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TagItSmart
Smart tags driven service platform for enabling ecosystems of connected objects

Grant agreement 688061

USE CASE DESCRIPTIONS, REQUIREMENTS AND MARKET ANALYSIS

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Changes made following M9 review comments

Reviewers' requests for D1.1 revised version:
The deliverable needs a clear specification of the requirements, both for IoT architecture and particular use cases. Furthermore, market analysis should be described in more details for use cases.

TagItSmart response:
With respect to specification of requirements, since these were specified in detail in the D1.2 deliverable that was released shortly after the M9 review and also in D2.2 (with respect to SmartTags used), we decided not to repeat them in this D1.1 revised version since it would be a duplication not offering something additional.

Regarding the request about the market analysis, section 3 in this revised version has been enhanced substantially and has become much more linked to the project's use cases.

Introduction

This document is deliverable D1.1 Use Case Descriptions, Requirements and Market analysis that presents the work done in work package (WP) 1 in the TagItSmart project during the first six months. The major goal of this WP was to specify the initial set of use cases to be implemented in this project, clarify the requirements for the use cases and identify the requirements that will drive the architecture design. The WP was envisioned to have incremental milestones, where the architecture might be revisited based on the initial results and feedback, especially from the industrial stakeholders, Open Calls and related work in the other technical WPs. The first objective of the WP was to identify, analyse and formulate in detail use cases that will be implemented during the TagItSmart project.

The work was started in the kick-off meeting in February, 2016. There we brainstormed the use cases in groups. The ideas were discussed and prioritized together and the owners were chosen for the use cases. People were able to continue the work by co-developing the use cases in an online platform, Owela. Owela (Open Web Lab) is an innovation platform created for user centric studies. It can be utilized to co-innovate and co-develop novel products and services with different users and stakeholders. The owners of the use cases wrote a more concrete description of the use cases. Other partners of the project contributed to the use case planning. The use cases were agreed in the project meeting in May, 2016. At the end, five use cases were chosen to be initially implemented during this TagItSmart project. The use cases are described in Section 1.

TagItSmart project sets out to redefine the way we think of everyday mass-market objects not normally considered as part of an IoT ecosystem (Figure 1). These new smarter objects will dynamically change their status in response to a variety of factors and be seamlessly tracked during their lifecycle. This will change the way users-to-things interactions are viewed.

Combining the power of functional inks with the pervasiveness of digital (e.g. QR-codes) and electronic (e.g. NFC tags) markers, zillions of objects will embed cheap sensing capabilities thus being able to capture new contextual information. Beside this, the ubiquitous presence of smartphones with their cameras and NFC readers will create the perfect bridge between everyday users and their objects. This will create a completely new flow of crowdsourced information, which extracted from the objects and enriched with user data, can be exploited by new services.

TagItSmart will create an open, interoperable cloud-based platform with all the tools and enabling technologies, which will address the challenges related to the lifecycle management of new innovative services capitalizing on objects “sensorization”. TagItSmart will empower all steps involved from creating smart markers, Functional Codes (FCs) / SmartTAGs, to supporting secure and reliable acquisition and consumption of such contextual data, while preserving user privacy, to the provision of generic functionalities and a service composition platform which will allow even inexperienced users to create and deploy their FCs based services while maintaining system efficiency.

To boost the platform adoption, a set of industrial use cases are used as a baseline for development, while additional stakeholders will be engaged through a co-creation Open Call approach. A carefully planned engagement activity will ensure the establishment and sustainable expansion of the TagItSmart ecosystem fostering long term innovation and exploitation capabilities well beyond the project duration.

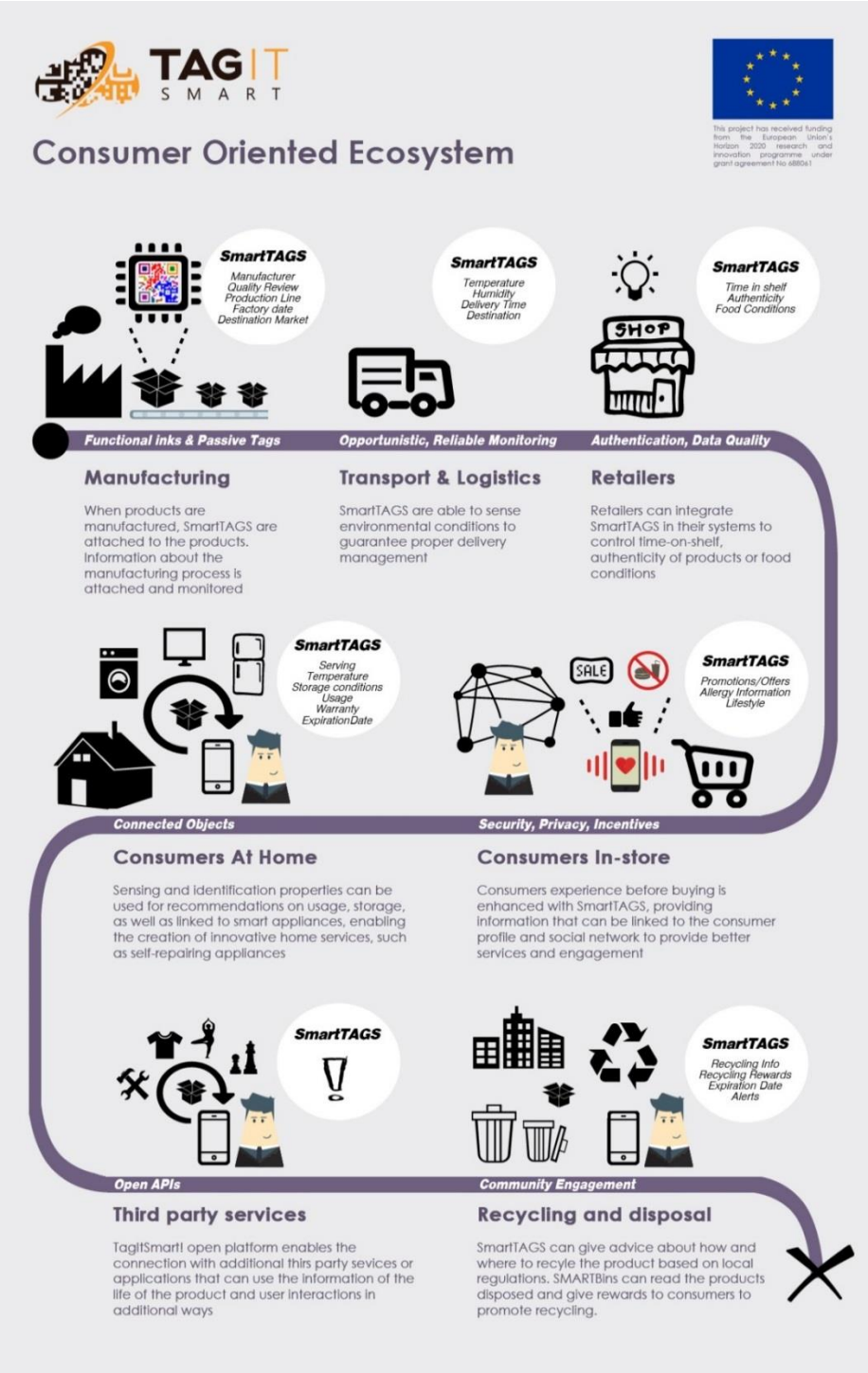

Figure 1. Basic concept of TagItSmart project.

This deliverable is divided in five sections. Section 1 presents the chosen five use cases and section 2 describes the architectural and technical requirements of the use cases. Market analysis related to these use cases is presented in section 3, updated in this version 2.1. This deliverable is concluded in section 4 and references are listed in section 5.

Section 1 - Use Case Descriptions

The use cases for the TagItSmart project were created by combining expertise and real-life interests of consortium partners. In total five use cases were selected. Table 1 summarises the use cases.

Table 1. Summary of use cases selected together with consortium partners.

Use case	**Owner**	**Partners**
Digital product	UpCode	FLE, UNIS, VTT, EVT, UNIPD, UPC, SIE, DUR
Lifecycle management	DONDE	DNET, FLE, EVT, UNIPD, UPC, SIE, TF, UNILEVER, DONDE, DUR, UNIS
Brand protection	DURST	DNET, VTT, EVT, UNIPD, UPC, SIE, TF, DURST, UNIS
Condition dependent pricing	Univerexport	DNET, FLE, UNIS, VTT, EVT, UNIPD, UPC, TF, UNIEX, DUR, UNIS
Home services	PICOM	DNET, UNIS, EVT, UNIPD, UPC, PICOM, DONDE, DUR

The digital product use case is a kind of umbrella use case including the whole value chain from manufacturer to transport, retail, consumer and recycling, see Figure 2. The other use cases concentrate more in details to one or two stages of the lifecycle of the product.

Figure 2. The TagItSmart use cases under the Digital product umbrella.

The use cases are described more in detail in the next chapters 1.1-1.5. In these chapters motivation and expected impact are also described. Functionalities of the use cases are presented in addition to the main stakeholders and benefits to the users.

1.1 Digital product

1.1.1 Description

This use case extends a base use case for fast-moving consumer goods (FMCG) that want to become “smart” via SmartTAG and TagItSmart. It combines novel solutions, and enabling technologies and tools to create smart solutions for the whole value chain; manufacturer, transportation, retail, consumer and recycling, see Figure 3.

To implement the use case, a real FMCG has been chosen. In this use case the beer and beer bottles are followed from the manufacturer until recycling the bottle at the end of the value chain. We are talking about “Digital beer” that can be modified to meet use case requirements which also can be used in piloting during TagItSmart project.

As digital beer itself is close to FMCG and FMCG’s on the other hand are “just” products, keeping that in mind, we worked around the idea that digital beer implements a base set of functionalities from TagItSmart’s digital product, where digital product is object marked with SmartTAG and has a defined set of functionalities. From TagItSmart’s digital product, digital beer needs at least functionalities for item-level control, life-cycle management, digital engagement and authenticity tracking. While each of these functionalities have a set of features they offer, digital beer chooses to implement full set of features from some functionality, while from some other functionality digital beer implements only a minimal set of features. Also digital beer needs some basic sensing capabilities for monitoring conditions of the beer.

This use case builds its foundation on top of discussions UpCode Ltd, the use case owner, has had with its clients (industrial, commercial, authorities, consumer…) from various domains (FMCG producers, medicine producers, retailers, etc…) during the last decade.

Figure 3. Digital product use case involves the whole value chain; manufacturer, transport, retail, consumer and recycling.

1.1.2 Motivation and expected impact

The Digital product use case involves every part of the FMCG value chain and provides base functionalities for the TagItSmart project and other use cases. Making this use case live could impact every stakeholder in the chain and provide them new possibilities now and in the future.

By implementing this use case the manufacturers are able to control products that leave their factories troughout their lifecycle, e.g. where and how the products are transported and in which conditions, when they have been delivered to the retail stores and when sold to the consumers. This use case also creates a new channel for manufacturers to communicate with the consumer, so that they can enable easy access to related information on product and item-level which is not only static but depend on lifecycle and historical data of the item. Especially consumer awareness has great potential when it comes to creating new business throughout

the value chain; especially it makes it possible for product manufacturers to create products that address market needs better. Consumer awareness links to both two-way communication and item information, with two-way communication consumer can initiate conversion directly between him/her and product manufacturer. This makes it possible to order customised products and removes overhead (and possible loss of information) when giving feedback of products consumed. But it also works the other way, product manufacturer can reach customers with updated information about product and conditions it was manufactured, sources they use, etc.

In this use case retail stores are not anymore midpoint warehouses but are more deeply engaged into the chain, giving them the opportunity to interact both with customers and product manufactures actively taking part in determining the next steps in product life-cycle.

This use case also opens up possibilities for new use cases and new business. These solutions can be easily extracted to other fast-moving consumer goods. It also provides base functionalities for advanced use cases like home appliances, new recycling processes and customer- manufacturer engagement. These (and any other) use cases can use functionalities implemented by digital product use case as they are, extend them or replace them in order to support use case specific requirements.

1.1.3 Functionalities exploited

The following functions are envisaged for the Digital product use case:

- Item-level tracking of product
  - With item-level tracking of items, TagItSmart makes it possible to track mass products during their life-cycle via IoT
- Product condition monitoring
  - With condition monitoring, actors in items life-cycle are able to provide/get information about items current/historical conditions
- Consumer engagement
  - With consumer engagement user can directly inititate communication process with product manufacturer. This also works the other way (if consumer it allows) so that product manufacturet can rapidly contact product users in case needed (product callback)
- Life-cycle management
  - With life-cycle management, actors in the item lifecycle are able to get information related to current lifecycle phase of the item. This makes it possible to provide accurate information related to consumer actions like buying, recycling,etc.
- Authenticity control
  - With authenticity control, actors in lifecycle of them item are able to confirm that the item is produced by its authorised producers. But also they are able to confirm that the item is sold in correct locations and by authorised resellers.
- Context information
  - With context information, actors are given accurate information based on their current context (location, time, etc.).

The following functionalities are considered optional:

- Condition based pricing
  - With condition based pricing, items historical data can be used to provide information to retail/consumer that item contents are not identical and actions can be taken based on this.
- Home services
  - With home services, consumer is given access to item related services. This enables user to reach out for services like recycling companies, event organisers, and maintenance more efficiently.

1.1.4 Main stakeholders involved and their role

- **Manufacturer (beer producer):** Manufacturer is a business owner that produces a product marked with SmartTAG. It gets information about their own products whenever scanned by other actors in the value chain.
- **Logistics, transport companies:** Logistics is an actor that transports products marked with SmartTAG between actors. It gets relevant information about the product by scanning.
- **Retailers:** Retailer (or mostly its point-of-sale (POS) device at store, used to scan products when they are bought) is an actor that sells/distributes products from product manufacturer. Retailers scan the products at least when they leave the store (at POS). Products can also be scanned once they arrive the store or in retail chains warehouse, although scanning might not be done for each item, but for its package/transport container.
- **Consumers:** Consumer is the end-user of the product that is produced by manufacturer. He/she buys products from the retail store, consumes and recycles them. Consumers are acting as important part of products end life-cycle; by scanning they will get useful information e.g. about manufacturer, transportation conditions, usage of the product and recycling.
- **Other business owners:** Other business owners are actors that relate to products life-cycle in some way, they can for example recycle products or part of the products or have business related to products, for example maintenance service.
- **Authorities:** Authorities are interested to get information via TagItSmart about products authenticity as well as information related to products recycling procedures.

1.1.5 Benefits to different users

- **All stakeholders during product's life cycle ("cradle to grave"):** An item level ID that can be made available to all stakeholders during the products whole lifecycle, from production to recycling/consumption/after-sales, opens up new possibilities for information gathering and sharing to the relevant stakeholders at the relevant time or in a relevant context.

Identifying products' authenticity at different stages of product lifecycle adds value throughout the chain. Getting information directly from information provider builds up trust and makes it harder to manipulate the information. More intelligent tags offer new solutions for every stakeholder and decouples the specialist scanner device from the information backend. Ubiquitoous mobile phones can now provide this function.

- **Value for business owner / product manufacturer:** This solution makes it possible for business owners to provide a new type of smart products and reach new market segments by allowing a customizable product (e.g. own personalized/branded beer for companies, large events and parties). It adds value to the product by increasing the value to the customer (e.g. customer can get a proof that the quality is not compromised during transport or storage). This also differentiates product and brand from other competing products and brands. Identifying the product batch by an unique code makes it possible to match the customer feedback or complaints and to provide better after-sales support. The direct feedback from the customers can be reflected into manufacturing process and it is also possible to get more accurate information about products life-cycle.

- **Value for POS:** The retailers can make sure that the product is transported in the required condition and that its condition is suitable for selling. This can increase the customer satisfaction and lead to more sales. The retailers gather useful information from manufacturer, POS, recycling and also valuable information about user behavior via data analytics.

- **Value for logistics:** Transport companies will get information about product conditions in every phase of transportation, possible problems can be tracked down more accurately.

- **Value for customer:** Customers are able to visually and/or via scanning make sure a first class product has not deteriorated due to irresponsible storage or transportation. They can create and order their own unique special brew. And also identify if the product is genuine and that it is sold in a place that has a right to sell this product (e.g. the product is not stolen).

- **Value for authorities:** Origin and authenticity of product can be checked by this solution. Producer of the product can be tracked down and contacted more easily. Tranport chain can be inspected to make sure that the product is sold in a right place. Furthermore, by carrying the concepts through the full product life cycle, proper recycling and disposal can be encouraged and monitored on a regional or even item specific level.

1.2 Lifecycle management / Consumer engagement

1.2.1 Description

The idea of this use case is to implement a system/technology that allows the lifecycle management of every fast-moving consumer good (FMCG), or consumer packaged good (CPG), that motivates and helps companies and citizens recycle their waste items, overcoming and solving current limitations and problems.

1.2.2 Motivation and expected impact

A key sustainability metric is the reduction in waste sent to landfill, but also the promotion of recycling. Items which are recyclable are often wrongly placed in a landfill bin, due to lack of awareness or engagement by the end user. This problem is compounded by the number of different regulations governing recycling at the local level and an inability to engage directly with end users at the point of product disposal. An opportunity exists for a system which can give end users geographically relevant information on the recyclability of an item at this point in time, either within the home, or at a range of other recycling outlets.

In this scenario, we find some **problems and limitations** that the use case can try to solve:

- **Different sets of local rules**/regulations determining what is recyclable (600 in the UK alone).
- **Local rules** on recycling are subject to **change over time.**
- Pack materials or design for re-usability will **change over time.**
- Information can be **hard to access and confusing** for consumers.
- Information is not presented at the **point of disposal**, where it may have greatest effect.
- Information may not be **updated** on a regular basis.
- There are **no standards** on how to **classify, recycle or dispose** a waste item (only icons and logo images or written instructions on packages, independent sets of instructions on bins, containers, webpages, etc.).
- There are **no standards** on how to publish **data related to waste** management.
- Little information exists on **what happens after** they deliver an item to the garbage.
- Many consumers are simply not **engaged** with the concept of recycling.
- No scalable methods exist for **accurately measuring** to the household level the success of initiatives / campaigns to promote recycling.
- No scalable methods exist for **giving feedback** on how consumers are doing in recycling.
- Manufacturers and retailers pay a **landfill tax**, based on assumptions / calculations on level of recycling.

- Little information exists on how a product was transported and stored and if it is in **suitable conditions** for using or consuming.
- Little information exists about which exact **materials and substances are contained in** a package (not only the ingredients of the product).
- Manufacturers have **little information and feedback** from retailers (distribution and product perspective) and consumers (product and consumption perspective).
- Hard to implement a **life cycle assessment** for cradle to grave of a product.
- Hard to know the exact **environmental impact of a product** (carbon footprint, raw materials and components, methods of production, impact of the distribution, etc.).
- **No interconnection** between different **ecosystems**.

These are some of the **current solutions** that stakeholders are using to solve the indicated problems:

- **Distribution via leaflets**: Local authority information on recycling is normally distributed via leaflets to households on an annual basis.
- **Websites**: Information is available on websites, but many of these are designed for people who already have high awareness and the information is highly fragmented, as every stakeholders manages different information depending on the waste item.
- **Commercials**: There are many national or regional campaigns to promote recycling, but they cannot provide information about specific products (e.g., aerosols).

This is the **expected impact** of the use case:

- **European implementation**: Highly scalable, with a potential reach of many millions of end users.
- **Improved consumer engagement**: All information available in an accurate, timely and engaging format for the consumers.
- **New communication channel**: Creation of new “direct to consumer” communication channel at point of use.
- **New European recycling database**: Creation of new large scale data at point of product disposal:
    - Analysis to provide new service business opportunities.
    - Analysis to drive local / national campaigns in recycling, to measure effectiveness and to drive and build future policy.
- Full alignement with green and sustainability agendas for increasing recycling.
- **Interoperational and adaptable technology**: Able to be implemented in a staged roll-out as new tag technologies develop.

1.2.3 Functionalities exploited

The following functions are envisaged for the Lifecycle management use case:

- FMCG products have a tag which can be read by a reader or mobile phone application
- Reader unit has a geolocation system
- Database of product packaging material can be created / accessed
- Database of local authority recycling information can be created / accessed.

Consumer journey

- A consumer purchases a variety of FMCG products during their weekly / daily shop.
- Over time, the packaging becomes ready for disposal (either as contents are depleted or “use by” dates exceeded).
- The consumer is uncertain as to the recyclability of some of the packaging – “I know I can re-cycle my plastic milk cartoons, but what about an aerosol? And does it matter what was in the aerosol?”.
- The consumer scans the packaging over an optical “reader” attached to a household bin. The reader may be a bespoke device attached to a bin, a smart phone), or integrated into the bin itself.
- The reader detects the barcode, which is unique to that product variant (or ‘Stock Keeping Unit, SKU). As other codes become standardised on packaging, the reader may detect to the individual pack level (QR code, electronic tag), or the individual pack together with a “threshold” status (functional ink tag) affecting the recycling decision even for the same product (e.g. an expired –or stored in a certain way- product may have become hazardous).
- The reader determines – based on location and “threshold” status; local authority database information and pack material, the current recyclability of the SKU presented.
- The consumer is informed via a simple feedback mechanism (audio, visual or other), of the recyclability of the packaging. The consumer then places the packaging in the correct recycling or landfill bin.
- If the item scanned is not currently recyclable via home collection; the consumer may be given information concerning other options for items disposal
    - Local recycling centres – local authority, supermarket, retailers -including opening times; directions to closest, etc.
- The data from the scan (code; time; status of Smart tag) is either recorded on the reader and uploaded to a cloud database at a particular time point, or (depending on the reader and connectivity) is directly uploaded to the cloud.
- The just uploaded data will be amalgamated with all uploaded data, and analytics performed on this data.
- The consumer may be given feedback / information based on their own data just scanned; historic data scanned; group data and chosen engagement platform (gamification, points, rewards, information, peer group digital platforms), or some other metric.

- The cloud based data may be analysed by the product originators to build new insights.
- Access to the cloud based data (or to analytic results performed on the cloud based data) may provide new 3rd party service offerings.
- The system may be expanded to have readers / reader holders on all home recycling bins.

1.2.4 Main stakeholders involved and their role

These are some of the stakeholders involved and their role in the use case:

- **Manufacturers:** Provide information on packaging material for each pack.
- **Retailers:** Retailers are partners in waste reduction campaigns, with the option to be distributers for NFC widgets, provide information on retailer recycling locations.
- **Consumers:** To adopt better recycling practises.
- **Local authorities / municipalities**: Provide information on recycling options and systems within the local area.

1.2.5 Benefits to different users

These are some of the benefits and value realised to different users:

- **Manufacturers**:
  - Reduction in landfill tax.
  - Direct communication channel to end users.
  - Insight generation at scale from information taken at a novel point in product lifecycle.
  - Alignment with key sustainability goals.
  - Information on storage conditions / package failure at home (using functional inks).
- **Retailers**:
  - Reduction in landfill tax.
  - Insight generation at scale from information taken at a novel point in product lifecycle.
  - Alignment with key sustainability goals.
  - Engagement via loyalty / reward card program linked directly to individual recycling.
- **Consumers**:
  - Immediacy of information on recyclability.
  - Accuracy of information on recyclability.

- Immediacy of other information pertinent to product (poor storage conditions, etc.) with functional inks.
- Engagement with recycling (rewards / peer group social media / gamification / information, etc.).

- **Local authorities / municipalities**:
  - Recycling metric tracking:
    - Check against national targets (budgetary requirements).
    - Rate success of campaigns / initiatives.
  - Real time data for optimum planning of current recycling service logistics.
  - Data analytics for longer term recycling agenda planning.
  - Link to feedback channel at point of use with consumer.
    - One-point information delivery – simplification.
- **New business opportunities**:
  - Data analytics to drive new service business opportunities.

In addition the environment itself will benefit from increased recycling and recycled items placed into correct disposal places, thus decreasing environmental impact from recyclable and reusable waste.

1.3 Brand protection

1.3.1 Description

Counterfeiting, specifically in textile products but also expandable to other goods, is caused by several factors including the simplicity of the production and refinement processes, the cheap way of production and the low structure complexity which widely opens the doors for illegal copying. Brand protection strategies based on the implementation of barcodes, tags of labels to the product till nowadays had only a moderate success rate, whereas sophisticated anti-counterfeit systems (e.g. active RFID tags, electronically secured packaging) are more limited to high-value products.

Subject of this use case is the development of a whole security platform for goods which includes both the direct digital printing of a functional QR code on an article or the printing on labels or the packaging and the generation of suitable coding and decoding architecture that are deployed at the production process that is simply implementable by the manufacturer directly on the product periphery or on the packaging. More specifically the aim of this use case is the development of functional QR codes and their readout for the purpose of a security platform for originality proof to be implemented on labels and tags. The basic mechanism of the security platform is a light-induced colour switch of inkjet-printed textures within the functional QR code; the colour switch is initiated by the readout using a smartphone.

1.3.2 Motivation and expected impact

According to the report on EU customs enforcement of intellectual property rights of the European Commission from 2015 for year 2014 [1] , 35.5 million enforcements of IPR by case were detected at the customs of the borders of the European Union with a total domestic retail value of 617.1 million Euro. Roughly 47 % of the cases were reported to be from textile products such as clothing, clothing accessories and shoes, which is even ahead of medicines and cigarettes.

The general purpose of this use case is to create a meaningful security platform by functional QR codes printed on either the article directly or onto labels, tags or packaging attached to the article in combination with a sophisticated encoding / decoding mechanism and the corresponding IT architecture. The concept due to its simplicity in integration to any manufacturing process is broadly applicable to low and high value products and therefore can compete with current solutions on the market.

1.3.3 Functionalities exploited

The functional QR code for Brand protection use case consists of three different inks illustrated in detail in Figure 4:

1. An ink bearing a dye / pigment that coloures after illumination with white LED light
2. An ink bearing a dye / pigment that decolorizes after illumination with white LED light and
3. An ink that neither coloures nor decolorizes after illumination with white LED light.

On an **Aspirin** box a **TagItSmart! „Proof me if you can!" QR code** is embedded to the package.
By reading the QR code using a common QR code reading software you get information on the product and a link to either downloading a secondary software / plugin or cloud access for the advanced readout: the "Proof me if you can!" originality proof. In the above QR code you just read **"0"**.

After having downloaded the **app / plugin / cloud access**, you get instructions how to **read the QR code again**. It communicates to your handheld device that the **LED light** has to be switched on during this read. While **reading the functional QR code again** and having the **LED on** illuminating it following a defined procedure, certain **textures** within the QR code **appear** and **dissapear** – new information is released!
The new information in the above scenario is **"01"**.

Figure 4. Operation principle of functional QR codes for brand protection.

Two readout scenarios have to be considered. In the first instance, the QR code can be read out by common QR code reading software. However, an interlink to the second readout, whose mechanism is strictly protocolled using white LED illumination, including the photochromic switches of the textures has to be implemented.

1.3.4 Main stakeholders involved and their role

The main stakeholders in this use case and their roles are as follows:

- **Manufacturer:** product originality in the day of manufacturing of batch needs to be established; therefore implementation of a digital printing process within the manufacturing process for printing of the functional QR codes is needed.
- **Retailer:** monitoring of brand originality via feedback to manufacturer (e.g. batch number, site of production, date of production)
- **Controlling organ (e.g. customs):** monitoring of brand originality, prevention of economic damage.
- **Customer:** proof of originality and/or secondary service.

1.3.5 Benefits to different users

The fundamental concept of this use case is the prevention of economic damage, basically for the manufacturer, but also to the customer that by him/herself personally can prove product originality. Counterfeiting is an increasing problem and has huge economical impacts. Accorging to EU, counterfeited and pirated articles threaten the health and safety of EU citizens, their jobs, community competitiveness, trade, and investment in research and innovation (EU, 2010). In 2010, EU Customs found over 103 million counterfeit and pirated goods, a figure that has almost doubled since 2009.

1.4 Condition dependent pricing

1.4.1 Description

This use case will use packed meat as an example product that can benefit from conditions dependent pricing. Each package of meat is tagged with a Smart tag on the production line. The tag is capable of detecting temperatures higher than allowed for storing fresh meat. Once the temperature goes above the threshold, the tag reacts and changes its content to indicate this event.
Once the package arrives to a shop it can be scanned by the retailer. In that case, the packages that were stored in wrong temperature conditions will be removed. However, individual scanning of each package is not possible and the packages might end up on shelves.

Once on the shelves, the consumers will be able to scan individual packages before buying. When consumers scan a package using a smartphone application they will obtain information about the meat: the origin, time of packaging, discount information and transport conditions. The obtained information is also forwarded to the meat supplier and potentially to other actors in the supply chain. At this point, it is possible to invoke condition dependent pricing mechanism depending on the relevant parameters like temperature in which the item was stored or time spent on the shelves.

Consumer takes the meat package to the cash register where it is scanned again. At this stage, the information is sent to the meat supplier and recorded in retailer's information system. In case the consumer had not scanned the item previously, the condition dependent pricing procedure is triggered in case the conditions for such procedure are met.

After the checkout, the consumer goes to the car and puts the groceries in the trunk. When scanning is done at home, the SmartTag might indicate wrong temperature and the TagItSmart application would then suggest appropriate measures taking into account the time since the item was scanned at the checkout, i.e. the last control point. In addition to this, the consumer will also receive information about the recipes suitable for the type of purchased meat as well as instructions on how to dispose of packaging.

1.4.2 Motivation and expected impact

The use case focuses on supply chain monitoring of fresh meat and is driven by Univerexport (UNIEX) based on the needs and the potential for improvement of work processes and quality of service offered to consumers.

Delivering safe and fresh food is one of the basic principles of Univerexport's business. This year (2016) the focus will be on fresh meat, fresh bread and pastries as well as on organic food, all produced by company's own farms, food processing plants and bakeries. Univerexport guarantees that fresh meat is delivered from farms to the shelves in maximum 48 hours. Consumers can trust that this is true, given the number of promotional messages and promises which are being launched on a daily basis but this is not hard proof. Providing the ability to check the time elapsed from the moment the meat is packaged, the conditions under which it is stored and transported to the shelf, as well as additional information about the product, and thus eliminating any doubts would significantly contribute to the control of the cold supply chain and provide a complete picture of the way the product has been treated.

Cold supply chains are in use in various industries for a long time. The main characteristics of these systems is that the monitoring is done on a box or a pallet level while the items are in a truck, refrigerator etc. Modern supply chains solutions do not cater for monitoring at individual item level. Also, monitoring at critical points, when items are being handed over between different modes of transport or between two cold points (refrigerators) is lacking, thus preventing the stakeholders from having to have the complete picture and potentially exposing them to problems. Particularly critical is loading items to a transport vehicle and unloading at warehouse stores.

Integrated dynamic systems for monitoring products, the conditions of transport and storage, the relationship of its expiry date and price are not currently available. If a consumer is not a member of a loyalty programme, neither supplier nor retailer have the ability to interact with consumers in an easy manner and learn about the consumer habits.

The goal of this use case is to enable monitoring of items at individual level, including at the loading/off-loading times. Further to this, the goal is to extend the monitoring of the item to its shelf time and further to consumer's house and eventually waste.
Using this approach all stakeholders will be able to obtain information that can be used to improve work processes and increase quality of service.

1.4.3 Functionalities exploited

The following functions are envisaged for the Condition dependent pricing use case:

- Monitoring events when temperature (mandatory) and humidity (optional) in which an item is stored go over predefined thresholds. It is important to also record the time of the event or at least who was responsible for the item at the time of event occurrence.
- Retrieval of information about individual items, including information generic to the type of the product as well as information specific to the item.
- Functionality being accessible to registered users only; roles based access
- Secure scanning of Smart tags
- SmartTags readable by smartphone applications and cash registers
- Platform capable of storing different types of documents (photos, video, etc.).
- Ability to interact with other information systems and share data between all stakeholders
- Time calculation algorithms according to the requirements of the goods monitored

In Figure 5 the use case is split into required services and high level requirements.

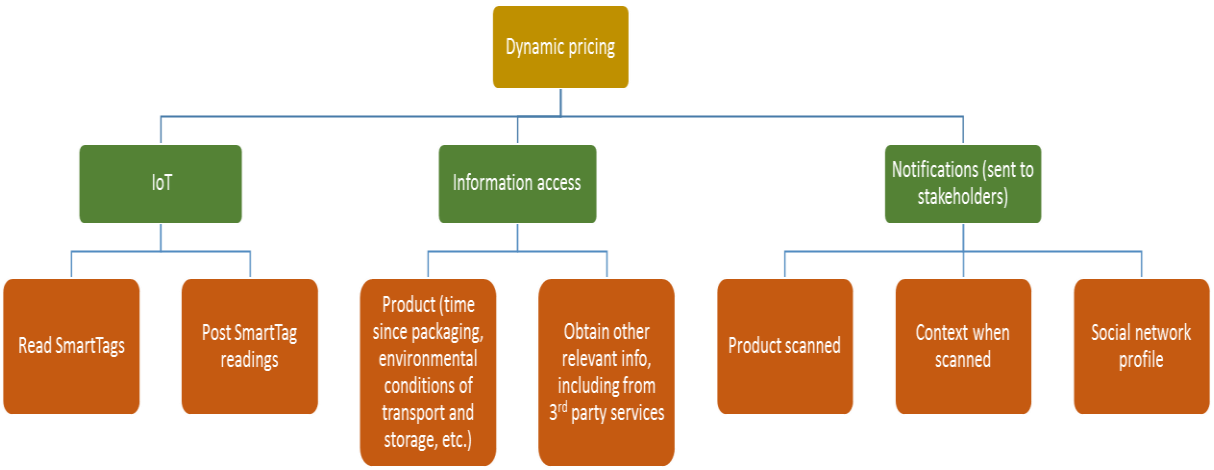

Figure 5. Service content of the Condition dependent pricing use case.

1.4.4 Stakeholders and their roles

The main stakeholders in this use case and their roles are as follows:

- **Manufacturer (meat production):** prints Smart tags on the packages of meat. Obtains information about the condition of the packages whenever scanned by other actors in the chain.
- **Transport companies:** can scan the tags to certify compliance with the regulation. Obtain relevant information about the products when scanned.
- **Retailers:** can scan Smart tags to obtain information. In most cases scanning will be done by consumers and retailers will use this information to check the quality of service provided by supply chain vendors as well as to dynamically change prices of individual items based on the scanned information. Products are scanned at checkouts and information is shared with other actors. Together with manufacturers build information sets to be provided to consumers.
- **Consumers**: scan products to obtain information about the origin of the product, the conditions in which it was transported and stored as well as how to use and dispose of the product. This information set can be tailored to the consumer's profile based on previous actions and social network profile.
- **Platform provider and supplier**: provides the core platform to register and distribute information about the product after scanning. Provides identification & authentication mechanisms. Gathers relevant information from other systems.

1.4.5 Benefits to different users

- **Consumers**
  - Have complete insight into the handling of the product they want to buy, the safety of the product and in general whether the processing is done in accordance with the prescribed rules.
  - The feeling of being able to get all relevant information in a trustworthy manner is invaluable.

- **Manufacturers**
  - Have up to date information about the way their products are being handled, the time a product was purchased (very important for the item that have expiration period of only several days) as well as the profile of the consumer, thus helping them to optimize production process and maybe even improve the products
  - Have opportunity to address the consumers directly by providing additional information available at the time of scanning
  - Can earn customers' loyalty because of a completely transparent process and the added value provided when shopping
  - Can gain information about consumers' habits

- **Retailers**
  - Individual item level cold supply chain monitoring enabled. This kind of traceability and cold chain control over time, gives unprecedented possibilities for application both in the food industry and in other industries.
  - Can offer customers a tool to check the product they are buying (better service)
  - Are able to run condition dependent pricing on individual item level without employing large manual work to change price on each item due for reduced price
  - Can gain information about consumers' habits

1.5 Home services

1.5.1 Description

A good usage of the heating equipment (e.g. a boiler and an associated filtering station) is one means to provide comfort and a healthy living at home. This implies proper 1) maintenance, 2) repair, 3) replenishment, and 4) monitoring. This use case will test different services to the customer all along the life of the equipment at home. Some of the services will leverage access to information related to the product, its environment and its use; and some will provide specialized services (installation, maintenance, repair, etc.).

One example is boilers. The retailer has referenced different service providers according to their abilities and location. One Smart tag is sticked on the boiler by the customer at home, by the manufacturer or by the retailer in-store. One Smart tag is sticked inside the boiler by the manufacturer or by the retailer in-store. One static Smart tag is sticked on the boiler's burner. Another Smart tag is sticked inside the filtering station upstream of the boiler.

1.5.2 Motivation and expected impact

Motivation and expected impact can be identified separately for both the consumer and the retailer.

From the customer point-of-view, motivation has the following aspects:

- Warranty is limited in time and the customer hardly knows whether their equipment is still under warranty or not.
- Home equipment requires regular maintenance and many customers forget to proceed with this action; thus causing malfunction, shortening the life of the appliance, loosing warranty, and loosing insurance protection.
- The environmental conditions at home are important to preserve the customer health and security, to control optimal conditions for the appliance operation (e.g. enough oxygen for proper combustion), and to detect malfunction of the appliance (e.g. carbon monoxide produced by the boiler) and optimize working conditions.
- Some equipment need consumables (e.g. tatar inhibitor for a filtering station) and reordering is frequently painful.
- The customer has to be sure he hasn't bought a counterfeit item.

From the retailer point-of-view, motivation has the following aspects:

- Warranty can only be set off in case of proper use and on time maintenance of the equipment and the retailer is rarely able to verify this point.
- Quality and durability of the appliance are leveraged by good maintenance practices and enhance customer satisfaction. But the retailer is rarely involved in this post-purchase process.
- Optimal use of equipment also enhances customer satisfaction.

1.5.3 Functionalities exploited

The following functions are envisaged for the Home services use case:

- During the installation process the boiler Smart tag visually informs the installer, if the boiler has been declared “technically compliant” by the manufacturer or the retailer. When reading the boiler Smart tag, the installer can easily authenticate the boiler, access technical, manufacturing and purchasing information, and access the installation guide.

- When reading the boiler Smart tag with his smartphone, the customer (e.g.. the new owner of a house) can easily authenticate the boiler, and access technical, manufacturing and purchasing information. Along the whole lifecycle of the boiler the customer can easily indicate energy consumption and compare it to previous periods, and get energy saving tips. Furthermore, the customer can access the use instructions, access the maintenance documents, access the past maintenance actions, schedule the maintenance action immediately or receive a notification when needed, receive quotations from service providers proposed by the retailer, and order services for a maintenance work (e.g. one for controlling the boiler and another one for sweeping the chimney). After maintenance the operator resets the tag. Also the boiler Smart tag visually informs the customer if the boiler has to be maintained in the days / months to come, and if the term for maintenance is over.

- The filtering station Smart tag visually informs the customer if there is water in the filtering station, if the water is safe and clear, and if the water supplying the boiler contains too much tartar or limestone. When reading this tag with his smartphone, the customer can easily order tartar / limestone inhibitor. After tartar / limestone inhibitor supply, the customer resets the tag.

- In case of a malfunction the boiler Smart tag visually informs the customer if the boiler is still under warranty, and if the equipment has been too much exposed to water, high temperature, etc. When reading this tag with his smartphone, the customer can easily access the warranty documents, confirm the warranty period, prove the correct conditions of use to the retailer, and order a service (among the providers proposed by the retailer) for a repair work. The Smart tag inside the boiler visually informs the repairer if the boiler has been opened (exposed to light) without permission. After the repair work, the repairer resets the tag. When reading the boiler’s burner static Smart tag, the repairer can easily confirm the burner is the original one.

- In the place where the boiler is located a series of boiler Smart tags visually informs the customer on the air safety in the room. When reading this tag with his smartphone, the customer can easily detect the type of nuisance or danger, receive an alert from the retailer, receive recommendations for immediate actions (e.g. room airing), receive recommendations for curative actions (e.g. boiler maintenance, chimney sweeping), receive a notification when optimal conditions are back (air is safe), and order a service (among the providers proposed by the retailer) for a repair / maintenance work. After curative action, the customer replaces the tag with a fresh one (unless the ink used is reversible). Alternatively, a connected sensor detects automatically bad air conditions (smoke, CO, CO^2, etc.), sends an alert to the customer (and the service provider), sends an alert to the boiler that switches off, and sends an alert to different actuators

(for window opening, ventilation system activation, etc.). Then, the customer can follow the same process.

- At the end of the boiler's life when reading the boiler Smart tag with his smartphone, the customer can easily access recycling information.

1.5.4 Main stakeholders involved and their role

The main stakeholders in this use case and their roles are as follows:

- **Customer**
  - defines the way his data can be used,
  - orders services and consumables,
  - indicates recycling actions.

- **Retailer**
  - sells products and consumables,
  - manages an ecosystem of service providers,
  - sells services,
  - aggregates different services in order to address an overall need.

- **Service provider (installer, repairer, …)**
  - sells services,
  - operates the service,
  - pays the aggregator fees for business intermediation.

- **Recycling company**
  - provides recycling information.

- **Platform operator**
  - captures data from sensors,
  - provides data to stakeholders and services.

1.5.5 Benefits to different users

Value for the customer

- No need to manage use, purchasing, warranty and maintenance documents of the equipment itself and its parts.
- No need to manage history of (maintenance) operations.
- No need to prove the respect of (some) warranty conditions.
- No need to search for a qualified service provider.

Value for the retailer

- Warranty applies only in relevant situations.
- New services leverage product sales.
- The tag itself is a new type of product.
    - The “reminder tag” can be used with an appliance sold by any retailer.
    - Another type of tag with “environmental control” features in order to monitor the home or the appliance context.
- Better knowledge of customer use of the product.
- Better knowledge of product reliability (new dimension in the relation with the manufacturer).
- New commercial services
    - Bundle composed with the product itself and premium services like a “warranty service”. This bundle is also relevant to different types of electronic products like a mower, a drill, a water softener, …
    - Automatic reorder thanks to the tag ; thus promoting recurring business models.
    - New services like maintenance, installation, etc.

Value for the service provider

- Easy access to a large range of customers.
- Enhancement of its own offer.

Value for the recycling company

- Better knowledge of products needing recycling (e.g. appliances containing hazardous chemicals).
- Better bin and reverse logistics management.

Section 2 - Requirements

This section describes the architectural and technical requirements of the use cases. This information will be used in the architecture design task. Architecture Requirements for an IoT platform are listed in Table 2 and technical requirements for the service in Table 3. Based on this table selection of technical building blocks and definition of a use case driven architecture will be provided in D1.2, and system components will be developed in WP2-4. These functionalities will be further evaluated during ecosystem trials in WP5.

2.1 IoT Architecture Requirements

EVRYTHNG, as an IoT platform provider, analysed in "*9 THINGS TO CHECK BEFORE CHOOSING YOUR IOT PLATFORM A Buyer's Guide for Consumer Electronics and Appliance Manufacturers*" [2] the aspects to consider when selecting an IoT platform. The following table summarizes these aspects and the subtopics that are defined within. These general aspects in conjunction with the use case requirements will be taken into account at the architecture design phase in TagItSmart.

Table 2. Architecture Requirements for an IoT platform

Requirements	Desired features
SCALABILITY AND AVAILABILITY	High speed, Low latency Guaranteed availability
FLEXIBLE DATA MODEL	Customization Web-Accessible APIs
SERVE MULTIPLE BUSINESS UNITS	Configurable, granular access policies
SECURITY AND PRIVACY	State-of-the-art encryption Partitioning and data separation Fine-grained access controls Privacy & security leadership
FLEXIBLE DATA ACCESS & ANALYTICS	Easy to export and analyse
FUTURE-PROOFED TECHNOLOGY	Works with all connectivity technologies Based on open standards Easy SDK and developer tools
CLOUD-TO-CLOUD INTEGRATION	Works with any third party cloud
COMPREHENSIVE RULE-SETTING	Programming flexibility Ecosystem-friendly action-reaction rules
RELEVANT DOMAIN EXPERTISE	A partner who 'Leans In' Follow relevant IoT best practices

2.2 Use Case Requirements

The technical requirements for the different use cases is presented in Table 3.

Table 3. Technical requirements for the use cases.

		Use cases				
Functionalities	**Requirements**	**1. Digital product**	**2. Lifecycle management / consumer engagement**	**3. Brand protection**	**4. Condition dependent pricing**	**5. Home services**
F1 - Item-level tracking of product	Unique product identification on each item	IMPORTANT	IMPORTANT	IMPORTANT	OPTIONAL	IMPORTANT
	Batch level identification on each item			IMPORTANT	OPTIONAL	
	Product sources and materials and their producers recorded	IMPORTANT	IMPORTANT	OPTIONAL	IMPORTANT	
	Recording production data	IMPORTANT	OPTIONAL	IMPORTANT	IMPORTANT	
	Product information (data recording)	IMPORTANT	OPTIONAL	IMPORTANT	IMPORTANT	IMPORTANT
	Product identity card			IMPORTANT	OPTIONAL	IMPORTANT
	Packaging data (recording of process)	IMPORTANT		IMPORTANT	IMPORTANT	
	Package materials	OPTIONAL	IMPORTANT		IMPORTANT	
	Components and parts		IMPORTANT			IMPORTANT
	Manufacturer data	IMPORTANT		IMPORTANT	OPTIONAL	
	Offline access to selected data accessible directly from the tag	IMPORTANT		IMPORTANT		
	Access to confidential/important data directly from its original server	IMPORTANT		IMPORTANT		
	Transport related data	IMPORTANT			IMPORTANT	
	Other life-cycle data				IMPORTANT	
F2 - Product condition monitoring	Storage conditions control	IMPORTANT	IMPORTANT		IMPORTANT	
	Sensor functionality in tag	IMPORTANT		IMPORTANT	IMPORTANT	OPTIONAL
	Alert on compromised conditions	IMPORTANT			IMPORTANT	
	Visual change in tags	IMPORTANT	IMPORTANT	IMPORTANT	IMPORTANT	OPTIONAL

	Environmental data recording				IMPORTANT	OPTIONAL
F3 - Consumer engagement	Manufacturer call-back for product	OPTIONAL	OPTIONAL	IMPORTANT	OPTIONAL	
	Personalised production	OPTIONAL		IMPORTANT		
	Manufacturer or retailer communication to consumers	IMPORTANT	OPTIONAL	OPTIONAL	IMPORTANT	
	Purchasing / warranty information			OPTIONAL		IMPORTANT
	Recommendation engine			OPTIONAL		IMPORTANT
	Personal cloud for documents storage			OPTIONAL	OPTIONAL	IMPORTANT
	FAQ, tips	IMPORTANT		OPTIONAL		OPTIONAL
	Consumer portofolio			OPTIONAL	OPTIONAL	
	Consumption benchmark with previous periods			OPTIONAL		OPTIONAL
	Social media engagement	OPTIONAL		OPTIONAL	OPTIONAL	
	Consumer feedback	IMPORTANT	OPTIONAL		IMPORTANT	
F4 - Reusing and recycling	Succesful recycling recording		IMPORTANT		OPTIONAL	OPTIONAL
	Recycling information	IMPORTANT	IMPORTANT		OPTIONAL	OPTIONAL
	Controlled recycling		IMPORTANT			
	User identification for recycling rewards		IMPORTANT			
	Repairing intructions and manuals					IMPORTANT
F5 - Authenticity control	Authenticity checking		OPTIONAL	IMPORTANT		IMPORTANT
	Authenticity checking, visual		OPTIONAL	IMPORTANT		IMPORTANT
	Authenticity checking by scanning	IMPORTANT		IMPORTANT		
	Tracking products life-cycle events	IMPORTANT				
	Protecting tag data	OPTIONAL		IMPORTANT	IMPORTANT	
	Controlling data access	OPTIONAL		IMPORTANT		
	Controlling products' retail location			OPTIONAL	IMPORTANT	

F6 - Context information	Buying location			IMPORTANT	IMPORTANT	IMPORTANT
	Use location		IMPORTANT	IMPORTANT	IMPORTANT	IMPORTANT
	Context based data access			OPTIONAL	IMPORTANT	
	Privacy settings controlled by user	IMPORTANT		IMPORTANT	OPTIONAL	
	Providing information based on context	OPTIONAL		IMPORTANT		
F7 - Condition based pricing	Time lapse tags				IMPORTANT	IMPORTANT
F8 - Home services	Products at home					IMPORTANT
	Authorized service providers					IMPORTANT
	Service providers marketplace					IMPORTANT
	Authorized retailers		OPTIONAL			IMPORTANT
	Retailers marketplace					IMPORTANT
	Re-ordering		OPTIONAL			IMPORTANT
	Supplies ordering					IMPORTANT
	Warranty conditions management					IMPORTANT
	Manuals and product instructions				IMPORTANT	IMPORTANT
	Safety control					IMPORTANT
	Maintenance / repair planning					IMPORTANT
	Alert management					IMPORTANT
	Home automation					IMPORTANT

Section 3 - Market Analysis

In this version 2.1 of the deliverable D1.1 a general market analysis on the IoT scene is updated with more clarity on the specific use cases and the target markets. Specific market state and opportunities for TagItSmart are analysed in the scope of the different use cases in chapters 3.4-3.8.

This market analysis is motivated by a set of business objectives, that aim to contribute to promoting Europe's position in ground-breaking research in the Internet of Things (IoT) space. To that end, the objectives are:

- Strengthen Europe's image role as IoT innovation leader.
- Develop affordable, item-level sensor technology.
- Develop a reliable and affordable tagging technology that provides more detailed and machine-understandable information about a product's lifecycle and interaction with its environment.
- Exploit the potential of smart tags to meet uncovered customer needs in key IoT areas that are currently occupied by other tagging technologies.
- Substantial adoption rate in IoT areas that are currently occupied by other tagging technologies.

3.1 What is TagItSmart technology and why does it matter?

TagitSmart is a EU-funded IoT initiative that aims to develop a novel technology for low-cost, serializable, smart tags that can leverage their current and past exposure to the environment to augment physical products with digital information. Traditional barcodes (linear or two-dimensional) encode a specific value, a number or URI for example. Once printed, the state of a traditional barcode cannot be changed. In contrast, a smart tag changes value when certain environmental conditions change, which each state being unique. The fact that a printed tag can assume multiple values is not new. The novelty that comes with TagItSmart is the convergence of smart tags with open IoT technologies, such as the Web of Things technology stack. Tags that encode multiple machine-understandable identifiers were until now the privilege of Near-field communication (NFC), radio-frequency identification (RFID) and proprietary barcode solutions. Smart sensors are ideal to sense environmental factors, but they require an active power source and/or a dedicated device to extract the data. Barcodes and smart tags can encode identifiers in human-readable as well as in machine-readable form. Table 4 summarises key differences between auto-id technologies in the IoT.

Table 4. Comparing conventional barcodes, smart tags and radio-frequency identification.

	Barcodes	TagitSmart	NFC	UHF/RFID	Smart Sensor
Production	Printing	Multi-process printing	Dedicated production line	Dedicated production line	Dedicated production line
Read distance	Medium	Medium	Low	High	Varies
Bi-directional	No	No	Yes	Yes	Yes
Requires local power source	No	No	No	Varies	Yes
Variable states	No	Yes	Yes	Yes	Yes
Reacts to the environment	No	Yes	No	No	Yes
Reading and decoding	From picture	From picture	Dedicated chipset	Dedicated chipset	Dedicated chipset
Environment friendly	Yes	Yes	No	No	No
Serializable	Yes	Limited	No	No	No

What would be a useful application for a SmartTag? Take an ice cream manufacturer for example, who wants to prevent ice cream from being sold after repeated taw-freeze cycles. A heat-sensitive QR code (a QR code is a type of two-dimensional barcode) could be printed on an ice cream package. Customers can use their mobile phone to scan the QR code. When kept frozen, the QR code directs customers to a customer engagement campaign. However, when the ice cream thaws, the smart tag changes and a QR code appears to warn customers not to consume the ice cream. At the same time, the ice cream manufacturer is notified about the incident. This information can be sent to parties involved in lifecycle of the ice cream, so that they are able to improve their processes. This data is anonymous.

3.2 Current market status

The Internet of Things was not immune to the hype cycle. The IoT would revolutionise industries, many predicted. Looking back, IoT pioneers and business leaders agree that the IoT did not materialise as rapidly as expected. However, IoT efforts were not in vain. Prototypes provided valuable information about the potential of IoT technologies.

Pioneering IoT companies and innovative large-scale IoT projects demonstrate the disruptive potential of the IoT. Supply chains, smart gas or water meters, to name visible examples of solutions which have adopted IoT enabled transformations. IoT efforts vary based on the region and industry. Asia-Pacific and European reports show increased use of the IoT for internal and external products, while North America internal IoT adoption slowed [3].

Broken down by industries, IoT adoption are strongest in industries that: a) contribute to supply chains, track and trace, consumer goods and retail; b) communication, transport and logistics; c) smart metering; d) connected cars and f) predictive maintenance. In construction and real estate IoT adoption lost traction [3]. Growth-share matrix for IoT use cases is presented in Figure 6.

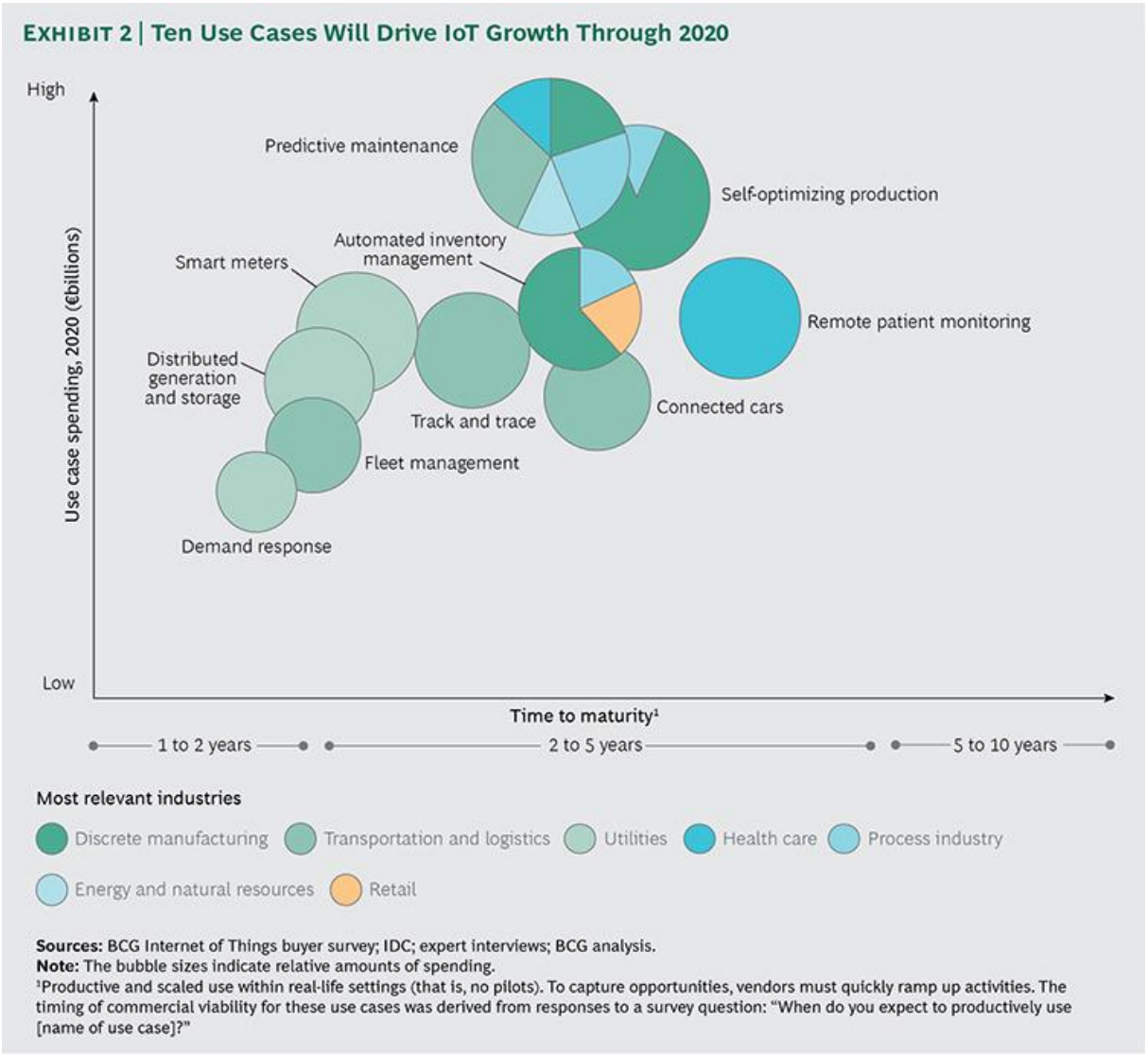

Figure 6. Growth-share matrix for IoT use cases [4].

3.3 Market analysis research objectives

Unique identification of each physical and digital object is at the core of the IoT. The more about a physical object's context is known, the more useful the object becomes for decision makers to elicit valuable information about the context of products and business processes. Based on this conclusion, and the specific business needs of consortium members representing different industrial domains, we identified five main use cases, where smart tags

have the potential to add significant value to all stakeholders: 1) digital product, 2) lifecycle management, 3) brand protection, 4) dynamic pricing and 5) home services. For each use case, the research goals are to:

- Understand the added value of smart tags
- Identify specific customer needs for smart tags
- Identify the primary environmental factors for each customer need
- Understand the drivers and barriers
- Understand key success factors
- Identify stakeholders and their roles.

3.4 Market analysis for Digital Product use case

This use case extends a base use case for fast-moving consumer goods (FMCG) that want to become “smart” via smart tags and TagItSmart framework. It combines novel solutions, and enabling technologies and tools to create smart solutions for the whole value chain; pre-production, manufacturing transportation, retail, consumer and recycling.

3.4.1 Key market figures

Global market figures for segments related to digital products are promising. Global forecast for beverages I only s expected to reach USD 1.9 trillion by 2021 [5].

3.4.2 Potential customer needs and value potential

Consumer engagement
Make context-aware product information accessible to consumers and engage consumers by using technologies that work with existing consumer-owned devices.

Product journey
Make a product’s journey, from manufacturing to recycling, digital and permanent by identifying each product uniquely and recording its interaction with the environment

Cold chain
Ensure that pharmaceuticals (medication, vaccines) are kept according to manufacturers’ specification, especially temperature. The cold chain breaks when an item is outside the specified temperature range. At this point, a medication or vaccine can lose its potency or be unsafe to consume. Smart tags provide item level cold chain information.

SWOT analysis for the Digital Product use case is defined in Table 5.

Table 5. Digital Product Use Case: SWOT Analysis.

Strengths	Weaknesses
• Item-level environment interaction • Fully GS1 compatible • Augments existing tags with context information without requiring a local power source • Works mostly with existing identification infrastructure • Works in very low-tech environments • Can be printed on existing packages • Serializable • Works with any consumer's smart phone • No dedicated reader required, smart phones can be leveraged as readers.	• Extensive trials are yet to be conducted • The time when a tag changes its value is mostly unknown • Can appear to stakeholders as "just another tag"
Opportunities	**Threats**
• Provide customers recommendations based on the state of a product • Record item-level interaction with the environment • Provides direct channels between consumer and producer • Food safety • Cold chain • Consumer-friendly apps	• Blueprints and best practices are not shared • Printing software is not able to cope with multi-state barcodes • Regulatory approval is delayed • Stakeholders are not willing to adopt the tag

3.4.3 Key success factors

Based on the SWOT, we identify the following key success factors:

- Scalable for high-volume printing
- Consumer confidence
- Manufacturer confidence
- State change works reliably in real-life conditions
- Functional ink can be printed on existing packages.

3.4.4 Competitors

Potential competitors for Digital product use case are defined in Table 6.

Table 6. Digital Product Use Case: Competitors.

	Product technology	**Products**	**Customer needs**	**TagitSmart added value**
Standard EAN-codes	Existing, static barcode technologies	GS1 defined barcodes		Sensitivity to the environment. Open IoT technology
Tempix	Barcode that becomes unreadable when the cold chain is broken	Tempix	Food safety, cold chain	Open IoT technology. Readable new barcode when cold chain is broken
Varcode	Barcode that changes state as a function of temperature	FreshCode	Food safety, cold chain, Consumer participation in health and safety	Open IoT technology

3.4.5 Environmental factors

We identify environmental factors that are of interest to customers in this use case. These environmental factors include:

- Temperature
- Humidity
- Mould.

3.4.6 Enablers and barriers

Enables and barriers related to the Digital Product use case are defined in Table 7.

Table 7. Digital Product Use Case: Enablers and barriers.

	Enabler	Barrier
Technology	• Barcode reading software in iOS and Android • Off-the-shelf and open-source software to read codes • Fully web-enabled • Consumer-friendly	• Printing hardware and software adaptions to work with smart tags • Untested technologies wrt. making smart tags • Development costs for each new type of smart tag
Interoperability	• Semantic and GS1 compatible data models • Works with existing infrastructure	• Semantics to describe items gain acceptance
Safety and Security	• Improve drug and food safety by measuring environmental factors	• For some use cases, regulatory requirements must be met
Intellectual property	• Patent barcodes for humidity, mould, …	• Heat-sensitive barcode technology is patented
Organisation and talent	N.A.	• Development and calibration of equipment to make smart tags
Public policy	• Increasing interest in regulatory requirements regarding health and safety	• Complex policies

3.4.7 Implications for stakeholders

Implications for stakeholders related to the Digital Product use case are defined in Table 8.

Table 8. Digital Product Use Case: Implications for stakeholders.

Stakeholder	Implications
Foodstuffs, pharmaceuticals	• Affordable item level context information • Cold chain in low tech conditions • Recalls with Item level precision • Direct, context-dependant channel to consumers • Use existing reader infrastructure
Consumers	• Participation in supply chain • Direct channels for customers to access relevant information about a product's state
Retail	• Keep existing reader infrastructure • Item-level visibility of shelf-life, keepability
Health services	• Item-level visibility of shelf-life, keepability, quality of drugs and vaccines • Cold chain in low-and medium income countries
Logistic companies	• Use existing reader infrastructure • GS1-compatible
Regulators	• Approve smart tags
IoT platforms	• Offer services for item-level context-sensitive identifiers • Provide infrastructure for consumer-engagement critical domains that involve consumers in business processes
Packaging companies	• Support printing of ink that changes according to the environment • Packages move up the value chain by being sensitive to the environment
Industrial printers	• Software update to support multi-state barcodes • Upgrades to support for functional inks • Increased costs due to slower printing processes
Insurance companies	• Reduce risk by gaining item-level visibility

3.5 Market analysis for Lifecycle Management / Consumer Engagement use case

A key sustainability metric is the reduction in waste sent to landfill, but also the increasing of recycling. Items which are recyclable are often wrongly placed in a landfill bin, due to lack of awareness or engagement by the end user. This problem is compounded by the number of different regulations governing recycling at the local level and an inability to engage directly with end users at the point of product disposal. Table 9 defines the SWOT analysis for the use case.

Table 9. Lifecycle Management Use Case: SWOT Analysis.

Strengths	**Weaknesses**
• Item-level environment interaction • Fully GS1 compatible • Augments existing tags with context information without requiring a local power source • Environmental-friendly technology • Serializable • Works with any consumer's smart phone • Fully web-enabled (no dedicated reader required)	• Uptake / maximum value requires coordinated large-scale changes to product labelling and design • Requires "proof of concept" with current technology before large players likely to get involved • Requires a standard on information about recycling locations
Opportunities	**Threats**
• Improve brand/image • Improve energy efficiency • Facilitates the implementation of European regulations regarding recycling and reusing • Provide a direct to consumer communication channel	• Any form of smart tag proves to be too expensive for mass market consumer goods role out • Inability to get coordination and standards agreed for tags between multiple manufacturers and retailers • Un-proven business model • Large investment required in maintaining secure digital system

An opportunity exists for a system which can give end users geographically relevant information on the recyclability of an item at this point in time, either within the home, or at a range of other recycling outlets. A smart label may also give extra value-added information concerning optimum usage conditions for a product, or indications that its condition maybe compromised due to environmental thresholds being exceeded in the supply chain.

3.5.1 Key market figures

With the EU having about 50% of the worlds share of recycling, recycling is directly contributing to the creation of jobs. Recycling-related economic activities could create between 1.2 and 1.3 million employment opportunities [6]. Global recycling market is expected to reach USD 35 billion by 2020 [7].

Table 10 **Error! Reference source not found.**shows the amount of municipal waste being recycled by country in the OECD. While these figures suggest commitment to recycling, there remains potential to further increase recycling.

Table 10. Figures of the OECD leading waste recycling [8].

Rank	Country	% of Municipal Waste That Is Recycled/Composted
1	Germany	65
2	South Korea	59
3	Slovenia	58
3	Austria	58
4	Belgium	55
5	Switzerland	51
6	Sweden	50
6	Netherlands	50
7	Luxembourg	48
8	Iceland	45
9	Denmark	44
10	United Kingdom	43

3.5.2 Potential customer needs and value potential

Consumer participation in sustainable supply chain
Smart tags provide a direct channel to individual consumers through their mobile phones, to for an engagement in sustainable supply chain. Smart tags allow customers to make informed decisions about responsible product disposal.

Reduction in waste production and increase of recycling rates
The ability to provide consumers with disposal information at the point of disposal (whether for kerbside collection or via deposition in municipal bins) is key to reducing the levels of contamination in the waste collection process and increase the recycling rates. This results in a more efficient waste stream process; less waste being rejected at recovery facilities and an overall cost saving.

3.5.3 Key success factors

Based on the SWOT, we identify the following key success factors:

- Verifiable reduction in waste contamination and increase of recycling rates
- Verifiable behaviour changes in terms of awareness of correct product disposal

- Level of municipal support and consumer engagement
- Risen consumer awareness about possibilities of recycling.

3.5.4 Competitors

Table 11 presents the competitors defined in recycling information and rewards, and in the area of FMCG thermochromic labelling.

Table 11. Lifecycle Management Use Case: Competitors.

	Product technology	**Products**	**Customer needs**	**TagitSmart adds**
OPRL	OPRL (On Pack Recycling Label) – visuals only. No account of geographic differences in recycling	A simple visual label showing recyclability	Kerbside and municipal collection	Sensitivity to the environment. Open IoT technology
WRAP	WRAP (Waste and Resource Action Program). Web based resource including geographic tracker for recyclability	Web page enables users to input location for location-relevant product disposal information	Kerbside and municipal collection	Sensitivity to the environment. Open IoT technology
Uzer	Eugene by Uzer. Consumer barcode scanner with recycling information and rewards	Barcode scanner combined with an App that indicates where to recycle the product and get rewards for it	Kerbside and municipal collection, and recycling rewards	Sensitivity to the environment. Open IoT technology

3.5.5 Environmental factors

We identify environmental factors that are of interest to customers in this use case. These environmental factors include:

- Temperature – to show product at optimum conditions for consumption
- Temperature – to show environmental thresholds have been exceeded in supply chain so condition may be time-compromised.

3.5.6 Enablers and barriers

Enables and barriers related to the Lifecycle Management use case are defined in Table 12.

Table 12. Lifecycle Management Use Case: Enablers and barriers.

	Enabler	Barrier
Technology	• Barcode reading software in iOS and Android • Off-the-shelf and open-source software to read codes • Fully web-enabled • Consumer-friendly	• Printing hardware and software adaptions to work with smart tags • Untested technologies wrt. making smart tags • Development costs for each new type of smart tag
Interoperability	• GS1 compatible • Works with existing infrastructure	• Large organisations in packaging circular economy may require their own closed systems
Privacy and confidentiality	• Consumer and industry awareness around data security	• End users (consumers) may have concerns regarding sharing PII • Large organisations internal policies regarding collection, storage and use of PII
Intellectual property	• Possible opportunities to patent system	• Thermochromic temperature inks already protected
Organisation and talent	• Aligned with corporate shift towards sustainability and waste minimisation	N.A.
Public policy	• Aligned with national policies to minimise waste	• Bureaucracy in public administrations to apply new recycling schemes.

3.5.7 Implications for stakeholders

Implications for stakeholders related to the Lifecycle Management use case are defined in Table 13.

Table 13. Lifecycle Management Use Case: Implications for stakeholders.

Stakeholder	Implications
Customers	• Gives opportunity to create a new digital communication channel with end users • Opportunity for data collection and mining at scale in current data-sparse segment of packaging circular economy to provide new business opportunities
Consumers	• Gives users the information required at point of product disposal – step change in information availability and simplicity; reduces confusion and complexity • Enhances product experience by providing optimum product consumption indication at point of consumption
Retail	• Opportunities to use the direct to consumer channel for communication, promotion, sustainability campaigns etc
Logistic companies	• Check integrity of cold chain at point of scan
IoT platforms	• Opportunity to integrate product information and consumer interactions at scale.
Packaging companies	• Data to validate compliance with packaging recycling directives

3.6 Market analysis for Brand Protection use case

Despite high-tech anti-counterfeit measures such as RFID-tags, counterfeiting is a global phenomenon and it is on the rise [9]. In a 2016 report, global import of counterfeit and pirated goods amounts to 2.5%, or $461 billion. It is damaging, financially and reputationally, to brands and products that are traditionally associated with counterfeits; perfumes, luxury bags or consumer electronics for example. But counterfeiters also target pharmaceuticals, plane parts or children toys and sell unsafe products that pose a risk to people's lives [10, 11]. Providing secure, affordable item-level smart barcodes make it harder for criminal organisations to introduce counterfeited and pirated goods to the market. SWOT analysis related to the Brand Protection use case is presented in Table 14.

Table 14. Brand Protection Use Case: SWOT analysis.

Strengths	Weaknesses
• Augments existing barcodes with tamper-sensitive information • Low-tech smart identifier for very low-cost goods • Does not require specialised readers, but might require special lightning • Increases the cost of manufacturing high-quality counterfeits	• Extensive trials have not been conducted yet
Opportunities	**Threats**
• Affordable smart tags for low- and medium income countries • Customer engagement to combat counterfeit and piracy • Combat counterfeit drugs and food	• Consumer confidence could be undermined if smart tags are not calibrated properly • Counterfeiters could find ways to easily replicate smart tags • Regulatory approval will increase initial costs and permits may not be granted • Environmental factors that tags can react to are insufficient for the industry • No regulatory approval for health and safety related applications

3.6.1 Key market figures

In a 2016 report, global import of counterfeit and pirated goods amounts to 2.5%, or $461 billion [10].

3.6.2 Potential customer needs and value potential

Textile
Counterfeiting, specifically in textile products, but also expandable to other goods, is caused by several factors including the simplicity of the production and refinement processes, the cheap way of production and the low structure complexity which widely opens the doors for illegal copying. Brand protection strategies based on the implementation of barcodes, tags of labels to the product till nowadays revealed only a moderate success rate, whereas sophisticated anti-counterfeit systems (e.g. active RFID tags, electronically secured packaging) are more limited to high-value products.

Global effort to coordinate anti-counterfeiting and piracy efforts
China, closely followed by Hong Kong, lead the manufacturing of counterfeits and pirated goods [10]. Europe is seeing an increase in counterfeit and pirated goods. Combating criminal organisations requires collaboration, and thus information system integration between government organisations (customs, law-enforcement), stakeholders participating in the supply chain as well as consumers *[10,12]*.

Customer-engagement for product authenticity
Consumers are often tricked into buying counterfeit goods [9]. Barcodes can be read by any mobile phone. Secure smart tags allow consumers to verify the authenticity of the product they are about to buy.

Medication and luxury goods
Expensive products medication and luxury goods are often targets of counterfeiters. In the case of medication, counterfeit medications pose a risk to people's health [11]. Luxury goods are prime targets of counterfeits and grey market trading [10].

3.6.3 Key success factors

- Very hard/expensive to fake
- State change works reliably in real-life conditions
- State changes induced by mobile phone technologies (e.g. mobile phone LED) work with any mobile phones
- Functional ink can be printed on luxury packages/items in an unobtrusive way
- Coordination and rapid response when a given secure barcode technology is compromised
- Technology that is accessible to all stakeholders (not only in rich countries) and thus covers the entire supply chain
- Combining backend services with SmartTags, create solid authenticity control.

3.6.4 Competitors

Competitors for the Brand Protection use case are defined in Table 15.

Table 15. Brand Protection Use Case: Competitors.

	Product technology	Products	Customer needs	TagitSmart adds
Avery Dennison	Tamper-proof labels and anti-counterfeiting 2D barcodes	Tamper-evident labels, Anti-counterfeiting labels	Brand protection, customer-engagement for product authenticity	Open IoT technology
Complete Inspection Systems	Proprietary barcode technology and mobile app	AC-HD Barcode	Brand protection, customer-engagement for product authenticity	Open IoT technology
De La Rue	Tamper-proof labels, anti-counterfeiting RFID tags		Brand protection, customer-engagement for product authenticity	Open IoT technology

3.6.5 Environmental factors

We identify environmental factors that are of interest to customers in this use case. These environmental factors include:

- Non-ionizing radiation (visible light, infrared)
- Humidity (fingerprints).

3.6.6 Enablers and barriers

Enablers and barriers related to the Brand Protection use case is presented in Table 16.

Table 16. Brand Protection Use Case: Enablers and barriers.

	Enabler	Barrier
Technology	• Same as for supply chain visibility	• Same as for supply chain visibility
Interoperability	• IoT technologies facilitate cross-organisational exchange of information	N.A.
Privacy and confidentiality	• Security awareness among consumers and the industry • Blockchain technologies provide a shared and secure platform for storing product identifiers	• Could include exchange of personal data • Companies and countries might be reluctant to share information about vulnerabilities
Intellectual property	• Need from the industry to combat piracy against copyright and IP infringements	N.A.
Public policy	• Increased willingness of countries to take IP and copyright infringements seriously	• China and Hong Kong remain the very resourceful leaders in counterfeiting/piracy

3.6.7 Implications for stakeholders

Implications for stakeholders are presented in Table 17.

Table 17. Brand Protection Use Case: Implications for stakeholders.

Stakeholder	Implications
Textile, foodstuffs, entertainment, tobacco, pharmaceutical, …	• Low-cost item-level fraud-detection • Direct channel to consumers for authenticity verification • Use existing reader infrastructure • Provide web-based apps for anti-counterfeit measures
Consumers	• Verify product-authenticity with a mobile phone • Direct channel to manufacturer in case of fraud
Retail	• Low-cost product authenticity verification works in low- and medium income countries • Item-level visibility of shelf-life, keepability
Customs and international law enforcement	• Item-level verification with personal mobile phones • Interoperability with other law-enforcement organisations and the industry by using open IoT standards • Recommend/develop smart tag technologies that are secure • Coordination needed if an smart barcode technology is compromised
Logistic companies	• Item-level verification with personal mobile phones • GS1-compatible
Governments	• Increased tax revenues
IoT platforms	• Offer higher-value, high-reliability and security services for item-level brand protection • Potential for long-term government/industry integration contracts • Offer essential consumer-engagement programs around product authenticity
Packaging companies	• Support printing of functional ink that changes when tampering occurred • Higher-value packaging that prevents fraud
Industrial printers	• Software update to support multi-state barcodes • Upgrades to prints smart tags • Higher costs due to slower printing processes • Ability to react quickly when a given technology is compromised
Insurance companies	• Reduce risk by gaining item-level visibility about a product's authenticity
Criminal organisations	• Develop capability to imitate secure smart tags

3.7 Market analysis for Dynamic Pricing use case

Each package of meat is tagged with a Smart Tag on the production line. The tag can detect temperatures higher than allowed for storing fresh meat. Once the temperature goes above the threshold, the tag reacts and changes its content to indicate this event.

Once the package arrives to a shop it can be scanned by the retailer. In that case, the packages that were stored in wrong temperature conditions will be removed. However, individual scanning of each package is not possible and the packages might end up on shelves.

Once on the shelves, the consumers will be able to scan individual packages before buying. When consumers scan a package using a smartphone application they will obtain information about the meat: the origin, time of packaging, discount information and transport conditions. The obtained information is also forwarded to the meat supplier and potentially to other actors in the supply chain. At this point, it is possible to invoke dynamic pricing mechanism depending on the relevant parameters like temperature in which the item was stored or time spent on the shelves.

Table 18 presents the SWOT analysis for Dynamic Pricing use case.

Table 18. Dynamic Pricing Use Case: SWOT analysis.

Strengths	**Weaknesses**
• Item-level environment interaction • Direct access to consumers, capable to secure utilisation of the product with very low-cost level • Augments existing tags with context information without requiring a local power source • Works with existing identification infrastructure • Can be printed on existing packages • Serializable • Works with any consumer's smart phone • Fully web-enabled (no dedicated reader required)	• Extensive trials are yet to be conducted
Opportunities	**Threats**
• Provide customers recommendations based on the state of a product • Record item-level interaction with the environment • Food safety • Cold chain guarantee • Consumer-friendly apps • Provide useful information about the product to the consumer • Provide discounts for target segment of consumers • It can be a useful tool for the implementation of loyalty programs • Improvement of sales performances with utilisation of data collected from the back-software system	• Cost of SmartTAGs • Consumers lack trust on SmartTAGs • Production (printing) of tags at the manufacturing site

3.7.1 Key market figures

The IoT opens new possibilities for dynamic pricing. Cold chain, and the monitoring of products, can influence pricing. Global forecast for cold chain monitoring is expected to grow from USD 3.11 billion in 2015 to more than double, USD 6.23 by 2022 [13].

3.7.2 Potential customer needs and value potential

Food safety and traceability
Improve food safety through item-level information about temperature ranges to which a food item has been exposed during transporting or storage. Smart tags irreversibly change state when entering the danger zone, in which food-borne bacteria can grow.

Transparency and user assurance
Retailers will be able to provide transparent service and assure consumers about the quality of individual products, thus gaining a competitive advantage over competition.

Add-on services
Retailers will be able to provide add-on services as well as enable third parties to provide novel services on top of the products sold in shops, thus selling the same product twice: to the consumers and to the service providers.

3.7.3 Key success factors

Based on the SWOT, we identify the following key success factors:

- Meet regulatory requirements for health and safety applications
- Consumer confidence
- State change works reliably in real-life conditions
- Functional ink can be printed on existing packages
- Getting consumers to trust TagItSmart.

3.7.4 Competitors

Competitors for Dynamic Pricing use case are defined in Table 19.

Table 19. Dynamic Pricing Use Case: Competitors.

	Product technology	Products	Customer needs	TagitSmart adds
Standard EAN-codes	Existing, static barcode technologies	GS1 defined barcodes		Sensitivity to the environment. Open IoT technology
Tempix	Barcode that becomes unreadable when the cold chain is broken	Tempix	Food safety, cold chain	Open IoT technology. Readable new Barcode when coldchain is broken
Varcode	Barcode that changes state as a function of temperature	FreshCode	Food safety, cold chain, Consumer participation in health and safety	Open IoT technology

3.7.5 Environmental factors

We identify environmental factors that are of interest to customers in this use case. These environmental factors include:

- Temperature.

3.7.6 Enablers and barriers

Enablers and barriers for Dynamic Pricing use case are defined in Table 20.

Table 20. Dynamic Pricing Use Case: Enablers and barriers.

	Enabler	Barrier
Technology	• Barcode reading software in iOS and Android • Open-source software to read codes • Fully web-enabled • Consumer-friendly	• Cost of tags
Interoperability	• Works with existing infrastructure	• Scalability
Safety and Security	• Improve food safety by measuring environmental factors	• Trust on the technology by consumers

3.7.7 Implications for stakeholders

Implications for stakeholders in Dynamic Pricing use case are defined in Table 21.

Table 21. Dynamic Pricing Use Case: Implications for stakeholders.

Stakeholder	Implications
Consumers	• Access to relevant information about a product's state and safety • Discounts for each product separately based on relevant information for that product
Retail	• Use existing reader infrastructure • Increased consumer loyalty • Consumer behaviour information. • New communication channel with consumers.
Health services	• Item-level visibility of shelf-life, keepability, quality of drugs and vaccines • Cold chain in low-and medium income countries
Logistic companies	• Use existing reader infrastructure • GS1-compatible
Regulators	• Approve smart tags
IoT platforms	• Offer services for item-level context-sensitive identifiers • Provide infrastructure for consumer-engagement critical domains that involve consumers in business processes
Packaging companies	• Support printing of ink that changes according to the environment • Packages move up the value chain by being sensitive to the environment
Industrial printers	• Software update to support multi-state barcodes • Upgrades to support for functional inks • Increased costs due to slower printing processes
Insurance companies	• Reduce risk by gaining item-level visibility

3.8 Market analysis for Home Services use case

A good usage of the heating equipment (e.g. a boiler and an associated filtering station) is one means to provide comfort and a healthy living at home. This implies proper 1) maintenance, 2) repair, 3) replenishment, and 4) monitoring. This use case will test different services to the customer all along the life of the equipment at home. Some of the services will leverage access to information related to the product, its environment and its use; and some will provide specialized services (installation, maintenance, repair, reorder, etc.).

Based on the SWOT presented in **Error! Reference source not found.**Table 22, the retailer s hould rethink its position in the value chain: a new, central and downstream one, acting as a services aggregator.

3.8.1 Key market figures

Home service market is experiencing considerable growth. The home market service in the United States of America (USA) is USD 600 billion [14].

SWOT analysis for Home Services use case are defined in Table 22.

Table 22. Home Services Use Case: SWOT analysis.

Strengths	**Weaknesses**
• Optimal working conditions of the customer's equipment • Product quality and durability enhancement (and customer satisfaction) • Optimal usage of the customer's equipment • Easy and efficient management of the service providers actions	• Heavy change management in the retailer's organization • Poor mobile app reach
Opportunities	**Threats**
• Recurring revenues for the retailer: customer subscription to consumables automatic replenishment, connected product rent • New business around services for the retailer: customer subscription to a pool of services, fees on service provider sale (maintenance & repair) • Knowledge about the product's usage for retailer's internal use or consulting to product manufacturers • Additional product sales as the product benefits from new services • New position and competitive advantage for the retailer in the value chain: close to the customer's life and customer's use of products • Long-term relation with customers (thus leveraging loyalty)	• Difficulty to convince customers to pay for service access and to services integration (as they do it by themselves today) • Difficulty to organize an ecosystem of efficient service providers • High cost of the IoT platform management • Difficulty to find a fair sharing of added-value between stakeholders (manufacturer, retailer, service provider, consumer) • Difficulty to implement a customer-centric approach (i.e. based on a TagItSmart app) vs a retailer-centric approach (i.e. based on the retailer's app) • Difficulty to roll-out SmartTags in open-loop supply chains

3.8.2 Potential customer needs and value potential

Proximity-based information

A physical product can be augmented with digital information, based on context. This feature of context awareness is what Dey and Abowd [15] "presentation". The aim is to make it easy

access to the product's identity card (identification, technical information, manufacturing information, recycling information, purchasing information, guides, manuals).

Proximity-based information
Provide relevant, i.e. context-aware information about a device in a home to help customers make pro-active, informed decisions with regard to their home's infrastructure through automatic alerts management (maintenance planning, repair reminder, consumables reorder).

3.8.3 Key success factors

Based on the SWOT, we identify the following key success factors:

- Attractive costs for customers
- Customer app integration to the retailer's mobile app
- Open source IoT platform
- Platform operator not involved in retail business.

3.8.4 Competitors

Competitors for Home Services use case are defined in Table 23.

Table 23. Home Services Use Case: Competitors.

	Product technology	Products	Customer needs	TagitSmart adds
Standard EAN-codes	Existing, static barcode technologies	GS1 defined barcodes	N.A.	Sensitivity to the environment. IoT technology
Amazon	Platform	Amazon Home Services	Access to hundreds of services types	Open IoT technology Item-level context-awareness
Amazon	Connected device or embedded technology	Dash	Manual and automatic reorder	Open IoT technology Item-level context-awareness
Amazon	Digital assistant	Alexa	Search, service access	Open IoT technology Item-level context-awareness
Google	Digital assistant	Allo	Search, service access	Open IoT technology Item-level context-awareness
Apple	Digital assistant	Siri	Search, service access	Open IoT technology Item-level context-awareness
Microsoft	Digital assistant	Cortana	Search, service access	Open IoT technology Item-level context-awareness

3.8.5 Environmental factors

We identify environmental factors that are of interest to customers in this use case. These environmental factors include:

- Temperature
- CO2

- Sudden heat increase
- Power consumption.

3.8.6 Enablers and barriers

Enablers and Barriers for Home Services use case are defined in Table 24.

Table 24. Home Services Use Case: Enablers and barriers.

	Enabler	Barrier
Technology	• Open source platform with an identified company for software evolution management • SmartTag reading software roll-out on major OS	• Inefficient SmartTag printing process and tools • High development costs of SmartTag
Interoperability	• Web of Things compliance • GS1 compliance	• Inability to use SmartTags and TagItSmart platform in open-loop supply chains
Privacy and confidentiality	• Efficient and easy-to-use opt-in functions	• Proposed services must be attractive enough to convince customers to provide personal data

3.8.7 Implications for stakeholders

Implications for stakeholders in Home Services use case are defined in Table 25.

Table 25. Home Services Use Case: Implications for stakeholders.

Stakeholder	Implications
Customers	• Easy "vendor relationship management" • Easy service ordering and consumables reordering • Access to relevant, qualified and cost-effective service providers
Consumers	• Better usage of products • New product experience
Retail	• New recurring business model • New knowledge on consumer habits • Competitive advantage • Competition with services industries (banking, insurance, telecom, …)
Health services	• Connected homes to provide home care services
Logistic companies	• Source-tagging process within the manufacturing process
Regulators	• Keep up with the pace of technological development
IoT platforms	• Interoperability with SmartTag reading and printing tools

3.9 The importance of personalization

In current and future access to FMCG/CPG products and services, information is available to consumers in seconds. This includes data that are ready to easily compare options available in the market, giving extensive information and enhanced decision power to consumers [16]. By engaging consumers into product/company with information on products pricing, sustainability, responsibility, details in a transparent and ethical manner makes it easier for consumers to make a decision to buy the product.

Nowadays 47% of digital natives look for product recommendations and suggestions before buying [17]. As digital natives are familiar with using services like Uber and Airbnb, they expect the same experience when they are buying goods from a local supermarket. This experience includes using an app while shopping, buying goods online and paying for the full price rather than dealing with inconveniences, etc. By analysing real-time data from consumers, companies are able to engage them into the buying process as well. Data protection and privacy become a key issue to convince consumers to be part of this relationships between them and the products they buy and all the stakeholders involved.

While consumers are not only looking for information about products and their sources, personalization of products is becoming a reality too. In a research conducted by business advisory firm Deloitte [18], over one third of interviewed consumers said that they are interested

in personalised products and services but on every sixth said that they had never been able to buy one.

In other research by Hanley-Wood Business Media in 2013 [19], it was shown that 78% of consumers stated that brands that create unique and personalised content are perceived as being more interested in building a relationship with them. Currently product customisations are generally limited to labelling changes. In the future we will begin to see personalisation of the actual product as brands recognise success with these initiatives. So far, take up on personalisation has been implemented when buying holidays, clothing and furniture but even in these product the highest amount of personalisation (holidays = 25%) is low, most advanced countries in product personalisation China or India.

Based on Deloitte´s research [18], 71% of consumers who bought personalised products are willing to pay more for premium. Ben Perkins, Head of Consumer Business Research at Deloitte states "*However, those businesses who do not offer an element of personalisation, risk losing revenue and customer loyalty over the longer term as consumers increasingly demand personalisation.*"

3.10 Consumer product trends

Based on the "*Consumer product trends: Navigating 2020*" [20] study, CPG companies can prepare themselves for a range of possible futures by harnessing technology, reinventing brands, and exploring new business models. In order to prepare to changes, a study found five potential "undercurrents" that may impact the consumer product industry in 2020 (see Figure 7).

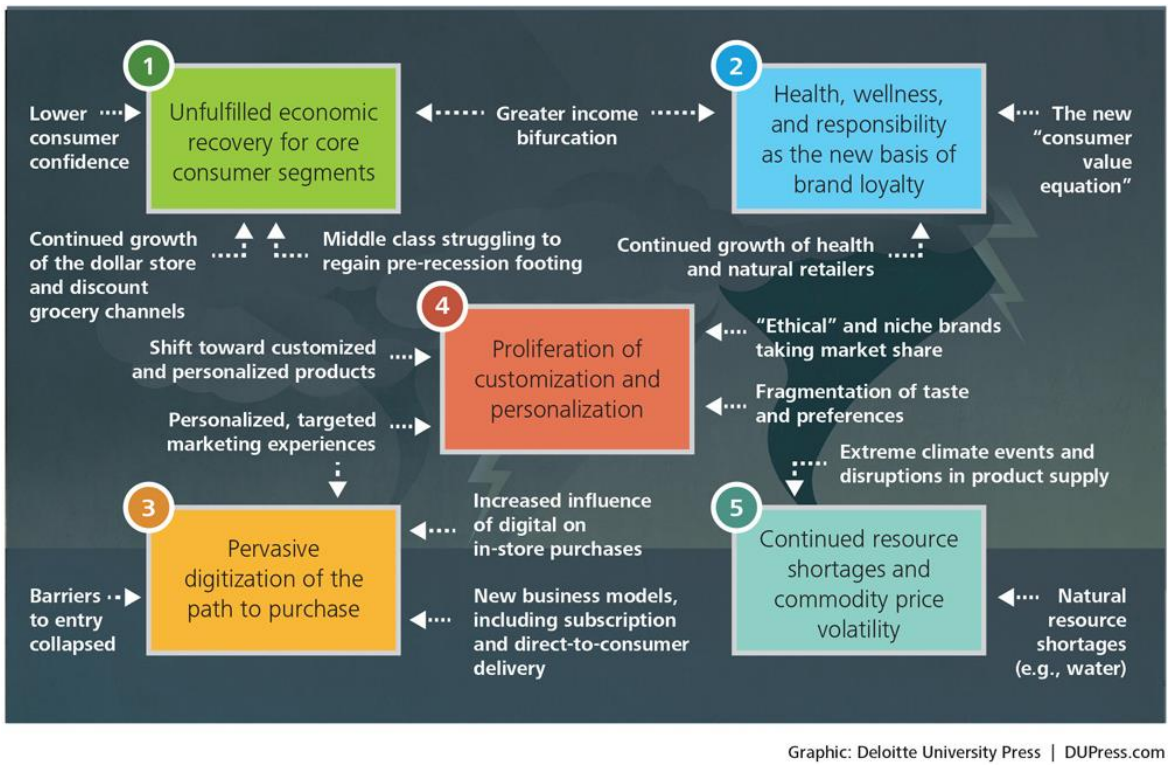

Figure 7. Undercurrents in the consumer products industry [20].

Based on this situation, by enabling the creation of smarter products with control and information throughout the whole lifecycle of the product, TagItSmart can help tackle some of these undercurrents:

- Undercurrent 2: Companies will experience greater pressure to better align offerings and activities with consumer interests and values.
- Undercurrent 3: The lion's share of consumer spends and activity -promotion, search, and procurement- will take place over digital channels.
- Undercurrent 4: Customization of both the product and the end-to-end shopping experience will be critical to capturing value.

The aforementioned study also presents future environments that are more receptive for the creation of a marketplace. This future goes well in hand with TagItSmart's digital product functionality as some of its key aspects are:

- **Pricing**: "Value-based pricing and dynamic, personalised promotions"
- **Promotions**: "Promotions based on customer signals"
- **Basis of consumer loyalty**: "Authenticity and value"
- **Consumer insights capability**: "Real-time, forward-looking, predictive"
- **Consumer engagement model**: "Two-way, dynamic collaborative conversation".

3.11 Reshaping the value chain

As explained in "*Rethinking the Value Chain: New Realities in Collaborative Business*" [21] by The Consumer Goods Forum (CGF) and Capgemini , consumer is the king of future too. This means that products and information don't flow linearly and sequentially from supplier to manufacturer to retailer to consumer anymore. But new value chains will increasingly organize itself as networks around consumers, offering a multiplicity of channels and interfaces across all value-add processes and business entities. This makes consumer the one in charge, whose decisions affect the whole value-chain. This study suggests three overarching priorities on which the industry could collaborate and which should deliver a positive return on investment:

- **Consumer engagement**
- **Transparency**
- **Last mile of distribution.**

Previous issues discussed are also identified by packaging industry Henrietta Åström from Wulff Entre reveals future trends for packing industry in: "*Unwrapping the packaging industry – Global Trends*" [22]. These trends state that the consumer is interested in sustainability more than ever; the past, present and future of products have become important as the promise for going "green" needs to be reclaimed.

In packaging industry, as results of consumers increasing knowledge about origins and manufacturing conditions, consumers have become more demanding in their request for transparency too. This raises needs in products and their packing for higher quality, authenticity and trust. But also packing industry identifies the need for personal user-experience and apps that support mobile engaged packaging. This aspect is also supported

by Gordon L. Robertson, adjunct Professor at the University of Queensland as he states smart labels as trend in future.

As in products, packaging industry shares interest in personalisation and transparency, both issues that TagItSmart will handle. While personalisation is now possible due to advancements in digital printing technologies consumers are looking into buying products that are in sustainable packages: “In a 2014 global online survey on corporate social responsibility by Nielsen (among 30,000 consumers), ~52% of respondents indicated checking product labelling before a purchase to ensure that the brand is committed to positive social and environmental impact. 51% of those who check product labelling and 51% of those willing to pay extra for products packaged in sustainable materials were millennials (born between early 1980s and early 2000s).” [23]

3.12 The Mobile Revolution in consumer interaction

As described in EVRYTHNG LTD´s “*PRODUCT RELATIONSHIP MANAGEMENT™ Turning physical products into owned digital media*” [3] whitepaper, the smartphones will play a crucial role as they are becoming our remote controls for the world and have become a key for consumer interaction, see Figure 8.

“Increasingly, products will ship with ultra low-cost ‘smart tags’ like NFC or 2D barcodes, easily readable by smartphones …

QR code scanning is up by an average of 132% year on year across China, USA, France, Germany, Italy, Spain and the UK[5]. China alone is now reporting 9 million QR codes scanned each month, rising from two million per month a year earlier. Globally, consumers scan more than three times per month on average, a 22% increase from a year ago….”

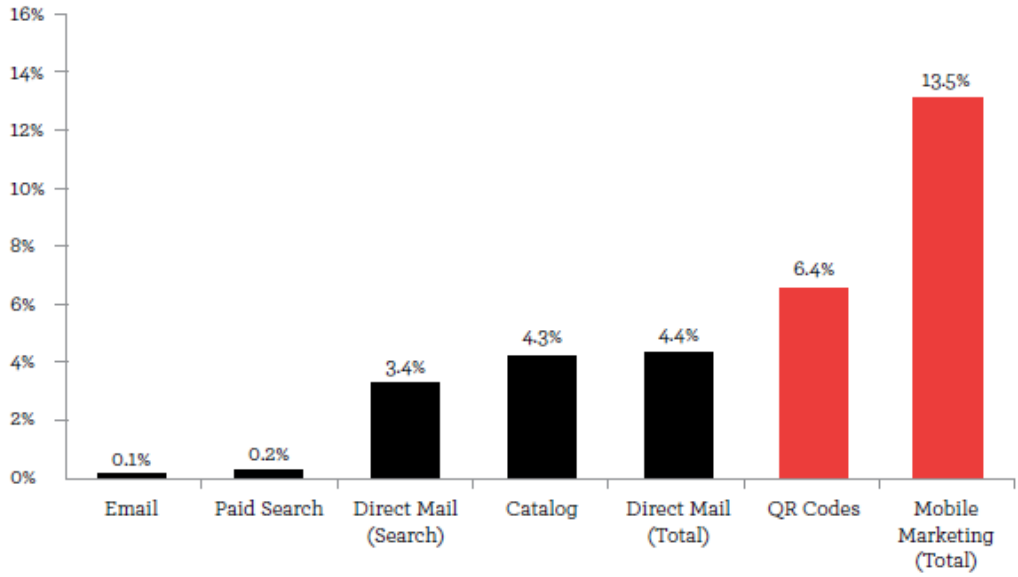

Figure 8. Average consumer response rates in the US to different marketing vehicles [24].

In the same report it is highlighted that when products have Smart tags, the interactions with the customers change too. Additionally, a unique addressable identity on the Web for the specific item enables the creation of the direct relationship between the customer and the product. This enables stakeholders (manufactures, retailers, service providers) to create innovative services on top of it, where the digital and the physical are combined to enhance the relationship with the consumer. Figure 9 summarizes the benefits for both users and business and how this is will impact sales for companies.

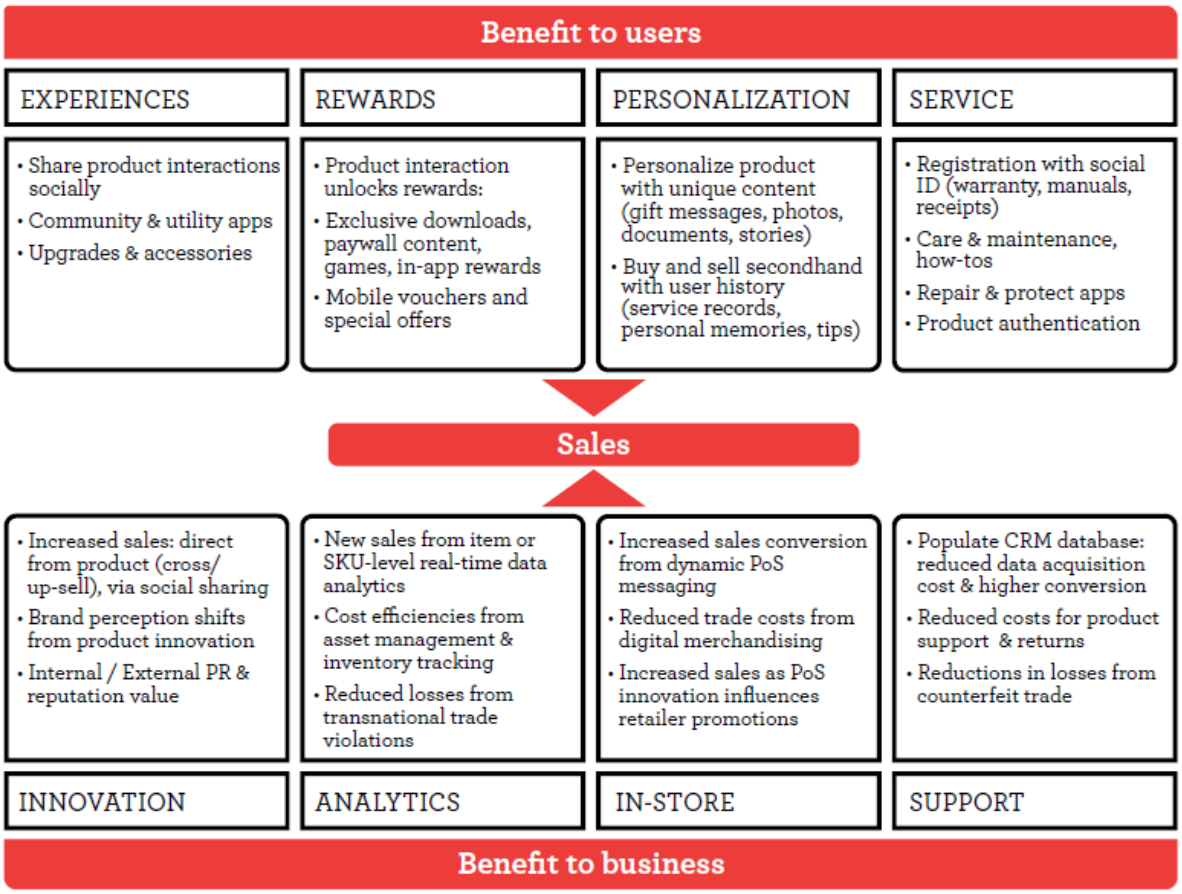

Figure 9. Business case drivers and benefits of delivering one-to-one customer communications and services direct to product [24].

3.13 IoT Market

Next we point out some relevant pieces of information that emphasize the importance of IoT in the present and the upcoming years and what is the volume of the market that TagItSmart could impact.

- In Figure 10 we can see the volume of units for different consumer categories, as reported for 2013.
- Figure 11 outlines the segmentation of the market in IoT (source: IoT Analytics, Quantifiying the connector world, 2015 [25])

- Figure 12 shows the evolution on the number of connected devices (Source: SeeDiscover, 2015 [26])
- Figure 13 shows some interesting predictions for 2020 in the IoT sphere (Source: SeeDiscover, 2015 [26]).

	Category	2013 Global Est. Volumes (B Units)
CPG	Food	1,890
	Beverage (Non-alcoholic)	640
	Beer	235
	Wine & Spirits	50
	Personal Care	140
	Home Care	85
	Tissue & Hygiene	85
	Pet Food	40
	OTC Pharma	12
Apparel & Footwear	Apparel	100
	Accessories	55
	Footwear (Pairs)	12
Durables	Electronics	4.0
	Appliances	2.5
	Automotive	0.1

Figure 10. Volume of the markets for some consumer categories (2013 data).

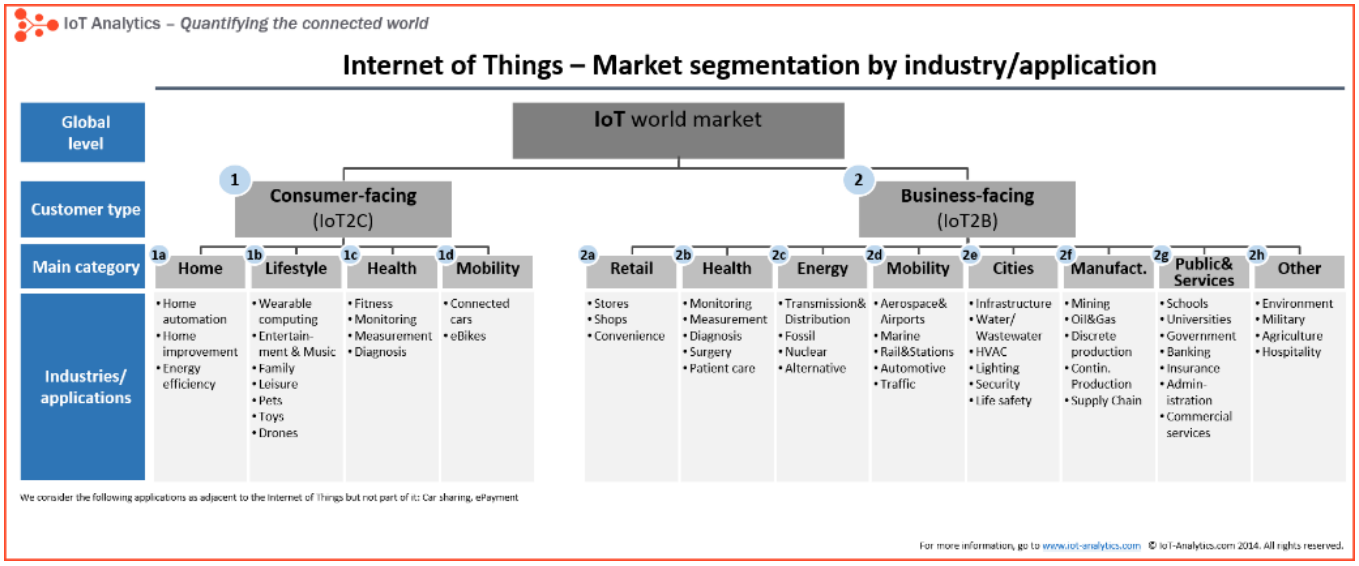

Figure 11. Market segmentation in IoT [25].

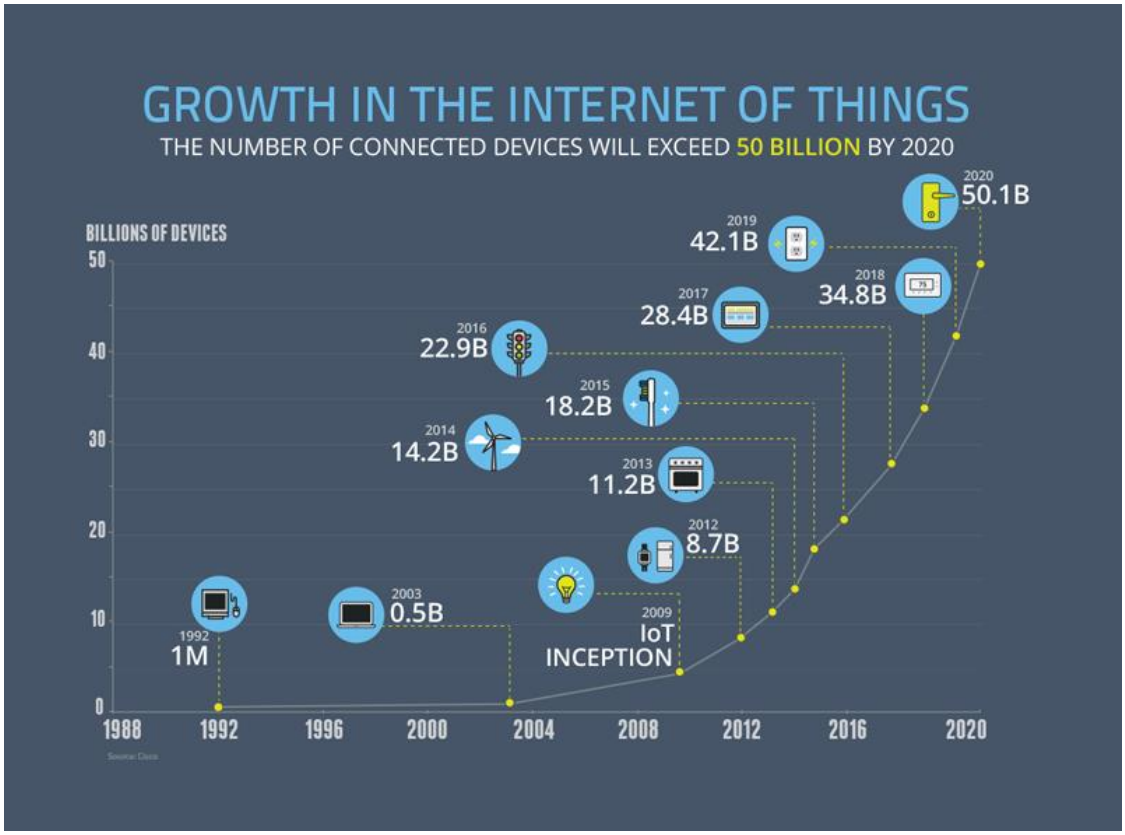

Figure 12. Evolution of the number of connected devices [26].

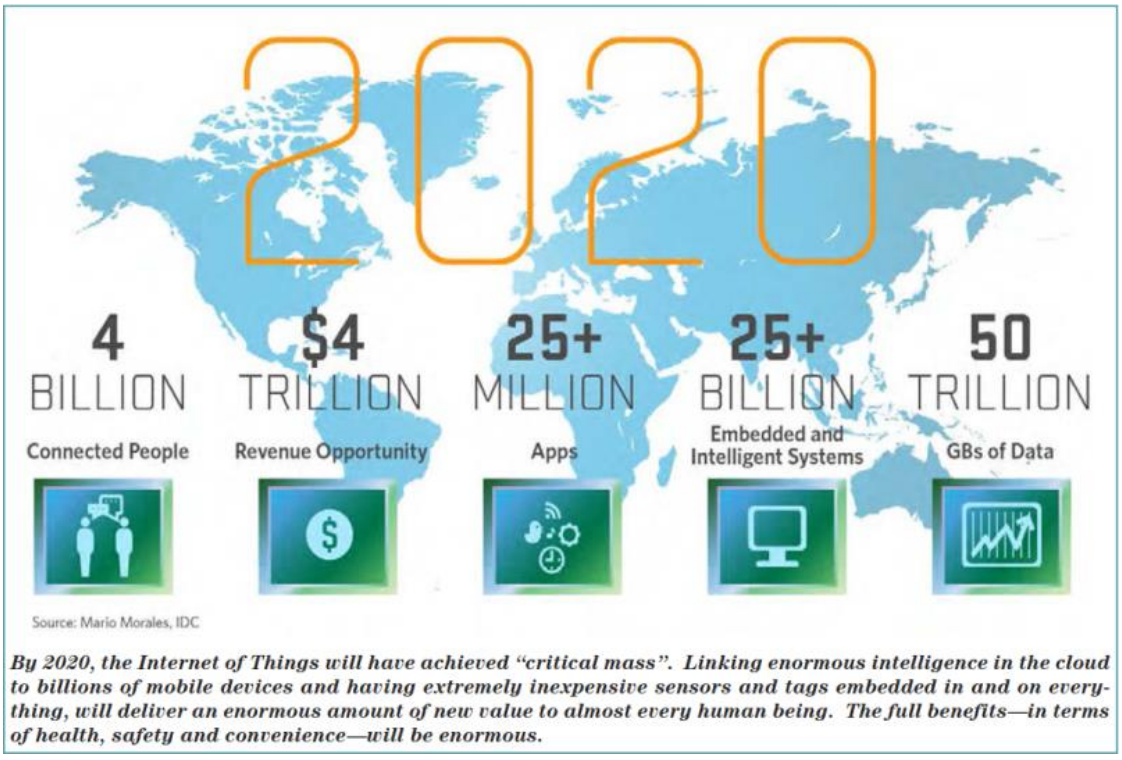

Figure 13. Expected growth of IoT in 2020 [26].

An important aspect to take into account, as stated by Cees Links, founder and CEO of GreenPeak, is the need for a service economy around IoT. "*The consumers don't really want things, they want solutions.*" [27]. He argues that for DIYers the current status of, for example the Smart Home scene, is perfectly fine but that for the majority of users to start rushing to get one, it should be provided as a service that simply automates and manages their homes, like a butler.

3.14 Impact

In this section we analyze some aspects that will shape the growth and economic impact of IoT that will be taken into account in TagItSmart. While here we present implications of IoT in general, specific aspects for theuse cases have been addressed in Section 1.

3.14.1 New ecosystems and business models

In "*Taking the Internet to the Next Physical Level*", Vint Cerf and Max Senges from Google Research [28], explain the benefits that the connection of objects and ultimately products to the Internet will bring, which is the underlying foundation of TagItSmart. They exemplify with the case of a washing machine that is Internet and cloud enabled empowering all the possibilities of creating a truly online ecosystem, see Figure 14.

Sharing information enables cooperation to provide additional ecosystem services and products will benefit from continuous understanding of contextual information and analytics, playing an important role too are APis and protocols that facilitate this interaction. "*smart behaviours that make them adaptive to new circumstances, more resource efficient, and generally user optimized* ". As additionally stated in this report, smart configurations can lead in these ecosystems to resource optimisation and energy efficiency in a scalable way. If the approach scales it can reach bigger industrial settings, which will bring huge cost reductions and greener results overall. The true potential will be reached when context of these objects is also considered and channelled to the adequate services.

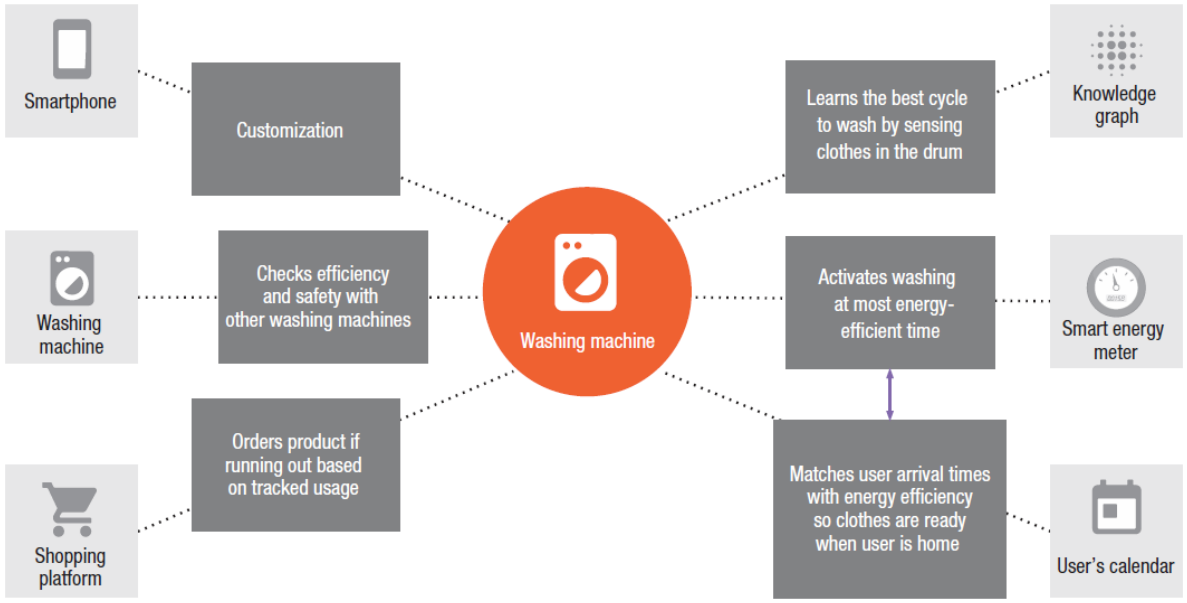

Figure 14. The various features and benefits enabled by connectivity and access to an online ecosystem [28].

These ecosystems of services are already affecting other industries. For example, it's clear that the insurance industry itself will quickly become a central factor in driving the adoption of IoT, especially in the smart home devices and services. Through incentives and partnerships with manufacturers, insurers offering innovative smart home based services will aggressively build profitable market share. We've already seen this in the automotive and healthcare insurance sectors – for example, Progressive's usage-based driving insurance, or John Hancock using data from fitness trackers to reward life policyholders for healthier living. Now it's the turn of the smart home. As a first example of this we have Beam, a company that makes a "smart toothbrush", which has upgraded its integration with the insurance industry [29].

Another interesting analysis is made by OpenMatters and the Wharton's SEI Center for Advanced Studies in Management [30]. They analyse different business models and their economic outcome. From the four models analysed, Asset Builders (physical capital), Service Providers (human capital), Technology Creators (intellectual capital) and Network Orchestrator (network capital), it is apparent that "*Network orchestrators, on average, grew revenues faster, generated higher profit margins, and used assets more efficiently than companies using the other three business models. These advantages resulted in remarkably higher enterprise values when compared with revenues*.". Figure 15 shows a comparison of different indicators for the analysed business models.

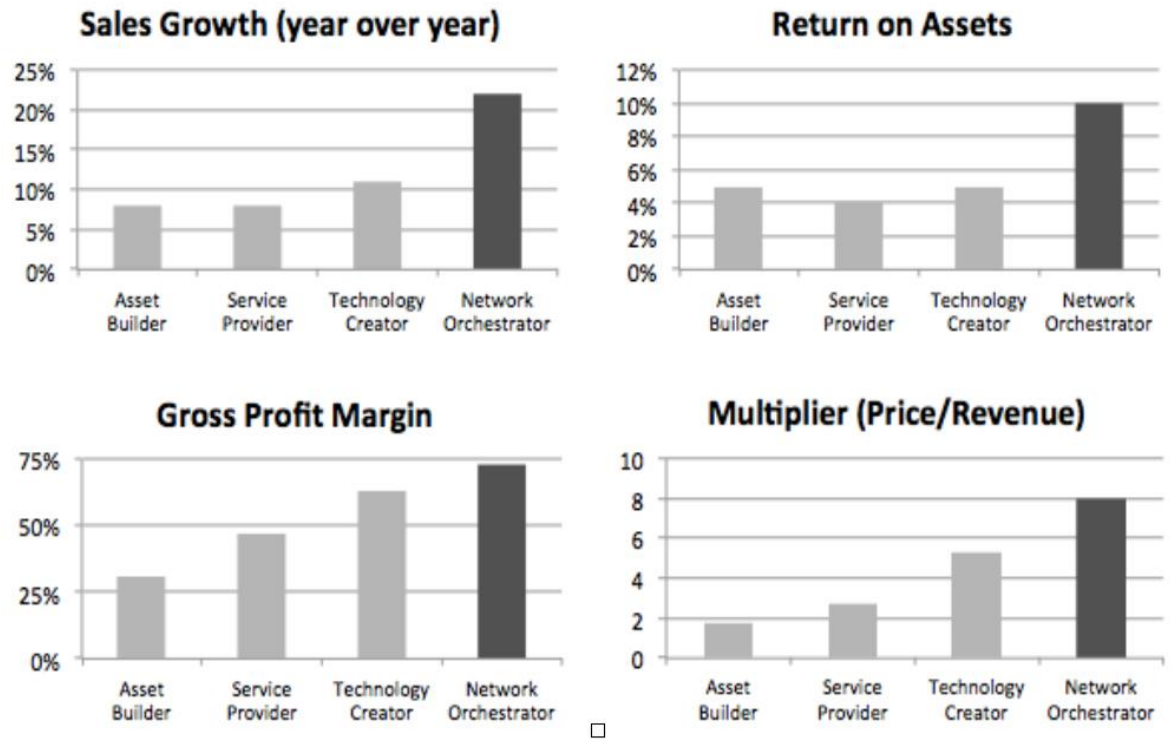

Figure 15. Business indicators for the different business models [31].

3.14.2 Economic Impact

In "*Monetizing the Smart Home Through Ecosystem of Services*", from NextMarket Research [32], new revenue paths are envisioned by the possibilities of having connected or "smart" objects (see Figure 16). Consumers will be more likely to buy additional products, upgrades or services when these are connected.

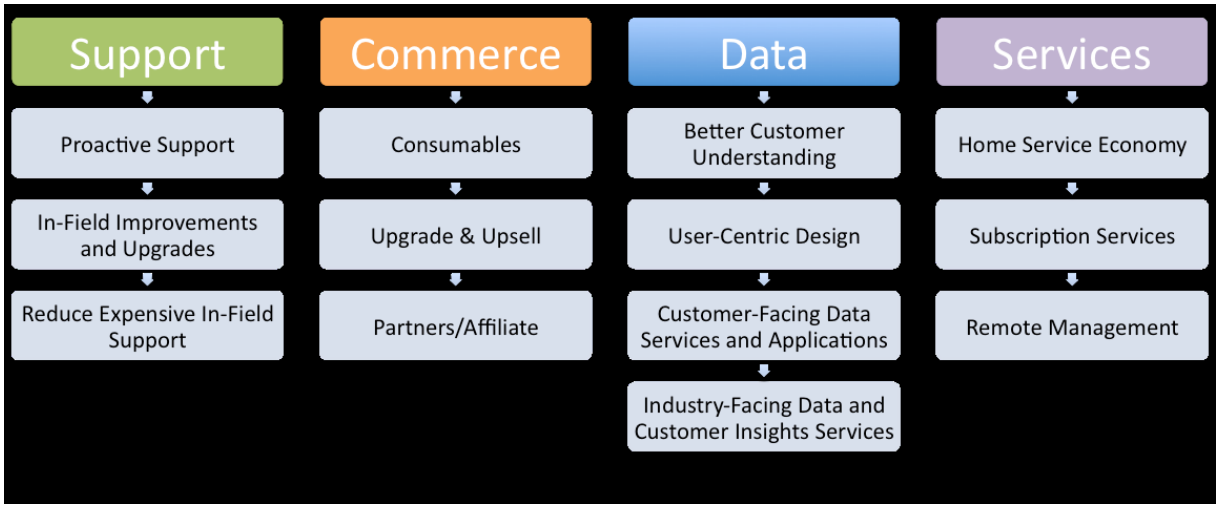

Figure 16. Monetization models for Connected Products [32].

Traditional commerce is now moving to other forms, such as automated consumption and ordering of consumables. There is potential for revenue for different stakeholders if they collaborate and coordinate together. Manufacturers, CPG companies and other consumer product companies can benefit from the integrated view of the product lifecycle in TagItSmart.

The value of the IoT for the economy in the upcoming years is being predicted by many sources as one of the biggest markets in the future. Business insider (2014), for example, forecast the value added to the global economy by 2019 in $1.7 trillion, promising benefits in efficiency by giving power to the user, but there is the need to overcome the hesitation brought by the security aspects. IoT Analytics (2015) [25] compiles the predictions and evolution from different sources from 2014-2020. Figure 17 shows these predictions. It has to be taken into account that the definition of "value" differs for all forecasts. For Cisco it is "value at stake", for McKinsey "potential economic value", for GE "potential global GDP for industrial internet only", and for Gartner "global economic value-add".

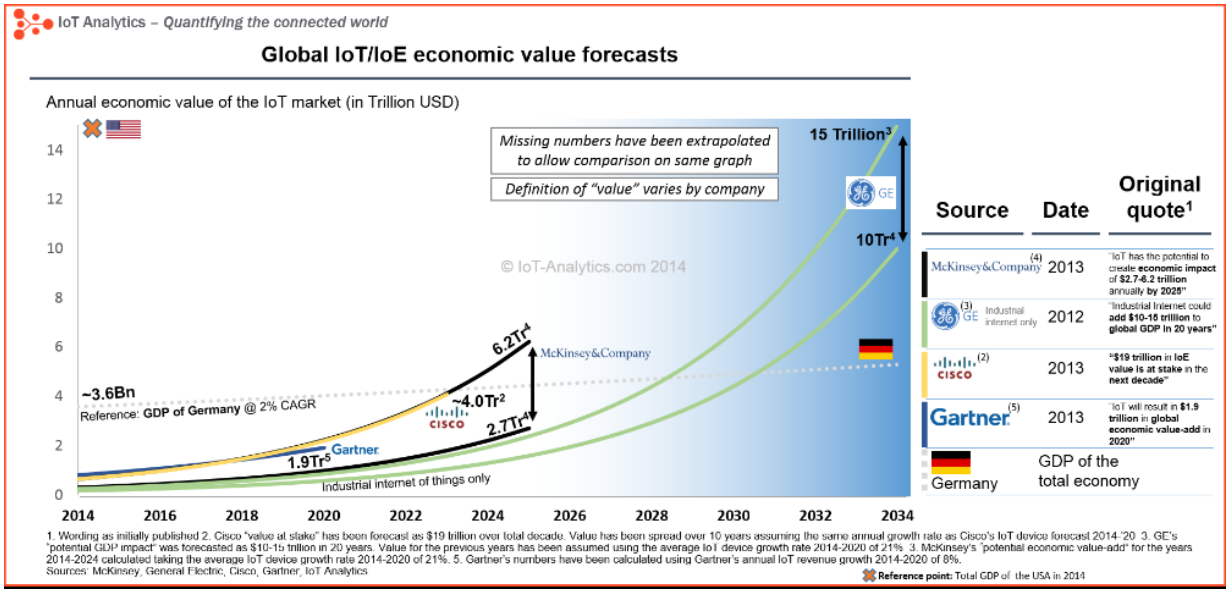

Figure 17. Global IoT/IoE economic forecasts [25].

3.14.3 Supply chain and product lifecycle impact

TagItSmart is aiming at revolutionising the lifecycle management of products and providing significant improvements in the supply chain in terms of optimisation of processes as well as reducing costs and providing new possibilities for the development of additional revenue streams.

Figure 18 shows a summary from different sources (Forrester, SAP, EU Chamber of commerce, Deloitte) about some aspects and predictions on supply chain related issues.

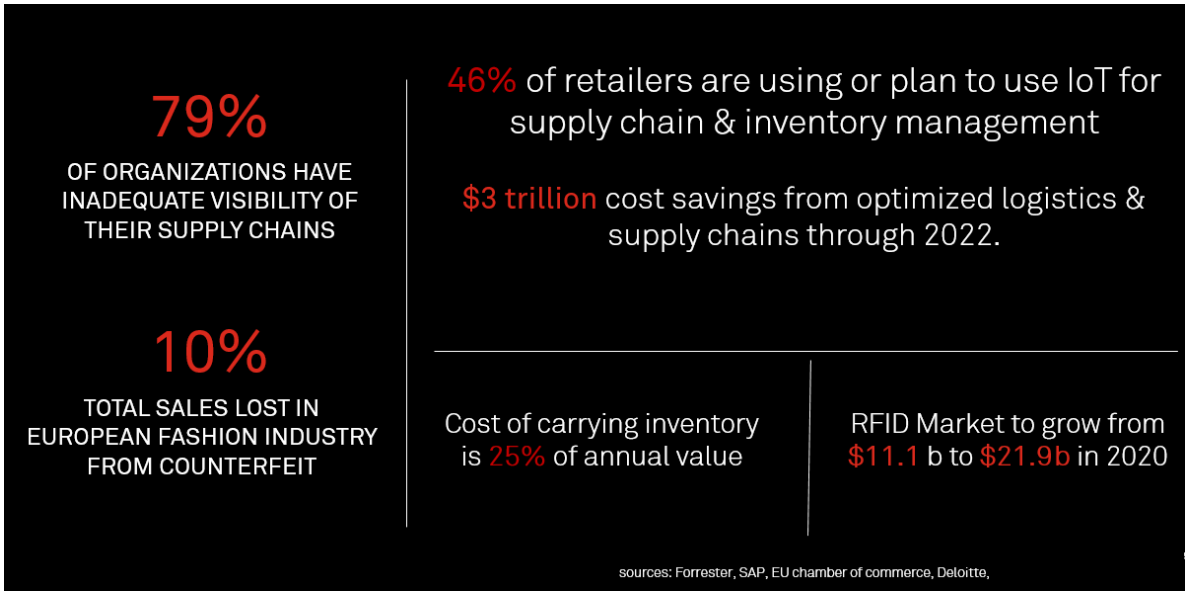

Figure 18. Opportunities to optimise supply chain operations.

For example, in monitoring the supply chain, TagItSmart is adding new value to all stakeholders, not replacing the existing solutions. This is not easily quantifiable at this early stage of the project, however, more information will be possible to be evaluated as the pilots are deployed in the different scenarios.

The benefit of using TagItSmart to monitor and augment the product lifecycle has already some clear examples in our use cases, such as as the condition dependent pricing based on the labels with functional ink, where, as our partner UniverExport explains, 1 EUR cent could be saved per item by not having to reprint labels. In addition to that, there is the labour cost associated to attach new labels. One person can attach approx. 500 labels per hour. While initially this does not sound a lot, we have to take into account that the number of articles is huge as well as the number of shops in which the exercise has to be done. Therefore, the savings can be significant, in particular in those countries where labour cost is more expensive. Another straight forward benefit for Univer-Export can be seen in regards to the creation of user engagement and loyalty programmes, where the cost of registering a new consumer to a loyalty club is approx. 10 EUR cents, in addition to 1 man day per 100 registered consumers. The use of the item level identification and scanning capabilities that TagItSmart aims to provide will allow the automatic registration of consumers, which would bring significant benefits to both consumers and retailers in terms of reducing costs, creating better engaging strategies and generating new possibilities to create new services.

3.15 Conclusions

IoT market is unstoppably becoming **one of the biggest markets** in the foreseeable future (already around 3000B units in 2013). The next wave of IoT applications and services come with the promise of **more personalisation, more information and more engagement** activities for consumers, which are already willing to invest in products that are smarter. Plenty of opportunities arise to optimise the whole value chain, as long as a network of **shared information about the products** is present. Many related industries are going to be affected by this, as packaging companies and insure companies, among others, are requested to be more transparent to consumers.

Consumers are inevitably **going mobile**, which is making the importance of tags that are readable by smartphones rise. Creating these relationships one-to-one between the consumers and the products bring many benefits for both sides. However, the growth in the number of available smart products will require **integrated solutions and the creation of ecosystems**, as consumers are ultimately more interested in solutions rather than in things.

The interconnection of products will promote **ecosystems of new online service**s, therefore **new business models** based on this network capital are gaining momentum. Sharing information throughout the whole lifecycle of products and reactivity to context information are key in the short term.

TagItSmart has at its core objectives and use cases many of the trends exposed in the market analysis. The use of **unique tags with sensing capabilities connecting products to the Web** is a key step towards personalisation. Improved **scanning mechanisms** based on mobile devices and different technologies (functional inks, nfc), linked to context information create opportunities for better experiences and **enhanced user engagement**.

TagItSmart will enable as well **sharing information about products**, from different stages in their lifecycle, involving all the interested stakeholders throught the supply chain, which will facilitate the creation of **ecosystems of products and services** and fosters **new business opportunities based on this information as well as cost reductions and optimisation of processes**. This will be made relevant in many of the use cases, from the creation of digital products, to the engagement of consumers in recycling activities, to innovative home services, as well as impacting the current operations and costs for retailers, such as the case of condition dependent pricing and brand protection.

In the use case specific analysis we found that smart tags, as proposed by TagitSmart, have an edge over existing solutions because they a) leverage existing formats and standards, b) are part of an IoT integrated ecosystem. Being an active identifier in the IoT allows for more inclusive business processes. Inclusive, because IoT technologies, such as the Web of Things, are accessible to all stakeholders. This provides a more holistic view of the supply chain, and lowers the barriers to adopting new technologies, such as the blockchain to share identifiers among all stakeholders in a tamper-proof manner.

The use cases also demonstrate the wide-ranging applicability of the labelling technologies that were pioneered as part of this project. While use cases provide concrete and comprehensive applicability scenarios, TagItSmart is by no means limited to those use cases however. By tackling cold chain and keepability requirements and needs for example, this project provides technologies that would be most beneficial for a range of further use cases in

low and medium income countries. Why could these countries benefit from TagItSmart. For three reasons. 1) Customers in these countries are mostly using mobile phones, TagItSmart, being usable with end-user technologies, can be read without specialised device. Furthermore, 2) electricity supply and counterfeit products are a serious concern for customers in low and medium income countries. TagItSmart would provide customers with the means to verify the quality of food or drugs they are about to buy. 3) by sharing TagItSmart technology on an open source basis, it would position Europe as a technology innovator and promoter of human-centred Internet of Things development, both very noble goals. We also believe the green benefit of TagItSmart. Green, because TagItSmart provides an affordable tool to enhance and augment recycling, conduct home service improvements and repairs before breakage occurs, thus reducing waste.

Section 4 - Conclusions and Recommendations

Five different use cases have been defined for the TagItSmart project: 1) digital product, 2) lifecycle management, 3) brand protection, 4) condition dependent pricing and 5) home services. The digital product use case is the umbrella use case including the whole value chain from manufacturer to transport, retail, consumer and recycling. The other use cases concentrate more in details to one or two stages of the lifecycle of the product. Stakeholders and their expected benefits, as well as required functionalities and architecture have been identified for each use case. Also market analysis for each use case has been made. Use case owners have been identified and partners participating in development of each use case have been identified for successful implementation of all technical parts of the use cases.

The market analysis provides high-level results, which we obtained through desk research. Based on these findings, we are confident about the potential of smart tags to address customer needs for various industries. However, we must to consider that there are already several competitors on the market. Therefore, we recommend a more in-depth study to evaluate our opportunities to:

- Understand which environmental factors provide IP potential: There are patents describing temperature-sensitive tags. These must be considered. Humidity-sensitive tags might be easier to patent and are also valuable.
- Understand reliability of smart tags to combat counterfeiting and piracy
- Assess partnership potentials with existing smart tags manufactures.

This work will be empowered with other work packages on architecture and other technical building blocks required for each use case. Finally, the use cases will be demonstrated and evaluated at ecosystem trials either at laboratory-scale, at controlled environment (pilot trials) and/or at real environments (field trials).

Using the co-creation approach, additional use cases will be considered during the task based on the feedback from the community/ecosystem and the Open Calls. Use cases and the requirements will be updated based on the received feedback for deliverable D1.3 (M24). For deliverable D1.3 needs and expectations of interested stakeholders and end-users towards the use cases will be scoped. For this phase of requirements definition, the usage of platforms for ideas collection, such as Owela (www.owela.fi), along with dedicated workshops, will help involve all the stakeholders and collect the ideas and requirements in a systematic way. The market analysis will be also further elaborated.

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