends on whether the standards and platforms being developed would match well the requirements of the specific IoT domains. In the extreme case of all application domains having “incompatible” requirements, the resulting solutions are unlikely to share common standards, platforms, and interfaces, thereby hindering the development of the IoT market.

3.6.4 Privacy and Security

For example, open data initiatives raise some concerns, where the potential threat to privacy is probably the foremost risk [22]. Reducing this is tough, as has been recognized by the government. In 2011, Cabinet Office minister Francis Maude said: *"It is my intention that no personal data will be shared with any third party as part of this initiative."* It is questionable whether this can be achieved, partly due to the jigsaw effect – the use of multiple sources of data, which can be combined to yield information about individuals.

Regarding the IoT solutions, confidentiality of private data stored at home or communicated over a home network, as well as restricted access to the control of home devices and appliances, is a necessary requirement. There is a strong need for confidentiality, integrity of data, and availability (with access control). In wellness solutions, the privacy of user data is important. The integrity and confidentiality of patient data while on the device, in transit, and on the platform, are vital in healthcare solutions [35].

4 Foresight Results

4.1 Trends

1. Emergence of a new consumer type: the working consumer [10]. Contrary to the conventional role of passive kings to be waited upon, consumers are now becoming more like co-workers who take over specific parts of a production process, whereby this process ultimately remains under the control of an organization [11] (e.g. retail loyalty schemes).
2. Emergence of a new model of computation named crowdsourcing, which harnesses human computation - *"wisdom of the crowd"*.
3. Although there may be challenges in defining the crowd concept, that is, crowdsourcing or crowd-based services, the trend is toward *"everyone as a service"* [2].
4. Emergence of distributed sensing using mobile phones, where the sophisticated sensing, processing, and communication capabilities of millions of smartphone users can be harnessed towards a common sensing goal [12]. Distributed data collection from mobile phones and other devices will produce an essential part of the *big data* trend.
5. The rise of social media platforms has shown that people want to create and share their content with others [13]. In the future, these will include the *Internet of Things* as part of social media.
6. Public organizations will provide *open data* for the creation of new services for smart cities. Cities and public authorities allow the generation of open data emerging from crowd behavior in cities. This enables a rethinking of *smart cities* of data as *learning cities*, with history and future planning.
7. Big data, including IoT, and open data trends will enable digital service mash-ups, together with crowd-based data, that is, people producing new information. For instance, energy and traffic data appears in new forms, while the ICT gluing these together can be used to create new service business models.

4.2 Challenges

1. Identifying and defining a new type of digital service for the user. *"You just can't' ask customers what they want and then try to give them that. By the time you get it built, they'll want something new."* (Steve Jobs, CEO of Apple)
2. Building the ecosystem for crowd-based solutions. Is it intentional and goal oriented or does the market decide what happens? The crowd concept must be revisited and redefined when big data opportunities become clearer. Passive crowd data collected from users' devices or active user behavior, given explicitly by users, are examples of categories that delineate crowd-based services from the crowd perspective.
3. The participation of the crowd in the crowdsourcing initiative is needed for its success - the contribution of a wide network of people is required for the initiative to reach a substantial scale.

4. The real issue is not acquiring large amounts of data, but what we do with the big data - with huge data sets and fine-grained measurement, there is an increased risk of false discoveries.
5. Successful open data initiatives involve more than just putting datasets online; they work to make data more accessible and re-useable.
6. The success of the Internet of Things will not so much depend on the development of new technologies, but more on connecting and integrating existing resources.
7. Current IoT solutions are fragmented and target specific vertical domains and/or specific types of applications – the need for common/dominant standards, platforms, and interfaces.
8. European cities need to secure high living standards through the innovation economy - smart cities must create new ways to enhance local innovation ecosystems and the knowledge economy overall.
9. Innovation ecosystems for smart cities have to be defined: help cities to identify revenue streams, broker public-private partnerships, and open public data up to developers, as well as user communities.
10. How to design intentional and directional learning cities from smart city data.

4.3 Recommendations

1. Look for creative ways to use crowdsourcing beyond idea generation, and source the challenge to the "crowd" - this applies to new digital ecosystem creation as well, where the challenge can be the deployment of a new application. Identify and nourish suitable test beds for industry.
2. Find ways to provide mutual benefit - people sharing information also benefit from that and take into account the privacy and security implications. This means work on European-level regulations.
3. Focus on interoperability of the services - dominant standards, platforms, and interfaces that match the requirements of the specific IoT domains. Encourage the standardization of technologies in research projects.
4. Assess business models – identify new value exchange and flows of revenues. Identify new ecosystems and roadmaps early, and actively build on them – (how) can we influence the transformation of them in Europe, for example with new kinds of investor relationships?

5 Conclusions

First, places were connected; next, people were connected; and now we are in the early stages of the next major inflection point for our industry: the connection of a vast array of "things". We are finally reaching the point when people are equipped with fast-speed, (almost) any-time and any-place information and communication solutions, enabling them to be connected with each other, and to interact with and through the rich world of Internet-enabled applications and services.

There is already now tremendous growth in mobile connected devices and the traffic generated by them. There is also a huge growth in non-phone and non-laptop devices, and this growth in connected devices will be dominated by the increase in machine-to-machine connections.

The result of this is the creation of an enormous amount of data. It is not just more streams of data, but entirely new ones. Thus, we are in the era of *big data*, which highlights the advancing trends in technology that open the door to a new approach to understanding the world in a new way, and making the best decisions. The real issue is not that we are acquiring large amounts of data, but it is what we do with your big data that matters. The wealth of new data, in turn, accelerates advances in computing, and by linking the communicating sensors to computing intelligence, we can see the rise of the *Internet of Things*.

In the forthcoming years, the Internet will undergo evolutions that can be expected to add billions of new connections to people and devices. The Internet of Things refers to the networked interconnection of everyday objects, where new breeds of smart services will emerge and mobile devices will assist users in managing their everyday tasks. The success of the Internet of Things will not so much depend on the development of new technologies, but more on connecting and integrating existing resources. Intelligent buildings and smart grids will provide the enabling technologies required for *smart cities*.

It is expected that soon more people will live in cities than in rural areas. The rapid growth in population poses new challenges for cities nowadays to meet objectives regarding socio-economic development and quality of life. Cities are becoming "smarter," as governments, businesses, and communities increasingly rely on technology to overcome the challenges of rapid urbanization, remarking the emergence of the concept of "*smart cities*". Cities and urban areas are emerging as innovation ecosystems, empowering the collective intelligence and co-creation capabilities of user/citizen communities for designing innovative living and working scenarios.

In addition, in recent years, *open data* initiatives have emerged, which consist of opening and sharing the public data of a country/city. Opening the public data to the web meets the requirements of transparency required by citizens and gives new opportunities for interconnecting information in a digital city.

In the future, the concept of the smart city needs to be revisited - what is the essence of smartness? It refers to the idea that cities have some goals as systems that bring

benefits to themselves. For the first time, it will be possible to collect data from such systems in a manner that can give not only a single benefit, but that can let us understand the behavior of the masses, or understand what the development opportunities in cities are – marking the emergence of *"learning cities"*. What is more, it is possible to affect the behavior through city planning and predictions, and to alleviate the problems arising from urbanization.

There is vast potential we can realize by integrating computation with human intellectual power; we can now harness "human computation" - *"wisdom of the crowd"* - in near real time from a vast and ever-growing distributed population of online Internet users. There are increasingly more entire business models that are fundamentally based on tapping contributions from crowds, where a primary source of value creation is from the crowd – hence the term *"crowdsourcing"*. According to Gartner [6], the benefit of crowdsourcing is high. The first crowd trend is "from Internet of Things to '*things of meaning*'", because people and the use context make the meaning for the systems of things.

Crowdsourcing potentially appears to significantly contribute to innovation, and it is often based on the framework of collective intelligence, the idea that knowledge is the most accurate when it consists of inputs from a distributed population – *"all of us together are smarter than any one of us individually"* [39]. Howe [46] argues that *"crowdsourcing isn't a single strategy. It is an umbrella term for a highly varied group of approaches that share one obvious attribute in common: they all depend on some contribution from the crowd"*.

With the popularity of mobile social networking and the emergence of ideas like participatory sensing, a remarkable trend in crowdsourcing is the use of mobile devices. *Mobile crowdsourcing* has the potential to help tackle an array of new problems that involve real-time data collection from, and coordination among, a large number of participants. Mobile crowdsourcing is an increasingly popular mechanism for realizing applications that harness a large volume of real-time data to improve daily life.

The crowd-based model aims to incorporate the information, knowledge, and skills of the crowd. According to Davis [1], we are witnessing the transition from crowdsourcing to crowdservicing, which echoes Petrie's [2] prediction of *"everyone as a service"*. There will be potentially large number of human agents with Internet access possessing diverse information, human-computation capabilities, and the willingness to contribute these in appropriate terms. Furthermore, this valuable resource can only grow with time, as more people worldwide become connected, and the digital divide narrows. According to Davis [1], crowdservicing has the potential to effectively harness the machine's enormous raw power and the crowd's genius. More importantly, it can assist us in tapping into the vast, unused capacity in the deep recesses of the collective human brain, for societal benefit [1].

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