BUTLER SMARTLIFE

COOPERATION

Project Deliverable

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Abstract :

Taking at starting point the various field trials implemented in BUTLER, this document aims at analyzing the impact of IoT services and applications from a social and economical point of view. This report is documenting three different aspects of the activities undertaken during the project regarding social and economical impact assessment:

- A global analysis on the expected impacts and challenges of IoT has been done. The vision and analysis presented in this section has been fueled by numerous interactions with the different stakeholders of the ecosystem over the three years of the project. It therefore provides a vision of the state of mind of the IoT community, it also provides a frame on which the BUTLER project impacts can be expected.
- An impact assessment of the 5 BUTLER field trials on social and economical aspects. The analysis is focusing on the potential business exploitation of the scenarios experimented in the trials and on the users feedbacks. Secondly, in echo of the cursory review of expected impacts promised by IoT, a global analysis in terms of impacts value chains is proposed for each scenario, in order to put in perspective the promising but also unexpected frames and impacts and possible conflicts to be addressed in order to deploy and implement these scenarios in large scale.
- A review of BUTLER main effective contributions to make progress on debates related to socio and economical issues and challenges.

Keywords :

Field trial, impact assessment , economic, social and environmental impact, perspectives and challenges of IoT, users' engagement, users' acceptance

Disclaimer

Revision History

The following table describes the main changes done in the document since it was created.

Revision	Date	Description	Author (Organisation)
V0.1	December 2013	Creation, tentative table of content	Bertrand Copigneaux (inno)
V0.2	September 2014	Updated Table of Content	Sophie Vallet Chevillard (inno)
V0.3	November 2014	Contribution and integration of contributions	Sophie Vallet Chevillard (inno)
V0.4	November 2014	Contributions and integration of contributions	Bertrand Copigneaux (inno)
V0.5	December 2014	Revision and update	Sophie Vallet Chevillard (inno)
V1.0	December 2014	Final integration and review	Bertrand Copigneaux (inno)

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1. Acronyms and Definitions

Acronyms	Defined as
ABI	ABI Research
AC	Activity Chain (IERC)
AED	Automated External Defibrillator
API	Application Programming Interface
APP	Application layers (OSI model)
CEO	Chief Executive Officer
CPR	cardiopulmonary resuscitation
CS	Computer Science
DDX	Device Data Exchange (BUTLER / Ericsson)
DG	Directorates-General (European Commission)
DIY	Do It Yourself
EMG	BUTLER External Member Group
ERDF	European Regional Development Fund
EU	European Union
EULA	End User License Agreements
FOSS	Free Open Source Software
GDP	Gross Domestic Product
GPS	Global Positioning System
HDL	Hardware description language
HMI	Human Machine Interface
ICT	Information and communication technologies
IDC	International Data Corporation
IDE	Integrated Development Environment
IEEE	Institute of Electrical and Electronics Engineers
IERC	Internet of Things European Research Cluster
IFC	International Finance Corporation (World Bank)
IHS	IHS inc.
INDRA	Indra Sistemas, S.A.
IoT	Internet of Things
IPR	Intellectual Property Rights
IT	Information technologies
KNX	Standard for home and building control
KPI	Key Performance Indicators
LED	Light Emitting Diod
LTE	Long Term Evolution (4G network)
M2M	Machine to Machine
MQTT	Message Queue Telemetry Transport
NFC	Near Field Communication
NPD	New Products Developments
OMA-DM	Open Mobile Alliance Device Management
OPEX	Operating Expenses
OS	Operating System

OSGI	Open Service Gateway initiative
OSI	Open Systems Interconnection model
PC	Personal Computer
PCB	printed circuit board
PHY	Physical layers (OSI model)
PPP	Public Private Partnership
PRISM	Surveillance program (NSA)
RECI	Red Ciudades Inteligentes (spain)
RFID	Radio Frequency Identification
SLA	Service Level Agreement
SME	Small / Medium Enterprise
SMS	Short Message Services
STB	Set Top Box
TLC	Telecommunication
TRL	Technology Readiness Level
TV	Television
UI	User Interface
USA	United States of America
WSN	Wireless Sensor Network

2. Executive Summary

The purpose of this document is to analyse the potential impacts of BUTLER IoT services and applications from a social and economical point of view. The BUTLER project main activities have provided many scientific and technical contributions to the definition of the IoT domain, with substantial contributions to the IoT enabling technologies (see Deliverable 2.5) and architecture (Deliverable 3.2) and the drafting of a functional prototype platform (Deliverable 5.2). This technical work has however been based on a clear and thorough requirement definition based on potential IoT use cases (Deliverable 1.1) and the project has been able to go up to actual deployments and interaction with end users in five field trials (Deliverable 5.2). The project has also been confronted with some of the ethical and privacy questions (Deliverable 1.4) that are raised by the development and deployment of the IoT. Therefore, despite the mostly technical nature of the project activities and the limitation of the scope of the actual deployments, it makes sense to analyze the potential larger scale societal and economical impacts that could derive from the project activities.

The work presented in this report is based on various sources, from the initial top down, technologically oriented definition of potential use cases for the project, to consultation of the IoT community, of specific experts (especially in the legal, ethical and privacy domain), the participation and organisation of several events, to the definition of end user involvement and evaluation methodologies for the project field trials.

This report is documenting three different aspects of the activities undertaken during the project regarding social and economical impact assessment:

- A global analysis on the expected impacts and challenges of IoT. The vision and analysis presented in this section has been fueled by numerous interactions with the different stakeholders of the ecosystem over the three years of the project. It provides a vision of the state of mind of the IoT community, it also provides a frame on which the BUTLER project impacts can be expected.
- An impact assessment of the 5 BUTLER field trials on social and economical aspects. The analysis is focusing on the potential business exploitation of the scenarios experimented in the trials and on the users feedbacks. Secondly, in echo of the cursory review of expected impacts promised by IoT, a global analysis in terms of impacts value chains is proposed for each scenario, in order to put in perspective the promising but also unexpected frames and impacts and possible conflicts to be addressed in order to deploy and implement these scenarios in large scale.
- A review of BUTLER main effective contributions to debates related to IoT socio and economical issues and challenges. This sums up specific contributions in other documents and in conferences, from the definition of the IoT "Smart Life", to the handling of privacy and ethical issues or the importance and methodologies of end user engagement.

The project contributions to the analysis of the potential socio-economical impacts of the IoT therefore provide both an overall vision of the consortium and community on the general challenges faced by IoT deployments, and practical methodologies and feedbacks that can be reused by other projects and stakeholders.

Although the IoT promise strong developments in the near future and, by its horizontal and integrated nature, is set to impact most aspects of modern life (see section 4.1.), these positive impacts are not straightforward in a complex ecosystem (see section 0) both for economical and societal reasons.

Although the transcending nature of IoT technologies promise cross cutting impacts on society, individual deployments have to define individual value propositions and analyze potential barriers and impacts in a case by case analysis (section 5 provides vision for the BUTLER field trials).

The use case definition of the BUTLER project, a long standing activity (since it was the basis of the project work and has evolved since over the three years of the project), provide meaningful feedbacks both on the potential nature of "horizontality" in the IoT and on the potential nature and different meaning of "smartness" in the IoT domain (see section 6.1.).

The key lesson of this analysis of the nature of IoT use cases, led to the definition of a user centered and user empowering smartness for the IoT. This include raising the awareness level of the user but also addressing its reasoning abilities rather than its feelings, providing access to further knowledge and ability to build and tinker applications.

This was reflected by the project evolving focus on end user interactions, from a theoretical analysis of ethics, privacy and data protection in the IoT (see section 0), based on experts and community inputs to the actual end user engagement methodologies deployed in the field trials (see section 6.3.).

The former provides direct recommendations on protecting end users data and privacy through general recommendations, technical tools, but also by integrating these potential risks as assets in the IoT business models and by improving user acceptance by using IoT technologies to increase user understanding and control (a detailed example is provided to handle the "user consent" question).

The later presents the general reasons to engage end users in IoT research and deployments originating from the project experiences and other community experiences; a presentation of the end user feedback tool developed for the project field trials and some best practices for end user engagement (begin as soon as you can, dedicate resources, engage with existing communities and use dedicated models and expertises).

If end user's engagement appears to be a key enabler to successful IoT deployment, the end user shouldn't be limited in a "user" role but rather considered as a contributor to an open ecosystem. This led the project to propose solutions for facilitating the take off of IoT technology and the emergence of reusable components and platforms in the form of the IoT Open Platforms initiative (presented in Deliverable 6.3 and online: http://open-platforms.eu/). This deliverable presents some of the economic reflections on the possible futures of open platforms in the Internet of Things ecosystem (see section 0).

Finally this reports looks at the potential quantifiable impacts of the IoT on economic, societal and environmental aspects by an analysis of the gains enabled by the real time generation, analysis and consumption of data of the IoT (see section 0).

As a conclusion, the BUTLER project numerous contributions to the community debate on the socio-economic context and potential impacts of the IoT provide a coherent vision:

- The IoT potential broad and deep integration in our society can be the cause for both important opportunities and key societal advancements but at the same time create complex ecosystems which can significantly delay potential deployments and positive impacts.
- The dialogue and interactions with the stakeholders must therefore be at the centre of any IoT deployment. This includes not only initial requirement analysis and ex post feedback analysis but should be conceived as a user centred co-creation process.
- This also lead to the conclusion that only a technologically open IoT can maximize the potential impacts as secondary data uses, and unintended uses, un-designed uses of IoT application can become the norm rather than the exception and lead to rapidly developing markets.

These conclusions should serve as a basis for future large scale pilots and large scale deployment of the IoT.

3. Introduction

3.1. Purpose of the Document

Taking at starting point the various field trials implemented in BUTLER, this document aims at analyzing the impact of IoT services and applications from a social and economical point of view. This report is documenting three different aspects of the activities undertaken during the project regarding social and economical impact assessment:

- A global analysis on the expected impacts and challenges of IoT has been done. The vision and analysis presented in this section has been fueled by numerous interactions with the different stakeholders of the ecosystem over the three years of the project. It therefore provides a vision of the state of mind of the IoT community, it also provides a frame on which the BUTLER project impacts can be expected.
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- A review of BUTLER main effective contributions to make progress on debates related to socio and economical issues and challenges. The section include contributions of BUTLER on:
    - the definition, of IoT smartLife, and especially a tentative to qualify what “smart” means and implies beyond the buzz word
    - Ethics, privacy and data protection in IoT
    - The importance and approaches to engage users in IoT experimentation and foster users’ acceptance,
    - The IoT platforms initiated and pushed by BUTLER and the current state of the debate on closed versus open and interoperable approach to foster the development of the Internet of Things
    - And then, the evaluation of the potential impacts of the increased use of “real-time” IoT data.

The report ended with some conclusions and recommendations about future work requested to go towards the expected impacts of IoT.

3.2. Intended Audience

This report is a final report of the project achievements. It is meant for the project partners as a summary of activities and conclusions on socio economic potential impacts of the IoT, but more broadly it targets the IoT community as a whole to offer feedbacks on the activities of the project and potential future directions of reflexion to maximize IoT positive impacts. Targeted audience can be other IoT research projects, IoT and ICT policy makers, industrials and SMEs interested in accessing the IoT market.

3.3. Suggested previous reading

This document can be read without any prior knowledge of BUTLER. However, to make the reader get the most of it, the following BUTLER deliverables should be read first:

- Deliverable D1.1 – Requirements and Exploitation Strategy. It provides the information about the BUTLER use cases, applicability domains and requirements.
- Deliverable D1.2 – Refined Proof of Concept and Field Trial Specification. It will provide a better understanding of BUTLER planned field trials and proofs of concept.
- Deliverable D1.4 – Ethics, Privacy and Data Protection in the IoT. It provides an overview of the main ethics and privacy related issues in the IoT and of potential solutions in the state of the art.

- Deliverable D5.2 – Final Platforms and Quality Assessment. It provides a technical vision of the BUTLER platform and the BUTLER field trials, as well as the technical quality assessment of the platforms.
- Deliverable 6.5 – Exploitation Plan. It provides a first vision of the project exploitation plan and identified business opportunities.
- Deliverable 6.3 - Progress on Standardization and Exploitation and Dissemination plans. It provides a final vision of the project exploitation plans for both common and individual exploitation opportunities.

3.4. Methodology

In this section we present the main activities undertaken by the project to form an opinion on the potential socio economical impacts of the IoT and the BUTLER platform. We also present briefly the overall evaluation methodology that has been applied to the BUTLER field trials deployments.

3.4.1. Activities undertaken

The project analysis of the potential socio economic impacts of IoT and of the BUTLER platform has been based on numerous activities spread throughout the project lifespan. The following is a list of the main activities conducted in the project and that led to the understanding of the socio economic context of the project and to the analysis of potential impacts.

- **Definition of use cases and requirements:** The project started by a definition of use cases and requirements with the definition of 70 individual use cases in 5 application domains and numerous detailed functional and non functional requirements. This definition, which has been at the basis of the project technical activities, was mostly an internal reflection on potential IoT use case and ecosystem. It enabled a common understanding of the nature of horizontal IoT use cases that has been the basis of the project reflections on socio economic impact.
- **Literature review:** Throughout the project, the consortium conducted regular literature reviews as well as monitoring of scientific and commercial publications regarding the Internet of Things. This activity enabled the project to follow the evolutions of the state of the art and of the market perspectives and potential societal implications of the development of the IoT.
- **Citizens' interviews:** Over the first and second year of the project, the consortium conducted 60 citizens' interviews in 6 EU countries. The interviews were open discussions (1-2 hours in average) on potential IoT use cases and the perception of the potential end users both from an economical perspective (customer behavior) and from a societal impact perspective. The selected profiles were various and covered very different sociological profiles with a focus on end user having no specific previous backgrounds in ICT. The interviews enabled better understanding of the citizens' expectations and identified risks regarding IoT deployments.
- **Expert consultations:** The project organized formal consultations with experts through the External Member Group of the project. This included participation of the EMG ethical and legal experts on the project's plenary meetings. A dedicated analysis of the Deliverable 1.1 use cases was made by the external experts and the expert consultation contributed to refine the understanding of the consortium on specific aspects of the potential socio economic impact (ethical and legal analysis).
- **Conference participations:** The project participated to the debates on the socio-economical impacts of the IoT by participating to several conferences, and by organizing dedicated sessions in several conferences:
  - In the IoT Week 2012, the project participated in the Ethical session of the IoT week nad initiated discussions with external stakeholders and the EMG members.
  - In the IoT Week 2013, the project organized and chaired a session on business models in the IoT, including the first IoT Business Pitch contest, and organized and chaired a session on "informed consent in the IoT". The project also participated to the organization and debates in other projects.

  - In the IoT Week 2014, the project organized and chaired a session on the Open Platforms concept, the project organized and chaired a session on IoT user experiences both from a methodological perspective and actual field feedbacks from several projects. The project presented some of its deployments in a common session and participated to the IERC AC7 session on Smartness in the IoT.
  - The project was present in several other events (see Deliverable 6.3 for a complete list of the project dissemination activities).

  The participation to these different events enabled the project to discuss the potential socio economic impacts of the IoT with the different stakeholders and to present and confront the project findings with the community.
- **Contribution and exchanges in IERC community:** The project participated to exchanges and discussions with the IERC community linked with potential socio economical impacts. This include contributions to the IERC AC5 position paper, contributions to the IERC AC3 work on pilot and exploitable outcomes of the projects, contributions to IERC AC7 work on smartness in the IoT, and contributions to IERC AC8 definitions.
- **Field trial activity:** Each field trial deployment included specific work on end user involvement, consultation of external stakeholders, definition of potential exploitation opportunities and business modelling and analysis of potential impacts. The next section describe in more detail the evaluation methodology proposed and applied to the trials.
- **Deliverable contributions:** As presented in section 3.3, the project produced numerous previous deliverable which helped define the potential impacts of the project. From the definition of a end user involvement framework and policy in Deliverable 1.2, to the detailed analysis of ethical and privacy implications of the IoT in deliverable 1.4, or the dedicated work to project exploitation and business opportunities in deliverables 6.5 and 6.3.

3.4.2. Evaluation methodology

The overall methodology set up to get and analyze feedbacks from the trials where implemented in a double perspective:

- First, the main objective of the trial was to fulfill the proof-of-concept of technical components developed in the project (including the open platform). This technical evaluation is completed in the deliverable D5.2.
- The second objective was to assess the non-technical elements of the trials, especially the economic, social and societal impacts. Regarding the economic impacts, the objective was to characterize the different trials with their tentative business models, value propositions and possible stakeholders. Regarding the social and societal impacts, the objective was to evaluate from the end-users perspective (at individual or global level) the possible impacts induced by the scenarios experimented regarding dimensions such as ethics (privacy, security…), inclusion and environmental aspects. The objective was to put in perspective the scenarios of the trials in the current global trends (ie. Smart cities, Sustainable growth, digital inclusion, etc.) and identify the long term expected impacts.

In order to gather relevant data, several activities have been undertaken. A formal methodological was established which include self-evaluation from technical developers (and reported in D5.2) and a feedbacks process to involve users all along the trials and are summarized in the following figure.

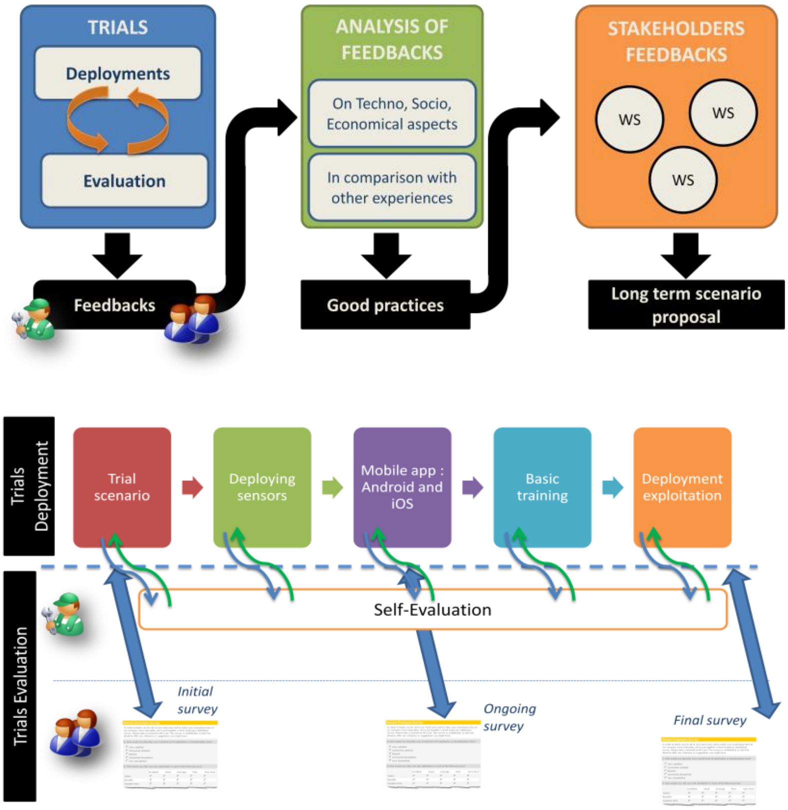


Figure 1: Evaluation process of the trials

In practice, the users' involvement has been heterogeneous among the five trials, depending of the nature of users and maturity of services deployed. Some trials (shopping and office) was involving importantly users at the different phase of the trial to define the use cases (through brainstorming session, interviews, focus group, etc), whereas other where more focused on technical aspects and didn't aim to fit entirely with users' expectations.

The figure below summarizes the approach followed by the BUTLER project during the trial.

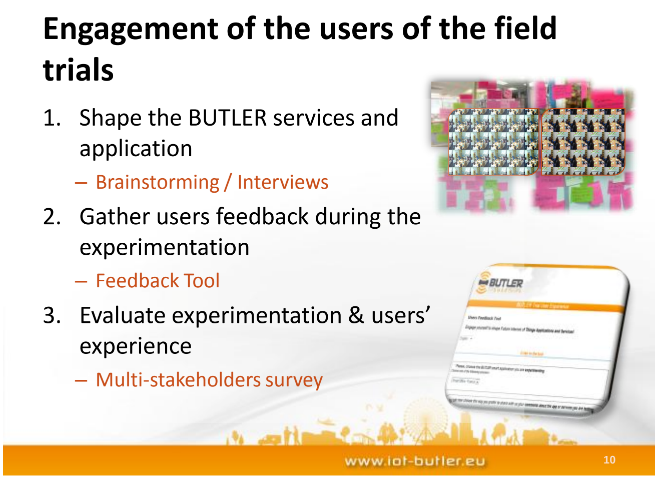


Figure 2: users' engagement in the trials

4. Expected impacts and challenges of IoT.

In this section we present the existing common expectations regarding IoT socio-economic impact and the potential challenges linked with its deployment. The vision presented has been fueled by numerous interactions with the different stakeholders of the ecosystem over the three years of the project. It therefore first provides a vision of the state of mind (or one could say “zeitgeist”) of the IoT community, it also provides a frame on which the BUTLER project impacts can be expected.

4.1. IoT Expected Impacts

The world we live in is a changing world and the European Union has already to face many challenges and more can be foreseen for the near future. The world’s first economy both in term of GDP and wealth is still affected by the ripples of the 2007-2008 global financial crises and the following Eurozone crisis. Facing a rising global competition in an increasingly multi-polar world, the EU faces other challenges, such as an ageing population, high level of youth unemployment and rising inequalities between internal regions threatening global cohesion. The foreseeable future of a world facing global warming and a probable end of economically and environmentally affordable fossil fuels add further challenges the policies of Europe.

To face these challenges, the European Union has set forth the Europe 2020 growth strategy, with clear target objectives, priorities and initiatives to reach a **smart, sustainable and inclusive growth** in Europe. The information and communication technologies play a strong part in this strategy, as illustrated by the Digital Agenda for Europe. The transforming power of ICT, linked with green technologies for energy production, storage and transport is expected to revolutionize our economies and lives as the new forms of communication become the medium for organizing and managing these complex eco-systems. As acknowledged by the European Commission [1] this “Third Industrial Revolution” [2] is the way forward for Europe.

The “Internet of Things” concept, of a worldwide network linking not only traditional ICT devices but also offering communication and computation capabilities and potentially autonomous behaviors to any device or system, is fully aligned with this vision. The broad interconnection of physical objects is expected to amplify the profound effects that large-scale networked communications are having on our society, gradually resulting in a genuine paradigm shift. Indeed the Internet of Things, or to the very least parts of it (such as Smart Grids, Systems of Systems and M2M communications), is expected to be an essential cornerstone to this industrial revolution.

4.1.1. Economical Impacts

The European Union vision of a **“smart growth”** is relying on the development of a strong knowledge economy that can act as a driving force for Europe. This includes a focus on education, research and innovation and the support of a digital society.

The development of the key component of an Internet of Things in Europe is expected to strongly support this vision. The European research is already at the forefront of the development of many of the necessary components of an internet of things. This is also reflected by an increasing number of cutting-edge, innovative European SMEs embracing this IoT vision and developing key products and services. The potential for the Internet of Things to drive innovations is expected to be strong and can be linked with the numerous potential application domains of IoT (as illustrated further in this section).

The deployment of an Internet of Things in Europe is expected to support potential for a better educated and more connected society. Beyond the connection of “Things” advocated by the Internet of Things, the vision is that of an interconnection of networks of sensors, peoples, and knowledge. Europe's research pole position as testified by the IERC seems to be however not well supported by the industry, nor is it giving strong direction to the national agenda's of the individual member states.

A General Electric report [3] focuses on the Industrial Internet, which comprises connected and intelligent machines, advanced analytics in real-time, and connected people at work. The adoption of Industrial Internet will lead to an increase in productivity. If the annual productivity in the U.S. grows by 1 to 1.5

percentage points and by the half of it in the rest of the world, the Industrial Internet is expected to add $10-15 trillion to global GDP by 2020.

The market expectation for the IoT are also very high, both in term of number of connected devices (Gartner estimates 26 billion connected devices, which are not PCs, tablets and smartphones, in 2020 worldwide [4], the number of "active wireless connected devices", raises from estimated 16 billion in 2014 to 40.9 billion in 2020, according to ABI [5], IHS [6] expects approx. 28 billion internet-connected devices in 2019 and nearly 50 billion in 2025); and in term of market value (For Gartner [4], the global economic value-add is estimated to reach $1.9 trillion, of which 80% are coming from services, IDC sees a worldwide $7.1 trillion market for IoT solutions in 2020, compared to $1.9 trillion in 2013 [7], Cisco's CEO envisions a economic value of $19 trillion over the next decade [8]).

Expectations of the market also concern the future IoT ecosystems and the potential business models of the different actors. The following figure presents a rapid view of the future ecosystem as it is anticipated.

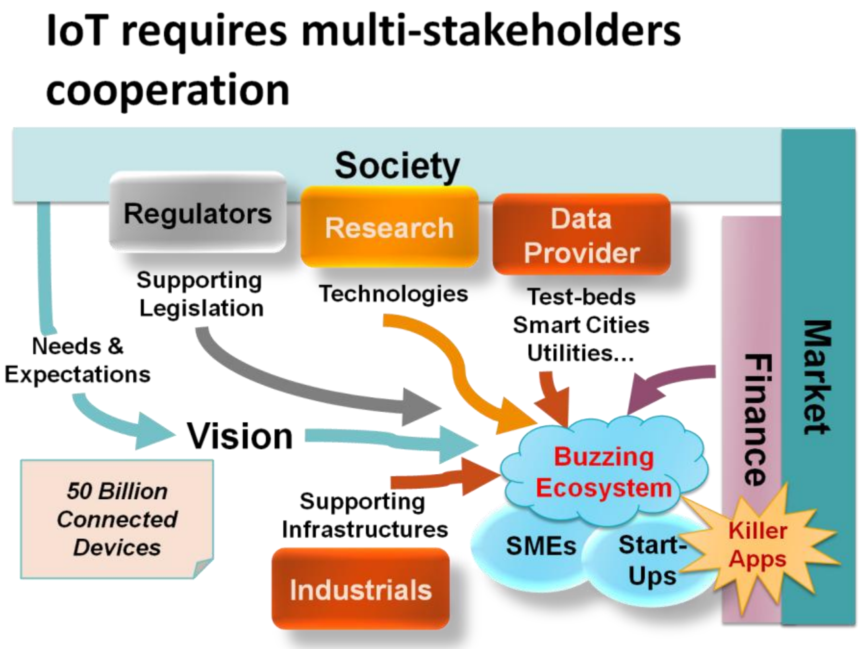


Figure 3: Expected Future IoT Ecosystems. (Source: BUTLER)

As we can see in this picture, the vision of the IoT is originating from society needs and expectations, but only finds its way to being a market through complex ecosystems of different actors:

- **Research organization** are seen as important provider of technologies, indeed the IoT development and deployment require scientific progresses. Their expected business model are classical for this type of organization, part of public research funding, and part of research result and IPR valorisation through patents, spin-offs, and licensing.
- The role of **existing Industrials**, especially in the **telecommunication, software and computing domain** is expected to be important as provider of supporting infrastructures for the ecosystem. Only those existing giants are seen has having the ability to provide these large scale infrastructures (including device manufacturing, and cloud infrastructures) in time for the IoT deployments. The business models anticipated include tradition product retail (for devices) and service provisioning (for software), but is expected to include more and more a “as a Service” approach.
- Another key enabler of the IoT ecosystem are **“data providers”** which provide access to real world facilities that will generate the data of the IoT. They are the backbone of the deployments. The monetization of data is increasingly seen as the relevant business model even though some issues might remain to be addressed.

- The actual production of end user applications is left for a most part to **SMEs and Start-ups**, backed by a necessary strong investment support. This shows the expectation of unforeseen applications and business models as only start-ups companies can produce.
- Finally a facilitator role is foreseen for **regulation authorities**, indeed as we have seen the IoT has strong potential impacts on many societal issues and it can be expected, especially in Europe that regulation authorities will play a role in the ecosystem.

4.1.2. Environmental Impacts

As presented earlier, the objective of sustainability is a strong objective of any society with an eye on the forecast for the 21st century. Both the indiscriminate exploitation of natural resources characteristic of the industrial age and some of its more direct and potent consequences (in the form of global warming) are no longer sustainable. Enough evidence (see [9] on global warming and [10] on the end of cheap oil) exist to support this claim and to acknowledge that societies that don't adapt to a changing environment are doomed [11].

The Europe 2020 priority of sustainability reflects the importance of reducing the impact of our economies on the environment and increasing our energy security. This results in strong expectations from the society on the future role of IoT to address sustainability issues.

Sustainable food

The development and deployment of an Internet of Things is expected to impact significantly our access to food. The ability to precisely monitor the quality of soils and the growth of crops combined with the ability to process and analyze the data gathered (through cloud computing) is expected to enable the development of a more efficient and less chemical intensive agriculture.

The ability to source and localize the origin and destination of every product, offered both to producers and consumers should enable the development of a more local food economy, but also to better match demand and production and to support the implementation of sustainable fisheries (through more efficient monitoring of quotas).

The ability to offer virtually costless and very accurate information on the origin and quality of food is also expected to help to make the general public better informed and more sensitive to their consumption choices.

Sustainable resources

The Internet of Things is also expected to affect the production and consumption of resources and raw materials, enabling detailed traceability of the origin and environmental cost of resources. This should favor more local and ethical sourcing for consumer as well as higher efficiency for producers, being able to track in near real time the demand for resources.

Sustainable energies

The "Smart Grid" use case is an emblematic use case of the Internet of Things vision, connecting consumers of energy and producers and using "smart" predictive algorithms to optimize production, transport and consumption of energy.

The smart grid is not only expected to enable a more energy efficient economy, it is an essential component to enable the decentralized production of energy, which is necessary to switch to renewable sources. Each node in the network should be able to not only to consume but also to produce and redistribute energy, mixing the producer and consumer role in a unique role known as "prosumer".

The precise monitoring of consumption is expected to enable fine-tuned load balancing and reduce loss of energy; it should also help to raise awareness on consumption and empower consumers, by providing them a direct visibility on their consumption. The home/office automation scenarios enabled by the internet of things further supports this vision, providing instant control and intelligent behavior to home appliances to enable higher energy efficiency.

Finally the detailed monitoring of energy consumption is expected to enable to precisely estimate the quantity of energy needed for the creation of product and services and therefore to integrate its potential environmental cost in the cost of manufacturing (either through direct cost or taxation).

Sustainable industries and services

The industrial production is expected to directly benefit from the gain in resources and energy sustainability presented above. In addition the massive connection of industrial production cyber-physical systems enabled by the internet of things should bring benefits of its own to the industry.

The Internet of Things is expected to enable strong customization of products under the conditions of mass production, generating high competitiveness and better value for consumers.

The industry is also expected to benefit from higher reliability by the introduction of methods of self-optimization, self-configuration, self-diagnosis, cognition and intelligent support of workers in their increasingly complex work.

Sustainable transports

Finally, the Internet of things is also expected to generate strong gain in the transport industry, which will affect public transports, individual transports and the field of logistics. High quality instant monitoring of public transport is expected to enable a better adaptation to the demand and better information of the users. This should result both in higher efficiency and increased usability.

Individual transport will benefit from increased security but the IoT is also expected to enable smarter sharing of resources (such as car pooling) increasingly necessary in a world facing both global warming and an end to cheap oil.

The logistics chain, as seen above in specific cases is expected to broadly benefit from the detailed monitoring and control capabilities of an internet of things, bringing both higher efficiency and reduced resources consumption.

4.1.3. Societal Impacts

As presented above, Europe is facing disparities between its different regions and member states, as well demographic (ageing population) and social challenges (low youth employment in certain region). In addition to supporting a “smarter” and more sustainable society, the Internet of Things vision can also have a decisive impact on the inclusiveness of society by supporting not only a higher quality of life but also reducing inequities and helping us to better live together.

Health

The Internet of Things offers several paths to increase health services quality. The ability to better monitor health conditions, through less invasive and costly devices and to relay the information to competent health professionals looks promising to offer more autonomy and quality of life to large populations. This should impact not only people with chronic diseases but also dependant and ageing patients; reduce hospitalization duration and hardness. Combined with increasing automation, people should be empowered to live their lives at high quality levels despite health concerns.

The Internet of Things is also expected to help to optimize emergency responses, by better monitoring of both critical situation as it happens and emergency response forces as they become available. This should reduce the time taken to respond to emergencies and increase the quality of the response (as ubiquitous monitoring of the environment can enable a more appropriate response).

As presented above, the IoT is expected to have a decisive impact on food sustainability but also on food quality reducing the impact of food on health conditions. Along the same line, IoT enables environment monitoring (air and water quality) and should help to reduce damages to the environment (as presented above) resulting in a lower impact of the environment our health conditions.

The quality of health can also be improved by higher efficiency in hospital, decisive advances such as a single patient file, or the tracking of medical material can increase both efficiency and security of medical procedures. Patient centric medicine includes patients earlier in the process and in general has a more holistic approach to including end-users (patients) in post as well as pre illness. Integrating mobile services that are already on smartphones, the growing commonplace of wearable, into a holistic approach to care and illness requires stable, secure and scalable networks.

Security

As presented above, the Internet of Things is expected to enable better emergency responses; this is not only true for medical conditions, but also for natural disaster and security threats prevention, monitoring and responses.

The IoT can especially be instrumental in detecting or reporting critical situation as they develop and combined with cloud computing analysis it could even help to predict some situations. The overall, ubiquitous and far reaching monitoring of society can be seen as a strong opportunity to enforce stronger control on all aspects of our lives.

As we will present later on, the IoT does raises some privacy and ethics interrogation but as it still is developing (and as recommended by the SMART 2012/0053 study: Europe's policy options for a dynamic and trustworthy development of the Internet of Things [12]) it can be seen as an opportunity to take a clear stance on the subject and establish it as a competitive advantage for Europe.

Economy

The Internet has had a very strong impact on the world economy, a recent McKinsey study [13] showed it is a net job creator, creating 2.6 job for each one lost to technology related efficiencies. Investment in the Internet infrastructures and ecosystem has been highly rewarding for countries who embrace it, A World Bank / IFC report of 2009 says for every 10 percentage-point increase in high-speed Internet connections there is an increase in economic growth of 1.3 percentage points [14].The same type of results are anticipated for the Internet of Things, a stronger impact on growth is even anticipated as it has strong physical links and touches many different application domains. As presented below, the market(s) of the Internet of Things and Cloud are still developing but the expectations are very high.

Democracy

Finally the Internet of Things can as much as the Internet did, influence and transform our democracies. The ubiquitous deployment of sensing technologies, combined with an Open Data policy, such as the one supported by Europe [15], can enable high level of transparency and unprecedented access to data for citizens. This has a potential to generate gain in knowledge and education for a very large population as quality internet access becomes widespread.

Policy planning, implementation and evaluation could also be greatly optimized through the access to real time monitoring and control of many aspects of society. The computing capability of the cloud could enable more systematic and efficient simulations of policy potential impacts. And the possibility to precisely control and apply policies to certain nodes of an Internet of Things, controlling real life systems, could enable more specific and fine tuned policies.

The increase in knowledge and awareness of citizens in an Internet of Things could be match by greater direct democratic control, especially at a local level. The IoT would also enable more dynamic associations of citizens around common interests, throughout Europe and despite the barriers of distance or language.

4.2. Challenges of IoT

4.2.1. Economic challenges of IoT

The IoT vision presented in section 4.1.1 is of a unified ecosystem and of applications cutting across activity domains. However, the real picture is still far from the vision and significantly more complicated. In this section we present some of the economic challenges that the IoT ecosystem face to achieve the positive impacts presented above.

4.2.1.1. Market definition

As we have seen the IoT has the potential to impact many domains and activities of our lives, from food and resource productions, to industrial processes, to various service industries (health, security, transports), or to of course the existing Internet and ICT economy. IoT also represent a complex mix of core and enabling technologies: from sensing and actuating technologies, communication networks in all layers (from PHY to APP), complex software middleware, and applications in many domains.

The frontier of the IoT definition and therefore of the IoT market are still emerging and blurred: IoT is clearly building, but not limited to communication networks such as LTE and in the future 5G. IoT is building on the existing internet ecosystem and its vibrant economy; it will reinforce and extend the existing digital services. IoT has strong needs of data processing abilities that are likely to be offered by the cloud / big data market. IoT is set to transform existing backbones of our economies such as transport systems, electric grids or the industrial complexes.

From that complexity, from the difficulty to establish a clear perimeter of IoT / non IoT applications, and from its many impacts and interactions with existing but also many developing markets, sizing correctly the current and potential IoT market is a complex task. Different assumptions can be taken, that provide different results: from inclusive or exclusive market boundaries, the market reliance on developing (but not clearly existing technologies), or the assumptions of technology adoption by the market and user choices.

This complex definition of the IoT market can be seen as an issue, not only as the validity of market projections can be seriously questions but also because this fuzzy definition reflect the yet unclear definition of the IoT business ecosystem and the relative lack of market readiness.

4.2.1.2. Time to market

According to Gartner [16], the Internet of Things is one of the technologies that reached in 2014 a peak of expectations. Indeed the Internet of Things has been very present in the news recently and several subtrends of the IoT (such as wearables, Smart Home market, Smart Grid or Smart City) have seen large industrial actors position themselves.

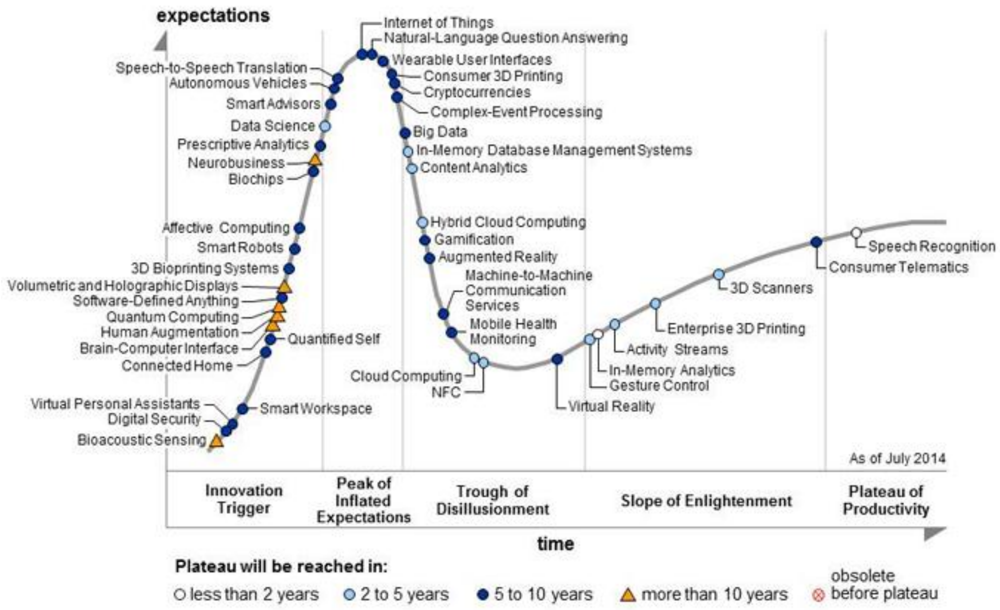


Figure 4: Gartner's 2014 Hype Cycle for Emerging Technologies

Although, as BUTLER demonstrates (see Deliverable 6.3 exploitation results), some technologies and deployment of the Internet of Things can already reach operational state, as a general concept the Internet of Things is to be expected to reach maturity only in 5 to 10 years.

As the figure above shows, the IoT can also be expected to go through a valley of disillusionment following the current peak of expectations before reaching maturity. This raises significant questions regarding the ability to sustain investment (which a large scale IoT still requires).

4.2.1.3. Competition of market forces

Despite significant uncertainty on which market(s) will be most able to support the development of the internet of things, and on how the future ecosystem(s) will organize, some elements can already be assumed from an analysis of the competition forces behind the internet of things development.

As presented in details in the report resulting from the SMART 2012/0053 [12] study, the needs for investment are still strong to develop the infrastructures necessary for sustaining a fully deployed internet of things. The current foresight models and data mining algorithms of the major rating companies, large banks and trend analysts may take into account the real-time traffic that is currently out there but cannot scale to traffic coming from 50 billion objects in 2020 (Cisco, 2009).

According to this study ("Free Market scenario"), the current regulation, investment levels and play of market forces, despite likely differences between specific application markets, will probably favour large, existing, international (mostly non European) ICT actors. That may result in a "stable situation of sectoral monopolies, oligopolies or cartels", where "the global IoT sector becomes a set of markets effectively stovepiped and closed to new entrants". This will bring "relatively few social and macroeconomic benefits in the form of jobs, innovation and new industry in Europe. Moreover, ordinary citizens will suffer because of the lack of effective governance in areas ranging from privacy to liability for malfunctioning of IoT networks".

Indeed, this can be already observed in current economic situation on the internet sector: among the 64th first internet companies (with market value exceed $1,5 billion), 83% of the capitalization is coming from USA, 9% from China, 4% from Japan and only 2% from Europe. India and Arabian countries are notably absents. In addition, this market is highly concentrated between historical actors: the first 10 companies represent 80% of the market capitalisation. These companies use strong predations strategies: as soon as one of them has a technological backwardness, it buys the innovative start-up to overcome its underdevelopment [17]. Thus internet industry has strong entry barriers into a market dominated by US actors. On this context, European internet industry has trouble to establish itself.

In such a scenario the potential innovative SMEs and new actors that will rise from the research will be either acquired or/and limited to marginal roles by big players controlling the infrastructures and imposing closed standards.

Disruption will also affect users: Due to the rapid adoption of mobile technology and ubiquitous internet access, the workplace is changing. 40% of America's workforce will be freelancers by 2020 (Quartz, March, 2013). What will these figures be in Europe and what does this mean for digital services that need be delivered anywhere to these workers?

Inside Europe the risk for an increased divide between different regions is also strong as the support, investment in infrastructures and local initiatives vary widely between the different regions the risk of IoT white-zones is significant. A clear stance on spectrum policy, as advocated in the Smart 2012/0053 study report, is strongly needed as could be support to user education and stakeholders' awareness initiatives.

4.2.1.4. Cutting across application domains

One of the key challenges of IoT is the necessity to break across existing silos. Indeed the vision of the expected ecosystem seen in section 4.1.1 ignores the different application domains and their interactions. This is not only a technical need of interoperability, but also the need for actors from different ecosystems to work together (which can imply serious delays in the IoT horizontal deployments).

M2M refers to end-to-end applications, between the module and the IT system of the client. In some way, the application is often controlled by a specific user only. On the contrary, the principle of the Internet of Things suggests access to the data by several (types of) players.

The necessity to evolve toward a horizontal IoT appears justified by the potential societal benefits. Indeed some of the most promising scenarios are only enabled in a fully deployed and horizontal IoT scenario (see BUTLER "life in 2020" horizontal story line [18]). The potential gains of the IoT individual scenarios can only reach their maximum impact, if information is cutting across domains to ensure a continuous user experience. As example, the promising market of Ambient Assisted Living, cutting across the "home" and "health" domain to offer a continuous user experience, the IoT vision requires cutting further across to integrate all aspects of human life.

However in the current situation, markets are more or less evolving in isolated silos with only a few exceptions. At least two concurring causes can be identified to this situation: on the one hand, the different actors have strongly different cultures and business interest that make integration between different domains more complex and time consuming than evolving in a simpler existing ecosystem. Relationships and business models need to be negotiated between the parties contrary to existing domains where values proposition and positioning of the actors are known a priori. On the other hand the deployment of M2M and IoT technologies at single silos level often already bring clear benefits to the actors. This creates a risk of each individual application domain aiming for a rapid and cheap gain but leaving out the possibilities of later integrations in a global IoT. Indeed interconnection may be harder to negotiate if each domain has already deployed technologies and standards, and operates in business models that are not compatible with each others.

4.2.1.5. Dealing with existing ecosystem of stakeholders

Another usual simplification of the expected ecosystem is the underestimation of the weight of the existing incumbents on the market. The IoT is not a free open field but building on existing Internet and ICT ecosystem as well as existing traditional market (health, food or energy for instance). As seen above the competition of market forces and high need for investment is strongly favouring existing big players of the ICT domain (most outside of the EU).

Indeed for IoT application scenarios to be relevant, the need for investment is often significant will remain so although new mechanisms (such as crowd funding) offer promising alternatives to traditional investment. The need to cut across domain (as seen in previous section) also play in favour of existing established business as they have more power to negotiate agreements with third parties from other activity domains.

In practice that mean that the industry giants have the potential to control (and delay) the roll out of disruptive innovations, including through the buy-out of innovative start-up to match their own agenda and schedule, which is hardly the "ideal free market".

A specific difficulty of some of the most promising IoT scenario is the difficulty to motivate some investments. Some of the gains of the IoT are made a societal level, while individual actors hardly benefit directly from their initial investment if they are alone. Installing a smart meter represent little direct benefit for the final customer, even though he might benefit from a global Smart Grid. Thus it is important to evaluate at which level the incentive for investment is most relevant for each IoT application scenario.

Finally investment by public authorities is a possibility (and a reality in the Smart City domain) but the origin of the investment and the management of the PPP have to make sure that the actual purpose is in line with the societal objectives of IoT (ie. Deploying IoT for the potential efficiency gains, not just as a visibility/city attractiveness move). One concern with public investment can also be in the fact that the local authorities ability to invest may be inverse proportionally to their actual need of IoT deployments (well functioning, developed rich cities or regions, vs less developed areas that may be less rich or higher in dept).

4.2.1.6. Open versus closed systems

The current silos isolated development of IoT seems to favour closed systems rather than open initiatives. Although large scale standardisation initiatives exist or appear on the Internet of Things (OneM2M, IEEE P2413...) for now the existing growing market (such as Smart Home or Wearables) are often relying on closed technologies.

This leads obviously to future interoperability and extensibility issues and can reinforce potential adverse societal impact (controlled society). Closed systems, even though they seem to offer faster to the market deployment can also delay significantly interactions with stakeholders from other application domains. The "data puzzle" identified by project PROBE-IT [19] can seem insolvable in a closed and proprietary environment.

Figure 5: The Data Puzzle (PROBE-IT project)

Even though the role of a "data broker" has been advocated as a solution for exchange of data (such as the DDX server from the BUTLER platform), the reality hasn't seen yet such role as feasible, in part because it is hard to agree on actual value of data before they are used. The choice of full openness and abandoning data value might therefore be a simple solution to accelerate IoT deployment.

On the platform domain, the need of open platform has also emerged, and can be considered as a strategy for European actors: as shown by the Open IoT platform initiative [20] (launched by the BUTLER project and now part of IERC as Activity Chain 1)

Given the broad potential reach of the Internet of Things, it can be hardly imagined that a single platform will fully fit all potential scenario and use cases. Even a "Horizontal" platform such as the BUTLER platform, could be complemented by other platform components either specific to a single vertical domain (health, home, city…) or specific to certain technological needs (cognitive technologies, semantic web technologies…). Therefore choosing an open approach is a guarantee that the proposed "platform of platform" is not only fit to current foreseen IoT scenarios but also able to adapt in the future to emerging needs.

The choice of an open approach, carried about by innovative research project that are at the forefront of the state of the art can be seen as a tentative to ensure a decisive strategic advantage: ensuring that the platform does not become a lock that a single (or a small group of) actor(s) can use establish a de facto monopole on the IoT market. A somewhat similar strategy has been used in recent years on the Smart Phone OS market by Google (Android) to establish rapidly a competing open source solution in response to the Apple rising market shares. The open platform initiative proposed by the IERC for now benefit from a first mover advantage (as a horizontal platform of platforms for the IoT) that may be exploited to ensure that openness of the platform is the standard in IoT future business model. The business value could thus be reoriented on other elements of the value chain (devices, infrastructures, applications, services, data market…). It can be argued that some of these other elements, were most of the value creation potential will be realized (such as applications and services) can benefit much more easily to small local actors.

4.2.1.7. Conflicting interests

Several conflicts of interest stand in the way of the IoT realizing the full societal vision described in section 4.1. As a general rule, capital is allocated to the most economical promising markets from a return on investment (often short term) point of view, not from a societal benefit point of view. In this section we review some of the existing conflict of interest that exist and that can modify the way the IoT answers to the expectations.

The interoperability example is a good example of a problem where cooperation by competing forces is needed if individual actors are to benefit from maximum return. However the temptations for closed, non standardised systems that can bring quick return on investment rather than participation in a long term standardisation process do exist.

The lifespan of IoT device can also be questioned: studies by Endeavour Partners [21] shows that the majority of users in the U.S. do not stick to a fitness or health wearable they have bought. In fact, a third of the users stopped using the wearable within six months, and after two years more every second consumer does not use the device any more. This issue of IoT devices being quickly abandoned by a high share of end user who cannot find value in them can be seen either as a problem or as a strong market opportunity. If the customer can be incentives to buy virtually useless devices (they do answer to basic human needs of showing off and belonging to a community) that they quickly discard for buying new ones, this makes a strong business model from the device manufacturer point of view (even though it might not be sustainable in the long run).

However this hardly enables the IoT to achieve the societal visions described above, and can have strong side effects on other markets. Indeed the electronics market is currently mainly driven by B2C market and a "product sell" business model. This impacts robustness, lifespan, and maintenance costs of the devices and make them hardly usable in some IoT application scenarios (such as industrial settings and critical services such as energy or water management). This pleads not only for technological innovation to make the devices more durable and adapted to adverse environments, but also to potential evolutions in business models for business models that favour long term efficiency and resilience of the device such as "as a Service" business models. In such model the cost of the maintenance of the infrastructure is on the provider of service rather than on the end customer.

Other potential conflicts of interests reside in the actual services brought by the IoT. The openness and access to information enabled by the IoT can render visible some issues that weren't before (water leaks, misbehaviours in the logistics chain, fault in industrial processes, etc...). Although this can be seen as a good thing from a higher level societal point of view, it would be a mistake to underestimate the human reaction of the ones potentially held responsible for these issues if they also have the power to slow the IoT deployment that would uncover them.

The potential positive effects on the economy in term of jobs can also be seen as a conflict of interest. If the IoT has the potential to create large amounts of technological jobs in a “knowledge” economy, they also have (as all production efficiency gains) the potential direct impact of destroying other kinds of jobs. Although from a high level societal vision, it can be argued that the overall gains are positive, this hide the different sociological typology of job lost and created (unemployed worker don’t turn overnight in skilled engineers).

4.2.2. Societal Challenges of IoT

If a fully deployed IoT can be expected to have strong positive societal impacts, its development and deployment however have to take into account societal expectation and to face societal issues on its own. The following section presents some of the societal challenges that are expected from IoT development and deployment.

4.2.2.1. Security, privacy, data protection

Privacy was named by the originator of ubicomp, Mark Weiser, the late chief scientist at Xerox Parc as a key issue (Weiser, 1991). Machina Research, in association with Latitude, Council and Info.nl – a trio of web 2.0 consultancy companies – ran a 2012 web survey, polling views on the future internet of things. One of the questions was related to concerns that people may have about living in a future connected environment. Privacy was mentioned by a clear majority.

The privacy and data protections concerns related to the deployment of an Internet of Things are multiple and complex (user informed consent, continuity and availability of services, contextualization of risk, profiling, ownership, management and captivity of data, applicable legislation and enforcement…), most are technically addressable if they are taken into account early on, some will require evolutions of the legislation to both better protect citizens and enable business development and a global rise in awareness and public debate can also be instrumental to favor a privacy respectful IoT. These issues have been well identified [22] & [23] and are the subject of dedicated work of the community (IERC activity chain 5). It can be anticipated that public authorities, especially in Europe, will continue to look into these issues and create regulation that will have to be taken into account in the development of novel IoT application scenarios.

A clear stance on security and privacy can however clearly benefit Europe in the development of Internet of Things based services as the recent event (PRISM) have shown rising distrust in US based services. Security and privacy concerns can result not only in unauthorized access to private data but also in brutal discontinuation of services [24], and have already been estimated as an opportunity for non U.S. players (in the cloud domain): “The U.S. cloud computing industry stands to lose $22 to $35 billion over the next three years as a result of the recent revelations about the NSA’s electronic surveillance programs” [25].

4.2.2.2. Ethical and societal impacts

Although, as presented above the potential for societal benefits are numerous and decisive, the development of an internet of things also raises some ethical interrogations.

Risks such as the emergence of a knowledge divide (reinforcing the existing digital divide), the potential loss of autonomy, skills and control by individuals, massive shifts in labor markets, blurring of moral barriers and invisibility of technology are some of the identified challenges [23].

The development of the IoT participates to the development of a new era of hyper connectivity that will affect human fundamental values at individual and societal level.

At **individual level,** the development of hyper connectivity can be expected to have serious impacts on important human values. The European Commission has started to assess these potential impacts in initiative such as the OnLife [26] manifesto, or the launch of a project call for a “human centric digital age”

[27]. Some of the human values mainly concerned by the hyper connected world of a fully deployed IoT infrastructure are:

- **Safety and Privacy:** Safety concerns are on the rise as ICT technologies are having a stronger and stronger impact on everyday lives not only in online world but also increasingly offline. The rise of privacy concerns is also a well documented risk as personal data collection; archiving, processing, transfer becomes the norm in many ICT scenarios.
- **Identity and reputation:** Several innovative ICT technologies and usage challenges the notions of Identity (relation that one bears to oneself) and of Reputation (relation that others bears to oneself). The limitation of ICT technologies to define rationally such notions that are, by human nature, multiple, complex and changing raises several challenges. From the right to be forgotten to the right to have complex and evolving identities that cannot rely on a single online or offline identity. As ICT is more and more used to store but also increasingly to generate automatically (through profiling and presentation) our identities and reputation, serious challenges can be envision on the definition of human identity and reputation.
- **Relationships:** ICT based relationships also face the same danger as identity: to try to define rationally, in a Boolean approach the complexity and evolving nature of human relationships. The rise of digitally mediated relationships questions the future of human relationships as physical interactions and non verbal language, key to human interactions, are for now mostly left out of digital relationships. Concerns can be raised both for those who are left out of the online conversation and for those for which the online conversation replace to a large extent real relationships. Questions of how to consider and handle relationships with purely digital avatars will also have to be handled as such relationships, once considered as farfetched science fiction become closer and closer to our reality.
- **Responsibility:** The rising complexity of ICT systems, the multiple roles of stakeholders and layered approach of hardware / software result in near to impossible attribution of responsibilities in case of failure, error, or denegation of ICT services. This will have stronger and stronger consequences as ICT systems get more complex and more intertwined with Physical devices and even in a far reaching vision with actual human beings. Difficulty to attribute responsibility raises the double risk of either putting too much constraint on ICT producers, and therefore impeding innovation capacity, or to the contrary that the risk entirely repose on end users.
- **Attention and motivation:** The collective data and knowledge production, publication, archiving and research capacity has since long far exceeded the human brain ability to process it. This raises serious challenges to both human attention (capacity to freely focus) and human motivation (capacity to freely choose on which information to process).
- **Adaptation to technical evolution:** The permanent roll out of technical innovation characteristic of our societies that combine a knowledge economy and a consumerist way of life create non negligible level of stress in the individuals that have to constantly acquire new technological artefacts and master new skills for fear of becoming obsolete.

At **societal level,** the rapid development of ICT technologies is having a strong impact on socio-structures that need to adapt accordingly. The very existence of a directorate general in the European Commission focused entirely on communication networks, content and technologies is proof enough of the need for adaptation brought forth by these technologies at societal level. The development of a hyper-connected era can be seen to impact:

- **Education**: If new communication infrastructure such as the IoT, inherently provides a strong opportunity for new or improved education tools and methodologies. The rapid development of new communication technology is particularly strongly felt in education, as the natural generation gap in understanding between teachers and student risk is being reinforced by technologies that are differently accepted and adopted across age groups. The education system is therefore in strong need of evolution to follow up the technological evolutions.

- **Culture**: The disappearance of traditional boundaries of time and space enabled by ICT is fuelling the definition of ever multiplying alternative cultures as group cutting across traditional boundaries come to define their own set of symbols and values that are coherent and meaningful in their understanding. At the same time the rapid ubiquitous communication mechanisms offered by ICT enable the rapid spread of cultural elements. The application of evolutionary principles to cultural elements (meme as defined by Dawkins [28]) shows that faced to this increased creativity and competition traditional cultural elements could be put to risk. The human impact of putting cultures at risks, with the risk of violent reaction and protective isolative move is a serious challenge.
- **Digital inequities:** As mentioned before, the deployment of the IoT can be seen as a key enabler to reduce existing digital inequities. However the deployment of the infrastructures and of the commercial services must be closely watched to mitigate risks of infraction to the net neutrality or low/slower level of deployment in remote areas (especially for transition and less developed European regions).
- **Existing political structures:** The horizontal nature of the network and the ability to rapidly communicate political opinions and relate to each other, can be seen as a threat to traditional representative democracy model and infrastructures. The evolution of the political models of Europe to cope with a world of hyper connectivity is a major challenge to avoid a loss of legitimacy of existing structures, hierarchies and laws.
- **Social divides:** The new skills of our hyper connected era, and the strong reliance on privately owned technological infrastructures (such as 5G) create the risks of the emergence of new ruling classes based on technological knowledge and proficiency, of the vulnerability to external intrusions and control (as shown in the PRISM scandal), and of the emergence of news means of opinion control (reliance on social media as a mean of control) that need to be taken into account.

4.2.2.3. Society readiness

It's a natural expectation of our societies that technical progress should lead to societal progresses whether in term of increased quality of life, education, culture or social justice. However, as all technological development, the creation of IoT infrastructure also raises important societal challenges. This is especially true in our societies where the evolution of technologies has become so rapid (in good part because of the development of ICT and near instantaneous communication) that both individuals and humans have issues to adapt. The emergence of the "Hyper Connected Reality" of a fully deployed IoT network raises several societal challenges at individual, societal and environmental level that have to be acknowledged and taken into account in the creation of the infrastructure. The permanent roll out of technical innovation characteristic of our societies that combine a knowledge economy and a consumerist way of life create non negligible level of stress in the individuals that have to constantly acquire new technological artefacts and master new skills for fear of becoming obsolete.

It is not evident that the society will be able to absorb such level of rapid innovation in the coming years, and forces fighting for the conservation of the current social structures should not be underestimated in their ability to downplay or delay the potential gains of the IoT.

Therefore IoT will have to be strongly supported by information and marketing support to be able to reach a large market. These investments shouldn't be underestimated. New potential marketing technologies and opinion influencing media such as innovative use of social media combined with big data as a marketing tool should be taken as another potential link for the IoT to deploy.

4.2.3. Environmental challenges

If the IoT can bring positive improvement of society sustainability and environmental protection, its development and deployment also contains important challenges to be addressed:

Health concerns: As with all new deployment of radio spectrum based technologies, potential health concerns shouldn't be underestimated, and need to be taken into account in the design and deployment of the infrastructures. Additional risks such as the repetition of multiple instances of the same infrastructures to accommodate the different commercial operators should also be examined.

Impact on the environment: As with all new infrastructure deployment, the impact of the infrastructure production, deployment, life and end of life should also be examined (life cycle assessment) to validate the type and quantities of resources necessary to produce the infrastructures, the energy necessary to produce and operate the infrastructures, the direct impact of the infrastructures on the ecosystems, and the preparation of legacy, end of life, and waste management life phase of the infrastructure.

From that point of view, the low robustness, short lifespan and strong dependence on rare resources (such as rare earth elements) of electronic (and IoT) devices form important challenges for their use in really sustainable solutions. Initiative for “responsible” sourcing of electronic device [29] have started to emerge but they are however very limited in size. Complete life cycle assessment of IoT products can be seen as a complex challenge especially if they take into account their necessary interactions with other devices and the environmental costs of computing and cloud services. The common assumption is that the potential benefit overweight the costs of IoT development and deployment, however this should not restrict the need for scrutiny and evaluation.

5. Butler socio-economic experimentation and assessments.

In this section, we present the assessment of the 5 BUTLER field trials on social and economical aspects. The analysis is focusing on the potential business exploitation of the scenarios experimented in the trials and on the users feedbacks. Secondly, in echo of the cursory review of expected impacts promised by IoT, a global analysis in terms of the possible impacts value chains is proposed for each scenario, in order to put in perspective the promising but also unexpected frames and impacts and possible conflicts to be addressed in order to deploy and implement these scenarios in large scale.

5.1. Introduction

As explained in section 3.4. , 5 field trials have been undertaken during the project. In the beginning of the project, several scenarios ("BUTLER Smart Life" in 2020, documented in BUTLER Deliverable 1.1) have been developed based a large set of interviews with possible end-users. These scenarios have been used as a basis to define the trials concepts and scenarios. These trials followed various purposes for the project. The most important one was to run a concrete and real implementation of the different components developed in the project (such as the gateway, the behavior modeling, the localization indoor, the security components, etc…) during a length of approximately 6 months.

In this section, we will review the potential experimented impacts of these scenarios through their implementation in the field trials. It was not in itself an objective of the trials to give deep insights on impacts, as the scenarios implemented are still immature for most of them and not yet ready for business exploitation. Consequently, all the required aspects to test the scenarios in real conditions have not been implemented and impede a comprehensive analysis of impacts. In particular, the context of trials implies limitations regarding:

- **The number of users targeted**. As the trials have been deployed as experimental level, only a few number of users (and certainly insufficient to observe large effects) have been involved, mainly people from the research centers and companies were involved into the trials.
- **The nature of users**. In most of the cases, the trials aimed to test the technological components, and don't involve *final* end-users (in the sense of the full value chain) but only intermediate users. Thus, potential impacts all along the value chain are for now mainly speculative.
- **The extent of the trials** in terms of scenarios and applications. Some of the trials focused on specific components that need further investigations and didn't propose a comprehensive scenarios which might produce leverage and wider effects (for instance, the smart transport trial includes only two scenarios, one related to child assistance, another to e-ticketing. But many other services based on real-time feedbacks might be combined to enable large acceptance and wider impacts of a comprehensive "smart transport" scenario).
- **The access to stakeholders**. In some cases, it has been foreseen in the trials (ie smart health trials), but in others, it depended on specific contacts of partners and was not budgeted.

Based on these statements, the impact analysis is done mostly on a theoretical and conceptual basis by extrapolating the global expected impacts stemming from the initial trials scenarios. Some hypotheses were so made to address complete partial scenarios. The approach taken of analysis relies on the development of value chains of impacts. The impact value chain presents in fact the advantage of explicating a theory of change by articulating the relationship between the activities/services as tested in the trials, outputs, outcomes and finally impacts and thus, make explicit the cause to effects relationships. Formally rebuilding this casual chain enables to explain and criticise the hypotheses done (most of the time implicitly) and to identify possible unexpected or unforeseen impacts or factors that could impede impacts to happen. It is a valuable preliminary step to be able to build means and tools to monitor and assess impacts (ie confirm or not the hypotheses).

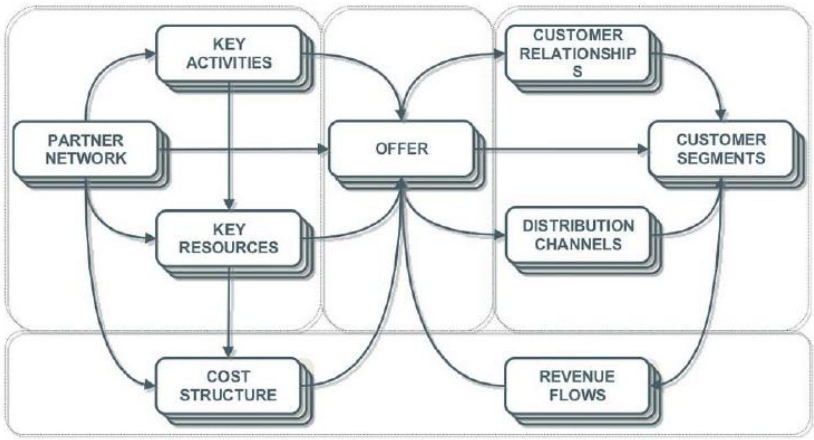
The value chains of impacts (and more generally the impact assessment) encompass several elements in order to distinguish:

- **The various stakeholders** that play a role into the casual relationships: basically the producers of services on one hand, and the users of the services in the other hand. But depending on the cases, other stakeholders appear also important, such as regulators, or policy makers. Furthermore, end-users are most of the time not a homogeneous group, and several users (in the sense of beneficiaries, which can take benefits from the application or service produced) should be distinguished in order to differentiate the related impacts accordingly, which might appear inconsistent and/or conflicting. The value chain of impact is thus a good mean to identify such conflicts and propose means to address them, for instance through regulation
- **The outcomes** which enable to identify the means to produce desirable effects, but also the possible blocking points for the different stakeholders.
- **The different natures of impact.** The IoT based applications of the trials are pursuing several kinds of impacts, and we distinguish social and societal impacts, economic impacts and environmental impacts (corresponding of the overall challenges of EU namely inclusion, sustainability and economic growth, cf. Section 4.1.). As for the stakeholder, the added value of the value chain of impacts is to stress the variety of expected impacts, their possible complementarily and leverage effect but also the potential conflicts and inconsistence among them.
- Finally, the **unexpected outcomes and impacts** are also introduced into the global chain to confront the possible and expected gains to the possible undesirable effects and then propose ways to address them.

5.2. Common framework of description and analysis

As explained in section 3.4.2, the same framework of analysis was used to review, analyse and assess the five trials. In practice, the various conditions of experimentation induce some heterogeneity in description and analysis depending of the level of experimentation, the TRL and the extent of experimentation.

The table below summarise the common framework followed to describe and analyse each trial.

Component	Description
Trial Overview and stakeholders ecosystem	Executive summary of this trial with a focus on the application and services provided to users (end users or not) and description of the different stakeholders (Techno Providers, Analysers, Users, Third parties….) involved in the trial with their role, engagement and interactions.
Economic assessment: Market consideration through the trial	Analysis of the value proposition based on the Osterwalder's model: 1. How to make the business happen (based on the existing assets such as the network of partners, the existing activities and resources) 2. What to propose to the customer (the value proposition) 3. With whom (as customers, possibly split into customer segments, and distribution channels) 4. The financial structure (detailing inflows and outflows)  **Figure 6: Osterwalder's business model canvas**
Assessment of users' acceptance through the trial	Description of how users have been involved in the trial and how they reacted (overall users' feedbacks). Synthesis of success, pitfalls, and challenges faced.
Proposition of value chain of impacts	Description of the chain of impacts and the possible unexpected impacts: ▪ Objectives pursued and clarification of the value proposition (at social, economic, environmental level) ▪ Stakeholders to be taken into account and possible conflicts of interest ▪ Causes to effects relationships ▪ Propositions of recommendations to make the scenarios happen.

5.3. Assessment of the field trials.

5.3.1. Smart health

5.3.1.1. Trial Overview

The aim of this trial was to test health care services developed by Tecnalia and included in Butler platform. The services tested in SmartHealth trial include:

- **GPS-enabled Fall Detector** is a portable device, hanging from the waist, which can detect a fall and then establish a hands-free phone call or send a SMS providing GPS location to a pre-configured phone number. It can also register and send to the cloud periodically GPS position independently of a fall detection. It can also inform periodically about outdoor positioning to track walks. Thanks to BUTLER integration, it can now provide indoor location as well, when a fall event is detected at a certain space enhanced with Zigpos infrastructure.
- **Emotion Detector** is a service which continuously communicates via Bluetooth measurements from a wearable heart-rate monitor to a smartphone. This latter one processes the information received and outputs the emotional valence (positive or negative –i.e., stressed) of the wearer.
- **Medication Intake Assistant** is a netbook (both complemented with a NFC-reader and voice output) which can read NFC-tagged medications assisting the user on the name of the medication (it was originally designed for visually impaired people). The netbook can inform about the correct dose and the right moment for the intake, according to a plan for medications included.
- **TV based Telecare Reporting Service** is basically a vital signs tele-reporting and messaging service. It is developed over a set-top-box (STB). Programming on that STB, we could show reminders and telecare information on the TV set, overlapping on a corner of the channel program. In the same way, the elder at home can send vital sign information obtained through Bluetooth medical devices: digital scale, pulse-oximeter and tensiometer.
- **User adapted videoconference for doctors service** connects remotely a doctor with a user. It employs desktop computer in doctor side, and a touch screen computer in patient side.
- **OSGI framework** acting as a gateway receives information from those aforementioned services when they are used or triggered and sends all this data to BUTLER DDX Smart Server as a data provider.
- Finally, **Mobile App** acts as a data consumer when connected to DDX server. This way, any relative or close friend of a service user providing service information to DDX can get alerts automatically about these events.

In these *health* trials the following stakeholders participated:

- **Developers:** people responsible of technology. They adapted the devices to the project needs and give support to the users during the trials if it was needed. They also were in charge of explaining to the users how the devices and services should be used and prepared some handbooks.
- **Participants/users:** they were recruited among workers of TECNALIA as final users for these trials. 43 people from different ages took part in the trials and tested the different services.
- **Testing responsible:** people in charge of recruiting testers and explaining them the testing. They were also responsible of the informed consent (collect the signatures and save the consents according to the law). They should collect the opinion of the participants, and the complaints if there are.

5.3.1.2. Economic Assessment: market consideration through the trial

The trial has been assessed following the Osterwalder's business model canvas. The trial was implemented in experimental conditions, and for the moment, it's just an "*educated guess*". This general approach and figures should be checked and brought to reality, at least at a regional geographic framework. The main results for each Canvas topic at the moment for this first approach are presented hereafter.

Value proposition

The value proposition is threefold:

- **Empower your own health and well-being knowledge and management:** Tecnalia's group of application let the user of devices and services receive updated information about health measurements, emotional condition, psychotherapy sessions, fall detection and medication reminders. (Only the fall detection was tested into the trial, but the others services are planned to be integrated as a whole).
- **Let your closer people know asap about your health condition and event, everywhere and at any time:** any relatives (secondary users) can get ubiquitous information about health condition of the person assigned as primary end-user via a mobile app.
- **Get medical information about your patient automatically and periodically an create a patient's history:** Tecnalia's gateway and BUTLER platform can get much information coming from other smart health services (daily activity monitoring, aggressiveness monitor, physical activity monitor, etc.). This service is targeted for tertiary users.

Customer Segments

The expected market effort is concentrated on four types of customers:

- **Primary end-users**: they are, basically, elderly people living alone, as main demanders of smart-health services provided by Tecnalia.
- **Secondary end-users**: this customer segment attends to relatives and closer friends who can now be noticed automatically through a DDX (digital data exchange) subscription about the use and trigger of main services being used by the primary user.
- **Tertiary end-users**: They are physicians, family doctor, psycho-therapist, etc. Some of the services provided are especially useful for the family doctor of the primary user (medication intakes, medical measurements).
- **Early adopters**: this customer group is very important for the market penetration, not only because they provide relevant information when being beta-testers of the applications but also as advisors of these services for other potential primary users. In this sense, Tecnalia keeps good relations with regional Elderly People Associations that might be considered as early adopters. However, and taking into account that the services are also provided for their relatives and physicians, in next steps these types of secondary and tertiary users should be included as advisors too.

These customer segments have been roughly sized considering just a regional context, The Basque Country, a very small geography for about 2.5 million people strongly affected by the ageing phenomenon. The table below presents the expected size of customers segments.

Customer segments	Market size	Remarks
Primary end-users (ederly people living alone)	100.000	Very rough data – making an educated guess – based on the closer geographic market of tecnalia for the 1st year
Secondary end-users (relatives and closer friends)	100.000	One relative for each primary end-user
Primary early adopters (primary users from ederly people association, as advisors)	20	Check of services' added value with real targeted end-users (primary advisors) by providing them for free for a certain period (initially one year)
Secondary early adopters (relatives, as advisors)	20	Check of services' added value with real targeted end-users (secondary advisors) by providing them for free for a certain period (initially one year)
Tertiary early adopters (doctors as advisors)	20	Check of services' added value with real targeted end-users (tertiary advisors) by providing them for free for a certain period (initially one year)

Customer Relationships

A draft analysis of the relationship with these customer segments had also been done by Tecnalia:

Customer Relationships	Explanation	Remarks
Primary end-users (elderly people living alone): From service Testers To Buyers.	It's a very heterogeneous market but we are accustomed to work for them. They pay much attention (and money) to leisure and health.	NEED TO GET CLOSER: It's probably needed to firstly convince their families as useful services for 'peace of mind'
Secondary end-users (relatives and closer friends): From service Testers To Buyers	Relatives of elderly people are a very important target group, not only as potential buyers of these 'peace of mind' services but also as relevant advisors for their elders. It's a market to explore, currently unknown for us	NEED TO EXPLORE AND SIZE
Tertiary end-users (physicians -family doctor, psycho-therapist-): From service Testers To Buyers and Advisors	This target group related to elder's doctors and therapists could take profit of the continuous information flow about elder's health. However, purchases are probably approved by Healthcare Company or Public Service, so normally decisions are not in their hands (despite it could be cheap).	NEED A DIRECT CONTACT: other desktop applications collecting individuals' health information and somehow processing it appear to be needed for a purchase decision.
Primary early adopters (primary users from Elderly People Associations -as advisors-): From service 'Beta' Testers To Advisors	They are frequently coming to our Labs to follow-up and test our developments. It's a profitable relation. Then, they could become 'advisors'	NEED TO STRENGTH: Next steps for service testing could include greater number of elderly people.
Secondary early adopters (relatives -as advisors-): From service 'Beta' Testers To Advisors	There's no relation at all with primary beta-tester relatives.	NEED TO INVOLVE: Next steps for service testing could include elder's relatives in order to test functionalities
Tertiary early adopters (doctors -as advisors-): From service 'Beta' Testers To Advisors	There's no relation at all with primary beta-tester physicians	NEED TO INVOLVE: Next steps for service testing could include elder's doctors in order to test functionalities

This vision is the endpoint that Tecnalia would like to reach. For now, the customers' relationships are mainly oriented in a research purpose with the primary end-users (elderly) through close relationships with regional association, and with tertiary end-users (physicians) to gather technical requirements for the medical devices. The relationships in terms of buyers and advisors should so be built.

Channels

Some aspects that must be reconsidered once the customer segments are deeply analyzed are those related to the commercialization channels and correspondent revenue stream types. As Tecnalia's services provide a huge amount of functionality not only dealing with mobile and desktop apps but also with devices for medical use, several channels have been considered.

Channels	Description
Android Marketplace	Google play and Tecnalia's website could serve as real markets to expose and sell elder monitoring application developed under BUTLER SmartMobile guidelines.
Health-related shops	Devices (especially Fall Detector, because the rest of medical devices used are of-the-shelf) could be sold at shops for elders, assistive devices shops or even fitness shops
Direct offer	Just for advisors.

An important aspect to take into account and roughly tackled for the moment is that concerning the potential revenue stream types which better fit with user's needs and preferences. In this sense, several different revenue stream types are studied: sale, subscription, pay per use, licensing, rental, advertisements inclusion, etc.

Key Activities, Resources and Partners

Firstly, some key activities have been found as critical for a market success. They are dealing namely with requirements exposed by the primary users, the elderly people. Robustness and usability of the services are at the top of these key activities. Another one is related with the price of medical devices that are used. They are mostly commercial off-the-shelf devices not manufactured by Tecnalia and a main activity should be related to achieve better prices when sold within our products/services.

Key activities	Explanation	Remarks
Product/Service robustness (fault tolerance)	Especially for primary and tertiary users, products and services are to be robust enough to NOT fail at all and, in any case, always providing a self-control feeling	Important market barrier
Product/Service usability	functionality might be quick and simple to access	Important market barrier
Low-cost medical devices	Medical devices cost (for in-home use) are expensive and a big part of cost structure. A main activity should be related to achieve better prices when sold within our products/services	Important market barrier

Consequently, a critical Key Resource is that medical device and a Key Partner should be its manufacturer and stakeholders of its distribution channels.

On the other hand, and counting on the importance of robust fail-tolerant service, software designers and programmers for interaction functionalities are also considered as Key Resources.

For a market success a dissemination campaign appears to be a strong requirement. It must be focused on primary users (elderly people) and using their preferred communication channels. This is a must and should be analyzed thoroughly.

Resources and partners	Description
Key Resources	• **Devices and manufacturers**: our services use off-the-shelf medical devices. In order to get better prices for the primary end-user, this is considered as a key resource to capture revenues • **Software developers**: for the services to be robust enough to break market barriers and reach users acceptance, it appears to be very important to count on expert technicians • **Dissemination campaign**: to reach the market, at least that related to primary and secondary users, a strong and direct marketing campaign is to be deployed, especially at those places frequently visited by these target groups when being together
Key partners/stakeholders	• **Medical devices manufacturers and distributors (Electronics Manufacturing)**: our services use off-the-shelf medical devices. In order to get better prices for the primary end-user, this is considered as a key resource to capture revenues

Cost Structure and Revenue Streams

Once all those aforementioned aspects have been analyzed in first draft round, we can go through a first approach for Cost Structure and Revenue Streams.

Everything in cost structure and revenue streams is considered under a time frame of a year (first year of commercialization). Tecnalia drew a very rough first approach that will certainly required several improvements and consolidation.

Regarding Cost Structure, several items have been identified:

- Equipment, namely as more important sub-items:
    - Fall detector + Zigpos module
    - Bracelet + smartphone
    - Medical devices
- Services' Test & Installation
- Personnel, regarding a new company structure
- Marketing activities

These items consume most economic resources involved in the commercialization.

We've also made the effort to classify those cost structure items into variable and fix costs, which will be later very important to size the minimum number of customers to reach to start financial profit.

Variable cost structure and revenue streams are firstly considered counting on a wild guess about:

- markets dimension and share (considering the three sorts of customers, which are somehow influencing each other),
- services and product prices, and
- typical revenue stream types for each product and customer segment, what still should be adapted to correspondent commercialization channel identified.

Regarding the Revenue Streams, Tecnalias also classified them into several types depending on the customer segments defined. These are:

- Incomes from Medical devices and related applications:
    - from advisors
    - from primary end-users
- Incomes from SmartMobile-enabled apps (thanks to BUTLER platform integration):
    - from advisors' relatives
    - from secondary end-users
    - from tertiary end-users

Figure 7 presents the general overview of the cost structure and revenue Streams, as foreseen by Tecnalia. **It appears to be a very optimistic approach requiring a strong investment of about 4.5 million euros, what is clearly not affordable by Tecnalia (that's about half of Tecnalia Health yearly incomes).**

Finally, figure 8 summarizes the different components of the Canvas template in a single overview.

Costs € 4.412.000

	Fixed costs	Cost	
1	Equipment: Fall detector + Zigpos module	€ 12.500	
2	Equipment: Bracelet + smartphone	€ 6.250	
3	Equipment: Medical devices	€ 6.250	
4			
5	Company Structure	€ 150.000	
6	Marketing	€ 25.000	
7			
		€ 200.000	*4,5%*

	Variable costs	Cost	Units
1	Equipment: Fall detector + Zigpos module	€ 702.000	7.020
2	Equipment: Bracelet + smartphone	€ 1.053.000	7.020
3	Equipment: Medical devices	€ 1.404.000	7.020
4	Services' Test & Installation	€ 1.053.000	42.120
5			
6			
7			
		€ 4.212.000	*95,5%*

	Other costs	Cost
1		
2		
3		
4		
5		
6		
7		

Total costs	€ 4.412.000

Revenues € 5.077.000

	1 Medical devices and applications for advisors	Revenue	Units
11	Empower your own health and well-being knowledge and management - Rental		
12	Empower your own health and well-being knowledge and management - Subscription	€ 2.600	
		€ 2.600	*0,1%*

	2 Medical devices and applications for primary end-user	Revenue	
21	Empower your own health and well-being knowledge and management - Sale	€ 1.200.000	
22	Empower your own health and well-being knowledge and management - Rental	€ 3.600.000	
		€ 4.800.000	*94,5%*

	## SmartMobile-enabled apps for advisors' relatives	Revenue
FAL		
##		

	4 SmartMobile-enabled apps for secondary end-users	Revenue	
41	Let your closer people know asap about your health condition and events, anywhere, anytime - Sale	€ 60.000	
42	Let your closer people know asap about your health condition and events, anywhere, anytime - Rental	€ 192.000	
		€ 252.000	*5,0%*

	5 SmartMobile-enabled apps for tertiary end-users	Revenue	
51	Get medical information about your patients automatic and periodically and create a patient's	€ 8.000	
52	Get medical information about your patients automatic and periodically and create a patient's	€ 14.400	
		€ 22.400	*0,4%*

		Revenue
1	-	
2	-	

		Revenue
1	-	
2	-	

Total revenues	€ 5.077.000

PROFIT
€ 665.000

Figure 7: cost structure and revenue stream for *smart health* services

Key Partners	Key Activities	Value Propositions	Customer Relationships	Customer Segments	(market size)
Medical devices manufacturers and distributors	Product/Service robustness (fault tolerance)	Empower your own health and well-being knowledge and management	From service Testers To Buyers	Primary end-users (elderly people living alone)	100.000
	Product/Service usability	Let your closer people know asap about your health condition and events, anywhere, anytime	From service Testers To Buyers	Secondary end-users (relatives and closer friends)	100.000
	Low-cost medical devices	Get medical information about your patients automatic and periodically and create a patient's history about	From service Testers To Buyers and Advisors	Tertiary end-users (physicians - family doctor, psycho-therapist-)	5.000
		Tecnalia's Gateway scalability (connectivity to many more smart-health services than currently provided to BUTLER platform)	From service 'Beta' Testers To Advisors	Primary early adopters (primary users from Elderly People Associations -as advisors-)	20
			From service 'Beta' Testers To Advisors	Secondary early adopters (relatives -as advisors-)	20
			From service 'Beta' Testers To Advisors	Tertiary early adopters (doctors -as advisors-)	20
	Key Resources		**Channels**		
	Devices and manufacturers		Android Marketplace		
	Software developers		Health-related shops		
	Dissemination campaign		Direct offer		

Cost Structure	€ 4.412.000	Revenue Streams	€ 5.077.000
Equipment: Fall detector + Zigpos module	€ 714.500	Medical devices and applications for advisors	€ 2.600
Equipment: Bracelet + smartphone	€ 1.059.250	Medical devices and applications for primary end-users	€ 4.800.000
Equipment: Medical devices	€ 1.410.250	SmartMobile-enabled apps for advisors' relatives and doctors	
Services' Test & Installation	€ 1.053.000	SmartMobile-enabled apps for secondary end-users	€ 252.000
Company Structure	€ 150.000	SmartMobile-enabled apps for tertiary end-users	€ 22.400
Marketing	€ 25.000		

Costs:	€ 4.412.000	Revenues:	€ 5.077.000
Profit: **€ 665.000**			

Figure 8: Canvas of Osterwalder's model for *smart health* services

5.3.1.3. Assessment of users' acceptance through the trial

Most of the user feedback has been sent through the feedback tool (see section 6.3.2) and complemented with interviews. Feedbacks have been collected about the various use cases:

Fall detector

Participants commented that in general they considered that the device is a too big, but one of the participants commented that for elderly, this size could be fine for them taken into account the dexterity of this population.

Regarding the usefulness of the service, all the participants agreed that it is very useful and comfortable and it would be more useful in case of elderly who lives alone, or workers who perform work that involve risk of falls, for example. Participants also agreed that the device more or less made what they expected except that sometimes it detected falls that did not occur (false positives).

Related to the interface, different opinions have been expressed: some participants think that the interface is really easy to use because it has only one button and some lights, so they could manage very fast (easy-to-learn), but others think that the code of lights (LEDs) is difficult to understand and learn. Some participants also commented that the flap is difficult to be open.

In general, the participants also rated their satisfaction with the service. Satisfaction was divided into eight categories (see section 6.3.2): functionalities, utility/usefulness, usability, ergonomy, performance, design, privacy and security. Most of the participants were filly and partially satisfied. We asked to users to rate each category into four levels (fully satisfied (4), partially satisfied (3), partially unsatisfied (2), fully unsatisfied (1), no opinion (0)).

During trials participants also had the possibility of reporting bugs, constraints and barriers that happened. In this case, only three participants reported this kind of information.

Finally, users suggested some improvements for this service:

- About the design, some participants suggested to make it smaller.
- Other participants proposed to add audible alert, for example, a beep, when it has low battery.
- For fall detector we included ZIGPOS technology for indoor location. Participants valued it very positively, but they commented that it would be very better if it could be implemented in the same device (now they are in two different devices).
- About the interface, some participants also commented to add some indicators (light indicators, for example) for battery: low battery, battery charged …
- Other participant proposed to make it water resistant to detect falls in shower or to have the possibility of using it in swimming-pools or beach environments.

Medication intake assistant

Participants in general felt very satisfied with the service. All of them commented that the service is useful and made what they expected. About the interface, they said that the design is very simple, easy-to-learn and easy-to-use. The only negative comment was about the device: a tablet with a resistive screen. Some participants sometimes had problems to accept the alert (press button). About the quality and interoperability of the application the participant thought that it was enough.

One user also reported a bug in the system, which was identified and then corrected.

Some participants complained about the flexibility of the application, because nowadays it cannot be customizable. This application is for prescribed medication and it cannot be customizable by patients, only by doctors or physicians. They suggested that some parts of the application could be open to patients to be customized.

Participants also suggested some improvements for this service:

- Participants would like to have the opportunity of changing the timetable, because some drugs should be taken after meals (breakfast, lunch or dinner). For now, the doctor should input the timetable of the prescribed medication and indicate the timeslot of the medication intake. If patient takes the drug later on, he could not inform (clicking in “I do” button) about it and the service register that the patient does not take the pill.
- Give the option to user to change the prescribed drugs. For now, only doctor or technician can do it, but sometimes maybe patient should have the option.

Emotion detector

As it was before mentioned, this service was tested only by three users, so few feedback were collected about it. Participants had some problems establishing connection between the Smartphone and the bracelet (heart rate monitor).

They also proposed some improvements for the interface and the application:

- The hearth rate is shown in the interface with numbers. One participant proposed to use colored graph with last values to show the values instead using numbers.
- Other participant commented that the “valence” data is not well understood by the user and the impact of it should be somehow explained. “*A broader explanation of this value would be appreciated*”, he said. Also, how health could be improved when this value changed could be interesting.

But the participants didn’t here entirely to the services and though that the device was quite too intrusive and not very comfortable.

Videoconference for doctors’ service

For this service, the only feedback came from the doctor of Tecnalia. He was satisfied and told that “it was very useful to have virtually access to all Tecnalia employees who are in different places from”. She also said that “health-related service has been very useful”.

To conclude, in general, the feedback collected give good insights and results about the usefulness of the services which have been quite well rated. Nevertheless, some changes could and should be done, specially related to the design.

5.3.1.4. Impact value chain proposition

This smart-health BULTER trial addressed the healthcare domain and especially the medical device side of the market. As seen in the previous sessions, the scenarios are addressing mainly ageing and/or dependant population (primary target) and are thus positioning on the high economic burden between the healthcare sector and the ageing population.

The trial encompasses broad smart-health scenarios comprising 5 different use cases: fall detection, Emotion detector, Medication intake assistance TV based telecare service and Videoconference for doctor services. Smart-health also denoted e-heath or m-heath applications are not a new topic and are raising more and more interests from various stakeholders for several years. The market is expected to explode in the forthcoming years[1]. New technologies are pushed by several actors including among others:

- Healthcare profesionnal
- Augmented reality companies
- Wireless device manufacturers
- Wireless infrastructure providers
- Wearable technology developers
- Embedded computing companies

[1] The global mHealth market will be worth some $23 billion by 2017, according to a report published by the GSMA in 2012.

- Wireless service providers of all types
- Mobile operators
- ...

The following scheme is a synthetic vision of the impacts value chain, from BULTER components at the left to global expected impact at the right.

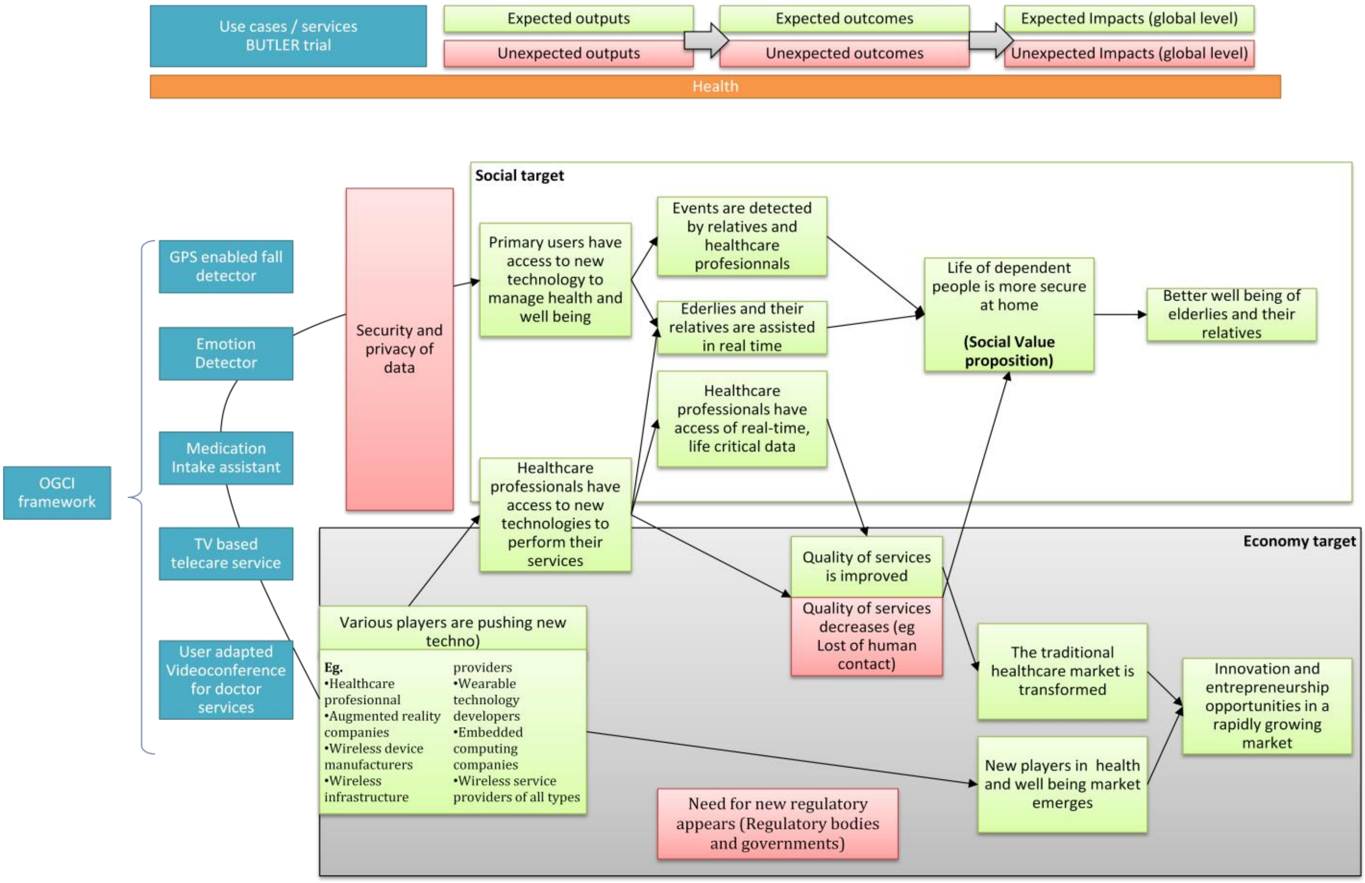


Figure 9: smart health chain of impacts

The **main proposal value proposition** of the scenarios is a social one: to support well-being and assist dependent people and in particular ageing people. This value proposition works at individual level and the usefulness of such services has been mostly well rated by the users[2].

It is noticeable that beyond the elderly themselves, the end-users - in the sense of customers - targeted by these medical devices are the relatives and caregivers of the ageing people (secondary target).

IoT based services appear in concurrence with other technologies (and older such as home automation), and the use of real time and context awareness capabilities in that scenario is not without posing problems in terms of users acceptance. Beyond the technology, what will play a role is the value brought to the users. In particular, security and privacy of data appear of paramount importance in this scenario.

The question on **interoperability** is also an important topic. At a first glance, operators and services providers have no interest to support interoperable solutions, and most of the classical home automation services are not interoperable. But to really reach large scales, and go beyond specialised solutions, interoperability should be foster, and is one of the cornerstones of IoT added value in comparison with classical home automation services.

[2] See deliverable 5.2 for the evaluation of the trial.

Aside the social target, **the economic target** plays also a major role in this scenario. Caregivers and healthcare professionals are important stakeholders in the ecosystem, with the ability of using (and pushing) the new technologies at their disposal to develop new services and improve their quality of services. It is expected important transformations of the current healthcare sector via a transformation of the traditional market players, but also via the emergence of new actors (coming from the technology side). At global level, the economical expected impact consists in rising innovation and entrepreneurship opportunities in a new and rapidly growing market. This economic target is in particular strongly supported by policy makers at all level (the namely silver economy is raising a lot of interest from regional to European level).

However, these two targets may diverge in terms of expectations and drivers. First of all, a classical risk pointed out relies on the possible loose of human contact, and what is seen currently as desirable from a technological perspective could appear opposed at the desire social impact of well being and should so be properly addressed. Many smart health applications will never enter the market for a number of reasons. Often the problem finds its origin in an unsuitable business model and a decorrelation between the users' needs and market drivers.

To respond to these concerns, a need of regulation (autoregulation or external regulation by policymakers) appears, to reach a balance between the economical and social drivers.

5.3.2. Smart transport

5.3.2.1. Trial Overview

Two use cases were implemented in the BUTLER transport field trial:

- **Smart ticketing:** *"Imagine that IoT solutions affect our lives in a way that everyone is able to use public transportation systems without take care about pricing or ticketing".* In order to ease the payment process for public travel, it is planned to use wireless technology to inform public transport companies about the used attendance of customers. Therefore, it will be possible for customers to pay for real used ways instead of overall or flat costs. The registration of a way cannot be forgotten by a customer as the ticket will recognize seamless the entrance of a public transport vehicle. For demonstrating the possibilities the same smart tags will be used to check, whether a customer is travelling with the transport company or not.
- **Children safety during travels in group.** A teacher or childcare person would like to make sure the bus/train/tram is not leaving a station before all members of her children group are on/off board the vehicle. The childcare person will carrying a smart mobile to monitor the children group without the need to count or see each member of the group. Each child is equipped with a smart tag. The bus driver will also have a smart mobile where the contextual information is shown. The trial would demonstrate that the door of a public transportation vehicle is only closed if all the members of a group are inside or outside it.

Figure 10: AutoTram Extra Grand at testing area Dresden

In terms of deployment, the field trial takes place in collaboration with TU Dresden ITVS (Transport Systems Information Technology) and Fraunhover IVI at AutoTRAM Extra Grand from June to October 2014. The use of the AutoTRAM instead of a real world public transportation vehicle was because of the opportunity to have as much time to do simulation and test under several conditions. A dedicated testbed allowed experimentation as often as possible. Due to the fact that the AutoTRAM is a complete working public transportation vehicle, future technologies could be tested in future environments.

For the two field trial scenarios there were different iterations of tests to get as much valid data as possible. There were use cases outside on different weather conditions but also laboratory based indoor measurements.

In these *transport* trial the following stakeholders participated:

- **Developers:** they performed the implemented functionalities in scenarios which mostly will not happen in the real world
- **Participants/users:** workers and students from TU Dresden, Fraunhofer IVI and ZIGPOS. People from different ages took part in the trials. Finally up to 50 people tested the different services.

5.3.2.2. Economic Assessment: Market consideration through the trial

The table below summarizes the different components of Osterwalder's model.

Categories	Description (distinguish what have been experimented / what is planned for the future)
Key partners/stakeholders	Experimented in a real world environment, future usage in public transport companies and private transport companies
Key Activities	More service quality in public transportation and easy usability for frequent traveller or visitors in public transport companies
Key Resources	Device manufacturers for lower the hardware costs to break market barriers
Value Proposition	Easy and save public transportation for young and old
Customer Relationships	**Frequent traveller/Visitors:** Easy usage of public transport vehicles. The user needs no cash, no ticket and can use public transport services as easy as possible **Child care taker:** Save usage of public transport services without any security doubts. **Private transport companies:** Acquire more users due to more quality of service
Channels	Local public transport company stores and tourist information
Customer Segments	Frequent traveller, Visitors, Child care taker, Private transport companies
Cost Structure	Monthly usage fee directly from public transport companies. All inclusive packet prices for private transport companies. Low cost solution for child care taker.
Revenue Streams	Fees and selling the hardware

5.3.2.3. Assessment of users' acceptance through the trial

A small questionnaire was filled by participant to give their personal impression over the functionalities. Most of the users get a good experience about the functionality and there was a good reputation from the child care taker. Personal impression was quite different due to the new technology and concerns about security. The biggest challenges expressed by the participants were related to the price that should as lower as possible and could represent an important market barrier. The other challenge identified is related to the worries about security that could impede user's acceptance.

5.3.2.4. Impact value chain

The smart transport case implemented in BUTLER is based on two simple scenarios. The first one is an e-ticketing system enabling public transport users to pay for their real use of transports (instead of flat cost). The second one is targeting children using collective transport by assisting personnel in charge of the children to monitor the children group without the need to count or see each member of the group thanks to a smart tag worn by each child. In that case, the analysis of stakeholders' ecosystem is important, because the introduction of new technologies (in the field trial, related to localisation capabilities and smart tags for children) introduce a new player in an already complex ecosystem. The current ecosystem is organized around 3 different stakeholders: policymakers, transport companies and users where policy makers and public transport companies deal with together to establish the overall framework of public transport (prices, lines, frequency, etc.). In the same time, the business relationship is organised and managed by transport companies with end-users.

Transport is currently in the heart of cities issues in terms of mobility, sustainability, energy and carbon footprint. The cities are pushing hardly to encourage more people (namely users) to change their behaviour regarding their transport habits. New technologies are seen as very promising to bring more value and simplify and improve the use of public transport system for users. The future H2020 call for projects on smart cities[3] is for instance exactly targeting these issues.

But it introduces a new player in the ecosystem and that raises several questions because it disturbs the current value proposition of public transport without identifying clearly (and several scenarios could emerge) who will pay for it among the three main stakeholders.

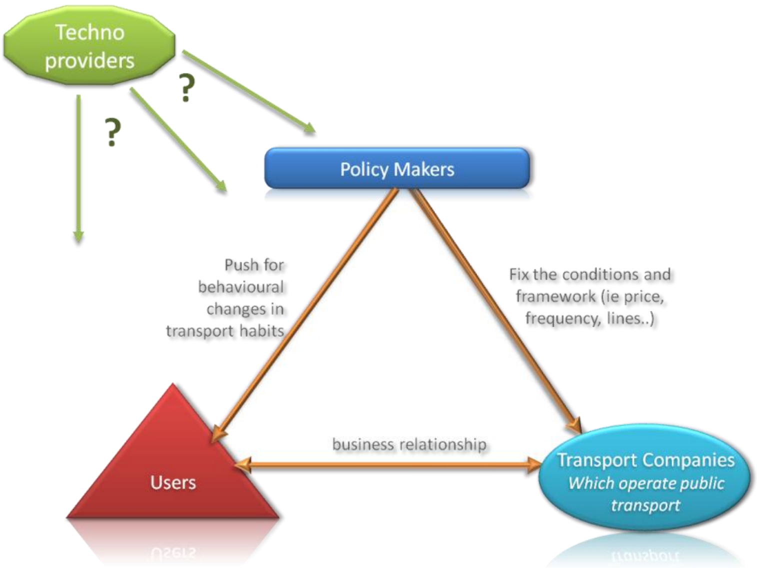


Figure 11: stakeholders of public transport

This issue related to costs (of infrastructures, of devices, etc.) is in the heart of the identification of impacts as it constitutes a potential market barrier (this aspect has not been explored in the trial).

In terms of impacts, several value propositions co-exist depending on the stakeholders targeted. We distinguish the consumer (or user) value proposition which consist in improving users' experience of transport (more affordable and more convenient). But at global level, we can also set-up a "sustainable" value proposition targeted by policy makers to reduce carbon footprint. The economic value (targeted by techno providers) proposition is unclear and dependent of models chosen within negotiations with public transport companies and/or policy makers.

If we analyse the impact value chain at individual level, the scenarios tested in the field trials are based on an exchange of data and a **win-win principle**: data are gathered regarding users' attendance of transport in real time to enable a charge of users depending on their actual usage on one side, and providing transport companies with accurate and real time data about transport system use on the other side. However, the risk appear of a resistance to the change from users and the potential risk of a double ticketing system which at the end could deserve the transport companies (and appear as a barrier for them to promote such services). Furthermore, even this scenario was not tested at large scale, interviews run after the test showed that people worried about security and privacy issues about their own data and report impression of being tracked. Previous examples of change in ticketing and charge system in public transport demonstrated similar issues (for instance, the establishing of a NFC card in Paris transport system that recorded travel data had been rejected by users that claimed for anonymity).

[3] http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/2148-scc-01-2015.html

In terms of business model, the question of data (collection, record, uses by whom and for which purpose) is in the heart of debates and drives conflicting positions between individuals, policy makers, techno providers and transport companies. The risk is high that a push without being entirely transparent about this issue could conduct to abandoning uses cases and has as consequences useless investments in infrastructure. A key success factor is consequently to encourage for a transparent dialogue among stakeholders, including also the consumers associations and data protection authorities, to prevent potential conflict and rejection from one or another parties.

Regarding the children use cases, the same concerns were not expressed by testers, and child care takers had good impression with the use case. Nevertheless, the "track" of children through tags and devices is currently in debate far beyond this transport scenario and raising several issues about the blur frontier between children protection and children surveillance. There is so an important risk of lack of acceptance from users regarding this scenario and pros and cons should be carefully identified and put in balance to identify possible business models behind.

The figure below synthesises the impacts value chain.

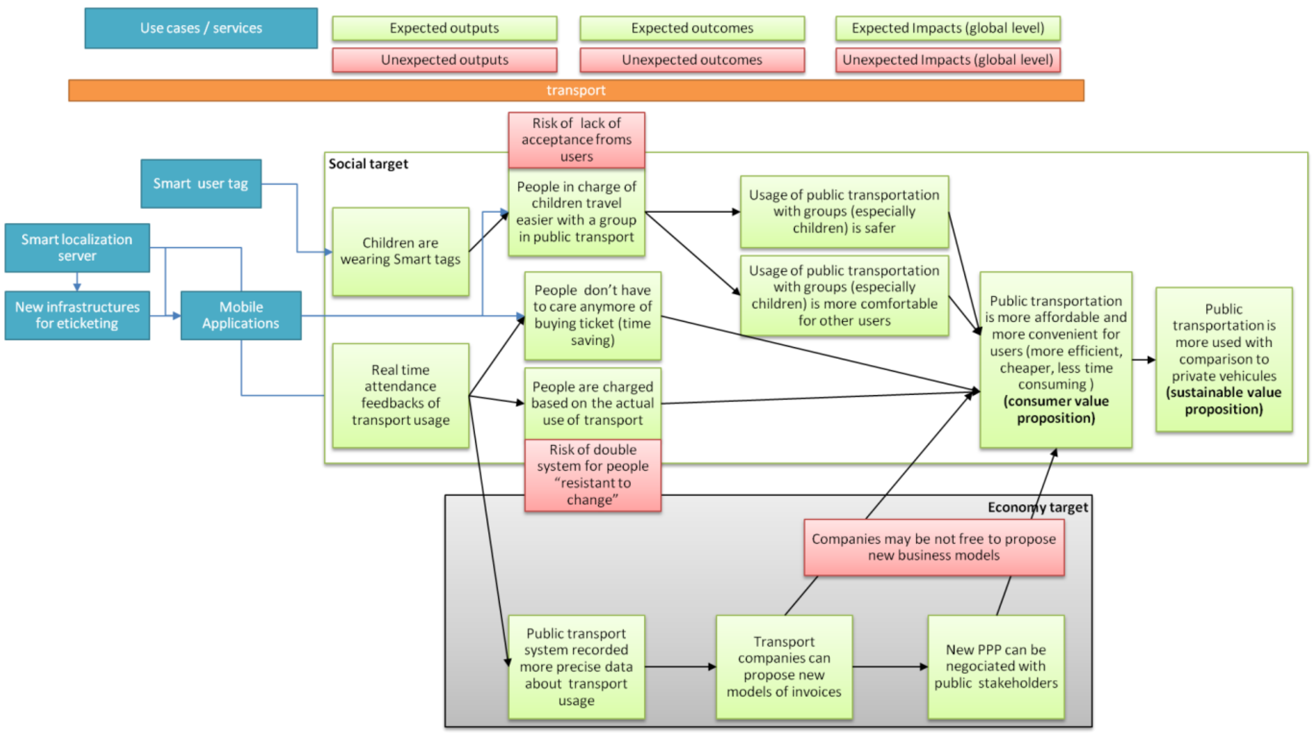


Figure 12: Smart Transport chain of impacts

5.3.3. Smart Shopping

5.3.3.1. Trial Overview

The Smart Shopping trial implemented a use case for merchants of the city of Santander. Even the users (in terms of final beneficiaries) are both merchants and citizens, the focus of the project was on the merchants. BUTLER created a tool that enables the direct interaction between merchants and citizens through the digital resources that Santander Municipality has created. Moreover, the relationship among them is not just a board; the merchants are receiving processed information about the status of the city based on past events and conditions so as to forecast the best moments for increasing the engagement between citizens (customers) and local merchants.

Regarding the deployment and implementation of the trial, one of the key aspects of the trial relied on merchant's involvement in the creation and selection of features that the platform should include. Their vision drove the creation of the platform and BUTLER role was facilitating a smooth usage, reducing as much as possible the complexity, the configuration aspects and just giving a simple triple feature tool for registering, promoting campaigns and modifying the ongoing ones.

The success of the collaboration has been reflected in the number of new users participating in the Field Trial after officially launching the application. We consider 40 participants including, commerce, bar, restaurants and hotels, around different zones of the city.

In this shopping trial, a large amount of stakeholders participated:

Techno Providers

The technology providers for SmartShopping trial are focused on two key groups:

- Data providers:
  - Open data platform – devices feeding open data sets
  - Banks – providing information about economic activity across the city
- Hardware/Software enablers
  - Smartphone – iOS and Android versions of the app for managing information related to each merchant
  - Cloud Dedicated Servers – The trial is using a dedicated cloud server for processing the information and create the interfaces among all the components
  - Third party SaaS platforms like Flickr.

The technology providers supply the tools for the reception, processing and delivery of both the information and alerts. The flow of the trial and how the different stakeholders participated in the scenario has been described in details in the Deliverable D5.2.

Analysers

The information collected must be analyzed so as to generate alarms and notifications that can be exploited by merchants.

Users

The users of the field trial are mainly city merchants. 80 subscriptions of active users were recorded (happening in the first 10 hours after the launch of the trial, achieving in a single day the figures target at the beginning of the trial). The most important lesson learned in this process is that there are always people willing to participate in innovative applications, and having them involved in the design process has multiple benefits, such as:

- Engagement of new users → new users are welcome and their feedback is also really good because most of the ideas and concerns are already overcome.
- User acceptance of new tools → the tool is not only an engineering exercise, the user interfaces and functionalities have been created according to user needs.

- Exploitation of platform features → the development time is optimized; all the features created are being used. They were included because a relevant amount of users demand them.

Their profiles were heterogeneous and it has been challenging in itself to create a tool understandable and usable for all of them. The requirements imposed by them guided the evolution and definition of the HMI (Human Machine Interface) and the selection of the different ways of accessing the service. The feedback process in which users have been queried 3 times helped in the identification of key features and in the modification of the HMI.

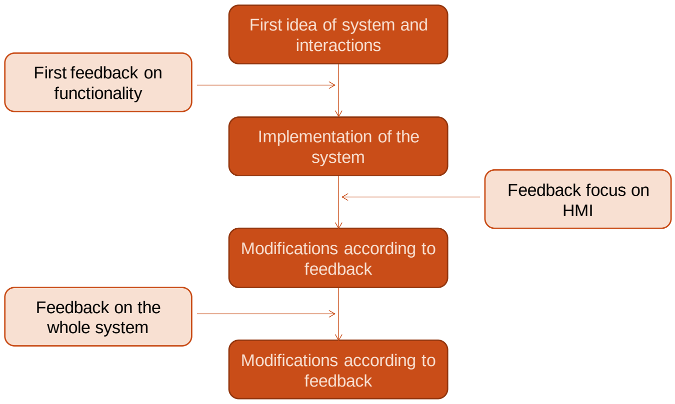


Figure 13: Feedback process in the smart shopping trial

Third parties

The field trial has focused not only in serving as an innovative tool for Santander city merchants, but also as tool that will be exploited by citizens and visitors. One of the most important aspects is to offer the possibility to third parties to get this information and create new applications based on it. The business model will be clear, the access is free, but in the case where the use is generating economical revenue, a fee will be applied. The open data platform provided by Santander city is based on CKAN [30].

5.3.3.1. Economical assessment: market consideration through the trial

Nowadays there is a strong fight between small local merchants and big retail companies and restaurants. Additionally, municipalities try to boost the expansion of the former for many different reasons. In this environment, with the rise of ICT technologies and the democratization of Smartphones it is easier to serve citizens useful information from the merchants directly to their hand considering context information for increasing the impact, and there is a promising business opportunity to be taken.

Value proposition

In terms of value proposition, SmartShopping field trial is proposing two different things to the customers. On the one hand, the real time analysis of information increase the knowledge about population and help in the identification of market opportunities, the detection of *"hot"* hours along the day based on the analysis of available information. On the other hand, the field trial provides all the technological enablers that are needed to communicate with the citizens and moreover, the exploitation of the knowledge derived from city analysis.

SmartShopping has defined a clear strategy for reaching prospects and disseminate the possibilities that the system and environment created in the project offers. In parallel there is also an architecture that must be followed so as to exploit all the features of the created platform, in case of not following this recommendation some of the functionalities will not be included, but in any case the whole infrastructure enables a system for communicating merchants and citizens in an open way so as to have the possibility of creating closer relationships and boost local economies.

Customer Segments

The Customer segments identified are the following:

- **Public Authorities** – Involved in Smart city program. The proposed field trial brings a new methodology to break the gap between citizens and Smart City concept. They usually ask for useful services, through this the Municipality can get a revenue stream for making sustainable the infrastructure created, and also offers a new way to boost local economy.
- **Merchants associations** – In addition to the previous case, the platform created can be enjoyed and managed directly from a group of merchants. In that case, they will receive the full list of items required, both for merchants and citizens. The possibility of having a lightweight, lower cost platform is also a good opportunity that must be considered.
- **Banks** – One of the key inputs in this system is the information provided by banks. The base platform can be enriched with banking information and this way providing an added value to banks so as to attract new customers by the possibilities brought by this.

Channels

The distribution channels considered are the following:

- Participation in relevant Smart City conferences
- Promotion of novel services introduced by Santander city through the Spanish Network of Smart Cities.
- Direct promotion contacting key people so as to maximize dissemination of results.

Cost Structure and Revenue Streams

The figure below presents an overview of the envisaged cost structure and Revenue Streams.

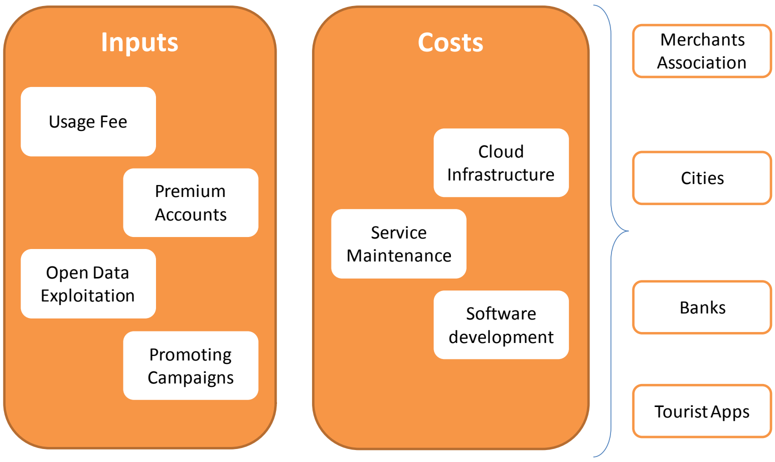


Figure 14: cost structure and Revenue Streams for Smart Shopping

Description of inflows:

- **Usage Fee**: We consider that merchants can pay a fee less than 1€ per having the info and having the possibility of direct accessing thousands of clients.
- **Premium accounts**: in addition to the previous item, it is also possible to have premium accounts. The key difference between the two kinds of accounts is related to the amount of information processed for receiving notifications about city status.
- **Promoting Campaigns**: Since campaigns are listed, the system will provide a tool similarly to what is already in social networks for promoting campaigns. Depending on final visualization application, the cost and features included can vary and also the price policy.
- **Open data exploitation**: The tool provided enables also the creation of a generic platform allowing publishing in CKAN based open data platforms. The open data platform can control who accesses to information and also it is possible to justify why they access, which kind of application will be created, and based on the business model of the new app, charge with a fee the exploitation of the information.

Description of outflows:

- **Cost of cloud infrastructure**: Typical OPEX cost derived from keeping with an effective SLA the service running. The cloud infrastructure must be able to deal with several tens of simultaneous merchants accessing to the platform.
- **Service maintenance**: The SLA requires from a maintenance service in charge of assuring quality of service. This should be more proactive than reactive including progressively modernization components that increase efficiency.
- **Software development**: First and most relevant costs derive from the software development of the whole tool. And lately the cost of developing and including new features into the service. Afterwards, the development of novel future features towards being innovative everyday is variable and depends on user requirements, but should be a must so as to keep a leading position in this kind of platforms.

The table below summarizes the key element of the proposed business model.

Categories	Description (distinguish what have been experimented / what is planned for the future)
Key partners /stakeholders	IT Cloud Providers Smartphone app creators Open data exploitation companies
Key Activities	Creation of offers Knowledge of environment Exploitation of city opportunities Learning of merchants attitude
Key Resources	Web portal smartphone app Open data sets Banking interface Management portal
Value Proposition	We offer a new system able to break the gap between citizens and merchants. Moreover the rising of Smart City concept also enables a new environment where these kind of services are mandatory for two main reasons, sustainability of platforms, usability of the resources.
Customer Relationships	The relationship with customers is direct firstly – for the deployment of the new hardware and the configuration of the management software. After that initial phase the relationship is just for maintenance.
Channels	Distribution – Spanish network of Smart cities Direct presentation to municipalities involved in Smart city initiatives Participation in Smart Cities conferences highlighting the novelties of the system created.
Customer Segments	Merchants and tourism offices aiming at developing new business lines by combining offers with culture We are targeting both private and public bodies involved in the dinamization of economic activities in cities Banks who want to provide added value information to their customers. Travel apps creators. Companies that want to add value to their offered city guides can also provide this feature too.
Cost Structure	The cost is shared among several aspects: • Hosting infrastructure • Access to special data
Revenue	The revenue comes from three main lines:

Streams	• Fee for merchants, provision of the full platform to a group of customers. • Licensing, the platform also enable the generation of data for public access, the information can be charged to developers in case they intend to create a business with it. • Promoting campaigns, it is also possible to create a premium accounts or special deals which can be shown in a higher position

5.3.3.2. Assessment of users' acceptance through the trial

The creation of the tool for SmartShopping has been driven by merchants' needs. The cognitive engine behind the user interface has been the result of the collaboration among all the users and partners involved. In this case the UI is a strong requirement because merchants profile is usually far from technological people and the scope is to create a universal application. In this sense, the final result obtained is that more than 80 new users were registered in the platform during the first 10 hours after opening the service.

The simplification of the options the user interface has gave the trial a good success, since only three people required some basic help, and in this case was due to the internet browser they were using was out of date.

The merchants have appreciated the tool since this way they will be able to exploit the different electronic equipment deployed in the city, and moreover, they will have a direct link with local citizens. The integration of BUTLER solution for SmartShopping in collaboration with the infrastructure already deployed in SmartSantander FP7 project increase the engagement of merchants and citizens with novel technologies.

Additionally, since all the information is also uploaded in the Santander Open Data platform merchants value the potential of it. This represents a key resource in the development of local economy by the exploitation of the data sets stored. New business models are planned based on the kind of application, the return obtained by the exploitation and the fees of the application usage.

In the path towards creating the final version of the SmartShopping tool we have faced several challenges. They can be classified in two big groups:

- Technical challenges – This category gathers the different problems that have required the development of wrappers or advanced software modules that transform generic digitalized data into data ready to be processed. A clear example of this is that Santander Agenda is digitalized, there is no problem with location or event title, but the time when some actuation performs is included in plain text in the description of the event. It was necessary to create a software module able to detect and extract time and duration from those descriptions. Another big challenge was derived from the usage of secure connections to the server platform, the certificates retrieved some errors that were solved.
- Social challenges – As it was aforementioned the profile of merchant is really wide, from technology experts to people that has never applied an update to their computers. The BUTLER solution target the wider spectrum possible, but we are aware that it would be impossible to create something valuable for all of them.

Finally it is also important to highlight the pitfalls encountered during the development of the field trial. Santander city already has a database for commerce and a department in charge of contacting them directly and centralize communication. However this is not happening with restaurants and bars in the city and required an extra effort so as to inform them about the application, the service and collect the feedback. But, this also allows BUTLER to increase the value and the impact in the city, since another outcome of the project is the registry tool created links with Municipality database and also includes in the open data platform allowing third parties to grow over the data available.

5.3.3.3. Impact value chain

The use case tested by the this trial consists in providing a group of merchants with proceeded data that enable them to adapt their commercial offers to the profile of potential customers based on context awareness information (such as city events, parking information, banking information, and other information related to the environment of possible customers). The overall impact of this scenario is not at individual level (for merchants), but at a city level, aiming to investigate new ways to revitalize the small businesses of town centres by introducing new ways of shopping in comparison to current habits of customers and is thus positioning in the boundaries between social and economical target. Nevertheless, the customers are indirect users in this scenario, and the main users are the merchants themselves that are provided with data through mobile and web applications to customize and commercialize differently their business.

The interesting aspect of this scenario relies on the intermediary outcomes and impacts to achieve the overall desire impact. In fact, the production of impacts is conditioned by a high level of acceptance from merchants that play an active role to set up their needs and customize their own offers. But the field trial reveals that a large heterogeneity exists through merchants regarding their habits and abilities to use digital services. Whereas some merchants are well prepared to this technology shift, for others, this transition is not that much straight forward. The meetings with merchants during the trial reveal this gap and the necessity to raise awareness of merchants about the possible usages and opportunities of digital services. The "*digital transition"* issue is currently importantly addressed by policymakers to facilitate digital usage in traditional businesses, as a key element on innovation, but also as a necessary condition of competitiveness[4]. The risk is high for businesses which will not take the path of 'e-economy' to face difficulties in comparison to the more agile and 'e-ready' ones. This kind of scenarios, which involves directly traditional business owners, has the potential to change their behaviour and attitude toward digital services, and support the necessary transition of this part of economy and consists of an impact in itself, independently of its achievement regarding the revitalization of small scale trade in town centres.

This field trial has been set up in the city of Santander which presents particular conditions in terms of sensors deployments and infrastructure available. The field trial is part of experimentations at city level to build a digital "smart city" and identify sustainable business models to exploit and make value on the deployed infrastructure. But this scenario could thus hardly be replicated in other contexts, without first deploying "framework conditions" for providing various data (as inputs for the use case). More generally, the success of the scenario is hardly dependent on the involvement of the key stakeholders able to provide data (in Santander, the city, but also external stakeholders such as banks, etc.).

Finally, the success of the scenario depends also of the adherence of citizens in the services and offers proposed by merchants. Current trends regarding customized and personalized shopping demonstrate a risk of lassitude from citizens that can induce a counterproductive effect.

The figure below summarizes the impact value chain.

[4] For instance, digitial economy has been a important topic of most of french Regions and has been strongly supported by european ERDF fund. This support continues for the next programming period 2014-2020.

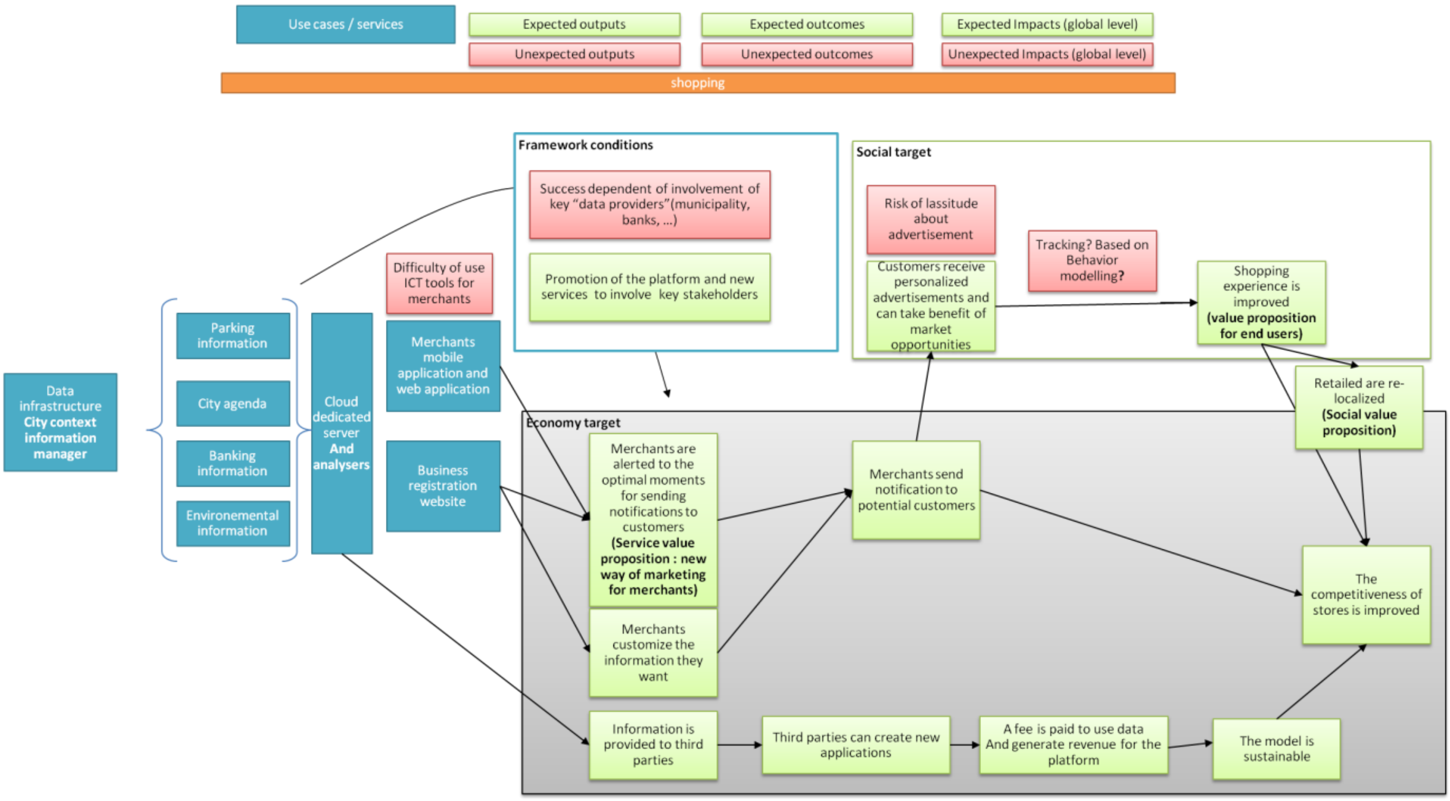


Figure 15: Smart Shopping chains of impacts

5.3.4. Smart office

5.3.4.1. Trial Overview

The starting point and idea of this trial is a direct and almost straightforward application of the project principles and results: what if we already were in 2020 and were trying to deploy BUTLER in our own lives? This has led to a Smart Office scenario, to analyse in parallel:

- The deployment of IoT technologies based on the BUTLER platform in the offices of some of the project partners,
- The gathering of requirements with the help of our co-workers to see what solutions IoT can provide in a bottom-up innovation process.

Three of the project partners have been providing experimentation sites for the project: inno TSD (France), Telecom Italia (Italia) and the iHomeLab of the Lucerne University of Applied Sciences (HSLU) (Switzerland). One of these deployments was built on existing "smart office" experimentations (iHomeLab), on built in parallel to new, but already scheduled, deployment (Telecom Italia) and one built from scratch and originating mainly from the project (inno).

The trial shared some key common characteristics:

- The three trials started from an in depth requirement collection process, involving strongly the end-users in a methodology of "co-creation". The objective of this phase was to gather real needs of the office workers, not limited by a technology vision. Interviews and brainstorming sessions were conducted with our co-workers (most of which have no ICT background) as well as with the site management to a build a vision of a Smart Office that is broader than IoT. The analysis of this requirement gathering process has provided feedbacks on the perception of IoT technology, on the real world use case they can answer, and on their limitations.
- Based on these specific requirements the three trials shared common functional requirements (information sharing, office well beings...). This translated into similar deployments that consisted of a social network like application gathering information flux from direct human sources (co-worker posting directly), from indirect human sources (access to calendar, reuse of data), and from sensors deployed in the office (Temperature, Light, Presence, Power Consumption…).
- The three trial sites participated in a common proof of concept of IoT information sharing beyond the scope of their own companies. A simple common denominator: coffee consumption was shared between the three offices.

The different deployments of the three sites, scenario involved, and co-creation process are presented in details on the IoT Open Platform[5.]

The following scenario have been developed and deployed in the project:

- Meeting room availability (inno)
- Kitchen activity monitoring (inno)
- Office presence sharing (inno)
- Social based and natural interaction with things (TIL)
- Desk light notification (TIL)
- Office energy consumption optimization (TIL)
- Office comfort through automation of lights and jalousies (iHL)
- Common trial: coffee contest (inno, TIL, iHL)

Each trial deployment also included end user feedback collection and evaluation of user acceptance through interviews.

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[5] http://open-platforms.eu/app_deployment/butler-smart-office-trial/

5.3.4.2. Ecosystem Trial Description

From its conception and objective (direct application of project technologies, direct user involvement), this trial was centered on interaction between technology providers from the project and end-users on the trial sites. The technology providers are therefore the project partners and most of the end users are employees of companies from the consortium. The following section describes each local ecosystem individually as well as the methodology deployed to ensure end user engagement:

Inno

Office description

For inno the main trial deployment has been in the Sophia Antipolis office of the group. Depending on several factors (business trips, presence of interns, presence of colleagues from other offices, etc…) about 15 to 25 people (with an average around 20) work daily in this office environment. This includes very different profiles: company top management, accountant and administrative assistant, economic development consultant (the majority of the workforce), and a few ICT consultants (2-3 people). The vast majority of the office doesn't have a technical ICT background. The office consists of several personal or shared offices, an open space, a meeting room, an archive room, a server locker, and a coffee/kitchen room.

Applied co-creation process

A core team with multi-disciplinary competences (ICT consultant/ Evaluation process consultant / project management) has been set up to work on the office field trial. This core team has had several meetings to define the basis of the office trial, including meetings with the other teams of the other partners involved in the trial.

The actual co-creation process has been launched in the form of 3 co-creation working groups that met to define the office needs. Two working groups included the employees of the company; the third one focused on the needs and vision of the office management team. The workgroup sessions were open, brain storming with members of the core team animating the discussions. To avoid influencing too much the discussion, the core team did not include technical feasibility discussions in this first round of working group. The core team also made sure not to propose directly scenarios to the work group but rather dimensions that could be improved in the office to launch discussions on the real needs and enable real user defined scenarios to emerge. The discussion started from two open questions (each one treated separately):

- The definition of the workers ideal "smart office", not limited by technological feasibility or scope (ie. Wider than IoT)
- The main fears and impediments they identified.

The ideas identified on each discussion were then evaluated through an open voting process to determine the one that the participants considered most important and most likely to happen.

Based on the analysis of the scenario proposed, a technical feasibility discussion was held with the core team to define what scenarios could be implemented. These scenarios have then been presented to the office co-workers for comments and modification in a second co-creation round before the actual implementation.

Figure 16: inno scenario co-creation sessions

Telecom Italia

Office description

For TI the main trial deployment is scheduled in the Joint Open Lab office in Milan. The lab is a premise of TI's Innovation department within the context of Milan Polytechnic's campus, hosting 7 permanent employees, as well as around 10 PhD students and researchers, and occasional TI employees or master students. Whilst TI employees mainly have a technical (TLC or CS) background, students and researchers also come from Business Innovation, Interaction design and Urban studies & architecture departments. Several countries are represented with very different cultures that complete the rich variety of sensibilities and approaches to the office daily life.

The lab consist of a couple of shared offices, an open space, a meeting room, an archive room, a server locker, and a kitchen/living room with TV and table football.

Figure 17: Telecom Italia Joint Open Lab

Applied co-creation process

We held an internal brainstorming in January 2014 involving 6 heterogeneous co-workers (4 from TI, 2 from university) composed as such: 3 engineers (2 TLC, 1 CS), 1 psychologist, 1 designer, 1 economist.

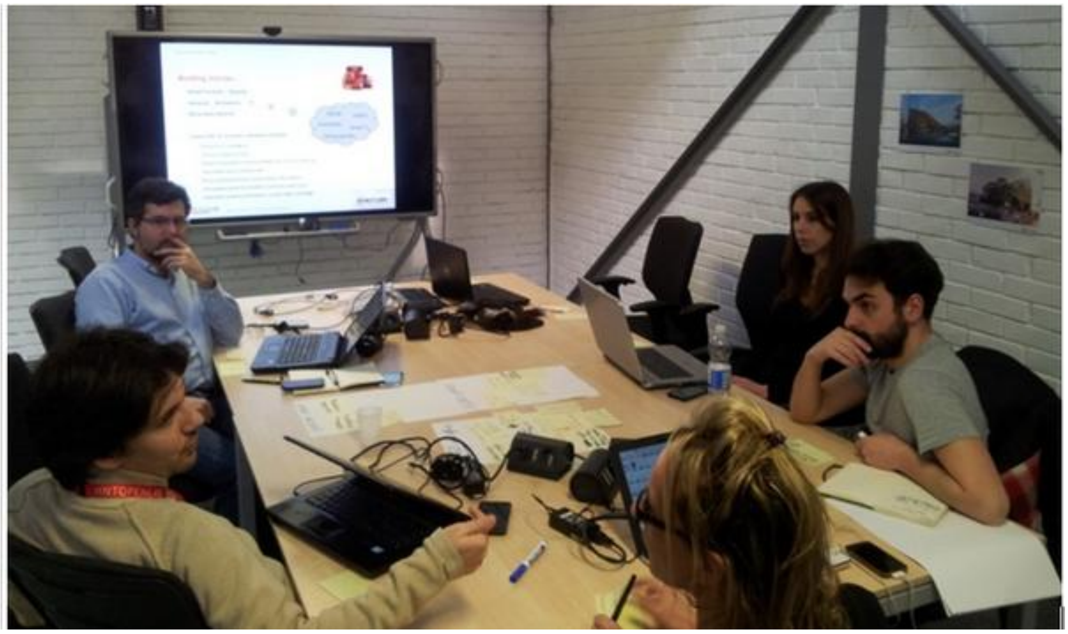

Figure 18: brainstorming session in TI

Further user involvement in the trial

In parallel, we worked at a questionnaire for user acceptance that was refined via several face-to-face meetings with the lab co-workers and some other TI colleagues of all backgrounds, including psychologists and usability experts, to clarify and validate it. The questionnaire was prepared by a PhD student from Milan's Polytechnic as part of her research work and is derived from the Technology Acceptance Model[6], further adding an experiential perspective to the traditional functional, yet rational evaluation. In particular, its goal is to address:

- the perceived control (e.g. privacy) and/or conditional value (e.g. technology promptness) of the proposed service and its impact on the intention to use;
- the social and emotional values perceived by the user (for example in terms of social or media influence, pleasure, etc), although moderated by the individual traits of each user.

The questionnaire contains questions gathered into 3 sections: technology readiness, drivers of technology adoption & demographic information.

This questionnaire was also shared with Inno for extended feedback and validation. A pre-test was run in April in order to have it ready for the trial scenarios and to collect feedback from the co-workers at the end of the trial period.

iHomeLab

Office description

The iHomeLab Living Lab has a long-term aim to close the gap between academia, industry and wide public through the co-creative methodology and user driven open innovation process in the IoT research area typically applied in the Building Intelligence applications of independent and/or ambient assisted living as well as energy-efficient buildings. Main idea of the initiative is to promote the IoT-enabled networked home, bringing together experts and stakeholders of different disciplines, sensitizing the public and pushing the development of a new generation of innovative, easy to use, reliable and affordable products and services as well as the underlying basic network infrastructure needed.

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[6] This research has been used as a basis to build the *feedback tool* described in section 6.3.2

Figure 19: iHomeLab office and exhibition space

The iHomeLab office facility at the Lucerne University of Applied Sciences and Arts campus in Horw, Switzerland includes an open space collaborative environment for 22 team members as well as 2 meeting rooms for 10 people each. Apart of that the office workers operate the iHomeLab Living Lab public showroom facility (attended by 3000 visitors annually) and one hardware certification / testing laboratory environment. The iHomeLab Living Lab staff participates in a high number of national and international project meetings, conferences, forums and exhibitions requiring them to travel 20 - 60% of their working time. The project topics cover wide range of topics relating to the use of technology for intelligent and independent living, aging research, including evaluation, usability and acceptance of technology by elders, issues in field deployments of wired and wireless. This variety implies interdisciplinary team work connect different user types in one office setup.

Applied co-creation process

In order to gather interest and feedback of end-users, the BUTLER project has created Smart Office focus group for collecting and storing office application ideas and data, as well as for analyzing and reporting out the results. This focus group consists of colleagues' mixture with backgrounds from ICT, adults' education, project management, event management, social work and medicine.

Co-creation process in the iHomeLab facility had two co-creation sessions consisting of use case identification workshop in February 2014 before installation and user feedback evaluation workshop in September 2014.

The first round of getting user inputs from iHomeLab Living Lab office staff has been organized rather informally and had a goal to capture expressed user interests and feedback Next iteration has been implemented in the form of workshop. End-users also fill in the feedback forms first after the initial setup and after the final installation of identified scenarios including KNX field bus with corresponding sensors / actuators.

Figure 20: iHomeLab end user input gathering

Further user involvement in the trial

After the initial setup and after the final installation the office staff has filled in the feedback forms including KNX field bus with corresponding sensors / actuators. After evaluation of feedback forms the iHomeLab has conducted the final validation of the smart office field trial scenarios in the form of workshop in September 2014.

Figure 21: iHomeLab workshop

5.3.4.3. Economic Assessment: Market consideration through the trial

The main outcome of this trial regarding market consideration is focused on customer requirement and value proposition. The other aspects of business development (partners, cost and revenues, distribution channels) have not been addressed in this trial as the experimentations were mainly internal to companies and with a strong focus on the definition of the scenarios.

An important aspect of this trial was to involve the co-workers of the different offices environment in the innovation co-creation process. One key objective of the trial was indeed to gather realistic needs from office life, as directly expressed from the workers and not to force a vision of what a "Smart Office" should be. It was therefore important to have a broad discussion, with the diversity of opinion involved. The goal of this strong user involvement in the trial was also to discuss openly and from the very start of the trial the potential ethical and privacy issues raised by such a deployment. **Overall the inclusive co-creation process enabled to formulate strong requirements, some that could already be answered in the initial deployment, some that will be dealt with in the short term and some that could be considered in the long term**. It also resulted in a strong user acceptance and participation.

In this section we present each local deployment analysis of the main requirements and risks identified by the end user.

Inno expectations and risks identified by the end users

Expectations

It was clearly noticeable that the type of expectations and scenario proposed were directly linked to the users' occupation, similar positions in the office requesting similar type of solutions to:

- Improve processes in the company
- Improve the efficiency of tasks thanks to automation, and avoid wasting time
- Assistance in the day-to-day work thanks to ICT based tools

Only few strongly disruptive innovative applications were proposed, most being rather innovations "at the moment" based on existing solutions and incremental progress. Expectations about comfort and health at the workplace also appeared as important. The main areas of expectations can be summarised as:

- **Shared Spaces:** Sharing office and external information, news, calendar, etc. through dedicated and non intrusive tools, available anywhere and that would not increase the amount of data to be handled (email for instance). Ex:
    - Shared screen in the meeting or coffee room
    - shared calendar
    - information about presence/absence of co-workers
    - information about availability of common resources (meeting room, kitchen…)

- **Digital office:** Solutions to improve the processes of the enterprise:
    - Automated expenses accounts
    - "Connectivity" through various supports to increase the "work anywhere" ability
    - Automated template and layout of docs
    - Vocal synthesiser for different tasks
    - Automated low level tasks (supply and maintenance of printers, coffee makers…)
- **Healths, comfort, work conditions:** Solutions to work in a safer, healthier and more comfortable area:
    - Automation of lights, heating and cooler,
    - Automated assistance on the position of desk, chairs…
    - Incentive to behave in a healthier way (coffee consumption, sport, …)
    - Bins and recycling
    - Solutions increasing the social life of the office (casual meeting points, team building, etc…)

Risks

Several areas of risks, fears and impediments were identified by the workers. Their definition of their fears started in most case from abstract, general worst case scenarios, relating often to cultural references (we don't want big brother, the matrix, terminator…) but rapidly evolved into careful and well defined areas of concerns. It can be noted that although the involved workers had no specific ICT, or science ethics background, nor previous knowledge of IoT ethics issues, the concerns they expressed matched very well the identified IoT ethics issues identified by expert (see BUTLER Deliverable 1.4). The risks identified are as follow:

- **Related to worker competences:**
    - Risk of loss of competencies based on automation: don't know what to do without technologies
    - Question of balance between financial investment in technologies versus salaries, and potential impact on employments.
- **Inclusion:**
    - Risk related to the ability to use high tech services, exclusion of some workers based on technological competence? Risk of a "social/digital" divide.
    - Risk related to hyper-connectivity: ability to handle growing solicitation? Risks in sensible human values: attention, motivation, responsibility
    - Loss of relationships
    - Impact on identity and reputation
    - Sense of restriction of freedom
- **Dependency and Security:**
    - Dependency to the technology: what happens in case of bugs, hack? Sensitive process and data of the company could be put at risk.
    - Dependency among system and need to preserve core function in a safe zone: a failure of the "Smart Office" should only lead to traditional office (this risk was best expressed in the sentence: we don't want the coffee maker to stop if your servers are out).
- **Confidentiality:**
    - Avoid tracking of sensitive financial data (salaries)
    - Privacy risk: what will management know? What will co-workers know? Strong need of easy to use controls to define what is shared with whom (authorization).
    - Risk on the balance between working life and private life.
- **Trust and Responsibility:**
    - No sensor to assess to performance of co-workers
    - Risk of loss of social values, lack of trust in "virtual" relationships.
- **Health:**
    - Fears related to radio waves health concerns

  - Risk of having "too many screens" resulting in visual and sound pollution
  - Hygiene related to tactile solutions

<u>TIL expectations and risks identified by the end users</u>

The co-creation session identified 3 main clusters as follows:

- **A. Collaboration / Social:**
  - **Live permanent video wall among offices:** Virtual "window" to chat with and meet co-workers from different sites e.g. for work purpose, to exchange idea, to occasionally chat during a break, …
  - **Shared common wall:** (e.g. display in a common area of the office,…) to exchange quick messages related to events, meetings, participants to meetings, status of common activities, …
- **B. Smart Control & Automation:**
  - **Automatic setting of your own work desk:** light is on only when needed and when the worker is at her desk, PC switches on when worker enters the office , smart notifications to educate about energy saving if there is a wrong habit (worker leaves the desk without turning off the light)
  - **Sensors in the work space:** to control e.g. noise level, right luminosity, air healthiness and eventually adjust them automatically to the right values or alert about a wrong situation
  - **Cross-office contest about energy consumption:** To easily monitor energy consumption of the various appliances inside the office and compare it with other offices
- **C. Personal(ized) life@office**
  - **Wearable sensors that "tell about you" (a kind of Quantified Self):** To monitor how much time the worker spends at the office for her own consumption (e.g. trough a wearable bracelet that tracks her habits and behaviors), To let co-workers know about delay when involved in a joint meeting
  - **Information about outside conditions:** E.g. traffic and routing info «personalized» based on worker context (notifications about the best solution when it's time to leave: time, "usual" route, public transportation,…)

Out of these initial clusters, a further refinement was made to identify some more specific scenarios for the trial described above, namely:

- Social-based and natural interactions with things (from clusters A & B)
- Desk light notifications (from cluster C)
- Office energy consumption optimization (from cluster B)

Some risks and impediments were individuated in the co-creation process. Security and privacy issues were the firsts questions had to be addressed ("How gather information with respect to individual privacy?" or "Are data stored in secure environment?"). Besides privacy and security, some technical risks were also identified ("What if I want my desk-light on and Office turn it off…"): an important point to note is that users must have the chances to force the "system".

<u>iHL expectations and risks identified by the end users</u>

The co-creation session identified 3 main topic families:

- **Office Information:**
  - **Information exchange between colleagues and offices:** office staff has expressed the wish to be able to send a picture with a text message onto the public screens easily using smart phone and to see the history of sent to the screens messages.
  - **Visualized information from sensors:** office staff has expressed the wish to see the sensor values visualized on smart phones and on any of the available public screens in the office.
- **Energy Awareness:**

  - **Office energy consumption visualization:** office staff has expressed the wish to see the current overall office (zone) energy consumption, its history and range values as well as the cumulated energy used since the beginning of the month. Categorization per device type basis (device types are: lights, computers, screens, coffee machine, printers, etc). Visualization on smartphones (Android or iOS) and on any of the available public screens.
  - **Energy saving procedures and hints:** office staff has expressed the wish to automatically turn off the unused devices and to get hints on how to run the office more energy efficiently.
  - **Competition:** office staff has expressed the wish to compare the energy consumption of the office (zone) to the one of the other offices (zones).
- **Automation:**
  - **Manual Office Control:** office staff has expressed the wish to control groups of lights and jalousies individually over a conventional switches as well as over their smart phones
  - **Automatic Office Control:** office staff has expressed from one side the wish for the adaptively learnable office based on user inputs and changes in their behavioral habits but from another side to be well-informed about reasons of automated office actions.

5.3.4.4. Assessment of users' acceptance through the trial

In this section we present the different scenario developed in the Smart Office trial and the feedback gathered for each trial. From the requirements collected through the co-creation process described above, each trial site derived different scenarios for actual deployment around the initial concept of a "multi-office social network of people and things". The choice of the scenario deployed was made following several factors:

- The ability of the scenarios to answer to demand identified as important by the participants in the co-creation process
- The respect of the identified ethical boundaries
- The capacity of the scenarios to use the BUTLER project platforms: Smart Servers, Smart Mobile, Smart Gateway/Object, to assess their qualities and to provide them feedback.

The deployments are described below as individual scenarios. Some have been deployed with local variations in several offices, others are specific; however, for each local trial site they form, grouped together on each site, a single user experience of the "smart office".

Meeting room availability (inno)

Scenario developed and deployed at inno Smart Office. The development and deployment of this trial started entirely within the BUTLER project.

Objectives and requirements

The objective of this deployment is to assess and communicate the availability of the office common meeting room. It responds to a need expressed directly in the inno co-creation session, and relates with the "shared space" requirement domain. As the meeting room is located on one end of the building and is not directly accessible, to be able to assess the presence remotely reduces unnecessary journeys across the office.

Additional requirements expressed were that the detection of presence had to be non intrusive (no video or audio feed), automatic (no action necessary to signal presence or book in advance the room), and able to respond to the different conditions of use of the meeting room: the door is often but not necessarily closed (lunch in the meeting room, open discussions), the light is not necessarily on, the projector is not always used…

Feedbacks

The current system represents a working prototype that has been used in the inno Smart Office deployment. Overall the system has proven some efficiency and has been appreciated by the end users.

Some potential improvements can be considered to both improve availability prediction and user experience:

- **Improvement of the availability prediction algorithm:** systemic observation of the sensor data over a long period of time, link with other context elements (time, access to calendars, presence and other sensors in the office) could help to refine and complexity the prediction model to increase the accuracy of the detection. However the simple setting of the current installation already provides acceptable results with a low impact of potential false-negative/positive (i.e: return to a pre-smart office process of checking by visual verification).
- **Support of additional sensors:** the BUTLER platform approach and use of the gateway enables the rapid addition of new sensors to the set-up, some additional sensors could clearly enhance the quality of the detection. In addition to the current sensor used, other type of sensor have been considered, two could be specifically interesting: as energy consumption sensors ("smart plugs") and sound sensors. Smart Plug would allow detecting use of plugged devices in the room which would possibly confirm presence in the meeting room, but they could also be used in a energy-monitoring scenario in the office which would demonstrate the possibility of "dual-use" of the multiple sensor approach chosen in this trial. The use of sound sensors without recording or transmission of the sound (local treatment) as proposed in the EAR-IT project would also be interesting to confirm the presence in the meeting room and work on user acceptance of sound sensors.
- **Stronger integration in the social network:** The current trial is using a basic initial deployment of an enterprise social network which was deployed along the Field Trial. The social network tool in itself cannot be considered part of an IoT platform as it was intended initially in BUTLER (and therefore very limited efforts were put in it, only to ensure a functional basis), but it is a strong support for this particular deployment. Stronger investment in the social network tool, and further integration with IoT could significantly improve the user experience. It would be also worth it to further develop social-network / IoT convergence along the "Smart Mobile" platform developed in BUTLER.
- **Formal booking of the meeting room:** Although an initial requirement of the user was to have has little direct interaction to "book" or announce their presence in the room, it has appeared as the usage grew, that the demand for booking of the meeting room appeared. As explained this is currently done through the wall/comment feature of the meeting room availability page on the social network. It would be interesting to refine the requirements and see if a more formal and complex booking process (priorities?) would be interesting.

Kitchen activity monitoring (inno)

This scenario came up as a result of the inno brainstorming session, taking into consideration the fact that the kitchen is one of the most important meeting spaces in the office.

Objectives and requirements

People use the kitchen at anytime during the day, to grab a cup of coffee or to warm up their lunch, and may find themselves often in contact with fellow workers being there at the same time. This makes the kitchen a strategic area where all employees go at least a couple of times a day.

Having a common area clearly stating whether someone is in the kitchen is not only useful for co-workers who want (or don't want) to use the kitchen at the same time as others, but also as a virtual shared space for kitchen users.

As such two elements are interesting to consider in this trial, first the luminosity (which means someone's entered the kitchen) and second the coffee consumption (through an accelerometer attached to the coffee machine).

Feedbacks

The functionality has been well received and is used by co-workers to post messages related to the usage of the kitchen. Several improvements have been considered to extend the use case.

A direct feedback on the use case came from the office assistant in charge of handling the coffee beans stocks. By detecting the number of coffee made we can detect the overall consumption of coffee and better adjust stocks and commands. The measurement of per coffee, bean consumption is currently ongoing and we consider in the future to progressively automating the coffee ordering process.

The addition of a presence sensor would be very beneficial as it'd allow the detection of cases when users leave the kitchen without turning the light off or allow turning automatically the light on/off when someone enters/leaves the room.

The integration of the coffee and presence information in the BUTLER context manager and the analysis of this context through the behaviour modelling Smart Server has been considered to enable predictions on future presence in the kitchen.

Office presence sharing (inno)

Scenario developed and deployed at inno Smart Office. The development and deployment of this trial started entirely within the BUTLER project.

Objectives and requirements

One of the requirements directly expressed in the co-creation session was the ability to identify presence of other workers in the work place and future availability.

One of the requirements involved classic digital agenda sharing features, but extended further: the direct detection of the presence in the office was considered desirable. And the possibility for the workers on business trips to signal their availability to be reached by phone or not was also important (especially to enable workers to reach the managers who spend around half or more of their time outside of the offices).

One important requirement however was the respect of privacy (as some use the same calendar for personal and professional activities. Some fears were expressed regarding the tracking of the users but after some discussion an agreement on a pilot, time limited, deployment was reached with regular involvement of the end user in validation of the features.

Feedbacks

This deployment received mixed feedbacks. Although the technical set up answered the initially expressed, the automated detection of presence was felt to be too intrusive for many workers. Only a small proportion of the office decided to opt-in on this option and most of them disabled it after a few weeks.

Potential extensions of the trial could be done from a purely technical point of view: better detection of the presence through sensors in the office, detection of location in the office, etc… but the very limited adoption of the end-user for this solution due to privacy concerns in our office make it entirely theoretical.

Social based and natural interaction with things (TIL)

Scenario developed and deployed at Joint Open Lab S-Cube (Telecom Italia lab). The idea of this scenario was already developed but the deployment started within the BUTLER project.

Objectives and requirements

The objective of this scenario is to demonstrate how social paradigm could be used in home/office automation. The scenario aims to allow user to have an easy and natural interaction with the environment. Most of people (not only ICT addicted) nowadays use Social Network on a day-to-day basis: in our opinion, using a Social-based interaction would allow users to perceive the "friendly face" of office automation.

Together with Social-based interaction, some other requirements were expressed. In order to improve the user experience in the environment, interaction had to be through natural language; voice control was also required.

Feedbacks

The system mentioned is currently working in Joint Open Lab S-Cube (Telecom Italia lab). The overall feedback of users is positive and the idea of the Social-based interaction has been appreciated. Some feedback were provided (in order to improve the user experience) regarding the use of one (SmartOfficeTI) instead of more accounts. Users idea is to provide one account per IoT object and this will certainly be a future improvement.

<u>Desk light notification (TIL)</u>

Scenario developed and deployed at Joint Open Lab S-Cube (Telecom Italia lab). The development and deployment of this trial started entirely within the BUTLER project.

Objectives and requirements

The objective of this scenario is to provide a smart and unconventional way of receiving information from the surrounding environment. Information is collected from public services and is provided to Smart Office users with some notification process.

During co-creation process some requirements were expressed. Weather forecast and traffic information had been chosen from users as relevant information. Notification process should also be non-invasive.

Feedbacks

The public information context is running and working in Joint Open Lab S-Cube (Telecom Italia lab). This simple scenario is much appreciated thanks to its efficiency and immediacy.

5.3.4.1. Impact value chain

The smart office trial was focused on technological integration of BUTLER components on one hand, and engages users in a co-creation process on the others hands. It was not expected to test a service or application that had the potential to go to the market, and the actual deployment was articulated to cover both users' requirements (but that go beyond IoT use cases) and the use of BUTLER component. Thus, no defined impact was pursued, except the three drivers (more than impacts) for a smart office expressed by the co-workers in the different places:

- Improve processes in the company and social based and natural interactions /communication among co-workers
- Improve the efficiency and comfort of working place thanks to automation, and avoid wasting time in repetitive and not valuable tasks
- Assistance in the day-to-day work thanks to ICT based tools

Nevertheless, the processes of users' engagement gave precised insights about the drivers and impediments in the deployment and use of what could be considered as "smart office" applications, in particular when related to the simple measurement of the quality, quantity or effectiveness of work of a co-worker. People are interesting in having better conditions of work based on ICT tools, but are evaluating carefully the pro and cons, namely the added value vs the possible loose (in terms of liberty, level tasks to be treated, such as emails notification, disturbance, etc.).

Another interesting finding is that the desired value of a smart office application is very specific to the work done and the actual office and conditions of works. In the brainstorming session, the users firstly identified applications that could support them in their daily tasks before thinking at disruptive innovation for the office. Even if generic drivers seem similar to the different offices (conditions of work, comfort, efficiency), the way it has been shaped during the brainstorming sessions showed that specificity counts and could be a key success factor for acceptance. This argue against a possible duplicable and generic solution of smart office, but rather a set of multiples services that gather together could offer a valuable smart office solution for a company.

5.3.5. Smart parking

5.3.5.1. Trial Overview

The aim of this trial was to test a technological component developed in the project that enables to carry out rapid prototype of smart parking solutions in various context in order to validate the feasibility and validity without deploying costly and scalable infrastructures. The use case was thus quite trivial: providing car drivers with a mobile app to identify and book free parking places, but outputs of the trial was not the test of the use case in itself but the test of the prototype.

In terms of deployment, the SmartParking device integrates a TSmoTe board and a set of sensors and actuators embedded into a robust boxcase, capable of being installed in an open environment. With the aid of a SmartGateway, several SmartParking devices can be installed in a parking lot, improving the way users can interact with the deployment. In addition, a number of services provided by consortium's partners have been incorporated into the parking system, making it easier to reuse them in future developments.

During the lifespan of the trial various locations in the city of Santander were elected for deploying the devices, including the private parking lot of a company close to TST premises, the public parking lot of the Palacio Real de la Magdalena and the parking lot situated inside University of Cantabria premises. In those scenarios, a group of users were able to test the technology, make reservations, park their cars and finish the reservation trough the check-in process. They experienced the ability of the SmartParking devices to display the status of a parking space using different LED light colors, and heard the rumbling sound produced by the buzzer when an alarm is triggered. Many of them passed over the device with their vehicles to discover the real resistance of the boxcase.

In this trial, several stakeholders were involved:

- **Inside the consortium**, the definition of the use cases around the SmartCity scenario was done under the surveillance of Swisscom at the early stage of the project. During the celebration of several synchronization meetings, the SmartParking trial gained importance as a PoC candidate. Many partners were involved in the decision making process of promoting it into a final trial. During this evolution the definition of the trial acquired value thanks to the commitment of several consortiums' partners, who provided their experience in similar areas. At the same time, many discussions have been held with different parties, for instance public authorities, potential stakeholders, hardware developers, deployment companies, social networks, and the like, in order to spread the word about a SmartParking solution and also finding new ideas or propositions to be included in the solution. This feedback collection process has been running since the very beginning of the project until now, and the plan is to keep improving it.
- On technical aspects, **developers** were responsible of designing of the technical solution, its manufacturing and development; the tests carried out; the improvements after intermediate trials; the deployment of the devices in the parking lots under surveillance; the maintenance of the deployment; and all other related peculiarities.
- **Users / participants**: the owners of private parking lots who were willing to discover how to enhance their parking facilities.

5.3.5.2. Economic Assessment: Market consideration through the trial

The SmartParking field trial enables two main business opportunities. On the one hand, the hardware provides new features that are not yet provided by any parking sensor manufacturing. On the other hand, the service offers new features derived from the usage of advanced hardware boards like the device created within the project. More in detail, there are three key scenarios that could benefit from BUTLER prototype:

- Short-term high dynamicity parking spaces – The possibility of actuating (signaling) and controlling individually each sensor is really useful for parking spaces with special needs due to the high mobility among their users. The combination of both hardware and software facilitates the management of agenda and taxing.

- Newly constructed areas of the city – Another scenario where this solution would cover a potential gap consists in the insertion of novel technologies in the city. The deployment of power lines enables a permanent installation of such devices reducing the costs derived from management and deployment.
- High relevance parking lots – Finally, in places like hospitals and so as to optimize where each ambulance stops, this system could be introduced in order to signalize the destination spot of each vehicle. The penalty for introducing these new features is the deployment of power lines, tough.

Value proposition

As presented in the previous section, the new features combined with the deployment of the devices enables new mechanisms that allow the optimization of parking management in the environments where the system is deployed. An example of this would be a typical day in 2020 where all courier vehicles publish their delivery routes and include a GPS module for reserving a parking lot automatically. The proposed system in collaboration with the hardware will dynamically modify and reserve the amount of special load/unload parking lots in the city based on the expected number of vehicles in the zone. Moreover, city parking management would be easier and smoother.

Channels

The field trial has been presented in Santander, thus facilitating the interaction with key people for dissemination and further exploitation of the concepts and hardware created. Santander Mayor is Head of RECI Spanish Network of Smart Cities; through his position the latest technologies tested in the city are disseminated to all the other cities participating in this association.

Besides that, the SmartParking initiative allowed TST to participate in pilot projects working in the optimization of ITS. In this sense, a strong collaboration is being held with key companies participating in parking business like Empark, and other providing global solutions like INDRA.

Cost structure and revenue streams

The inflows and outflows of the system are presented in the following figure.

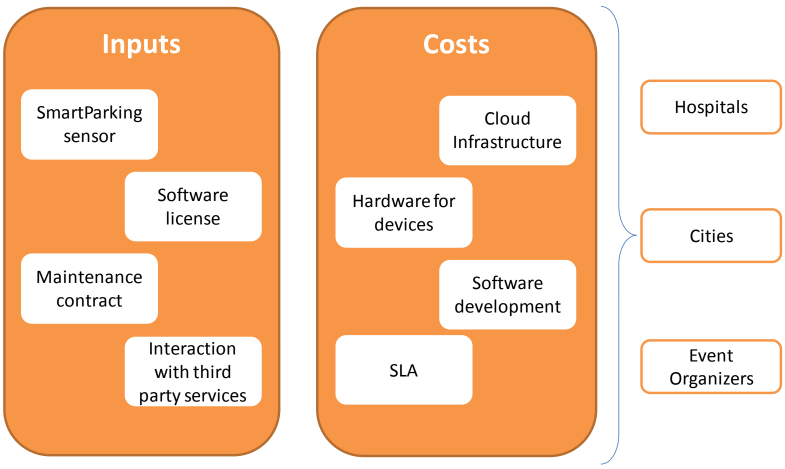

Figure 22: cost structure and Revenue Streams for Smart parking

The inputs come from selling the parking sensors, the licenses of the parking management application and the MobileApp, and also for the maintenance contracts derived from the assurance of certain SLA. Additionally, as presented in the trial, third parties, as commerce associations could be interested in showing commercial information to customers, the relationship between the corporations will fix a price that also produces a revenue stream.

On the other hand, the costs of the system are derived from the hardware and software development, the cloud infrastructure renting and the effort required for assuring the SLA signed with final customer.

The modular design of the solution facilitates splitting it among components thus creating opportunities only based either in hardware (parking sensors) or software (parking management platform).

The table below summarizes the key element of the proposed business model.

Categories	Description (distinguish what have been experimented / what is planned for the future)
Key partners/stakeholders	Cities Companies focusing on parking business Hardware components provision Cloud infrastructure companies Smartphone manufacturers Molding companies Civil engineering companies
Key Activities	Monitor parking usage Allow parking reservations Display parking information Integration of external information for automation of the reservation system Signalling of parking lot status Guidance to parking lots
Key Resources	SmartParking device MobileApp application, WebPanel for overall management Well defined parking lots Context information available for increasing system awareness
Value Proposition	Enhance parking management Reduce human interaction increasing parking efficiency Increase dynamicity in parking spaces Facilitate the nearest parking lot possible for VIPs in large events
Customer Relationships	The relationship with customers is direct firstly – for the deployment of the new hardware and the configuration of the management software. After that initial phase the relationship is just for maintenance.
Channels	Distribution – Spanish Network of Smart cities Direct presentation to municipalities involved in Smart City initiatives Collaboration with companies derived from other project's consortium Participation in several large IoT events
Customer Segments	Cities Private companies with strong parking requirements Hospitals Event organizers
Cost Structure	The cost is mainly derived from two parts: • Hardware → SmartParking device and its deployment in field • Software → the application (web and mobile) that enables users and managers to interact in this new parking paradigm
Revenue Streams	The revenue comes from two sides: • Hardware selling and maintenance • Software license for parking management.

5.3.5.3. Assessment of users' acceptance through the trial

The SmartParking field trial encompasses a wide range of users who experienced in different ways the proposition offer by this solution. While the feedback collected from final users (those who tested the MobileApp, made reservations and parked their cars) is taken in consideration for system improvement, it is worth noticeable that the opinion of potential stakeholders, hardware developers and city council representatives is also very important for this trial (these users also had a look at the demo in different events, meetings, etc.).

From final users' side, they were pretty satisfied with the idea of providing a solution that allows reserving a parking space in advance. A great number of users provided good ideas to improve the system, mainly in the business part. However, the most noticeable underlying opinion is that the smart parking solution is not still prepared to be used as a commercial solution. In their opinion, there are some weak points that need to be reinforced in order to prompt the sensation of a closed solution:

- it is a bit unclear why sometimes it is offered the possibility of doing the check-in via the MobileApp and sometimes via an NFC card > *to demonstrate that we are able to integrate both methods (or more) if required by any specific scenario*.
- The reservation system allows one to reserve more parking spaces than necessary > *it is quite difficult for an SME like TST to provide a robust reservation system, so the key idea is to build a solution with the ability to integrate existing commercial solutions for booking management*.
- The parking spaces can't be paid with real money yet > *same situation here, the system is prepared to integrate any existing commercial payment platform, even using NFC (ongoing work in MobiWallet FP7 European project [www.mobiwallet-project.eu])*.

On the other side, Public Authorities and parking managers were quite optimistic about this technology, specifically about the SmartParking device, because it is proven to work as it says:

- A robust prototype that can be installed in a harsh environment.
- Works both battery-powered or line-powered.
- The adaptability of the device's communication capabilities enables the integration in already existing city networks. Moreover, it is also possible to include new ones with low effort.
- The technologies selected for linking Smart Servers and SmartParking devices is ready to be part of a large scale deployment.
- The inclusion of acoustic and lighting signals, and besides that, the possibility of tuning them dynamically, represents an added value since as the device would be prepared to be used by disabled people.

All in all, the subjacent idea of building this SmartParking Field Trial is not only to provide a closed way to interact with an enhanced parking system, but to overcome a series of handicaps when it comes to the development of a solution in the scope of a SmartCity scenario.

5.3.5.4. Impact value chain

The smart parking trial is specific in the sense that the targeted beneficiaries were not the ends-users themselves (ie drivers in various contexts and situations, like citizens, ambulances, participants to a specific events, …) but the municipalities and stakeholders responsible of parking facilities and management that could decide to invest into a smart parking solution. The trial target was to experiment and test a prototype of smart parking including several technological propositions in terms of connectivity, power technology, payment possibilities, etc. to give to stakeholders insights about what they should choose for a large scale deployment. Proposing such "*quick*" prototype solution is providing in itself a valuable proposition to stakeholders because "smart parking" in large scale required costly infrastructure deployments and should respect high level of fiability immediately. Thus, being able to test solutions, and in particular its integration into city fields is an efficient way to analyse the framework conditions and possible barriers before undertaking large scale deployments.

In terms of impacts, the same challenges appears than the ones emphasized for the smart transport scenario, especially regarding the stakeholders ecosystem and the sharing of responsibilities between possible technological providers, business organizers (which could be the city itself and/or a private companies), users. Similarly, business models options should be carefully studied to identify what is gaining added value, who is willing to invest in infrastructure, and who is able to pay for the added value. The possible impacts could vary importantly depending of stakeholders' specific objectives.

But beyond this smart parking scenario, as part of a comprehensive smart city scenario, new businesses opportunities could also appear in private contexts (ie private companies parking, parking in university) or to manage traffic dynamicity (for ambulance for instance). As well, opportunities may also target other vehicles than cars such as boats or planes.

The figure below is summarizing the identified value chain.

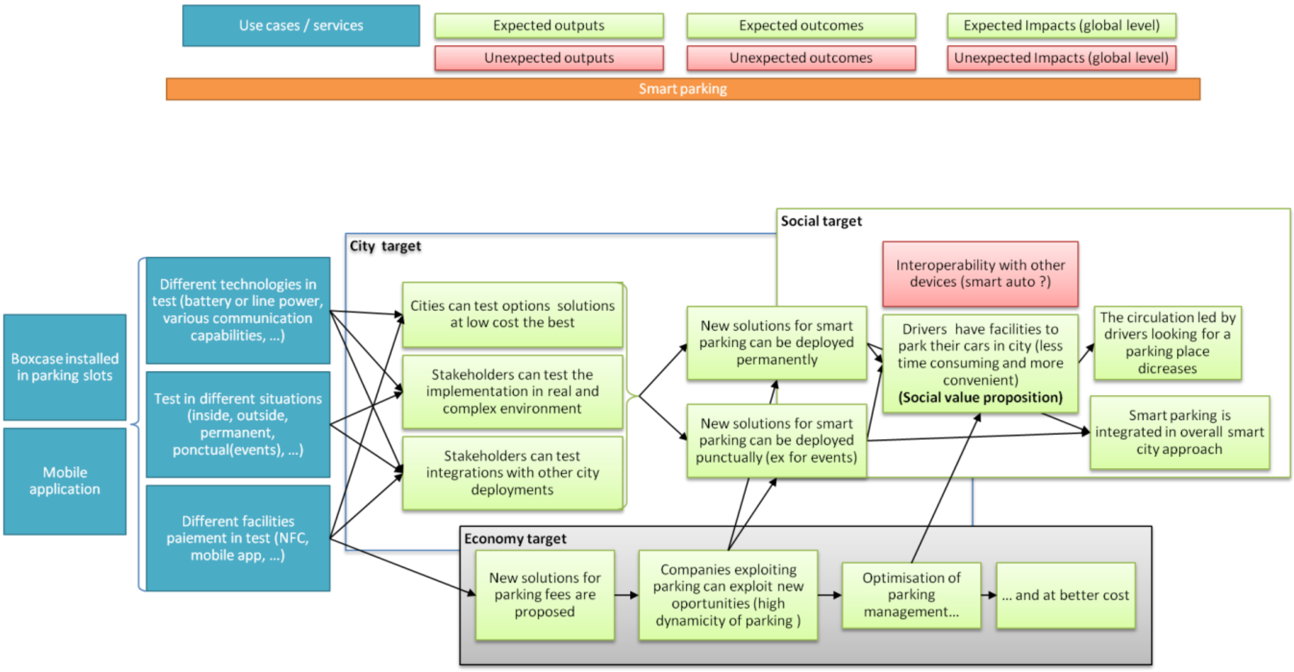

Figure 23: Smart Parking chain of impacts

6. Effective contributions of BUTLER in IoT

6.1. Definition of IoT SmartLife

6.1.1.1. Approaches to define the "*Smart Life*"

In this section we examine BUTLER contributions to the definition of IoT application scenarios in a cross cutting, horizontal and user centered vision of the IoT.

The development of the BUTLER platform and of the BUTLER field trials has been based on the definition of the requirements that originated in Work Package 1. The objective of this initial work was to define a "horizontal" storyline, based on well defined individual use cases that would cut across application domains from transport, health, home, shopping, and city environments. This was meant to enable the definition of clear functional and non functional requirements for the BUTLER platform, a platform that was again meant to cut horizontally across application domains.

The following picture presents the overall process of requirement building in the BUTLER project, from an initial internal definition of use cases across application domains, to consultations with various stakeholders (external experts from the EMG, citizens' interviews, stakeholders from the field trials).

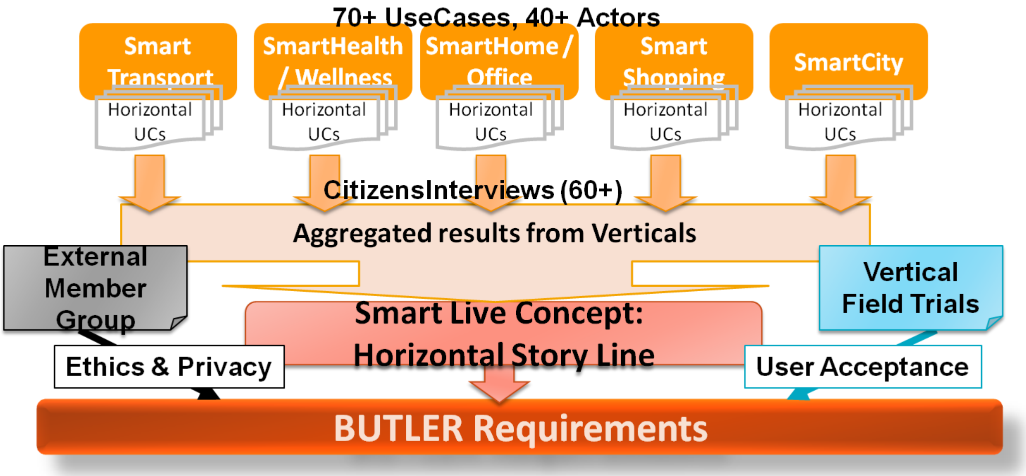

Figure 24: BUTLER Requirement collection process

In the second year of the project, these requirements have been refined through different steps:

Citizens' interviews

First they were validated through citizens' interviews to measure the public perception of potential IoT use cases in the general public. More than 60 interviews were organized in 6 European countries (Switzerland, France, Italy, Spain, Germany, and Luxemburg). The interviews lasted around 1 hour each, and were open discussions with limited direction from the interviewer (to limit as much as possible direct influence and maximize interviewer objectiveness). The interviews consisted in a brief presentation, through a "comic-book" image and brief description of some (10 to 15) of the use cases selected by the BUTLER project as most relevant. The interviewees were selected to represent diverse profiles (based on the personas identified in the use case selection of the BUTLER project), all with no specific knowledge or experience in ICT technologies. The objective was to get first impressions of attitude, expectations, and fears of the customer reactions considering usage of IoT products. There was no possibility to test or get in touch with a device or application for the respondent.

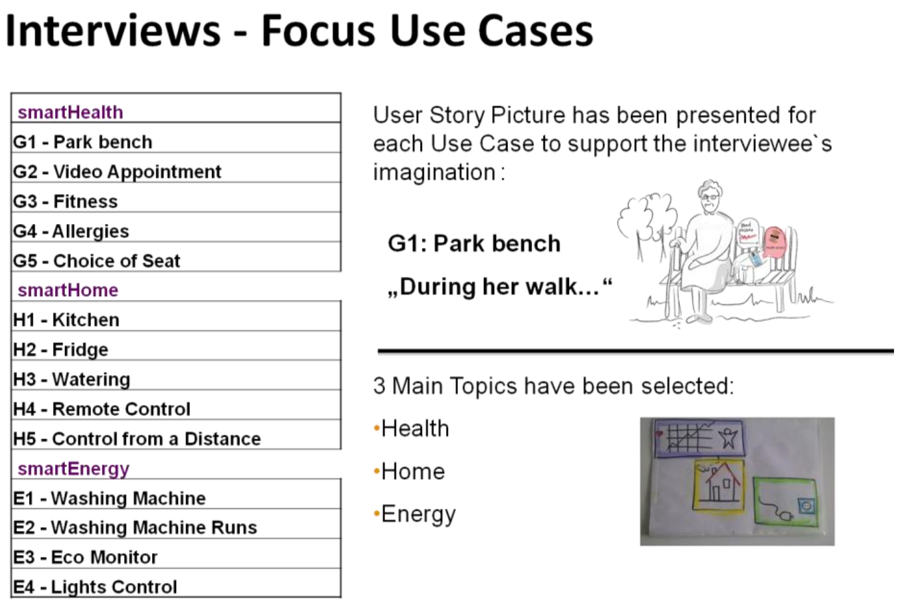

Figure 25: Use cases presented in citizens' interviews

The results of the interviews were unique for each interview as the profile selected varied widely and the open nature of the interviews led to open ideas and discussions. However significant trends could be observed over several interviews and similarities, even across countries could be observed enabling the definition of common expectations.

The interviews resulted in the collection of citizens' expectation over several aspects:

- Product design expectations
- Trigger and additional expectations to motivate a customer behavior
- Perceived benefits
- Perceived barriers
- Ethical and privacy issues

The following picture presents some of the main and most important results of these interactions:

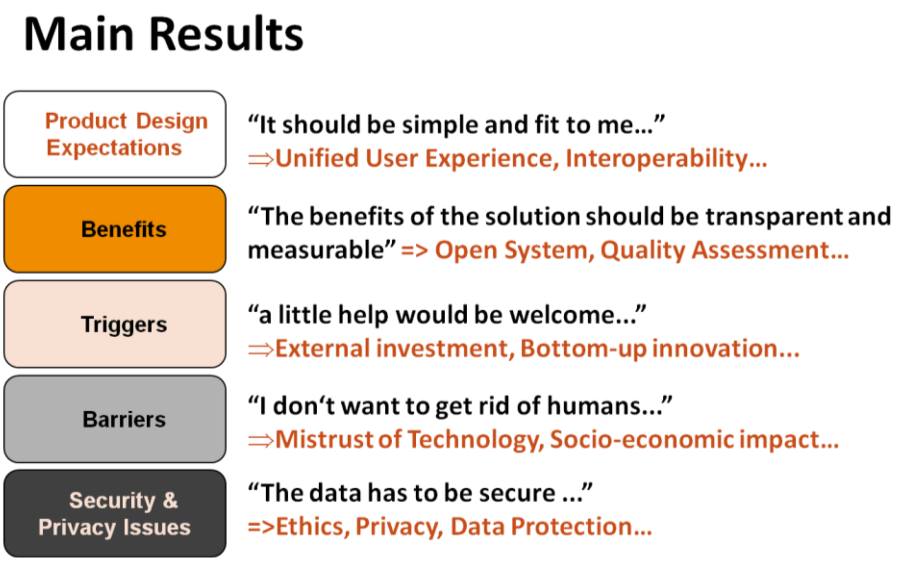

Figure 26: citizens' interviews main results

Regarding **product design**, the simplicity of the user experience was significantly stressed both positively (desire for simple, helpful technology) and negatively (reject of complex technologies). One common expectation is also of an integrated environment with “things working together” without increased complexity for the end user. This pleads clearly for a need of either technological interoperability or economical monopoly.

The definition of **perceived benefits** was often complex and very disparate from one interview to the other (some use case being strongly desired by some while completely rejected by others). However a common expectation was the ability to measure and understand the benefit provided by IoT applications, especially in term of economical gains (how much will I save) but also in other aspects (ability of health application to save lives, ability of energy application to impact CO2 emissions…).

The definition of “**buying triggers**” was also very disparate from one interview from the other. Two important trends that emerged were related to the complexity of the ecosystem and the need for investment at a level often larger than the individual customer either through the direct support of public authorities in “Smart Cities” deployment or through the sharing of risks and benefits (health insurances supporting Smart Health scenarios). The other trend was the request to be able to extend and modify the use case and technology solutions to fit the user needs and the strong willingness of citizens to participate to the definition of solutions.

Regarding **barriers**, the feedbacks were surprisingly detailed and complex but revolved around two main criticisms: First a general mistrust of technology, concerning the reliability of IoT technologies (it will bug), the usability of IoT technologies (it will be complex), and the usefulness of IoT technologies (we don’t need that). And second detailed negative expectations regarding the socio economic impact of IoT, especially on the impacts on individual and social essential human values described in section 4.2.2.

Finally regarding **security and privacy issues**, the need of data security and privacy was often voiced but with clearly a limited understanding of the potential risks. A good example is the general mistrust of scenarios implicating a “camera” but general acceptance of scenarios deploying a large variety of sensors and profiling technologies that can generate privacy breach at a high level and with potentially more impact. This reinforces the vision that privacy and security are important issues for citizens but that they have a low level of education of what are the potential threats.

Expert consultation

To explore in more details some aspects of the IoT horizontal storyline the project also organized consultations with external experts through its External Member Group (EMG). This included the creation of a specific thematic group on Ethics and Privacy. The discussions were initiated in the Ethical session of the IoT Week Venice (June 2012), continued in September 2012 with a participation of the EMG to the Luxembourg plenary meeting, and continued with regular interactions and dedicated sessions in the IoT week in Helsinki (June 2013) and London (June 2014).

Among other contributions, the external experts contributed to the detailed analysis of a set of use cases resulting from D1.1. The selected use cases have been broken down to the aspects relevant to ethical and privacy issues so that a set of interesting topics can be identified. This led to direct recommendation on the use cases, but also to general observations:

- While (mis-)usage of data seems to be a common pattern, **the (unintent) use** of it may happen in many different ways. Thus the possibilities what can be done with such **data needs to be evaluated** with every new service.
- **Technical Standards** which services can be in compliance with, may help to **protect users privacy** whithout impacting the experience in using the service.
- **Raising the awareness** for such topics may help to guide **customers** to choose offers that comply to such standard and achieve a higher level of data privacy in a world of IoT

Figure 27: Ethical issues session BUTLER - conclusion from the discussions

The importance of privacy and security issues was identified early on in BUTLER (as clearly defined in the project objectives and description of work) but the importance of these issues was reinforced through the project as both individual citizens and experts insisted on the importance of these issues. The contributions of BUTLER on these issues is presented in section 0

Horizontal proof of concept

Finally, at the end of the second year, the set up of a complete, integrated horizontal proof of concept, based on the BUTLER platform initial release was presented in the project second review. The objective of this proof of concept was to demonstrate the viability of the BUTLER horizontal approach in a fully integrated scenario, cutting across application domain and at the same time to present the initial result of the platform development.

This proof of concept was important for the scope of its scenario. Indeed, if the technical complexity of further proof of concept and field trial deployment has been clearly exceeding this intermediary proof of concept, and if the field trial provide more in depth details on the short term deployment possibilities of the IoT technologies, this second year proof of concept remains the most integrated horizontal scenario fully demonstrated to date, with clear interoperability across the verticals.

6.1.1.2. Evolutions and perspectives: *"smartness"* in IoT

The definition of the "BUTLER SmartLife" therefore had still to evolve to match the feedbacks of the field trials and the last consultations of the project.

Field Trials feedbacks on horizontal storyline

The BUTLER field trials, described in D5.2 and above provided important feedbacks on the horizontal storyline of BUTLER.

First, the perspective of horizontality presented in the BUTLER project (and achieved in the proof of concept) had to face limits and constraints. The deployment environment of the field trial limited the horizontality of the scenario developed in the trials; In part because of local technical constraints such as the necessity to integrate in an existing deployment (Smart Shopping in Santander, Smart Health in Tecnalia…), necessity which implies the need to operate with legacy technologies and limits the possibility of use of a fully horizontal platform; But also because of local ecosystem and business models constraints which limits the scope of the possible scenario deployable in a single deployment.

From a purely scenario perspective, the five trials have different level of horizontality:

- Smart Parking and Smart Shopping can be considered as vertical by themselves, but they share information (shopping information to merchants based on parking availability) and can be operated in a single scenario (shopping deals sent to parking users). The full interoperability of the two trials has however only been limited to a technical proof of concept for operational reasons (requirements of the shopping application to integrate in the Santander portfolio, lack of large scale deployments of the parking devices).

- Smart Health is partly horizontal through the mixing of different scenarios from both the health and multimedia/home domain.
- Smart Office is mostly vertical but integrates elements that could lead to more horizontality in further deployments (such as link to energy scenarios and link in with business processes of the office).
- Smart Transport is mostly vertical.

However, the trials were enough to validate the perspective of horizontality of the BUTLER project. From a technical point of view the trials demonstrated horizontality of the platform as the same platform components were able to be used in trials with very diverse application domains. The use of the horizontal platform provided key advantages to the trial development: their advanced functionalities enabled the rapid development and deployment of the trial, even for partner with no previous knowledge of the platform (Tecnalia entered the consortium in the last year and deployed the Smart Health trial). The access to the advanced enabling technologies embedded in the BUTLER platform (Security, Localization, and Behavior Modeling) was a strong asset to build effective and value providing applications. In that sense the platform really make sense from a business point of view by this ability to share the development of advanced components between different application domains. And the trials also help prove that interoperability between the deployments was important to enable rich application. The case of the Smart Shopping / Parking trial is especially important in that aspect: each trial can function individually and provide useful services, but the combination of the two can bring new type of services.

Thus a conclusion of the project can be that horizontality is clearly desirable and technically achievable but it does require dedication to face the operational constraints of deployments.

Perspective of Smartness in the IoT

Another evolution in the last year of the project targeted the definition of the project scenario as a “Smart” life for the Internet of Things. This work originated from the continuous reflection on the project originally defined scenarios (D1.1) and their confrontation with the feedbacks from end user interviews, experts’ consultations and live feedbacks from the field trials. It was presented at the IoT Week 2014 in London in the session “Smartness in the Context of IoT Technologies” organized by the IERC Activity Chain 7.

One common feature of many IoT applications, deployment and scenarios is the use of the word “Smart” to define the improvements brought by the Internet of Things. BUTLER is no stranger to this phenomenon as the platforms are called “Smart”-Servers, Mobile, and Objects, and the application domains “Smart”-Health, Transport, Home, Shopping, City. The “Smart” trend can be considered as a marketing term (“buzz word”) for the IoT and is now used very commonly without reflection on the actual meaning of the term.

However the term Smart does convey expectations, especially for the end user, and especially when he is not “accustomed” to the IoT. Failing to acknowledge and understand these expectations can be dangerous for the IoT if they cannot respond to the expectations and therefore create wrong or over ambitious expectations.

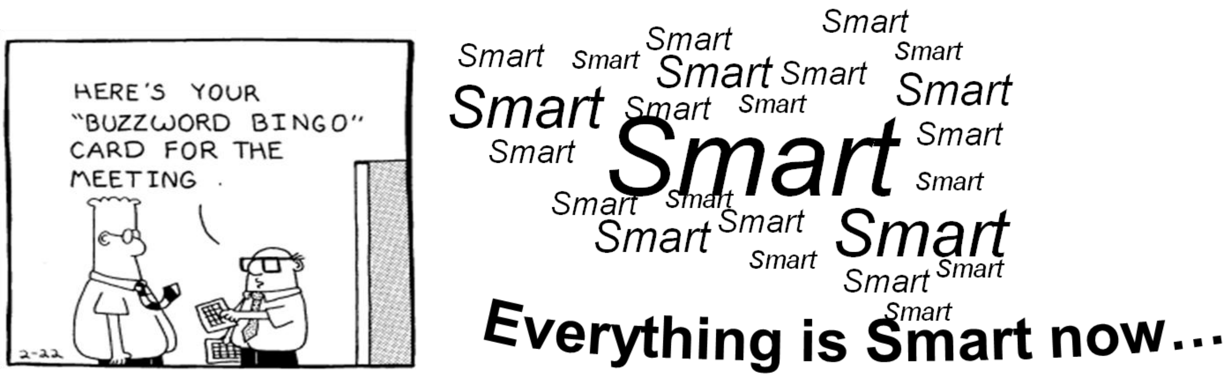

Figure 28: overuse of the Smart term in the IoT

We have therefore looked into several possible acceptations of the word "Smart" commonly found in the IoT ecosystem through discussions with different stakeholders (industry experts with different backgrounds: software / telecom, researchers, ethical experts, end users...)

A first interesting remark can be that from a direct dictionary perspective the term smart already has different understandings:

Smart: Dictionary Definitions

Smart (*comparative smarter, superlative smartest)*

1. Causing sharp pain; stinging. !
2. Sharp; keen; poignant.
3. Exhibiting social ability or cleverness.
4. Exhibiting intellectual knowledge, such as that found in books.
5. Equipped with intelligent behaviour.
6. Good-looking.

   Cleverly and/or sarcastically humorous in a way that may be rude and disrespectful.

8. Sudden and intense.

Figure 29: Smart definitions

Definition 5, and to some extent 3 and 4 can be attached to IoT applications and use cases but they can still have different understandings. The following are the main understandings that we have found in the community, followed by our analysis.

- **Smart as better than the state of the art:** As we have noted, the very common use of the term Smart is often only a marketing artefact. Anything improved in a way or another through technologies that can be in a way or another linked to the concept of the Internet of Things is described as "Smart". This understanding is common but insufficient; it doesn't describe the nature or extent of the improvement. It is an understanding of Smart that can be common among technology developers but that is near to inexistent for the end user. It is also dangerous in that it place value on the complexity of the technology without linking this complexity to any actual improvement or value for the end user.
- **Smart as autonomous:** When asking potential end users with little or no previous knowledge of the IoT technologies or concept, this understanding of Smart is often found at least initially. The

"Smart" world described then by the potential end user is similar to many science fiction worlds where humans are assisted by a horde of autonomous robots that take care of unpleasant tasks instead of them. This understanding as however strong limits. Mainly because the level of autonomy of the device is not necessary linked with its capacity to fulfil the actual needs of the end users. An application functioning in complete autonomy, even though it can sense some of the needs of the end user through advanced context aware technologies, cannot directly compete in term of usefulness with a similar application that is not entirely autonomous in the sense that it is able to receive direct commands, preferences and programming from the end user.

- **Smart as communicating:** The Internet of Things being a communication network, a common understanding of the "Smart" term, especially in technological stakeholders, is that a "Smart" thing is a communicating thing. This understanding can seem convenient at first because it is not too ambiguous. However it is also clearly problematic because it cannot only difficultly be linked with the "dictionary" definition of Smart, and therefore it can be expected to create undue expectations for the end user (if the end user expects an object to be "equipped with intelligent behaviour" and find it to be merely able to connect to a communication network...).
- **Smart as smarter than the end user:** It is a common understanding in the IoT community that the IoT will generate vast amounts of data, but that the actual value is in the treatments of these data to generate information, knowledge and potentially wisdom.

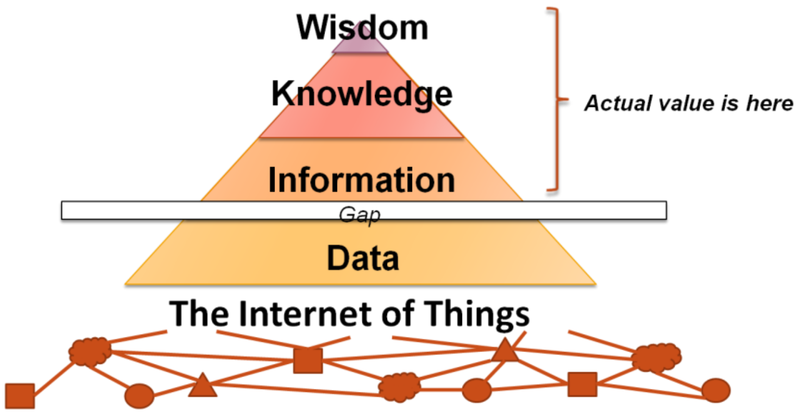

Figure 30: from Data to Knowledge

This leads to a common vision in the community that through the access to these vast amounts of data, the IoT will be able to generate application that will be better informed and better equipped than their end user to take decisions. This techno centric understanding of the "Smart" term is rarely shared by the general public and comes with significant risks.

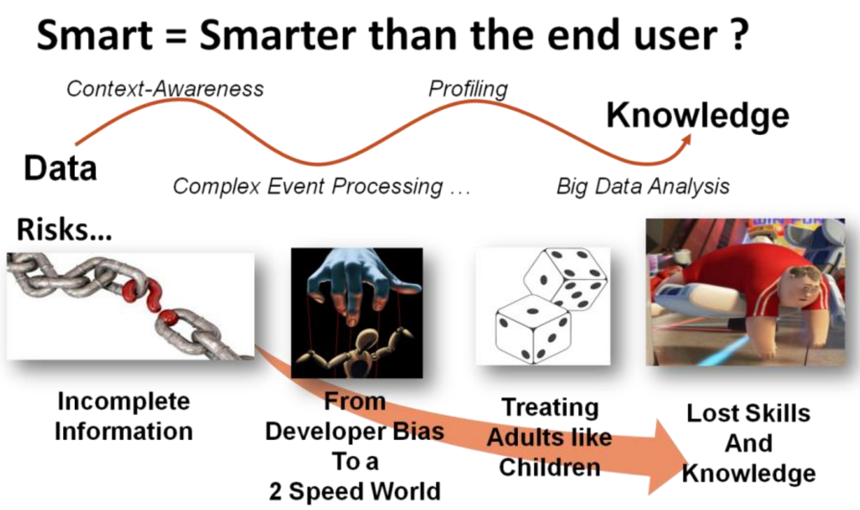

Figure 31: Smarter than the user, risks.

Despite the vast amount of information that the IoT can contain, an application will often be facing incomplete information which can lead to dangerous effects, if left entirely autonomous in its decision making. Any application and decision engine is also directly influenced by its creator's assumption creating risks of developers' bias influencing the decisions of applications users. This can be even reinforced and aggravated with the trend of "gamification" and "incentivisation" often found in "Smart" application, which lead the end user to take decisions (such as reducing his CO^2 emissions) for the wrong reasons (to gain points in game). In the long term this could lead as it is argued by ethical expert to a divided society with a technological elite and a dependent general public.

Faced with these various and conflicting understanding of the Smart term, we have proposed an alternate understanding. It is not meant to replace others (at it is fine that a word can be understood by different persons in different ways) but to complement them and to provide reflection opportunities for the IoT community:

- **Smart as empowering the end user:** As a reaction to the previous understanding, this one is proposing not to oppose the system and the user but to reunite them and to use the IoT as an empowering opportunity for end users. This include raising the awareness level of the user but also addressing its reason ability rather than its feelings, providing access to further knowledge and ability to build and tinker applications. The following figure presents some proposed guidelines.

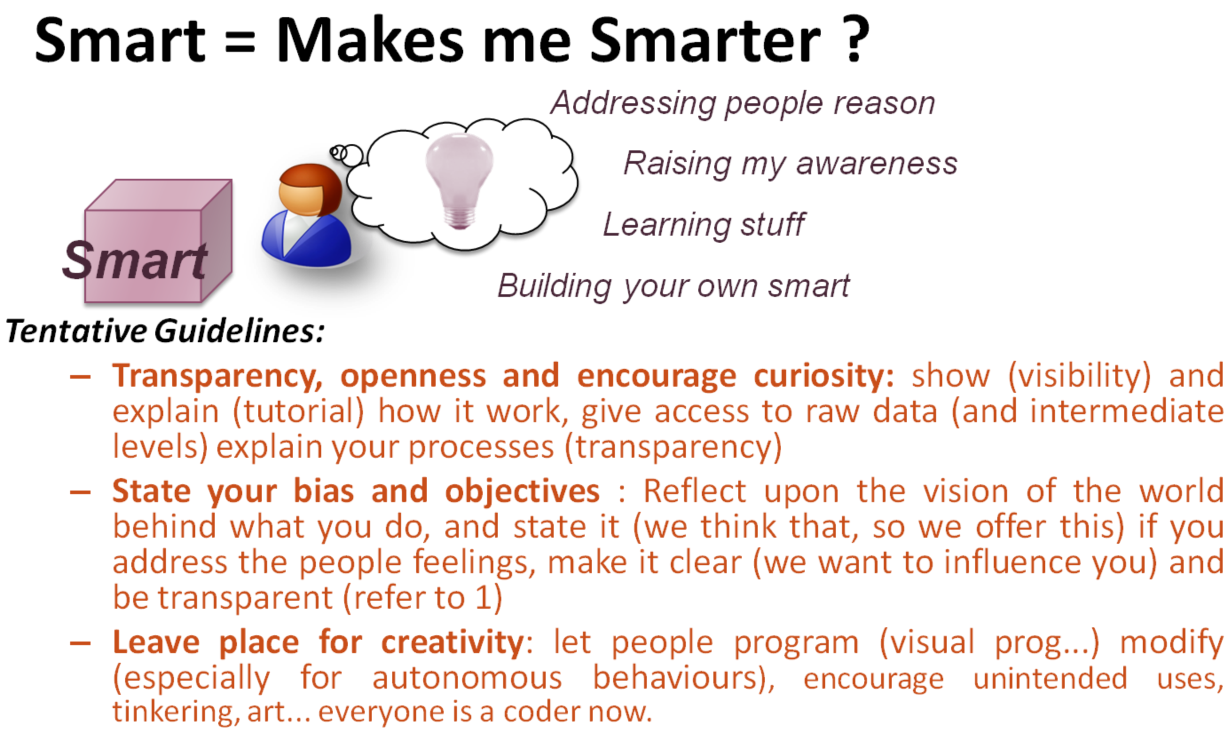

Figure 32: Smart as user empowering

Transparency, openness, and participatory innovation principles, such as the one advocated by "user centric innovation" are well aligned with this definition of the "Smart" IoT. From a project perspective it is to be directly linked with the activities on the importance of user acceptance (see section 6.3.) and with the Smart Office user involvement process in the third year[7].

This alternate understanding of the smart term is also interesting if we refer to a possible origin of the "smart" trend that is the arrival of "Smart" phones with Apple first iphone. At the time of its

[7] see description on Open Platforms portal: http://open-platforms.eu/app_deployment/butler-smart-office-trial/

first presentation, the iphone main innovation was not on the communicating, or autonomous behaviour of the device (it did few things new in regard to previous “Personal Digital Assistants”), but rather on its unique end user interface. It also became a rapid success by enabling the user to customize the product with a vast choice of applications, and by building a strong developer community.

6.2. Ethics, Privacy and Data Protection in the IoT

In this section we present BUTLER contribution to the debate on IoT ethics, and to the protection of data and privacy in a fully deployed IoT world.

6.2.1. Overview of activities in the project

Privacy concerns have accompanied the development of the IoT since the early days of ubiquitous computing [31]. BUTLER aims at a system where network reactions to users are adjusted to their needs (learned and monitored in real time). The main ethical issues then seem to be, how to guarantee: the security of the data stored (or mined) to support the BUTLER services and the privacy of the user. Of these two issues data Security is more of a technical problem, and while no doubt difficult to achieve, it does not raise deeper ethical questions, privacy on the other hand is undoubtedly also an ethical issue.

The BUTLER project had therefore activities addressing the security and privacy problem from a technical perspective: security as an IoT enabling technology in WP2 and its integration in the architecture (WP3) and in the platform (WP4 and WP5). But at the same time the project provided contribution on the ethical treatment of privacy and data protection in the IoT.

From the very beginning of the project, Deliverable 1.1, in identifying the use cases, scenario and functional and non functional requirement clearly identified privacy and data protection as strong, horizontal requirement for the IoT. Based on these requirements Deliverable 2.1 analysed in more detail the privacy and security requirement and provided a complete review of the state of the art, and detailed requirements for the security and privacy enabling technologies for the IoT. This deliverable has been the basis of WP2 activities related to security and privacy, which lead to numerous peer reviewed publications (concerning both lower and upper communication layers of the OSI model) and which eventually translated in the development of BUTLER platform component ensuring security in the three platform (documented in all technical deliverable of BUTLER but maybe more completely in deliverable 5.1 and 2.5).

While the technical aspects were being addressed, the interactions with the end users in citizens' interviews and the first year project review confirmed and reinforced the need of more analysis of the problem from a societal and business modelling perspective, and led to the creation of deliverable 1.4. The objective of this deliverable was to better analyse the expectations regarding ethics and privacy (analysing different sources, from literature, experts views, EU run surveys and citizens' interviews), to look into the existing solution proposed in the state of the art (including a review of the legal framework and contributions by other projects) and based on this analysis to provide a common statement from the project and some recommendations.

The project also participated to several events related to the treatment of IoT from a security and ethical perspectives (including by the organization of sessions in the IoT week) and contributed to the work of the community in IERC activity chain 5 (with a substantial contribution to the position paper) and activity chain 8 (on socio economic aspects of the IoT).

6.2.2. Initial analysis

We provide here a summary of the Deliverable 1.4 analysis of the ethical and privacy expectations of the IoT and of their potential impacts on its development and deployment.

Ethics and the IoT

Internet has dramatically changed the way we interact with information (personal, business, legal, health, etc.) and allowed reliable and rapid exchange of large amount of information between people without any distance restrictions. These transformations of our way of life gave rise to several ethical concerns in particular related to privacy and the sharing of personal information. The Internet of things extends and automates the information sharing features from humans to machines, machines that have not any ethical concerns as humans. Machines (e.g. sensors) can capture more and more information on users and their surrounding environments. Furthermore, the machines (e.g. actuators) have the power of modifying the physical environment of users. IoT adds therefore additional ethical questions such as the potential risks linked with the control of the “real world devices” by internet, or the ethical implication of a society where monitoring is ubiquitous.

As presented in details in the Ethics Factsheet summarizing the findings of the ethics subgroup of the IoT Expert Group of DG Connect [32] the main identified issues regarding Ethics in IoT are:

- **The risk of social divides**: although many societal benefits are envisioned for IoT, their deployment and spreading may not be uniform across the population, creating a risk of an increased digital divide (between those who can afford and use the new applications and services and those who cannot). This risk is reinforced may even amplify in a “knowledge divide”, between those who know and understand the technologies behind an IoT world and those who don’t and who are therefore unable both to take full profit of it and to avoid potential dangers.
- The key issue **of trust and reliance on IoT** which is mostly linked, but clearly not limited to the respect of privacy and data security. The massive deployment of IoT enabled technologies and services will pose the question of their reliability and how, when, and why the user can, or has to rely on these new services in a trustful relationship. This need for a trustful relationship and the risk associated are even stronger in the case of “smart”, context aware applications who advise decisions to the end user. This pleads for the need for openness and reputation / ranking systems as strong needs to establish this trust.
- The risk of a **blurring of context** in the society perception of what is private and public, what is virtual and what is real. This evolution of society values and perception is not necessarily an issue in itself, but it has to be understood, monitored and reflected upon to make sure that it doesn’t result in additional issues or increase existing risks (such as the risk of social divides, especially between different age groups).
- The **non neutrality of the IoT metaphors and vocabulary**. Many terms and metaphors (such as the “smart”-things) used to describe IoT technologies, product and services assume that IoT will ease the lives of people, and they convey this meaning and raises expectations. This non neutrality and the associated expectations are important to be understood not only by the stakeholders defining the IoT but also by the targeted market.
- The necessity of **a social contract between object and peoples**. This necessity arises from the stronger and stronger reliance of societies on technologies envisioned in the IoT vision. As IoT objects are more and more autonomous, connected and involved in our lives, this may result in loss of control for users (as object take decisions for them) and in blurring of responsibilities for stakeholders (whose in the end really responsible for the decision). This pleads for a strong reflection on how IoT objects should behave and interact with people and with each others. A need that is furthermore reinforced in the case of context awareness by the ability of objects to create profiles of users and stakeholders based on the data gathered.
- And the **issue of informed consent and obfuscation of functionalities** which here again rejoin the privacy and data protection issue (without being limited to it). The actual understanding of what is happening in IoT scenarios, which is necessary for a truly “informed” consent by the user, is complicated by the strong tendency of IoT deployments to be actually nearly invisible as communicating objects are miniaturized, hidden, and their true features obfuscated. This pleads for an ability to make IoT deployment visible for inspection, education and explanation needs.

Privacy, Data protection and the IoT

As described above, in addition to these “high-level” Ethics interrogations related to IoT, the main, more immediate and practical questions relate to the risk of privacy breaches and the necessity to ensure the security of the huge quantities of data gathered and used by IoT systems. These privacy and security issues are essential because of their major impact on the development and acceptance of IoT.

Based on the findings of the privacy and security subgroup of the IoT Expert Group of DG Connect [23], and their analysis in the BUTLER project (see Deliverable 2.1), the main identified privacy and data protection issues in IoT are:

- **Continuity and availability of services:** As the deployment of IoT spreads and more and more systems and persons rely on these new products, applications and services, the issue of continuity and availability of the services rises. The strong integration of IoT devices in our day to day lives, and especially in critical services (such as health, security, and energy) increase the impact of a potential loss of service.
- **Sensibility of user data and contextualization of risks:** As Smart services gather more and more information on the user (willingly or even without notice), the question of the sensibility of these data, arise. The internet of things complicates this issue as it gathers more and more information that, despite a harmless appearance, can turn out to become sensitive when analyzed on a large scale. For example the collection of household power consumption can seem to hold no important privacy issues, however these data when statistically analyzed can reveal much on the content of the user home and his day to day habits. The actual sensibility of gathered information is therefore not always known at the time when data gathering is decided and / or accepted by the user. In an IoT world, the risks related to privacy and data security are dependant of the context and purpose in which data is gathered, and used. And this context can be evolving, which support the need for a context-aware management of security and data protection.
- **Security of user data**: The user data must therefore be protected against unauthorized access, and this security should be ensured at each level of communication. The multiplication of communicating devices characteristic of the Internet of Things therefore increases the difficulty of this protection as the number of link to be protected increases. The potential impact of security breaches is also on the rise as the data stored have more and more applications, and thus give more and more information on the user and give more and more access to critical parts of our lives. (Increasing risks linked to identity theft and electronic identification).
- **Management of data:** Even when the security of the user data can be guaranteed against unauthorized access, the question of the actual management and storage of the information by the service provider remains. Questions such as: “How much data is collected to provide the service?”, “Is this strictly necessary?”, “Who is responsible to handle these data?”, “Who has access, how and when to the data?”; can be expected from the user.
- **Ownership, repurposing and communication of data:** The question of the ownership of the data collected is also central to the IoT Ethics issue: getting propriety or access to user data and reselling these data can be a significant source of revenue. The monetization of user data can raise several issues: how is the additional revenue shared between the service provider and the user? How aware is the user of this use of his data? How much control does he have on it? What are the third parties who get access to the data and for what?
- **Captivity of data:** Even as the service is becoming more and more used and accepted by the user, the ethics question remains: what happens to the user data if the user leaves the service? And how feasible is it for a user or consumer to change service provider once he has been engaged with one for a significant time? These questions are important to avoid consumer captivity through data that would result in an unfair advantage, destroying competition with all the eventual consequences (suppression of consumer choice, degradation of user service and reduction of innovation).
- **Applicable legislation and enforcement:** Given the global nature of IoT and the number of stakeholders necessarily involved in an IoT deployment, the question of responsibility and applicable legislation arise. This is reinforced by the fact that in a truly “Internet” of things vision the different actors will be spread across different countries and regions, increasing the number of potential legislation involved. This issue impact not only the users, which may be confused on which legislation the service he uses follows, but also the policy makers and the whole IoT value chain as developing IoT applications and deployment without a clearly identified chain of responsibilities and applicable law represent a strong business risks.

- **Availability of information:** Finally in a world where technical and legal complexity increase, the quality of the information available to the user is key to the management of the ethical issues: the service provider must ensure not only that the information is available, but that it is presented in a way that ensure it is correctly understood by the user.

All these concerns leads to the so called “Privacy Paradox” : By collecting personal data, better “personalized’ services can be offered to the users; but on the other side, these personal data can be collated, linked with transactional data, processed by powerful data mining techniques and assembled into user profiles that may become so detailed, that identification becomes possible. Once this “personal data” has been disclosed, the owner of the data cannot control how the collector will use the data. With this conception, should the user thus refrain from disclosing personal data? And therefore refuse life improving services?

Potential impacts

As the concepts and technologies behind IoT are relatively new, until recently ethics and privacy issues had been mostly ignored by service provider, and treated only when concerns arose and threatened their business. However, with the numerous cases of privacy breaches observed in the social network field, and the increased concerned on communicating object (observed for example with the crystallization of the public opinion on RFID technology) the general awareness has been raised to pay more attention to the data users are spreading around. The public true understanding of the issue remains low, but the mere rumours of a potential threat to privacy is often enough to damage business.

Already some example demonstrates the importance of the ethics and privacy issues such as the backlash on smart metering technologies. The recent events in the Netherlands (where the deployment of Smart Metering had to be made optional to respond to privacy concerns)[8] illustrate the initial lack of concern for the potential ethics and privacy issues transformed into a threat to the whole industry. The complexity of the technology involved in the new IoT services envisioned can lead to a general misperception of the potential threats to privacy of new technologies and services. This misperception can happen in one way (as a underestimation of the potential threat to privacy of new use cases) or in the opposite (as an unrestricted reject of a technology based on overestimated threats to privacy), both way being damaging for society as a whole.

However, if treated accordingly, the ethics and privacy issues transforms from a threat to an opportunity. Better understanding of the service by the user increase acceptance and create trust in the service. This trust becomes a competitive advantage for the service provider that can become a corner stone of his business model. In turn the economical interest of the service providers for ethics and privacy issues, derived from this competitive advantage, becomes a guarantee for the user that his privacy will be respected.

6.2.3. Technical contributions

As presented before, the BULTER project has strongly contributed to the development of security and privacy enabling technologies as part of its work on IoT enabling technologies (WP2) and the production and integration of the BUTLER platform (WP4 and WP5). We will not detail again in this document the scope of the security framework provided but we provide however a short summary of the project main contributions.

Data technical protection mechanisms include two major aspects. One is the protection of the data at data storage, the other one the protection of the data at communication level. The protection of data at communication level is one the major area of research. Many communication protocols implement high level of end-to-end security including authentication, integrity and confidentiality. At communication level,

[8] http://vorige.nrc.nl/international/article2207260.ece/Smart_energy_meter_will_not_be_compulsory

the major issue is the deployment process of the security keys and the cost of the required hardware and software environment to run the security algorithms in efficient and secure way.

However, Privacy and Security do not only refer to security of the exchange of data over the network, but shall also include: a) Protection of the accuracy of the data exchanged, b) Protection of the server information, c) Protection of the usage of the data by explicit, dynamic authorization mechanisms, d) Selected disclosure of Data and e) The implementation of “Transparency of data usage” policies.

BUTLER provides an Authorization Server as a security service path distinct from the application path. The Authorization Server and the managed resources share bootstrap security credentials enabling generation of session keys. The Authorization Server authenticates user and application for providing the application with access token and session keys for accessing a specific resource.

The protocol is based on OAuth2.0, already used by Facebook and Google, and identified as a mature technology used for Identity Management. The Identity Management is a new security and privacy service offers by the Authorization server that also enables the pseudo-naming.

BUTLER provides a lightweight bootstrapping mechanism between the sensor nodes and the gateway at Wireless Sensor Network (WSN) level based on the use of asymmetric cryptography with the elliptic curves. This can address the challenge of device authentication. This lightweight bootstrapping handshake is designed for large scale deployment of sensor devices, which can also address challenge of secure setup and configuration.

The joint use of the Authorization Server at application level and of the bootstrapping mechanism at WSN level enables to address end-to-end and hop-by-hop security problem between a sensor node belonging to the IoT domain and an end-user application connected on Internet. The gateway located at the border between the Internet world and the WSN domain ensures the communication standard interoperability. For the hop-by-hop security mechanism, the gateway authenticates to the Authorization Server in the Internet world and the sensor node bootstraps to the gateway in the WSN domain. The security credentials generated by the Authorization Server could be pushed by the gateway until the sensor node. This mechanism may be useful for mobility scenario. For the end-to-end security mechanism, the sensor node authenticates to the Authorization Server to retrieve the security credentials.

BUTLER strongly supports information-theoretic security at the physical layer to increase the privacy of wireless communications due to its achievable characteristics: unbreakability, provability, and quantifiability. Information-theoretic security is stronger than traditional computational security because no assumption on the computational power of the eavesdropper is needed and perfect secrecy can be theoretically achieved. On these bases, BUTLER proposes in particular a concrete implementation of secret key generation for short-range communication systems, introducing the concept of geometric secrecy.

BUTLER provides also a threat analysis model that could be used to evaluate the threat on dedicated use cases and scenarios, this threat analysis has been applied to the project field trial (see D5.1 and 5.2).

The involvement of end user in the scope of the project requires handling their data and privacy concerns carefully. The following issues must be considered in the organization of end user involvement: a) technical security mechanisms must be set up to ensure the security and privacy of the participants. This involves secured data communication and storage, and in the scope of the BUTLER project these are addressed by the enabling security technologies developed and integrated in the BUTLER platform; b) the participants must be well informed of the scope and goal of the experiment. In the case of BUTLER, this involves specific efforts to explain the scope and goal of the project to a larger public; c) The consent of the participants must be gathered based on the information communicated to them. The consent acknowledgment form must remind the participants of their possibility to refuse or withdraw without any negative impact for them; d) finally both a feedback collection and a specific complaint process have been designed to offer the possibility to the participants to raise any issue identified.

6.2.4. Further analysis and recommendations

The work on deliverables D1.2 (trial definition) and D1.4, initiated the production of recommendations of the BUTLER project regarding ethics and privacy issues handling in the IoT. These recommendations are not only technical but involve economic aspects (business model), ethical behavior and corporate policy.

General principles

The following general principles can give a first overview of policy to be applied to Internet of Things applications to reduce the risk of privacy breach:

- **Transparency of usage of the data**: User – data subject in the European Union (EU) parlance - shall give explicit consent of usage of data.
- **Collected Data shall be adequate, relevant and not excessive**: The data shall be collected on "need to know" principle. This principle is also known as "Data Minimization". The principle also helps to setup the user contract, to fulfil the data storage regulation and enhance the "Trust" paradigm.
- **Collector shall use data for explicit purpose**: Data shall be collected for legitimate reasons and shall be deleted (or anonymize) as soon as data is no longer relevant.
- **Collector shall protect data at communication level**: The Integrity of the information is important because modification of received information could have serious consequence for the overall system availability. User has accepted to disclose information to a specific system, not all the systems. The required level of protection depends on the data to be protected according the cost of the protection and the consequence of data disclosure to unauthorized systems.
- **Collector shall protect collected data at data storage:** User has accepted to disclose information to a specific system, not all the systems. It also could be mandatory to get infrastructure certification. The required level of protection depends on the data to be protected according the cost of the protection and the consequence of data disclosure to unauthorized systems. As example, user financial information can be used to perform automatic billing. Such data shall be carefully protected. Security keys at device side and server side are very exposed and shall be properly protected against hardware attacks.
- **Collector shall allow user to access / remove Personal Data**: Personal Data may be considered as a property of the user. User shall be able to verify correctness of the data and ask – if necessary – correction. Dynamic Personal Data – for instance home electricity consumption – shall also be available to the user for consultation. For static user identity, this principle is simply the application of current European regulations according access to user profile.

Ethics and Privacy in a Business Model

Integrating "privacy" in a business model rely on the analysis that privacy is a clear need of Internet of Things future end users. This "customer" need, presented in deliverable 1.4, can be summed up in a business point of view by the fact that most customers, when presented with two offerings, on which the sole distinction is their respect for privacy, will choose the most privacy oriented one. A privacy oriented business model will therefore integrate this customer need in the offering to use it as a competitive advantage.

The first organisations to adequately answer to this customer need, without reducing too sharply any other advantage of the offering (such as functionalities, availability or price), will, if they can build a strong communication on it, benefit from rapid and important growth in both users and revenues. By classical market mechanisms, a competitive race will then follow; pushing competitors to increase their efficiency in privacy protection and the quality of their communication on the way data is gathered, stored and used.

The case for a "privacy" oriented business model is especially strong in the perspective of IoT as to be a real success, IoT depends strongly on the quantity of data collected and therefore on the trust and acceptance of end-users. Building on the need for privacy and providing privacy oriented applications and adequate information to the user will therefore increase acceptance and create the necessary trust in the service.

Furthermore a virtuous circle can be initiated as in turn the economical interest of the service providers for ethics and privacy issues, becomes a guarantee for the user that his privacy will be respected.

On the other hand, ignoring altogether the privacy requirements of end users and treating privacy only as legal burden can only be a losing strategy in the long run. First because of the increasing over time, risk that a competitor will take advantage of an aspect that you neglect. Secondly because from an economic perspective respecting privacy legislation becomes a burden for which the organization have to pay without any competitive benefit. And finally because building a business on ignorance and dissimulation, even ethics considerations aside, is usually not considered a wise choice in the long run and creating an IoT world without privacy would strongly imperil innovation [33].

To take advantage of the “privacy” asset, an organization would first have to integrate privacy in the conception and development of its offering (following for example the Privacy by Design framework). This can mean modification to the organization culture and decision process to integrate the privacy requirement in the hierarchy, become more transparent about the use of data and focus on user-centric privacy HMI design.

6.2.5. Handling of user consent

BUTLER being committed to a user centric approach, the handling of user consent as the main source of legal and ethical ground for handling personal data collected by the IoT is of particular importance for the project. It led to dedicated work on the subject with the organization of a dedicated session in the IoT Week 2013 and with the presentation of a paper [34] at IEEE World Forum IoT in Seoul. The solution is partially a technical solution but include an important focus on the end user relation both by the topic addressed (improving “user consent”) and its behavior (use of communities to refine choices).

Problem definition

Informed consent is a term which originates in the medical research community and describes the fact that a person – such as a patient or a participant in a research study – has been fully informed about the benefits and risks of a medical procedure and has agreed on the medical procedure being undertaken on them. An informed consent can be said to have been given based upon a clear appreciation and understanding of the facts, implications, and future consequences of an action. In order to give informed consent, the individual concerned must have adequate reasoning faculties and be in possession of all relevant facts at the time consent is given.

From a legal perspective, the notion of consent is essential in data protection as the consent of a data subject is often necessary for a third party to legitimately process personal data. Within the European Union, the data protection directive [35] that defines conditions under which personal data can be processed specifies that the consent must be “freely given, specific and informed” and “unambiguous”. The foreseen evolutions of this regulation [36] further strengthen this definition of consent by narrowing it to “explicit, clear affirmative action” excluding the possibility of implicit content.

Ensuring this level of “informed consent” can already be an issue in itself for traditional ICT applications, the technical and legal complexity of the problem being already an obstacle to informing potential end users. This has lead to the development of End User License Agreements (EULA) which are often too complex or too generic for most of the End User.

As a result a “consent fatigue” has developed, most end users accepting by default the license agreements and often without reading it. This is reinforced by the fact that the consequences of a potential privacy breach are distant and vague while the consequences of not accepting the end user license agreement are immediate and obvious (no access to the service or application). This effect has been observed and documented in [37] and [38].

This “informed consent” issue is further complicated by some the technical specificities of the Internet of Things. The tininess of the potential IoT devices, their distributed nature and integration into everyday life object complicate the necessity of information of the end users. The numbers of potential data operations in a fully deployed IoT make even less practical than with the internet a systematic control of the data subject on each data operation.

The size of the data sets and complexity of the data operations taking place in cloud based infrastructure also enables advanced profiling which can reconstruct data and identify an end-user based on information that taken separately are not considered critical [39]. This ability is especially important as from the current and foreseen European legislation the legal definition of “personal data” is anything that can enable directly or indirectly (through profiling) the identification of the data subject.

Finally the distributed nature of the Internet of Things further complicates the informed consent issue as the end-user and data subject roles are more often separated than in traditional ICT applications: the distributed and decentralized nature of the IoT being therefore in conflict with the user centric problems of consent and privacy.

Proposed solution

This analysis led to the conclusion that an automated approach is necessary to fit the vast number and complexity of data operation authorization decisions characteristic of a fully deployed IoT. The proposed solution takes into account various sources (user defined rules, context, user behavior, community) to take decisions and advise the user on how to best protect his privacy by authorizing access to his data.

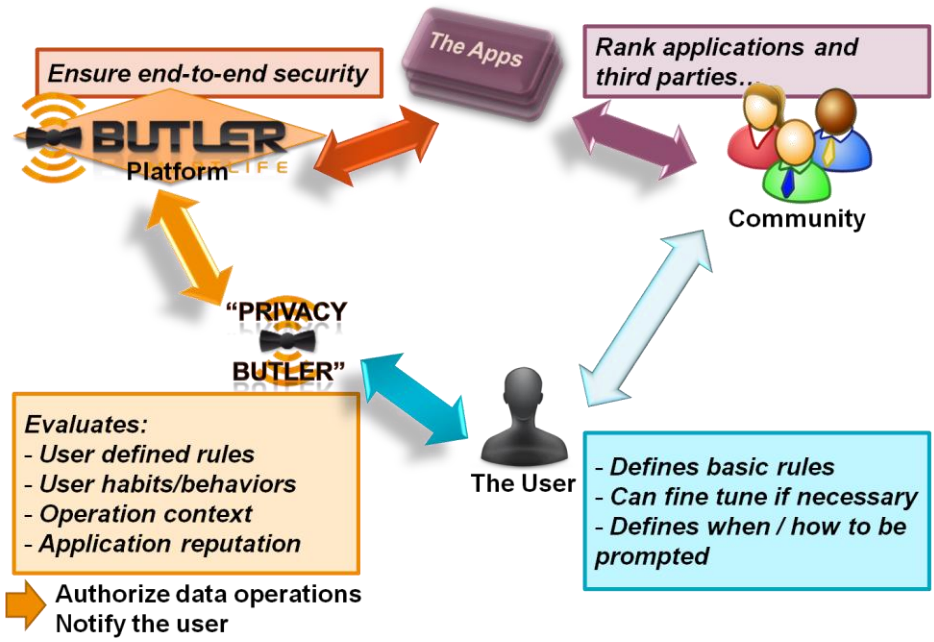

Figure 33: BUTLER privacy coach concept

As described in figure above, the “privacy coach” or “privacy butler” system proposed is user centric. A graphic user interface enables the user to define a set of rules that should be both simple to comprehend for the user and complex enough to enable advanced users to fine tune if necessary. The user can also define how and when to be contacted by the system. The privacy coach in itself is a semi-autonomous agent whose main role is to authorize or deny data operations on behalf of the user. To take each decision the agent evaluates the rules defined by the user but also context elements, and eventually user behavior and reputations of third parties. To handle the reputation system, the user is able to participate to communities which evaluates and rank IoT applications and third parties (service providers, application developers…). To ensure the end-to-end security of the interactions between the different elements of the systems and to ensure that third parties applications respect the decisions of the privacy butler, the whole system is built upon an IoT platform: the BUTLER platform. Some architectural components of the BUTLER platform (behavior capture, data manager, context analysis…) are used by the “privacy coach” system.

The systems propose to differentiate rules for handling personal data based on different criterion such as the type of data (location, contacts, environment, direct personal info (age, gender, name) indirect personal information…), the type of action (collection, transfer, processing, history, licensing to thirds parties ...), the trust that the user put in the third party (user defined groups of trusted third parties: high, medium, low trust, friends, coworkers…) and the context (location, time and date, connectivity, identity of the IoT device...).

The following diagram presents a summarized view of the potential algorithm governing such a system:

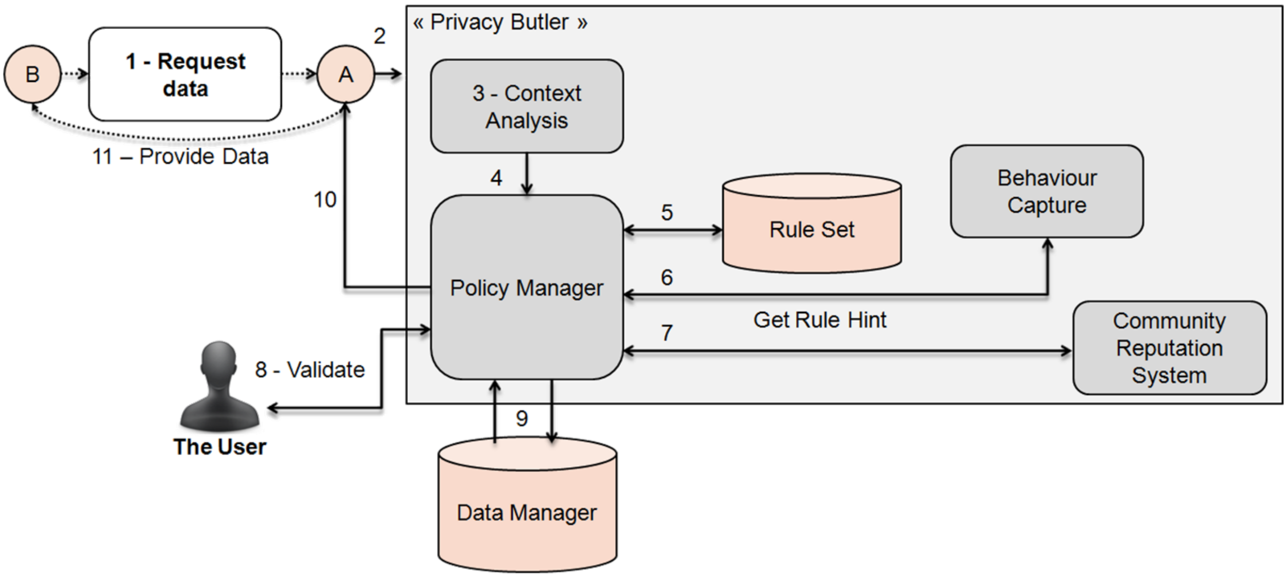

Figure 34: BUTLER privacy coach workflow

Analysis

The proposed approach can significantly improve the way the informed consent question is handled. The definition of rule can be very specific (taking into account the type of data, type of operation, identity of the third party requesting the data operation and context of the operation) enabling detailed control by the end user. For operational constraints of the project (project scope, time and budget) it is however to be noted that the BUTLER project has not been able to implement this concept in the scope of the project but this is considered as a further development of the Smart Mobile platform.

At the same time, the possibility to group elements together and the semi autonomous nature of the agent enable to limit the time needed for the end user to define his rules. The advices given by the behavior modeling system and the community based reputation system further simplify the task of the end user. The system could be initially populated by rules defined through a user-friendly questionnaire that introduce the user to the issue of privacy in the IoT.

One of the potential issues to be addressed is the “all or nothing” behavior of the “privacy coach” decisions. It can be expected that many third party applications will simply stop to function altogether if a data operation they requested is denied by the privacy manager. This issue could be addressed by introducing different level of data obfuscation as alternative to the deny operation.

Another potential issue to be further addressed is the increasing differentiation in the IoT between the end user and the data subject (i.e. an IoT application, such as a sensor network, may collect personal data on data subjects that are not directly users and therefore may not be able to give consent). We believe that this issue, as well as the correct enforcement by the IoT applications of the rules defined by the “privacy coach” could be handled by the adoption of common, standardized IoT platforms, with end-to-end security (such as the one the BUTLER project aims to develop) and supported by specific governance.

6.3. Importance of user acceptance

In this section, we present the contributions of the BUTLER project regarding the ways to engage users in IoT based applications and improve users' acceptance. This question was the subject of a dedicated session in the IoT week 2014 (London) chaired by the BUTLER's project. The paragraphs hereafter summarize the main conclusions of this workshop that gathered several current projects running experiences and activities regarding users' engagement.

The question of acceptance of users is an important part of the success of an IoT based services and applications, and the preliminary interviews conducted with around 60 people reveals their barriers to adopt innovation (ie. mistrust of technology in its technical aspects (bugs) or regarding its usefulness). Moreover users clearly identify the possible negative impacts of such applications and services dealing with their individual and human values.

6.3.1. Conceptual contribution: the drivers for users' acceptance

Users' acceptance is an important parameter of success for many IoT based use cases and scenarios. In fact, many applications are depending on a large spread among possible users and could be successful (even at the stage of experimentation), only if a minimum scale of users is reached. Similarly, some scenarios include the building of live communities (eg crowdfunding) and again, users' acceptance is one of the most important parameters to ensure the success of the application. As seen in section 6.2. above, the services and applications could imply several potential issues in terms of security, privacy, hyperconnectivity, loose of human interaction, etc. which may not been foreseen and anticipated by technological developers. There is thus a need to involve users in the definition and development of innovative IoT solutions to take into account their experience (user's feedback), understand what they accept and their concerns and include them as a process in the requirements definition. It is estimated that the failure rate of new products in computing and electronics companies is around 65% ~ 90% but diminish drastically for firms with effective "new products developments" (NPD) process with include interfaces with customers. 80% of the top performers are running periodically test customers preferences. These figures demonstrate that understanding the drivers of consumers' acceptance of new technologies plays an essential role. Considering users as co-innovators in the innovation process has several benefits including:

- Better defining use cases
- Understanding the foundations of users acceptance
- Engaging users
- Adressing users' concerns
- Addressing strong societal issues

On a theoretical background, the functional level appear insufficient to explain the acceptance (or lack of acceptance) of a new technology. In the model that we propose, we also identified an experiential level that play a comparative and even more important role to drive acceptance.

The figure below gives an overview of the model for drivers of acceptance.

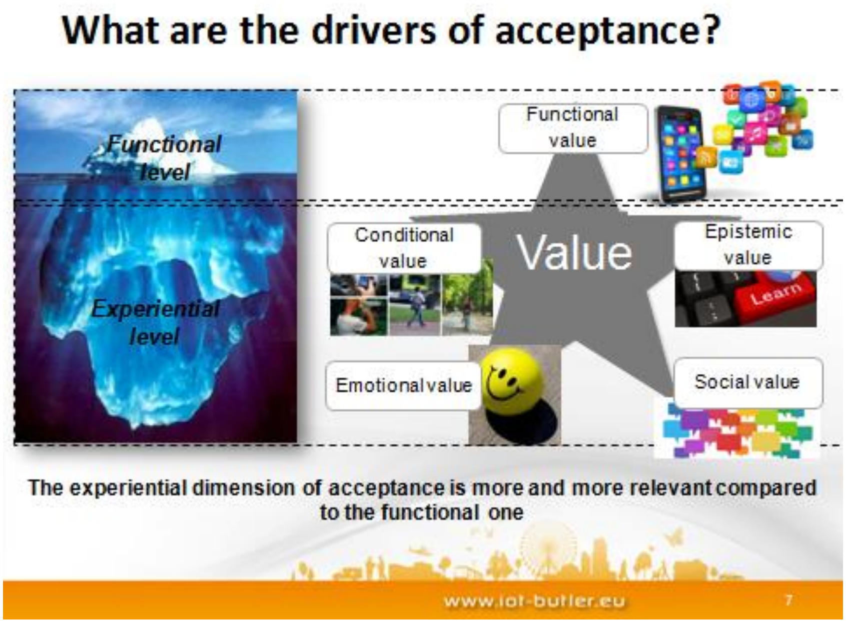

Figure 35: drivers of users' acceptance

The underlying assumption under the proposed model is that, contary to most of past researches, functional value is not the only relevant dimension in explaining the acceptance or adoption of a technological innovation by consumers. Functional value in fact represents only the top of the ideal 'iceberg' that is the consumer experience. Other values should also be considered, namely conditional, epistemic, emotional and social values. They represent the hidden, not rational, subconscious part of the consumer acceptance, that has, however, a greater importance than the functional part in shaping the consumer acceptance (ideally the hidden part of the iceberg,that is bigger).

Functional value: is composed by usefulness, ease of use and price of the technological innovation

Social value: is the influence of relevant others on the single user. The influence can come from family, friends, coworkers etc..

Epistemic value: derives from the capability of the product to spur learning or curiosity in the user

Emotional value: is constitued by the emotions the tech product transmits to the user, such as happyness, pleasure etc

Conditional value: is the context in which the product is actually used, so the time, the place and the people with whom the user interact while using the product.

6.3.1. Conceptual contribution: users' experience feedback framework

In conjunction to the field trials, we thus develop specific tools and framework to involve users in the trials with a balance of specificity and common material among trials. The overall objective was to assess the trials through users' feedback both on technical aspects (proof of concept) but also on non technical aspects such as business models and value propositions perspectives, ethical issues, societal outcomes, etc. Users have been considered as important players in the *"Learning process"* to identify risks & impediments on **non-technical and social aspects,** identify **good practices** in terms of Business Cases and identify **Smart applications expectations***.*

To implement this, a conceptual framework has been developed that took as starting point a mix of evaluation concepts (in terms of results, outcomes and impacts) and users' acceptance theories. Furthermore, both users and developers and trials deployers have been targeted to give their feedbacks as direct stakeholders of experimentation. The figure below summarizes the dimensions retained to gather stakeholders' feedbacks. It has been developed in a generic way in order to be applied in various context, at least in the five BUTLER trials, but with the possibility to be relevant for others experimentations with few updates. For each dimension, a set of metrics of interest has been identified that combine description information (such as the number or nature of users), self-evaluation information (such as satisfaction or feeling) and performance indicators (such as technical sustainability or reliability).

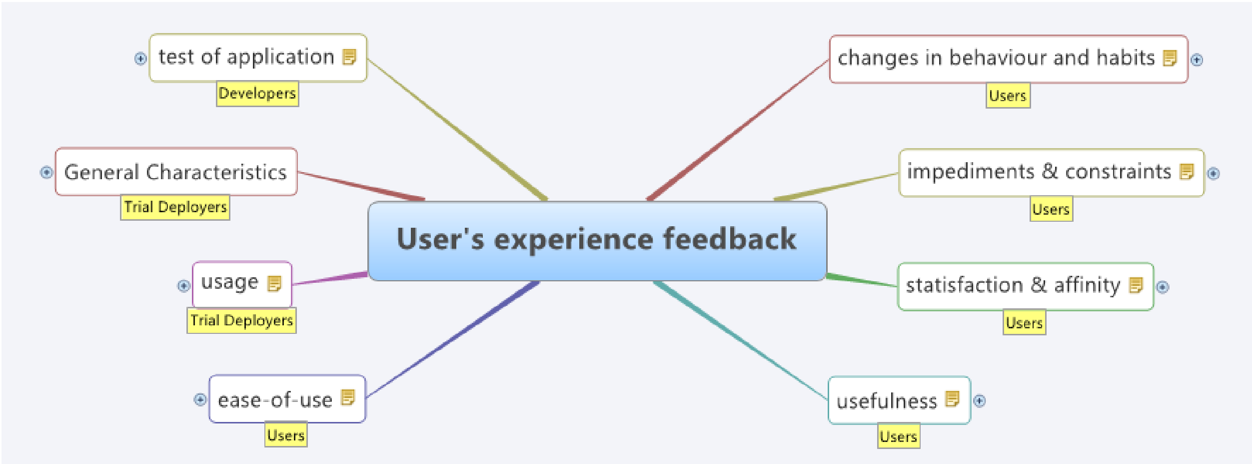

Figure 36: User's experience feedback dimensions.

Dimensions for developers and deployment operators:

Test of application corresponds to indicators related to technical performance. It includes indicators about validation and performance assessment and correspond to the KPI and requirement defined in the objectives of the trial or experiment.

General Characteristics describes the characteristic of the trial regarding the users targeted such as nature (for instance, a specific group such as merchants, care givers, etc...), their role (active or passive), the importance of dynamic group in the use case, and the requested engagement and promotion strategy to reach the final user.

Usage describes the actual usage of the services / application under test in terms of number if use, frequency of use, numbers of users, etc. This dimension should be updated according to the trial targets.

The figure below summarizes the proposed indicators and metrics.

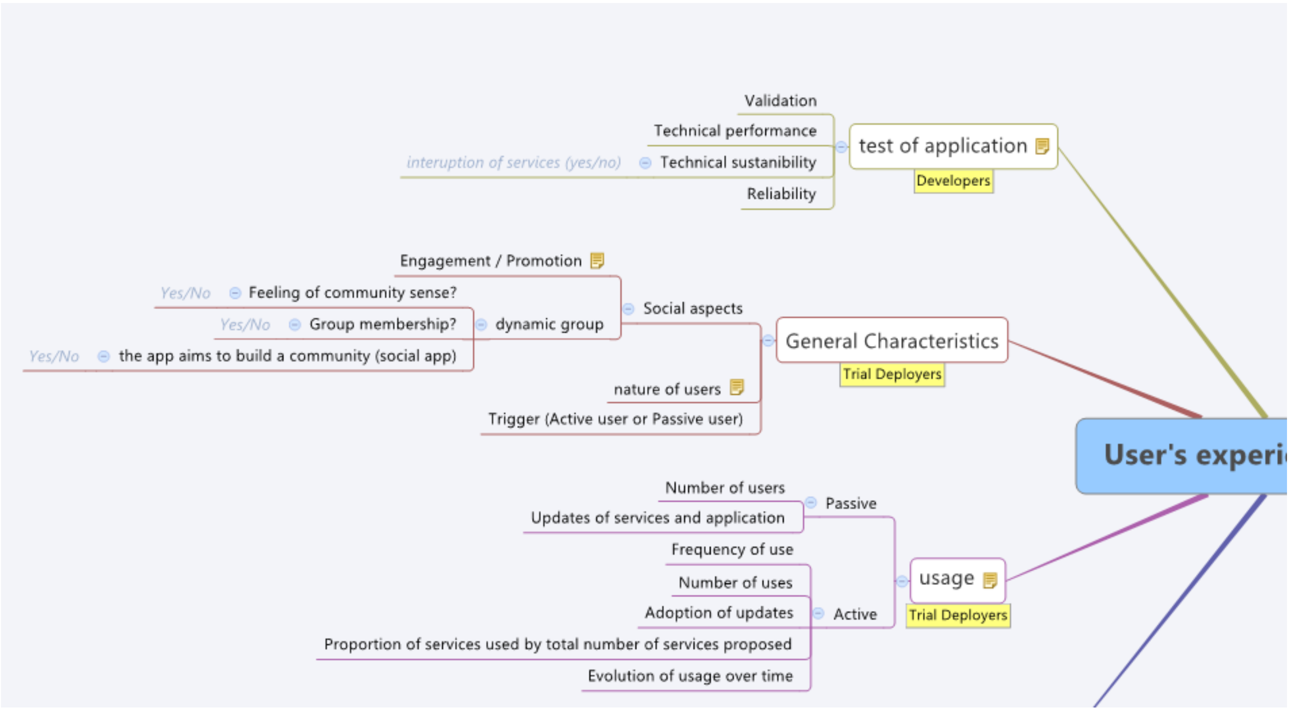

Figure 37: Feedback Dimensions for developers and deployment operators

Dimensions for users

Ease-of-use describes the outputs of the services/applications under test from a users and usage perspective. It deals with dimensions such as ergonomy and usability, accessibility, reliability and adaptability that characterise the experience of the user. Several indicators derive from each of these dimensions and are summarized in the figure below.

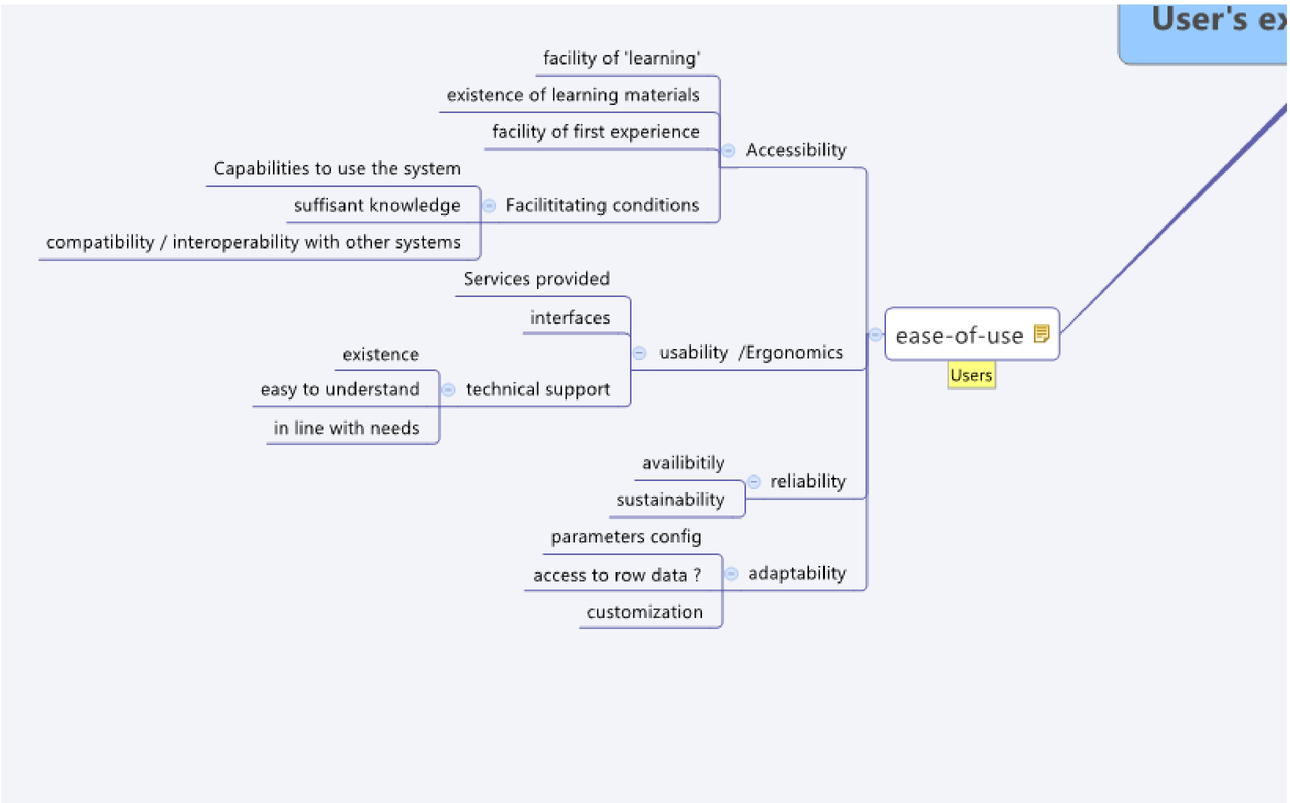

Figure 38: Feedback dimension: Ease of use

Changes in behaviour and habits is related to the expected impacts of the use cases under experimentation and describes the actual achievements of the trial in terms of acceptance / disacceptance, and measure the actual changes at individual and global level. Under this dimension, the factors that explain the changes in behaviour are also documented such as influences, but also voluntary changes and constraints imposed to by the services and application to the users. The figure below summarizes the criteria and indicators.

Figure 39: Feedback dimension: Changes in behaviour and habits

Impediments and constraints give information about users' feeling regarding the constraints and impediments in using the services and applications under test. It includes threats perceived, and possible negatives feelings, but also improvements proposed to address and fix the identified impediments. The figure below summarizes the criteria and indicators.

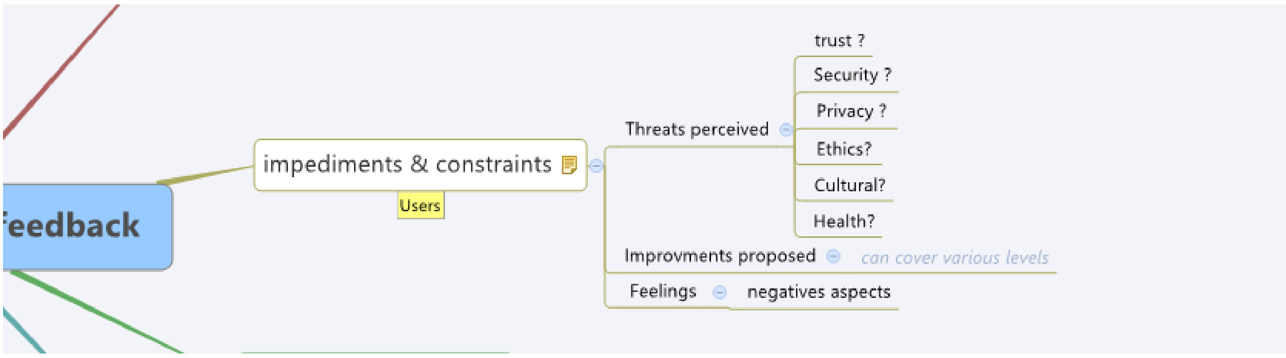

Figure 40: Feedback dimension: Impediments and constraints

Satisfaction and affinity documents users' feeling using the services and applications under test. It includes both aspect related to functionalities, but also other aspects such as fun and emotion, in order to evaluate the perception of the users in rationale and irrational aspects. It also includes an indicators related to the reason of use and non use and the wishes in a long term perspective. The figure below summarizes the criteria and indicators.

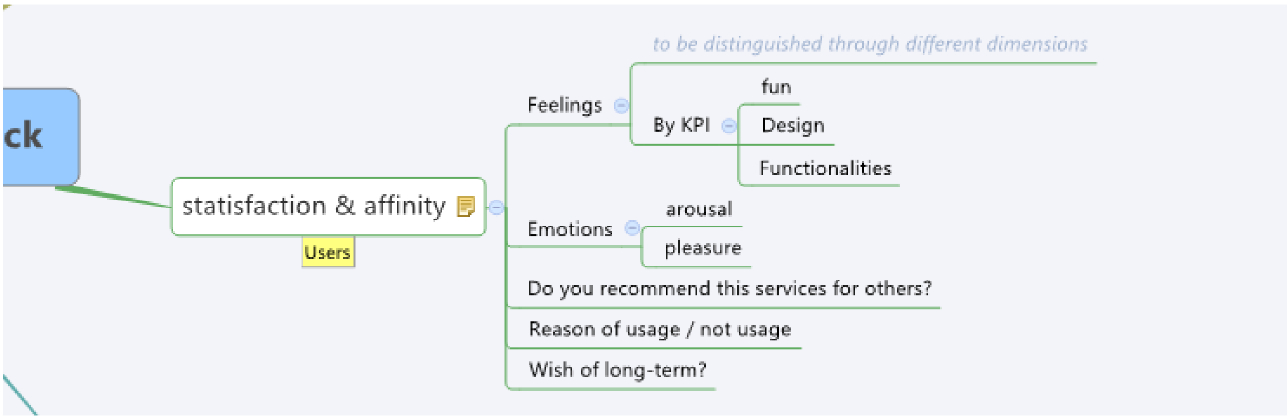

Figure 41: Feedback dimension: Satisfaction and affinity

Finally, **Usefulness** includes indicators related to the KPI from the users perspective. It documents and measure the added value and innovation perceived by the user, and validate or give insights about possible business models (who pay for what ?). Other KPI defined by the user shall also be added.

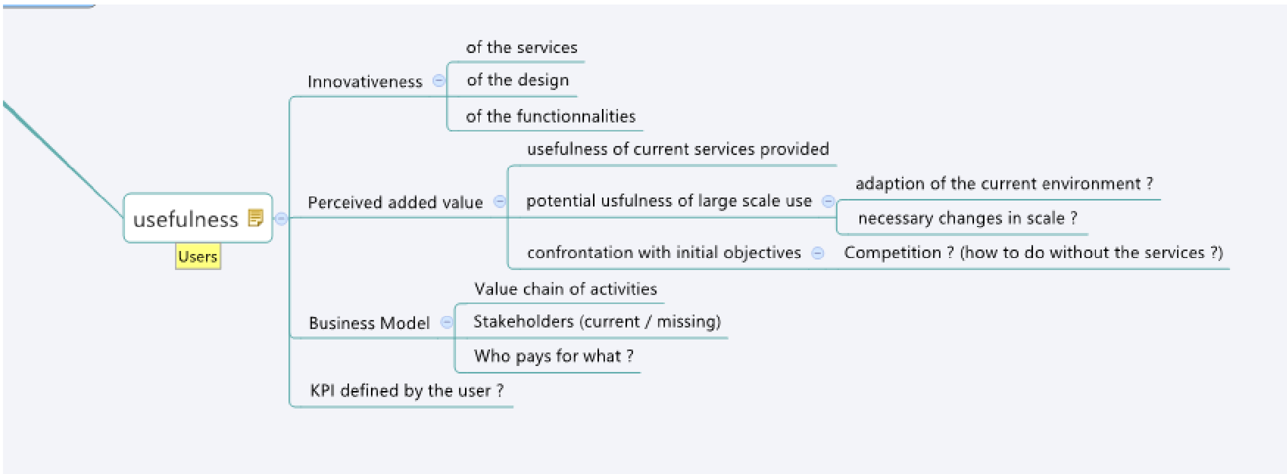

Figure 42: Feedback dimension: Usefulness

6.3.2. Practical contribution: Butler feedback tool

Some of the dimensions related to users' experience of the comprehensive framework have been implemented into a pragmatic tool to enable self and real-time feedbacks from users. This tool has been conceived to be complementary to other direct contacts with users through interviews and users' workshops. The BUTLER User Feedback Tool aims at enabling users of IoT experimentations to give their feedbacks on their own experience. The tool is user centric and designed to make the feedback activity as simpler as possible for the user. It combines a mix of open questions, requests for comments on specific aspects (e.g. functionalities, design) and possibilities to reports bugs, suggest improvements and give opinion about the experimentation under test.

The objective of the tool is twofold:

- Provide users with the ability to feedback about the experimentation, giving them the role to shape the applications with their needs and wishes;
- Provide developers with requirements in real time to improve the quality of experience and services for the users.

The user feedback tool is shaped as a web survey. A set of dimensions and questions have been identified and designed from users' acceptance dimensions completed with other dimensions related to satisfaction, impacts (eg change in behavior) and barriers and impediments to let the users choose the most convenient and relevant mean to commit its feedback. A user centric approach has been designed to facilitate feedback activities of the users by allowing them to share their view from rapid feedback to detailed opinion. Entering in the tool could be done through different manners depending on the wishes of the user. A quick access gives the user the possibility to feedback very quickly and easily. On the contrary, a user wishing to spend more time and participate more actively in the innovation process have the possibility to detail its experience in each of the proposed categories. Finally, the tool has been designed to be evolutionary and the user can add new categories if he/she wants.

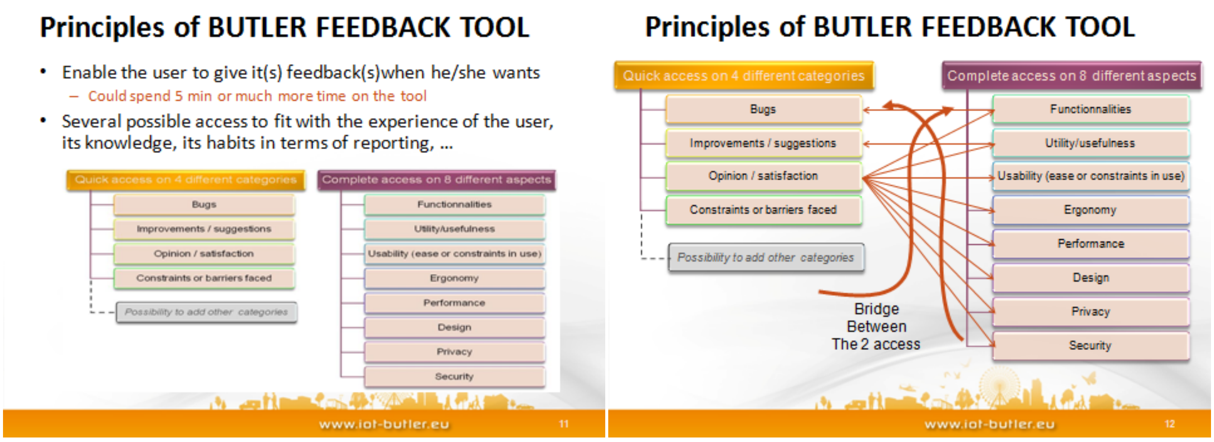

Figure 43: principles of feedback user tool

The retained set of dimensions is composed of 12 categories. The first four are related to user's perception of its experience:

- report bugs
- suggest improvements
- give opinion
- report on faced constraints and barriers

The next eight are related to the quality of experience self assessed by the users on the following dimensions:

- Functionalities
- Utility / usefulness
- Ergonomy
- Performance
- Design
- Privacy
- Security

For each category, it is proposed to the user guidelines about the manners to feedbacks upon its experience with a multiple choice question and a space for free comment.

Example: report Bugs

1. *What is the nature of bug(s) you face?*

- *The app crashes without a reason*
- *The app doesn't make what it is supposed to do*
- *I can't customize the app as I would like*

2. Please, describe the bug(s) you face?

The tool is composed on three different surveys with bridges from one to the other:

- An introductive survey which goals are the following:
    - presentation of the aim and functionalities of the tool
    - choice of the trial
    - choice of the language
    - choice of the manner to enter the tool
- A feedback by areas survey corresponding of the dimensions related to the quality of experience
- A feedback by nature survey corresponding of the dimensions related to users' perception.

The comprehensive tool has been published on the open platforms portal and the source and template of questions has been made available for others willing to reuse and adapt it in their own context. The tool is easily reusable in other context and for other experimentations. The questions and dimensions have been voluntary written in a sufficient generic way to apply to several situations (e.g. the 5 trials implemented in BUTLER covering scenarios of smart shopping, smart office, smart parking and smart health).

The tool and its dimensions are in particular relevant for technical developers that would like to gather clues about users' acceptance of their products or services but don't want to spend time in redefining the dimensions of interest. They can pick and chooses categories of interests in the proposed framework.

The figures below present some snapshots of the tool.

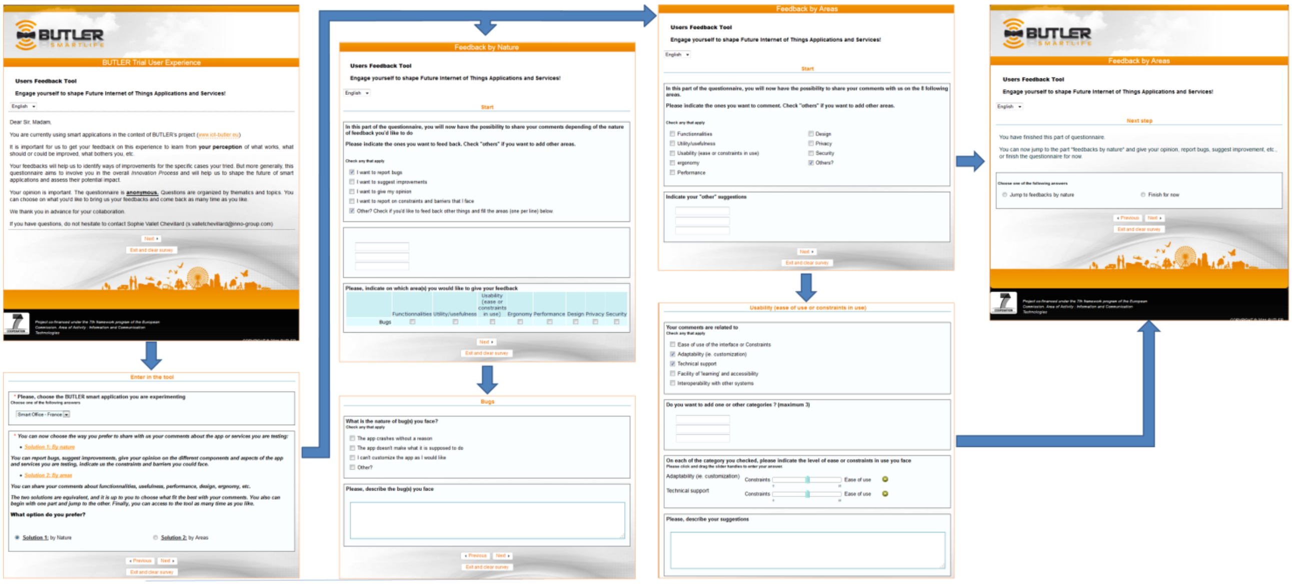

Figure 44: snapshots of the feedback tool

The feedback tool has been mainly used in the smart health trial. Unfortunately, this tool didn't fit perfectly with the habits of the users and was hardly filled by the users of the trial. It should not be considered as a unique way to collect feedback, but should be seen as complementary with short face-to-face interviews in the moment of collecting devices. In a trial perspective, this enables to engage more the users, as this way the participants will not forget to fill in the questionnaires, and is more feasible and easy to fill in the questions. Some complaints also have been reported against the tool about the difficulty to sometimes understand the question to fill it or the time it took. A improved version of the tool should certainly be developed to better adapt to the context and nature of users of each trials.

The tool was not intensively used during the others trials, because, less users ware involved, or other ways of feedbacks was already in place (ie smart shopping in which focus groups with merchants took place regularly). Nevertheless, the same criticisms were not expressed.

6.3.3. Proposition of best practices and traps to avoid when involving users

During the IoT week, several IoT projects involving users presented their approach to involve and engage the users in the use cases and experimentations. Some conclusions have been drawn and are presented in the following paragraphs.

The role of users in IoT application is double:

- Users are considered as factors in the sense that they are providing data and are themselves an *"input"* for IoT applications to provide services, with the possible conflicts and rejection regarding the tracking, tracing and monitoring of individuals.
- Users should also be considered as actors to exchange and participate into the human experience and input and influence the technical deployment and avoid the waste of having technologies, but no use case.

Furthermore, many stakeholders are involved and need to be engaged (for instance, actual users but also the potential ones, and even the non users, the customers, voluntary contributors, etc.). Each follows its own benefits and has its own incentives. Moreover, possible conflict may exist between the various stakeholders. It is thus necessary to assess the value proposition for each of them.

There is also a need of mutual Learning among stakeholders: *"By default, I refuse to be tracked and monitored…….But … If it saves life, I can accept".* Users' engagement process should so also enable dialogues among the stakeholders, to permit understanding of each wishes and expected benefit from each of them, be able to converge on a compromise and finally speed up innovation spread and acceptance.

In terms of key success factors, some clues have been established by current IoT projects:

- **Begin as soon as you can.** Users should be part of the community and be involved from the beginning. If not, the risk is high to need important extra effort to implement usability and software integration. Furthermore, users' engagement should follow the evolution of the project: starting small to drive interest in further participation and scale up involve also scale up in engagement
- **Dedicate resources** to users engagement
- Users' engagement should not be considered only in terms of techno push, but need to be related to the value proposition for stakeholders:
    - There is a need of **expertise** to translate "words" from users into technical requirements
    - It is also important to look not only at needs but also at demand
    - Finally, a marketing attitude should be adopted from the beginning
- **Engage with existing communities:** the wheel should not be reinvented each time, and it's less costly to build and get support from existing federal communities which have already thought on their interest and have rapid access to end users
- **Models**: Finally, it is important to need and capitalize on models to take into account taxonomy of dimensions

In conclusion, users' engagement processes are in themselves in a stage of experimentation and there is an important need to capitalize and move from experimental approaches to systematic users engagement methods (quality, robustness, efficiency) and share good practices with the community to foster improvements.

6.4. Platforms and openness

In this section we present the contributions of the BUTLER project to the definition of IoT platforms and to debate on closed versus open and interoperable approach to foster the development of the Internet of Things. The documentation of the BUTLER platform is available in D5.2, while the exploitation plan of the project (D6.5v1.5 and D6.3) presents some of the economic reflections on the possible futures of the BUTLER platform.

6.4.1. The emergence of platforms in the IoT

The emergence of a large market from the current environment of fragmented competing technologies, actors and standards will require increased interoperability and standards. In the context of technical interoperability, the IoT will evolve into billions of devices from different brands. The number of different devices will grow rapidly, and the task of making all of them interoperable is not trivial; rather, different vendors with different ideas about their systems must reach consensus on how their devices will connect to other devices. This consensus is not easily achieved, especially when different vendors often adopt different technologies. Interoperability in terms of syntactic and semantic will be much harder to achieve compared to that of technical interoperability. It is one thing to make devices communicate with each other; however making devices effectively communicate and understand each other is significantly more difficult. In other words, data interoperability refers to the ability of devices to understand each other, even if different devices use different data formats to communicate.

The creation of technical platforms, including not only standard communication protocols but also reference architectures, and key component implementations is considered a credible answer to this need of interoperability at different level. Other specific characteristics of the IoT reinforce the likeliness of the emergence of platforms, such as the strong need for an interdisciplinary approach in IoT or the overall needs of security and issues with privacy. In that matter, the privacy and data protections concerns related to the deployment of an Internet of Things are multiple and complex (user informed consent, continuity and availability of services, contextualization of risk, profiling, ownership, management and captivity of data, applicable legislation and enforcement…), most are technically addressable if they are taken into account early on, some will require new developments, or evolution of the legislation to both better protect citizens and enable business development (see section 6.3. above). The emergence of platforms, including embedded security mechanisms both in lower and higher communication layers can be a decisive asset in handling these issues and therefore further reinforce the likeliness of the emergence of platform on the IoT Market.

The figure below shows the current (non-exclusive) landscape of this ecosystem with the main actors involved.

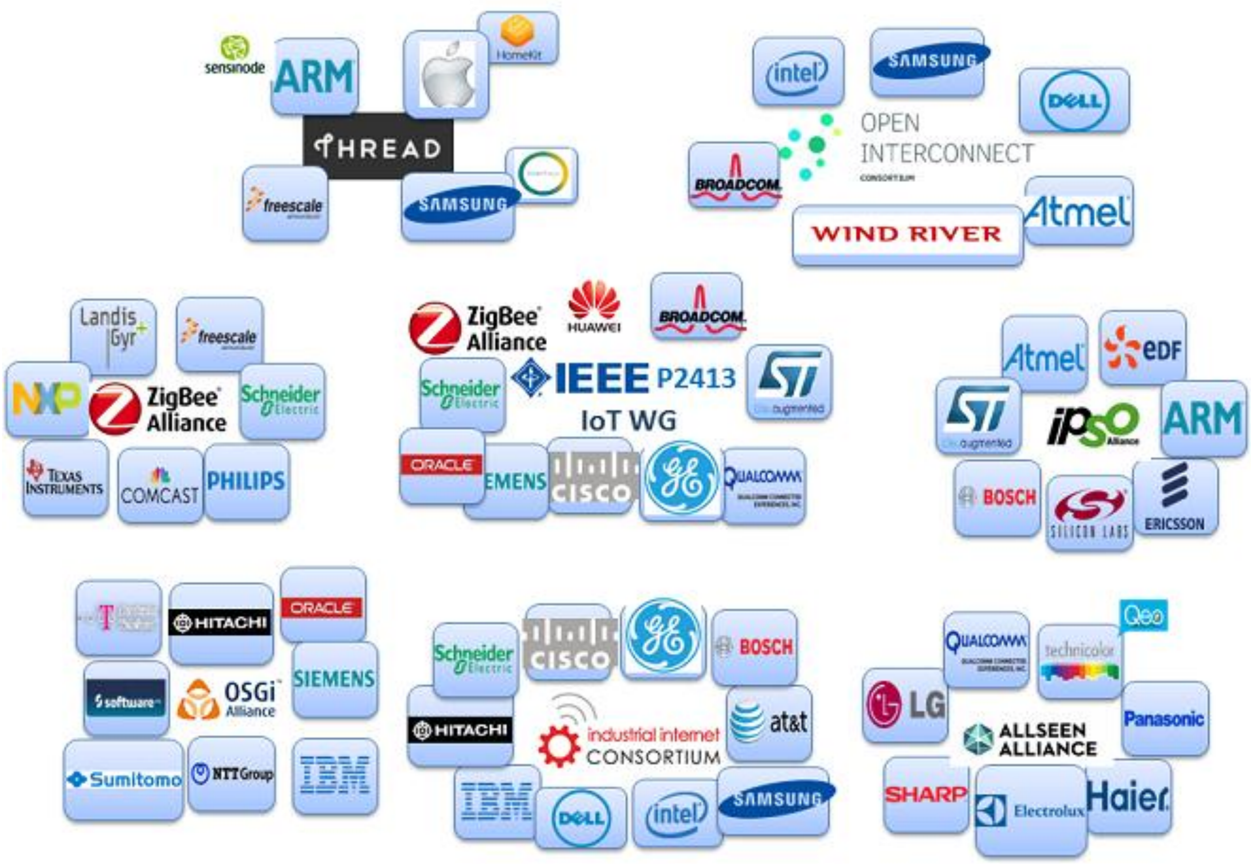

Figure 45: Industrial alliances in the current IoT ecosystem

It can be observed that those groups are mainly driven by large industrials that want to leverage on some of their existing solutions. This is well aligned with the vision of the "Free Market Scenario" and confirms that established players form a strong barrier to entry. However, we can observe that many companies are present, at the same time, in several of those groups showing that there is not really a proper strategy and still an opportunistic vision in the IoT domain.

6.4.2. Open platforms

Open platform is defined by Wikipedia [40] as being "a software system which is based on open standards, such as published and fully documented external application programming interfaces (API) that allow using the software to function in other ways than the original programmer intended, without requiring modification of the source code. Using these interfaces, a third party could integrate with the platform to add functionality. The opposite is a closed platform." Many initiatives already exist in the field of IoT and M2M. An example among many, built upon the Eclipse IDE (Integrated Development Environment) is the m2m.eclipse.org project which aims at "using the Eclipse platform as a base for the creation of an interoperable and extensible set of tools to simplify the development of M2M solutions". It focuses on the implementation of lightweight protocols such as MQTT or OMA-DM. Nevertheless, existing initiatives in the Do It Yourself (DIY) move, suggest extending this definition to include the hardware perspective. A number of **open-source hardware** projects emerged over the past few years. Arduino [41] and Raspberry Pi [42] are probably among the most known in the field of IoT but others may exist and can be identified in on-line directories [43]. Within Open-source hardware projects, information about the hardware is publicly accessible. The hardware designs (i.e. mechanical drawings, schematics, bills of material, PCB layout data, HDL source code and integrated circuit layout data), in addition to the software that drives the hardware, are all released with the Free and Open Source Software (FOSS) approach [44].

Still within the IoT, (open) **data platforms** such as Xively (formerly Pachube) have emerged [45]. Pachube proposed an open source platform enabling developers to connect sensor data to the Web and to build their own applications on it. It was designed as a data brokerage platform for the internet of things, managing millions of datapoints per day from thousands of individuals, organisations and companies worldwide.

Finally, cloud based offers allowed the delivery of **Service platforms** providing the most adequate services based on both application requirements and contextual facts. Provided services can cover a wide range of functionalities as part of the XaaS (everything as a Service) approaches but some are closer to the IoT ecosystem. An example is the OSGi service platform: In this case, applications or components (coming in the form of bundles for deployment) can be remotely installed, started, stopped, updated, and uninstalled without requiring a reboot. Application life cycle management (start, stop, install, etc.) is done via APIs that allow for remote downloading of management policies. The service registry allows bundles to detect the addition of new services, or the removal of services, and adapt accordingly [46]. Another example is the case of a Service Platform for Mobile Context-Aware Applications; applications describe their requirements by defining the desired services and the contextual conditions in which the services should be executed. The platform should autonomously react to reaction rules, in which the contextual conditions are checked against contextual facts [47].

In addition to these concepts of open platform, BUTLER introduces the concept of **horizontality**: deployed usages should not restrict to one particular, vertical applicative sector but should span across several, leveraging on (context) information gathered in one vertical to infer added value services in another sector.

In the context of BUTLER, a **horizontal open platform is thus a set of components**:

1. Providing fully documented external programming interfaces
2. Able to be interconnected in different ways to serve different purposes
3. Not specific to one or few vertical sectors
4. Open to expansion and updates of supplied API or inclusion of new components
5. Having software or hardware implementations, ideally supplied following FOSS IPR rules.
6. Spanning across the OSI layers

6.4.3. The case for openness

The choice of a fully open strategy rather than a closed initiative can derive from several considerations:

- First, given the broad potential reach of the Internet of Things, it can be hardly imagined that a single platform will fully fit all potential scenario and use cases. Even a “Horizontal” platform such as the BUTLER platform, could be complemented by other platform components either specific to a single vertical domain (health, home, city…) or specific to certain technological needs (cognitive technologies, semantic web technologies…). Therefore choosing an open approach is a guarantee that the proposed “platform of platform” is not only fit to current foreseen IoT scenarios but also able to adapt in the future to emerging needs. The choice of an open platform initiative therefore takes root in the conviction that from a user perspective the possibilities of an open, “platform of platform” offers much more benefit than closed approaches. The potential gains of a knowledge and performance in term of “big” data analysis and predictions are much larger is the platform allows data to be confronted from a large variety of sources. Only an open approach can therefore enable the full potential of the “internet of things” vision, and closed platform approach would only enable “intrAnet of things” that barely approach the full potential.
- Second, the choice of an open approach, carried about by innovative research project that are at the forefront of the state of the art is a tentative to ensure a decisive strategic advantage: ensuring that the platform does not become a lock that a single (or a small group of) actor(s) can use establish a de facto monopole on the IoT market. A somewhat similar strategy has been used in recent years on the Smart Phone OS market by Google to establish rapidly a competing open source solution in response to the Apple rising market shares. The business value can thus be

reoriented on other elements of the value chain (devices, infrastructures, applications, services, data market…) on which the core participants to the open platform initiative would have a key competitive advantage. It can be argued that some of these other elements, were most of the value creation potential will be realized (such as applications and services) can benefit much more easily to small local actors rather than existing industry giants.

- Finally as presented above in section 6.1. , the choice of openness can be linked with the desire to produce user empowering “smart” applications. Transparency and openness can encourage curiosity and creativity in the general public and is a potentially potent way to rapidly build a strong and dedicated user community. The potential applications and extensions of a platform built this way can evaluate faster than in a centralized and closed approach. The vast number of potential application domains of the IoT also strongly pleads for openness as secondary data uses, and unintended uses, un-designed uses of IoT application can become the norm rather than the exception and lead to rapidly developing markets.

6.4.4. BUTLER contributions

Based on this analysis, the BUTLER project internally committed to the openness of key components of its platform. This drove the common exploitation plan of the project and led to the launch of the Open platform initiative.

This “platform of platforms” initiative originated in the BUTLER project as part of the project exploitation activities and rapidly evolved into **a cross EU-research project initiative** (as part of IERC Activity Chain 1) aimed at supporting the use of existing platforms as well as their improvement in the view to create comprehensive ecosystems of platforms and associated tools. The Open Platforms initiative originated in the 2013 IoT Week in Helsinki, the debate launched by the BUTLER project received several initial declarations of interests. The concept were then refined into a working paper [48] which defined the basis of the requirements of the Open Platforms portal and several working items. In January 2014, the Open Platforms initiative was formally integrated in IERC activity chain 1, renamed IoT Architectures and Open Platforms.

The problem addressed by the Open Platforms initiative can thus be formulated as such: many IoT platforms are emerging, some solving part of the interoperability challenge, some providing additional services and extending the reach of the IoT. Yet from an end user / application developer perspective it is not clear **which platform is most adequate for which use case**, and how can different existing platform initiative cooperate and **be made interoperable in a single application.**

The need of **“platform of platforms”** approach able to **document reusability, interoperability and relations to use cases and deployments** of the different existing IoT platform initiative emerged to address these problems.

To address those objectives, the Open Platforms initiative concretized around a web portal: http://open-platforms.eu/. The goal of the portal is to reference the open technologies that can be used to create Internet of Things applications but also to document their interoperability, relationships, and reference to existing use cases, infrastructures and deployments. For now most of the components documented on the portal originate from European research projects, but the initiative isn’t limited to this scope. The Open Platforms portal can be seen as a tentative map of the Open Internet of Things Ecosystem.

The purpose of the portal is to enable technology choices and as such should document not only the technical whereabouts of the open platforms components but also and more importantly all the information that enables their reuse (IPR, Service Level, Security...). The eventual objective of the portal is to be able to answer complex queries for IoT enabling technologies and reusable components:

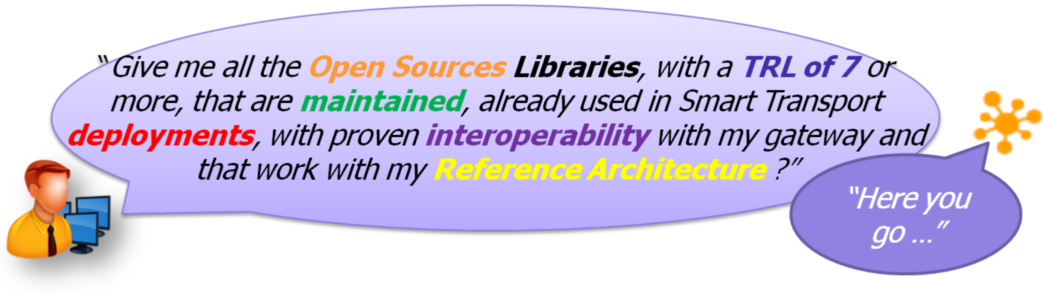

Figure 46: Open Platforms portal use case

The BUTLER project has been a strong initial contributor to the Open Platforms initiative with all the platforms components documented on the portal and a strong commitment to open source for most of the project productions. This includes the project Smart Gateway platform which can be considered as a corner stone of any IoT deployment by enabling connectivity between different objects through different protocols.

The open platform initiative will continue beyond the scope of the project, first because of this strong openness commitment of the BUTLER project partners, but also because it is now supported by the IERC cluster and receive contributions from various project of the IoT community you have joined the initiative (IoT-A, Open IoT, COMPOSE, ICORE, FIWARE...).

It however remains to be seen if this initiative can impact the IoT ecosystem as a whole and compete with developing closed platforms promoted by large corporate players.

6.5. Real-time data potential impact: triple bottom line

The following section presents an evaluation of the potential impacts of the increased use of "real-time" IoT data. It summarize the more complete analysis presented in annex of D6.5 v1.5 (a restricted deliverable of the project).

6.5.1. Introduction: the value of one second

The value of real-time information is closely linked to the perceived value of time. Although not a straightforward synonymous, device data is one of the main sources of real-time data and its availability is known to be a cornerstone of real-time data.

Financial traders in highly volatile, fast-moving stock markets know too well that one second could determine the difference between thousands of dollars in gains or thousands of dollars in losses. More tied to device data, a second's delay to the proper administration of cardiopulmonary resuscitation (CPR) and defibrillator shocks diminishes a person's chances of survival by 3.6%[9]. While there is no precise monetary value to human life, it would be sensible to assume that every second of life taken away translates to a fractional loss in the individual's future lifetime economic output.

Due to the relative value placed on time, measuring the global aggregate value of real-time data is a challenge. The authors of Ericsson's Networked Society City Index acknowledged the difficulty of fully encapsulating the benefits of ICT development in a society due to the complexity and intertwined nature of socioeconomic science[10]. Hence, we decided to present the triple bottom-line benefits of real-time data in a more incremental context using six specific dimensions (not comprehensive):

Economic Value:

- Revenues earned from developing and downloading real-time applications
- Cost-savings from improved productivity through real-time applications

Environmental Value:

- Reduced carbon emissions from operating the Device Data Exchange
- Reduced carbon emissions from using real-time traffic re-routing applications

Social Value:

- Increased life expectancy and government cost savings from citizens' use of real-time medical and healthcare applications
- Value of real-time disaster prevention

"Real-time" is defined as the actual time during which a process or event occurs. In computing systems, it refers to the process of updating information at the same rate the system receives the information. The term "near real-time" (NRT) refers to the time delay introduced by system processing times. The difference between real-time and near-real-time is oftentimes ambiguous because the definition would depend on the tolerance for latency and the arbitrary perception of delay. For the purpose of this study, we did not find it imperative to draw the line between real-time and near-real-time, and that a 60-second data delivery delay would generally be considered non-mission critical.

The triple bottom line effect was calculated based on the data collected from Ericsson's internally and externally available documents and publically available sources. Some of our resources include:

- Business and academic articles, whitepapers, studies and reports
- Statistical data from international organizations

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[9] "Every Second Counts When Performing CPR: Increase in Survival When AED Used Less Than 10 Seconds after CPR Pause," Science Daily, 21 June 2011, 20 July 2012 <http://www.sciencedaily.com/releases/2011/06/110620183238.htm>.

[10] "Networked Society City Index Part II Citizen's Index" (Ericsson, 2012)

- Statistical data from national and city/regional statistical offices
- Business papers from leading management consultancy firms
- Data analysis by independent research houses
- Websites, online articles, and credible blogs

We believe our findings would serve as a good starting point to understand the positive externalities of real-time data. There are still many areas where the value of real-time open data can be further explored such as the macroeconomic effects of open data in terms of increased economic activity, the social and environmental benefits of moving from traditional to digital sources of data, and how real-time open data improves and provides more equal access to information. It is our deepest hope that this research would motivate stakeholders to invest in real-time projects to help build smarter, more sustainable societies.

6.5.2. Economic value

- Only **3.5%** of applications in the two biggest application stores, Apple iOS and Google Play, use real-time data; clearly, there's a market opportunity to create more real-time applications. Increasing access to real-time data potentially increases both revenues from app development and downloads.
- Developers earn approximately **€36,000** in service revenues for every real-time application they develop. Total developer revenues today are estimated to be at **€1.4 billion** and are projected to organically grow to **€4.2 billion** in 2016. For every **100 real-time** applications created, developers gain a total economic benefit of **€3.6 million.**
- Users pay an average of **€3.00** per application download. The total revenue from real-time application downloads is **€40 million** today, and forecasted to reach **€134 billion** by 2016. We estimated that **13 million** real-time apps have been downloaded as of this year and will organically grow to **44 million** apps in 5 years.
- **Tools or Utilities, Travel** and **Business** were the most downloaded categories for both application stores. However, out of all the real-time paid applications on the Google Play store, wherein most apps can be downloaded for free, customers downloaded and paid for **Medical (54.1%), Travel and Local (37%) and Health and Fitness (31.7%)** real-time applications.
- The cost of time was measured through a citizen's income per minute. For example, a daily traffic delay of 30 minutes in Spain can cost up to **€13.20** for a five-day workweek. An analysis of 15 countries (Australia, Brazil, Canada, France, Germany, Italy, Japan, Korea, the Netherlands, Poland, Russia, Spain, Sweden, the United Kingdom and the United States) shows that **the aggregate value** for all users who've downloaded a functional application such as transportation waiting times, re-routing, etc., and was able to **save one minute of their time** is equal to **€2.2 million.**

6.5.3. Environmental value

- One of the value propositions of DDX is to minimize multiple data owner to developer interactions by enabling a cloud-based platform that will serve as a data marketplace. The minimized use of transportation as a result of operating DDX reduces CO_2 emission by **15,486 tons** (best case scenario).
- Every minute of being stuck in a traffic jam not only wastes an average of **3 gallons** of fuel, but it also releases **57 pounds** of harmful gases into the atmosphere. With real-time re-routing schemes, which can reduce travel times up to **81%**, a commuter can save **100 gallons** of fuel annually and reduce his or her carbon footprint by **1,900 pounds**.
- An analysis of 10 countries (Australia, Brazil, France, Germany, Japan, Korea, the Netherlands, Spain, the United Kingdom and the United States) shows that real-time re-routing brings an aggregate environmental benefit of saving **575 million gallons** of fuel and reducing carbon emissions by almost **5.5 million tons**.

6.5.4. Social value

- Real-time disease management applications help patients with chronic diseases such as stroke and diabetes to prolong their lives. The adjusted value of extending a diabetic patient's life for one more year through better disease management is **€5,683,** while a stroke patient's is**€3,491**. These values represent the patient's income opportunity for living another year.
- The value of real-time healthcare management applications helping a minimum of **10,500** users prolong their lives for at least one year is estimated to be worth **€52 million.**
- Patients who actively monitor their vital signs visit the hospital less and file lower health claims. Thanks to real-time healthcare applications, the government can save approximately **€1,067** for every diabetic patient and **€4,500** for every stroke patient without investing in expensive healthcare management programs. For every 2,000 users of real-time medical apps, the government can save **€4.7 million** annually.
- In evaluating the impact of real-time disaster warnings, we found the estimated number of saved lives to be relatively low due to a combination of factors - low penetration of real-time data, low probability of disaster occurrence and low probability of fatality. However, we approximate that if real-time apps can save at least **600 lives in the next 5 years**, the total economic value would be **€193 million.**

6.5.5. Conclusions

Data velocity and the speed of insight have always been the main drivers of real-time data initiatives. Our research underscores the fact that apart from adding value to businesses, real-time data also has measurable economic, social and environmental benefits to the society. We established the substantial benefits real-time data provides to government in terms of increased consumer spending through paid application downloads, reduced carbon emissions, reduced traffic road congestions and significant savings on healthcare. Hence, it would be in the best interest of governments and municipalities to play an active role in promoting real-time application initiatives to reinforce the social surplus from technology and innovation.

Many other areas require deeper analysis in order to fully understand the value of real-time information. We encourage further research on how real-time data drives the growth of complementary industries such as wireless sensor hardware providers, data management software, among others. For instance, deploying real-time sensors to a 35 km^2 city such as Santander requires 12,000 sensors, which translates to a €1.8 million business opportunity to a sensor provider. Quantifying the magnitude of industry interdependencies might be meaningful in building partnerships, strategic alliances and synergies in advocating real-time data initiatives.

As a final note, we truly believe that advancing and promoting real-time data initiatives will exponentially increase the triple-bottom line benefits discussed in this research. We hope our analysis would inspire stakeholders to actively participate, promote and pursue real-time data projects.

7. Conclusions

This report draws some analyses about the potential impacts of the IoT based technologies developed and experimented during the three years of the project. BUTLER main activities have provided many scientific and technical contributions to the definition of the IoT domain, with substantial contributions to the IoT enabling technologies and architecture and the drafting of a functional prototype platform. This technical work has moreover been based on a clear and thorough requirement definition based on potential IoT use cases and the project has been able to go up to actual deployments and interaction with end users in five field trials. The project has also been confronted with some of the ethical and privacy questions that are raised by the development and deployment of the IoT. Therefore, despite the mostly technical nature of the project activities and the limitation of the scope of the actual deployments, it has made sense to analyze the potential larger scale societal and economical impacts that could derive from the project activities.

The impact analysis presented in this report was based on a joint conceptual and field analysis, taking at starting point the various existing literature on this topic, the contributions and views of the experts mobilized during the project, the feedbacks received from the IoT communities meet in many events in Europe and broader (and especially the work undertaken under the umbrella of IERC activities chains), and the final users (actual or potential) of different natures (citizens, policy makers, enterprises) of the possible concrete applications and uses cases that could emerge from the project.

This report overviewed the three different aspects of the activities undertaken during the project:

- A global analysis on the expected impacts and challenges of IoT which provides a vision of the state of mind of the IoT community, and a frame on which the BUTLER project impacts can be expected.
- An impact assessment of the 5 BUTLER field trials on social and economical aspects with a focus on the potential business exploitation of the scenarios experimented in the trials and on the users feedbacks and a global analysis in terms of impacts value for each scenario to put in perspective the promising but also unexpected frames and impacts and possible conflicts to be addressed in order to deploy and implement these scenarios in large scale.
- A review of BUTLER main effective contributions to debates related to IoT socio and economical issues and challenges.

The project contributions to the analysis of the potential socio-economical impacts of the IoT therefore provide both an overall vision of the consortium and community on the general challenges faced by IoT deployments, and practical methodologies and feedbacks that can be reused by other projects and stakeholders. Although the IoT is promising strong developments in the near future and, by its horizontal and integrated nature, is set to impact most aspects of modern life, these positive impacts are not straightforward in a complex ecosystem both for economical and societal reasons. The transcending nature of IoT technologies promises cross cutting impacts on society, but individual deployments have to define individual value propositions and analyze potential barriers and impacts in a case by case analysis to be successful.

As a conclusion, the BUTLER project numerous contributions to the community debate on the socio-economic context and potential impacts of the IoT provide a coherent vision:

- The IoT potential broad and deep integration in our society can be the cause for both important opportunities and key societal advancements but at the same time create complex ecosystems which can significantly delay potential deployments and positive impacts.
- The dialogue and interactions with the stakeholders must therefore be at the centre of any IoT deployment. This includes not only initial requirement analysis and ex post feedback analysis but should be conceived as a user centred co-creation process.
- This also lead to the conclusion that only a technologically open IoT can maximize the potential impacts as secondary data uses, and unintended uses, un-designed uses of IoT application can become the norm rather than the exception and lead to rapidly developing markets.

These conclusions should serve as a basis for future large scale pilots and large scale deployment of the IoT. It is noticeable that BUTLER is positioning relatively upstream in the TRL and still far away from the direct market application. But the analysis done during the field trials and the interactions with users enabled to precise the challenges for the users and the possible gap between the technological promises and the users' expectations and give some insights about the roadmaps to be followed for successful large scale deployments (and for research and innovation with higher level of TRL):

- Users' engagement is a key success factor, and ensuring a dialogue between users and technological providers as well as analysing user's feedbacks should be considered as a major activity as important as technical development with if not the risk of a lack of users' acceptance and a quick abort in terms of usages. The usrs' engagement should explore in depth the gap between the value perceived and the desire added value and segment carefully the various stakeholders that could take benefits.
- Beyond the individual level, an assessment at global level (at sectoral level for instance) is also an important aspects. The new players should pay attention of current business models and establishing actors and carefully addressed their needs and ability to change. The question and challenges of digital transition and digital divide are beyond, and should be addressed for and by the possible users.

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