2

IoT Ecosystems Implementing Smart Technologies to Drive Innovation for Future Growth and Development

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"What is it good for, if not for Human Mankind?"

2.1 Introduction

In the early 1990s, James F. Moore was at the origin of the concept of business ecosystems [1], now becoming an interesting approach for the design of Internet of Things (IoT) evolution and deployment.

Moore defined "business ecosystem" as "an economic community supported by a foundation of interacting organizations and individuals – the organisms of the business world. The economic community produces goods and services of value to customers, who are themselves members of the ecosystem. The member organisms also include suppliers, lead producers, competitors, and other stakeholders. Over time, they coevolve their capabilities and roles, and tend to align themselves with the directions set by one or more central companies. Those companies holding leadership roles may change over time, but the function of ecosystem leader is valued by the community because it enables members to move toward shared visions to align their investments, and to find mutually supportive roles".

Given the current state of IoT evolution, and the complexity of IoT systems and actors involved, applying the concept of ecosystem is highly promising; in particular for two reasons:

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[2]The views expressed in this article are purely those of the author and may not, in any circumstances, be interpreted as stating an official position of the European Commission.
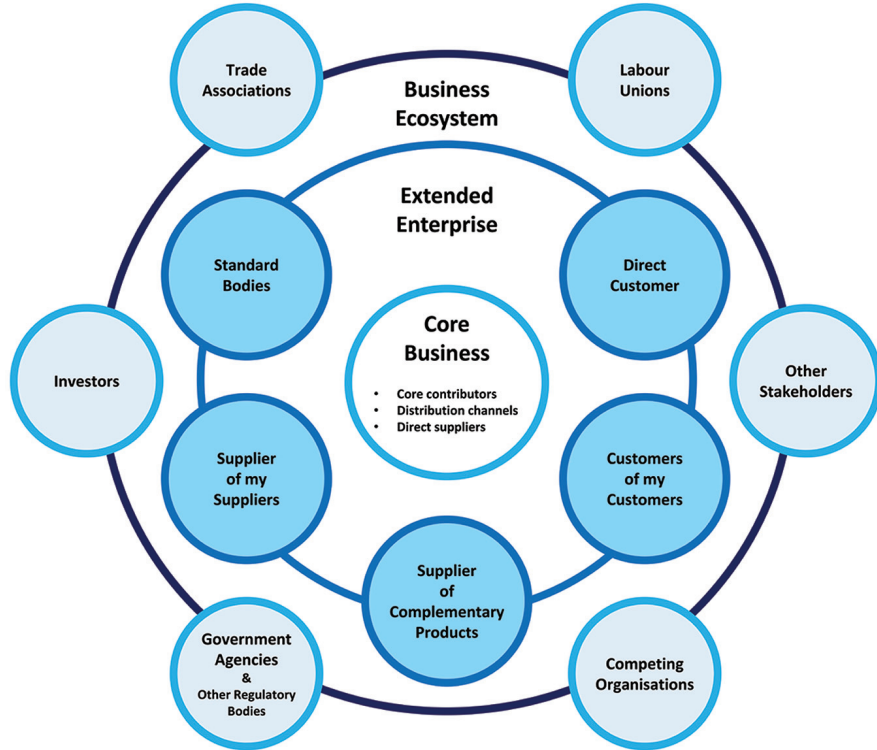
Figure 2.1   Business ecosystem [1].

- the nature of IoT itself prompts towards new ways of conceiving ICT systems, and changing the understanding of business and interaction processes and,
- a multitude of service providers involved whose role can change over time.

The European Commission has thus decided to apply this concept for its current IoT research and innovation policy. This concept is often similarly specified as either IoT Ecosystem, IoT Innovation Ecosystem or IoT Business Ecosystem; for reasons of simplicity we will talk here only about IoT Ecosystems (used in plural as there will be one or more IoT Ecosystems). Although this concept is certainly of universal nature, we will focus on IoT Ecosystems with a European center of gravity – less in the sense of a limitation but more as an operational vector of European values.

As the concept of IoT includes both a vertical and a horizontal dimension, a key feature of an IoT Ecosystem will therefore be the dynamic

interaction between the providers and users of horizontal IoT platforms and applications and the providers and users of vertical solutions/domain-specific environments. Evolution of the IoT will also bring new devices to the market, around which IoT Ecosystems will take shape, and the IoT will act as an essential driver for innovation and competitiveness. More jobs are expected to be created, driven by the need for developers to work on applications and interfaces. While today around 300,000 developers worldwide contribute to the IoT, a new report by VisionMobile [2] projects 4.5 million developers by 2020, reflecting a 57% compound annual growth rate and a massive opportunity. As a consequence, the need is arising for well-educated employees in terms of education and training in the EU, having the necessary digital and interaction skills.

2.2 Support for IoT Ecosystem Creation

Whereas it might very be tempting to apply observations from natural and biological ecosystems onto human social and economic systems, several factors indicate that a one to one translation is not directly possible – humans through their brain evolution have a different understanding of existence that other species in natural systems whose primary objective is survival.

Figure 2.2   Self-organising systems [9].

Moreover, the necessary system thinking for ecosystems is a radical change compared with a former system thinking from the last century, where the control paradigm and a more technical understanding of systems were principally dominating. In modern system theory, this understanding has been replaced by an evolutionary approach and the vanishing of the idea of a central controller. The present system thinking is based on self-organisation, self-reference, co-evolution rather than opposition, and a more dynamic understanding of time. Following this approach, the influence of IoT Ecosystems is possible through the setting of boundary conditions; however, any direct influence should be avoided as the ecosystem will resist or ignore this input [3, 4].

In order to provide suitable boundary conditions for future IoT Ecosystems, the European Commission, since 2014, has launched the following actions:

- Stimulation of IoT Community building through the IERC – IoT European Research Cluster, in particular extending the outreach of ongoing projects through platform creation and international cooperation.
- Preparation for the creation of an industry-driven Alliance for IoT Innovation which was established in 2015 and counts today 500 members and 13 dedicated workgroups, based on the condition that members should possess a strong foothold in Europe.
- Launch of a 51 MEUR call for proposals on large projects for IoT Ecosystems in 2014 as part of the innovation programme Horizon 2020, linked to platforms for connected and smart objects. This call included from a systemic perspective a mix of Innovation actions and complementary Support actions for overcoming the fragmentation of vertically-oriented closed systems, architectures and application areas. Up to 10 MEUR were targeted to SMEs and start-ups working with these platforms.
- A series of community building events, gathering more than 300 people for discussing the call for IoT Ecosystems and providing a platform for federation and a learning space.
- Preparation of an IoT Large Scale Pilot innovation programme with a corresponding funding of around 100 MEUR for 2016–17, addressing Smart Agriculture, Assisted Living, Wearables, Smart Cities and Connected semi-autonomous cars. This will be coupled with a dedicated subsequent call on future IoT architectures, concepts, methods and tools for open IoT platforms advanced concepts for end-to-end IoT security and privacy (35 MEUR).

- Fuelling the IoT community with input from leading and large IoT-deploying regions such as Japan, Korea, and Brazil through joint calls.
- Opening of the IoT innovation area to new players from the Cloud, Big Data, Semi-autonomous systems and 5G domains, and to creativity and art – makers, innovation hubs, geeks and artists (not to forget the STARTS [5] initiative).
- Creation of an IoT Focus Area for improving coordination across Units, Directorates and Directorate-Generals of the European Commission and for providing a more centralised entry point to IoT.

These activities are complementary with various IoT initiatives in European Member States and should not be perceived in isolation to further European initiatives such the Digitising European Industry strategy.

2.3 Spurring Innovation in Lead Markets

With industry players all battling to "own" customers and their data, the IoT market looks chaotic and fragmented.

Tangible business opportunities for IoT technologies can be found across all "smart" environments identified by various experts. By combining estimated market size and growth potentials, some of these environments have emerged as offering the most realistic opportunities between now and the coming five years.

The challenge is to foster the deployment of IoT solutions in Europe through integration of advanced IoT technologies across the value chain, demonstration of multiple IoT applications at scale and in a usage context as close as possible to operational conditions. Compared to existing solutions, the roadblocks to overcome include i) the integration and further research and development, where needed, of the most advanced technologies across the value chain (components, devices, networks, middleware, service platforms, application functions) and their operation at large scale to respond to real needs of end-users (public authorities, citizens and business), based on underlying open technologies and architectures that may be reused across multiple use cases and enable interoperability across those; ii) the validation of user acceptability by addressing, in particular, issues of trust, attention, security and privacy through pre-defined privacy and security impact assessments, liability, coverage of user needs in the specific real-life scenarios of the pilot,

Figure 2.3 IoT industry's fragmentation [10].

iii) the validation of the related business models to guarantee the sustainability of the approach beyond the project.

The most prominent "smart" environments, already producing a number of use cases, are the following:

- Smart Homes will offer business opportunities in home security, energy applications and household appliances.
- Personal Wellness applications and wearable devices for both generic and health-specific purposes are a big opportunity in the area of Smart Health. They will be accompanied by remote health monitoring.
- In Smart Manufacturing, operations and asset management already represent a fertile ground for IoT solutions and applications.
- Smart Cities are equipped with sensors, actuators and other appliances providing information that, properly valorised, will improve the living conditions of their inhabitants.
- Smart Mobility will require new mobile ecosystems based on trust, security and convenience in order to ensure the security and convenience of consumer-centric transactions and services.
- For Smart Energy, smart meters and smart grids are powered by IoT and can optimise energy consumption, whereas IoT solutions and services can help change behaviour and consumption patterns.

- In Smart Farming data gathering, data processing, data analysis and automation technologies jointly orchestrated allow for improved operation and management of a farm and further down the value chain.
- Earth and ocean observation systems and the future blue economy where IoT can help maximise the use of oceans' potential, in terms of fishing, marine platforms and aquaculture notably.
- For the Circular Economy, IoT can facilitate the transition to new business models where all actors of the value chains are closely interconnected and use collaborative platforms to share data on resource flows, and end-users are empowered in their consumption patterns.

The Alliance for IoT Innovation – AIOTI has established a number of working groups in the areas that it considers more mature for IoT innovation and where a greater potential for cross-cutting business models is looming ahead [6]. In addition, the support of creativity-based innovation is pivotal, adding the force of cultural and creative industries to foster smart, sustainable and inclusive IoT services and products.

As an outcome of extended consultations and studies, the European Commission has decided to finance IoT pilot projects with a larger scope and a potential for changing the perception and acceptance in the following fields:

- Pilot 1: Smart living environments for ageing well (EU contr. up to 20 MEUR)
- Pilot 2: Smart Farming and Food Security (EU contr. up to 30 MEUR)
- Pilot 3: Wearables for smart ecosystems (EU contr. up to 15 MEUR)
- Pilot 4: Reference zones in EU cities (Smart Cities) (EU contr. up to 15 MEUR)
- Pilot 5: Autonomous vehicles in a connected environment (EU contr. up to 20 MEUR)

These pilots are complemented by two categories of support actions:

- Co-ordination of and support to the pilots through mapping of architecture approaches; interoperability and standards approaches at technical/ semantic levels; requirements for legal accompanying measures; common methodologies for design, testing and validation; federation of pilot activities and transfer; exploitation of security and privacy mechanisms, international cooperation and exploitation of combination of ICT and Art.
- Consideration of responsible innovation and societal aspects, also through involvement of experts outside the traditional field of IoT.

It is expected that these IoT Large Scale Pilot projects will enter into action as of January 2017, complementing the already active IoT Ecosystem projects from the previous call for proposals, now brought under the common umbrella IoT European Platform Initiative – IoT-EPI [7]. Conceptually the future IoT Large Scale Pilot projects are a variant in terms of IoT Ecosystem building and target in particular innovation integration and the overcoming of acceptance, adoption and legislative barriers against wide-ranging IoT deployment.

2.4 Outlook

Looking forward, we can contemplate that the current and upcoming IoT activities, when properly set up, will contribute a lot to the birth and evolution of IoT Ecosystems in Europe.

The recent EC Digital Single Market (DSM) technologies and public services modernisation package provides a set of coherent policy measures aiming at the digital transformations of our industries and at maximising their impact on economic growth. The actions for IoT are listed in the communication "Digitising European Industry – Reaping the full benefits of a Digital Single Market [8], the communication "Priorities for ICT Standardisation for the Digital Single Market", and under the free flow of data initiative of the DSM Strategy.

Fostering an interoperable environment for IoT Ecosystems and the development of missing interoperability standards will be pivotal. Exploration of options and guiding principles, including developing standards for trust, privacy and end-to-end security, e.g. through a 'trusted IoT label', are equally high on the policy agenda.

With regards the Horizon work programme 2018–20 for IoT, it is expected to support IoT Large Scale Pilot initiatives of societal and industrial relevance and to facilitate use cases crossing existing IoT pilots and implementations, both in Europe and with international partners. In addition, the existing IoT Focus Area might also encompass more aspects of Cloud technologies, Big Data analysis, autonomous behaviour, interface technologies and art.

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