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Next: the Internet of Things

Mehdi Nemri*

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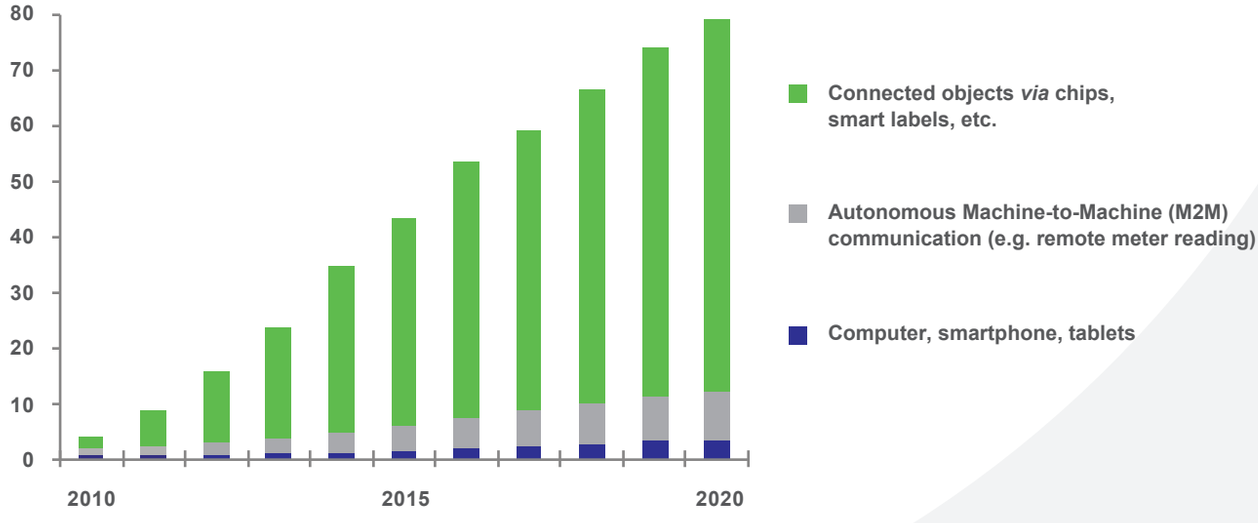
In just a few years, the Internet has become the principal means for disseminating information and an essential infrastructure in numerous domains, used by individuals, businesses and institutions. Nevertheless, there is still massive potential for expansion. Today, the Internet connects computers and mobile terminals; in the future, it will allow interaction amongst a growing number of objects, and between the objects and their users. The Internet is gradually becoming an extended network, known as the Internet of Things (IoT), connecting billions of human beings – and tens of billions of objects.

This transformation will radically alter sectors still relatively unaffected by the Internet, such as healthcare, housing, automotive and insurance: a formidable economic battle is expected in the next few years, not only for control of the platforms, but also for the sharing of value between traditional economic players and newcomers from the digital sector.

Many questions will be raised as these changes take place, regarding not only the economic growth and social transformations they engender, but also concerning individual freedoms and national sovereignty. For France and Europe to be full-fledged players in this revolution, the priority is to facilitate experimentation with projects, create an open platform within the IoT dedicated to public services, make security and protection of privacy a competitive advantage, support European industry in standardising its technologies and increase European presence in standardisation bodies.

Number of connected objects by type (in billions)



Source: IDATE (2013).

* Sustainable Development Department

English version of "Demain, l'Internet des objets", *La Note d'analyse*, n°22, January 2015;
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INTRODUCTION

The objects (known as "connected", "communicating" or "smart") composing the Internet of Things could number between 50 and 80 billion worldwide by 2020; there are already nearly 15 billion.

The recent development of connected objects for consumers indicates that we have reached a tipping point: in some sectors, "restructuring by use" has allowed digital businesses to capture a growing portion of the added value of a given product or service. This transformation is already underway in the cultural, tourism and audiovisual sectors, and is taking shape in transportation and healthcare. Although France is currently well-positioned in the domain of connected object design, the absence of European digital platforms to support the objects' dissemination and use means that we will soon face issues concerning value sharing, as well as the survival of activities historically based in Europe.

As a follow-up to the study *La dynamique d'Internet, prospective 2030* (The dynamics of the Internet, prospective 2030)[1], this *Note d'analyse* provides a panorama of the IoT and shows how this sector is maturing: it is clearly a source of opportunities, but also of uncertainties.

THE INTERNET OF THINGS: WHAT IS IT?

Interconnected information sensors

In the professional world

Logistics and distribution chains were the first to integrate electronic chips in products to ensure traceability and optimise their operations, in particular maintenance activities and energy consumption. Some are even testing the deployment of wireless beacons in stores (*iBeacon*) to transmit personalised information to customers and guide their purchasing process.

More generally, the IoT provides the means for companies to rationalise their internal processes, guiding business strategy with the information collected (e.g. on purchase motivations, customer satisfaction with the service or the customer's path through the store). In the manufacturing sector, "connected factories", known in Germany as "Industry 4.0", in the United States as "Smart Manufacturing" and in France as "L'usine du future" (the factory of the future) will become a benchmark over the next few years.

In the public space

Several cities (*Songdo* in South Korea, *I-City* in Malaysia) are deploying IoT technologies to meet challenges concerning energy and urban development. In these cities, lighting, traffic, waste collection, air quality and fluid distribution are continuously analysed and optimised. Public services management is designed to be more predictive and automated, leveraging information collected by sensors deployed in public spaces and transmitted to the city's information systems. Urban services also gain efficiency: transport systems run more smoothly, street lighting is optimised and exposure to pollution is reduced.

In private life

The dissemination of objects in private life is more uncertain. Connected objects are beginning to be part of individuals' daily activities, measuring their health data with "wearable devices", or helping them to better understand their environment – home, car, office, etc. But most people do not presently perceive a significant practical value for these connected objects.

Connected bracelets and watches are a particularly good illustration of this lack of utility, with users quickly deeming them obsolete and abandoning them[2]. Connected objects in the home have also been the subject of initiatives, thus far inconclusive, such as the connected refrigerator. The key will certainly be to make the devices appealing and user-friendly.

A new technological use of objects

From owning goods to the use of services

A connected object has greater value: the additional value of the service provided based on the digital connection can exceed the value provided by the unconnected object. This new valorisation logically draws traditional players and service providers closer, to offer services with high technological content, but also to compete for revenue sharing.

Additional services will be offered that bring the user closer to the service provider, resulting in very rapid dissemination *via* network effects. Service providers will be the big winners, as 80% of added value in OECD countries produced in the Information and Communication Technologies sector (ICT) is generated by services[3].

1. Gille L. and Marchandise J.-F. (dir) (2013), *La dynamique d'Internet.* Prospective 2030 (The dynamics of the Internet. Prospective 2030), study carried out for the Commissariat général à la stratégie et à la prospective, Paris, Études, n°1.
2. Arthur C. (2014), "Wearables: one-third of consumers abandoning devices", *The Guardian*, 1 April.
3. Siné A., Hausswalt P. and Garcin C. (2011), *Le soutien à l'économie numérique et à l'innovation* (Support for the digital economy and innovation), Inspection générale des finances.

The reorganization around information exchange platforms

All connected objects are part of a community: a car will interact with surrounding cars, as well as the driver, insurer, mechanic or emergency services. Wearable objects exchange data *via* social networks, as is already the case with the *Jawbone* bracelet.

These platforms will play a key role in structuring the sector because, besides managing data exchanges, they also bring together the players in a connected object community – developers, suppliers, users, managers of services, etc. They thereby provide access to services that can be improved based on user feedback and usage data.

Digital companies like Google are therefore already seeking to develop the platform for the IoT: for cars, with Android *Auto* to give the driver direct access to the services of their Android phone from the dashboard; in wearable devices with *Android Wear* to provide digital services such as e-mail, messaging and social networks; or in *Google Fit* to consult health-related data measured by its objects.

Ten platforms of the future, according to *L'Usine Nouvelle*

Android Wear: Wearable Google. *This OS* was designed for "wearable technology," particularly watches and smart clothing.*

Windows 10: *for every kind of screen. Version 10 of Microsoft's OS will be unified for all screens, from PC to connected object and for objects with a visual UI.*

QNX: BlackBerry's new asset. *The Canadian company is attempting a comeback via connected objects, with QNX, acquired in 2010. This solution is already being used in some automobile systems.*

Tizen: Samsung's bid. *This OS, supported by Samsung and Intel, may have a new chance at success following its failure on smartphones. It will equip connected bracelets and TVs.*

Contiki: the king of measurement. *From the Swedish Institute of Computer Science, this open source OS was designed specifically for wireless sensor networks.*

FreeRTOS: the real-time champion. *This open source OS for microcontrollers allows execution of a large number of tasks simultaneously and managing priorities in real-time. It is particularly aimed at objects incorporating several types of sensors.*

TinyOS: for micro-objects. *This OS is well-adapted for miniature systems with very little memory, i.e. basic sensors. However, it is not a real time system and is not scalable.*

VxWorks: flexible and modular. *Designed for embedded computing and robotics, the architecture of this proprietary software from Wind River has been adapted in order to equip varied types of connected objects, in particular objects with a visual UI.*

RIOT: the Linux of connected objects. *Stemming from academic research in France (supported by INRIA) and Germany, it can theoretically run on any type of connected object, with or without a screen.*

LEPTON: small but tough. *This French real-time OS has been used for more than five years in industry. Its designers have made it more flexible in order to equip a wide range of objects, with or without visual UI.*

* Operating System.

Source: S. Arnulf, « Quels OS pour les objets connectés ? » (Which OS for connected objects?), *L'Usine nouvelle* n° 3402, 11 December 2014.

The sector's economic structure reveals one of the strategic risks faced by traditional businesses. The examples of car manufacturers, some of whom chose Google and Apple platforms[4], and companies such as Withings (specialising in connected objects for healthcare) which have initiated a partnership with Google Fit and Health Kit platforms, indicate that traditional players will select platforms created by players from the digital sector. This gives these players several advantages: they will benefit from additional revenues generated in the sector concerned and access to usage data that will give them an extra competitive edge. This scenario will have the direct consequence of marginalising players who have not opted for their platform.

Data: creator of value

Data is the key element of some platforms' business models. Analysis of their users' needs by studying the "digital footprint" left by Internet use allows targeting advertisements to users and offering them a service that is not only personalised, but sometimes, also geo-localised. This will be a strategic battleground for the Internet of Things. Knowledge about customers can go a step further if data produced by the objects can be accessed, providing information about the user's habits, preferences and relationships. Major players in the digital sector have already understood the importance of controlling the users' digital

4. However, others, such as Renault and Nissan, have hired Digitas LBi (London) to handle their new global digital platform.

footprints and augmenting their volume. Some are now trying to take control of how objects are identified.

The battle over the objects naming standards

An object must be identified by another in order to exchange information. Objects are therefore given one or more identifiers. The GS1 System was the first to offer object identification technology, seeking to replace bar codes with RFID tags providing a unique mapping of an object's logistics information to an URL. Major Internet players are also very interested in object naming: Cisco has acquired Evrythng, a British startup that offers active digital identities for objects; Google has announced its Physical Web project to uniquely associate an URL with an object[5]. Public authorities must control these object naming technologies in order to head off concerns about openness and universal access to services in the Internet of Things.

A SECTOR HEADING TOWARDS ECONOMIC MATURITY?

From a technical point of view

Around smartphones?

The IoT requires systems that manage the connected objects and analyse their usage. The maturing of the smartphone market will, *a priori*, encourage IoT players to structure themselves around these devices. They already centralise a growing volume of data and services related to digital products, and their graphic UI can control connected objects via dedicated applications.

However, it is not certain that smartphone platforms will be needed as intermediaries. The smartphone will only have this role if the associated ecosystems remain dominant and if the platforms of forthcoming connected objects (watches, glasses, TVs with Internet box, tablets – which are just a further development of smartphones) do not compete by providing ecosystems that are more attractive. Another possibility would be the adaptation and dissemination to the general public of industry-oriented platforms.

Around the *cloud*, *Big Data* and architectures to support connected objects

The proliferation of heterogeneous connected objects requires growing amounts of computing power for processing data and the use of remote services for storage and content analysis. Technologies like artificial intelligence will therefore be increasingly integrated in information systems[6].

Another imperative is to guarantee acceptable response time for objects that exchange data with the *cloud*, to avoid slowdowns. The forthcoming 5G standard should allow more dynamic management of resource exchanges and smoother, real-time data transmission modes.

Finally, to interconnect dissimilar objects, architectures that incorporate strong constraints for adaptability, security and latency must be developed. The exchange of data with a very consistent size and format can drive the creation of specific market niches. For example, low-throughput telecom operators like Sigfox and M2oCity have positioned themselves to transport small data packets.

Around interoperable technologies: standardisation

Standardisation of interoperable technologies promotes wider dissemination of solutions. Several projects are being carried out in this regard, around industrial clusters such as the Allseen Alliance, the Open Interconnect Consortium and the Industrial Internet Consortium, and standards organisations such as ETSI[7] and NIST[8]. *De facto* standardisation strategies are also executed in parallel by major digital players like Apple and Google.

Given the heterogeneity of applications, it is likely that multiple standards will coexist. The lack of major European players presents the risk of standards being imposed that do not respect European ones. This makes it all the more important to have a strong European presence in the forums where standards are discussed and defined.

Around future technologies

One of the key technologies for the IoT, RFID (Radio Frequency IDentification), demonstrates that the emergence of new technologies sometimes gives rise to a convergence of disciplines that might appear unrelated, such as computer science, biology and medicine. Wireless communication technologies, for the most part still under development, could be incorporated into specific solutions: there are already connected contact lenses that measure glucose in the human body and tattoos that communicate a patient's vital signs. What seemed unthinkable yesterday is possible today: the Cyborg 4.0 project at

5. Source: Proximamobile.
6. *Ibid.*
7. European Telecommunications Standards Institute.
8. National Institute of Standards and Technology.

Reading University focuses on communication between humans *via* brain implants. In view of continuing improvements in IoT technologies, society must address the question of what normative technological framework to apply.

A "right to experiment" for innovation in the Internet of Things?

One way to promote innovative companies' development would be to allow them to rapidly test their project under real conditions to evaluate its limits concerning security, respect for privacy and, more generally, the limits of the solution. To this end, they would operate, in a temporary and supervised manner, outside of constraints imposed by regulations. A specific regulatory framework for this experimental phase would be defined and inserted in the existing legislation, providing exceptions within precise limits for certain innovative companies.

From a social point of view

Rethinking mobility

The smartphone boom has made digital services available to users in any location, rather than solely from their desktop. This transformation, associated with the development of the IoT, should lead to the emergence of a vast number of new services.

Auto manufacturers (or other players) should offer support and monitoring services based on connectivity; this could eventually develop into automated driving[9].

Revamped Health Management?

Some objects (e.g. scales, pedometers, bracelets, watches), once connected, will allow us to better understand our habits. Combined with software specialised in genetic code analysis, such as *Pathway Genomics* and *23andMe*, they will help to provide detailed knowledge of people's health without recourse to a specialist.

Using sensors, a doctor will be able to remotely monitor a patient's health, make a diagnosis and provide care. The interconnection of domestic objects will also allow improved comfort and quality of life for dependent persons at home. These developments will all call into question the organisation of healthcare and the role of health professionals (e.g. doctors, pharmacists).

A redefinition of the foundations of insurance

Detailed and continuous monitoring of an individual's behaviour by sensors will give rise to a radical paradigm shift for the insurance industry: the insured party will pay to cover an individualised risk, based on his behaviour. Much more than today, insurers could reward good behaviour or penalise bad behaviour. One could even imagine insured parties renegotiating their premium if they consider their behaviour to be trustworthy. Insurers will rethink their model, forging closer ties with producers of connected objects that will give them access to data. Some actual examples foreshadow this scenario: AXA offers insurance called "e-Modulango" whose conditions allow clients to benefit from the Withings Pulse vital signs monitor; TomTom offers insurance in partnership with Motaquote, a British insurance company, with a premium based on driver behaviour.

Protection of privacy and security of transmissions

The use of objects that are increasingly capable of collecting personal data increases the risk of infringing personal privacy and security[10]. If broad use of such devices plunges society towards an Orwellian nightmare characterised by constant monitoring of individuals' activities, the gravity of this situation could lead people to reject the deployment of these technologies.

The arrival of connected objects is already generating fears of weakened protection for personal data, as shown by a Havas Media study (January 2014), with particularly resounding repercussions from revelations about monitoring carried out by the US National Security Agency. In a context where broadened network connectivity places every digital device under the threat of new forms of cyber-attacks, we must strengthen and reaffirm people's rights and develop technologies that will respect those rights.

From an economic point of view

New management models

Services related to connected objects require contemporary economic logic to be re-examined. Traditional businesses must adopt a more horizontal structure to promote information dissemination and the taking of personal initiatives. They must also increase investments in innovation and in deployment of IT tools. Digital solutions require a very flexible organisation that responds quickly to the changing needs of the user.

9. *Série Robotique – 1 – Les révolutions en chaîne de la voiture sans conducteur (Robotics Series – 1 – The series of revolutions concerning driverless cars)*, 19 June 2014, Paris Tech.
10. See the opinion of the European Data Protection Authorities (G29) on the Internet of Things, adopted on 16 and 17 September 2014.

Companies that fail to adapt their production and organisational models to these transformations will see the value generated by their activities decrease, perhaps to zero. These new models will show strong similarities to those for the current digital economy, in particular based on the valuation of analysed data and the sale of additional applications or services in order to create a link with the user.

Capturing value with platforms

The emergence of digital platforms available to any economic player will profoundly disrupt established business models and massively redefine the value chains. The arrival of new players – telecom operators, technology SMEs and leaders in the digital sector – will drive traditional players to develop their own applications, with the risk of being marginalised, or to form closer ties with these players and benefit from the existing ecosystem. Orange (a major French telecommunications firm) demonstrated its understanding of this challenge by announcing, in 2014, the launch of its *Datavenue* platform for connected objects. States must also position themselves in the midst of these developments.

An open platform, dedicated to public services

Public services should be major users of the IoT, in particular the healthcare sector and the day-to-day urban management. Production of applications and data collection will likely be decentralised, under the responsibility of the cities or services concerned. To benefit from these innovative projects, while preventing duplication of effort and mutual incompatibilities, applications that are developed, as well as data, must be organised around open platforms, and access must be given to other public authorities. An example of this sharing is the certification of applications that respect standards for protection of personal data and security. This "app store" for public services would also provide access to this large customer base for businesses that produce outstanding products.

How is France positioned?

Numerous French startups and SMEs producing connected objects, such as Netatmo, Parrot and Withings, as well as operators like SigFox, have already gained international recognition. Of the ten best-selling connectable objects for iPhones in the App Store, four are French, and several French connected objects won awards at the Consumer Electronics Show (CES) in 2014, but international competition appears tough.

Bpifrance is the leading investor in French companies producing connected objects, with €82 million already invested in 43 connected objects. On 12 September 2013, connected objects were singled out as one of 34 industrial priorities by the Ministère du redressement productif (French ministry for industrial recovery). Six actions were approved in June 2014, including one to create a "connected city" in Angers.

However, the European Union lacks a true industrial vision; the IoT was first discussed at the *Internet of the Future* ministerial conference held in Nice in 2008. The European Commission published a communication in 2009 designating the sector as a "*vital resource for the economy and society*" and proposing a right to "chip silence" that would allow users to disconnect their objects from the network. Nevertheless, this communication did not give rise to any significant action except a public consultation on the governance of the IoT in 2012, whose results were published in early 2013[11]. Since 2008, €70 million have been invested to fund more than 50 research projects[12]. However, standardisation structures remain too administrative and unresponsive; SMEs are poorly represented. Participation in the standardisation process imposes significant costs on businesses. This hinders small players in favour of large groups.

International comparisons

The United States

US startups, such as Fitbit and Jawbone, specialising in connected wristbands, are already major producers of connected objects. GAFAM position themselves as platforms, with a strategy combining external growth and adaptation of their digital technology; traditional Internet companies like Cisco, IBM and Intel are investing in the sector through partnerships.*

The US government addressed this subject when issues of security and privacy were raised by the FTC[13]. This concerns Cyber-Physical Systems (CPS), thus broadening the scope of the question from the interconnection of objects to that of their control. For now, few government-financed projects have produced significant results. In December 2013, the NIST (National Institute of Standards and Technology) launched the "SmartAmerica Challenge" with $500 million in funding in order to "accelerate advances in [CPS] by providing a venue for innovators to present concepts for interconnected CPS technology, programs, and test beds […]." ".

11. Conclusions of the Internet of Things public consultation.
12. Figures from 2013. See: Fidler M. (2013), *Ubiquity, Interrupted? European Governance of the Internet of Things as an Emerging Technology*, Stanford University, July.
13. Federal Trade Commission, Chairwoman Edith Ramirez (2014), *Protecting Consumer Privacy in a Big Data Age*, The Media Institute, Washington DC, May.

China

In 2009, Prime Minister Wen Jiabao delivered a speech in the city of Wuxi calling for rapid development of the sector and for a proactive policy to position China amongst the global leaders for the IoT. This city now boasts 1,000 companies with 100,000 employees, generating €10 billion in annual sales. Wuxi is the site of nearly 40 production centres and collaborates with the army and the National Development and Reform Commission (NDRC), the national planning agency responsible for the implementation of China's economic policy.

The Internet of Things has been included in China's 12th Five Year Plan (2011-2015) as one of seven strategic areas for priority development.

* Google, Amazon, Facebook, Apple and Microsoft

CONCLUSION

We are far from being able to predict the precise form that the IoT sector will take. Convergence with nanotechnology, biotechnology, artificial intelligence and robotics will have a significant impact on its development. Numerous French SMEs, some supported by public authorities, seek to take a leading position. However, considerable financial resources are being mobilised in the United States and China.

Many actions are already underway in France: the government's "Plan objets connectés", its industrial strategy; competitiveness clusters; better access to funding for startups; promotion of the *French Tech* quality label for French high-tech businesses; improved coordination of government information systems and management of public data. These actions must be strengthened, coordinated – to get past the "silo mentality" – and extended at European level to ensure the development of an open, interoperable Internet of Things that addresses issues of personal data protection and security.

Keywords: Internet of Things, IoT, connected object, digital, platform

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Press contact:
Jean-Michel Roullé,
Head of publications and
communication unit
+33 (0)1 42 75 61 37
jean-michel.roulle@strategie.gouv.fr

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