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IoT Platforms Initiative

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9.1 Introduction

The scope of Internet of Things (IoT) European Platforms Initiative (IoT-EPI) is to create ecosystems of "Platforms for Connected Smart Objects", integrating the future generations of devices, embedded systems, network technologies, and other evolving ICT advances.

These environments support citizens and businesses for a multiplicity of novel applications. They embed effective and efficient security and privacy mechanisms into devices, architectures, service and network platforms, including characteristics such as openness, dynamic expandability, interoperability, dependability, cognitive capabilities and distributed decision making, cost and energy-efficiency, ergonomic and user-friendliness.

Such smart environments are enriched through the deployment of wearable/ambulatory hardware to promote seamless environments. The platforms from the beginning involve and connect technology developers and application developers and complementors who will enhance the impact of the IoT platform. The IoT European Platforms Initiative is coordinated by two consortia UNIFY-IoT, Be-IoT and include seven research and innovation projects.

The IoT-EPI program includes the research and innovation consortia that are working together to deliver an IoT extended into a web of platforms for connected devices and objects. The platforms support smart environments, businesses, services and persons with dynamic and adaptive configuration capabilities.

The goal is to overcome the fragmentation of vertically oriented closed systems, architectures and application areas and move towards open systems and platforms that support multiple applications. The European Commission funds the IoT-EPI with EUR 50 millions. The projects are presented in the following sections.

9.1.1 AGILE Project: A Modular Adaptive Gateway for IoT

AGILE builds a modular and adaptive gateway for IoT devices. Modularity at the hardware level provides support for various wireless and wired IoT networking technologies (e.g., KNX, Z-Wave, ZigBee, Bluetooth Low Energy, etc.).

It allows fast prototyping of IoT solutions for various domains (e.g., home automation, environment monitoring, wearables, etc.).

At the software level, different components enable new features: data collection and management on the gateway, intuitive interface for device management, visual workflow editor for creating IoT apps with less coding, and an IoT marketplace for installing IoT apps locally.

The AGILE software can auto-configure and adapt based on the hardware configuration so that driver installation and configuration is performed automatically. IoT apps are recommended based on hardware setup, reducing the gateway setup and development time significantly.

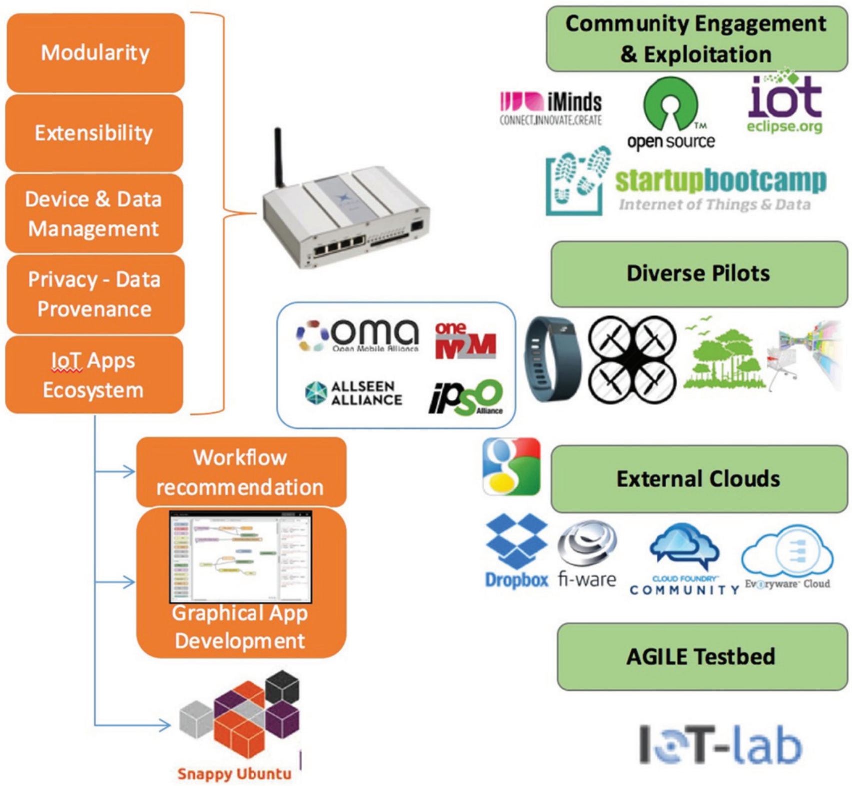

Figure 9.1 The AGILE project overview.

9.1.2 The Challenges

Prototyping an IoT solution is a complex process that involves the careful selection of appropriate components, both at the hardware and software level.

On the hardware side, there are many wireless and wired communication technologies and protocols to choose from and support. For non IP-based networks, there is always a need of a gateway for connecting smart objects to the Internet. Unfortunately, gateways provided by vendors nowadays cannot be extended easily to support new protocols and are domain-specific and closed solutions.

From the software perspective, the plethora of communication protocols complicates the selection of the most appropriate ones for device communication with external services and Machine to Machine (M2M) interaction.

IoT vendors implement their own Cloud-based solutions that are vertical, product-oriented and closed, since there is no standardized way of creating end-to-end IoT applications and no wide acceptance of an IoT platform model. This leads to great privacy and data control issues.

9.1.3 The AGILE Solution

AGILE creates an open, flexible and widely usable IoT solution and puts it at the disposal of industries (start-ups, SMEs, tech companies) and individuals (researchers, makers, entrepreneurs) as a framework that consists of:

- A modular IoT gateway enabling various types of devices (wearables, home appliances, sensors, actuators, etc.) to be connected with each other and to the Internet;
- Data management and device control maximizing security and privacy, at local level and in the cloud, technologies and methodologies to better manage data privacy and ownership in the IoT;
- Support of various open and private clouds;
- Recommender and visual developer's interfaces enabling easy creation of applications to manage connected devices and data;
- Support of mainstream IoT/M2M protocols, and SDKs from different standardization bodies for device discovery and communication;
- Two separate gateway hardware versions: a) the "makers" version, based on the popular RaspberryPi for easy prototyping and b) the "industrial" version for more industrial and production ready environments.

9.1.4 The AGILE Use Cases

To demonstrate the applicability of the AGILE modular hardware and software gateway, the project is developing the following use cases in five different pilots:

- Quantified Self (wearables for self-tracking)
- Crop and livestock monitoring using drones
- Air pollution monitoring
- Port radiation & pollution monitoring using drones
- Smart retail solutions for enhanced shopping experiences.

AGILE will become part of the existing IoT-Lab infrastructure in France managed by INRIA. With more than 2.500 sensors deployed in five locations, AGILE users will have the opportunity to evaluate their IoT applications in real environments, collect and store sensor data, and interact with real devices.

9.2 BIG IoT: Bridging the Interoperability Gap of the IoT

Despite various research and innovation projects working on the IoT, no broadly accepted professional IoT ecosystems exist. The reason for that are high market entry barriers for developers and service providers due to a fragmentation of IoT platforms. Developers who want to make use of smart objects hosted by various providers need to negotiate access to their platforms individually and implement specific adapters. Since the efforts to negotiate individual contracts often outweigh the possible gains, platform providers do not see strong incentives to open their platforms to third parties.

The goal of this project is to overcome these hurdles by **B**ridging the **I**nteroperability **G**ap of the **IoT** (BIG IoT) and by creating marketplaces for service and application providers as well as platform operators.

Previous EC-funded projects that address such enablement of IoT ecosystems are, e.g., IoT-A[1], by providing a common architecture, FIWARE[2] that offers Generic Enablers as building blocks, or projects such as compose[3] and OpenIoT[4], which offer dedicated IoT platforms to aggregate other platforms and systems. BIG IoT will **<u>not</u>** develop **yet another platform** in order to enable cross-platform IoT applications. Instead, we will address the interoperability gap by defining a generic, unified Web API for smart object platforms, called the BIG IoT API. The establishment of a marketplace where platform, application, and service providers can monetize their assets will introduce an incentive to grant access to formerly closed systems and lower market entry barriers for developers.

With this approach based on the generic BIG IoT API, an IoT ecosystem will come to life, as it will offer a functionally rich but at the same time easy way to discover, access, control, manage, and secure smart objects.

The API will be designed in an open community process and the project consortium will engage with current standardization initiatives to receive input and deliver contributions to specifications. The BIG IoT API will be implemented by overall eight smart object platforms.

Following an evolutionary and agile approach, the developed technologies will be concurrently demonstrated in three regional pilots involving partners with strong relation to public authorities. Under a common theme of "smart mobility and smart road infrastructure", various use cases within the pilots will validate the developed technologies.

[1]http://www.iot-a.eu
[2]http://www.fiware.org
[3]http://www.compose-project.eu
[4]http://openiot.eu

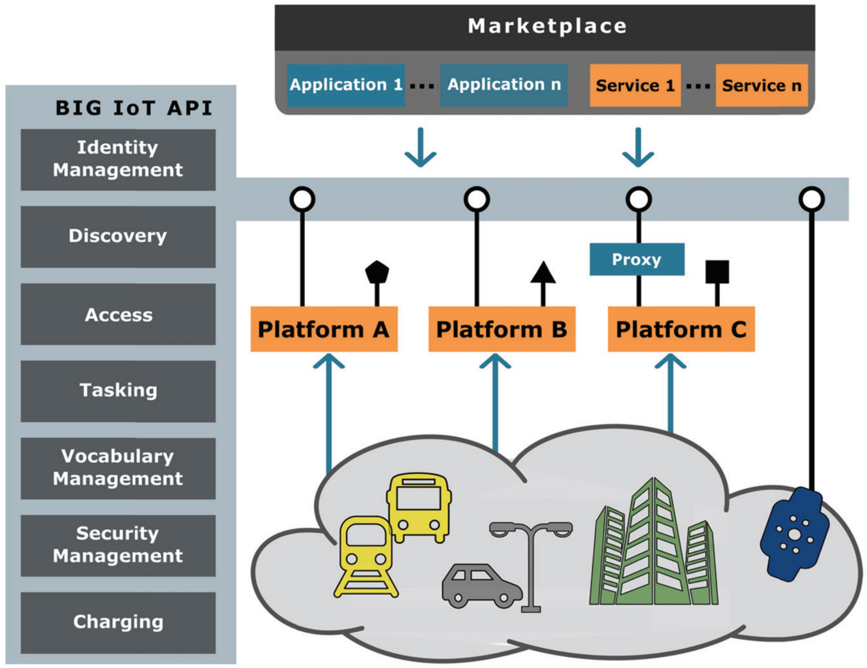

Figure 9.2 Overview of the BIG IoT approach[5].

To foster the external implementation of the BIG IoT API the project will conduct focused dissemination and exploitation activities to leverage the developer community. Further, an Open Call will be conducted as part of the project to engage SMEs in the implementation of the services, applications, and platforms conforming with the BIG IoT.

9.3 bIoTope: Building an IoT Open Innovation Ecosystem for Connected Smart Objects

New IoT applications that leverage ubiquitous connectivity, system interoperability and analytics, are enabling Smart City initiatives all over the world. Although the smart city paradigm paves the way for societal and economic opportunities (e.g., to reduce costs for societies, foster a sustainable economic growth...), they also pose architectural and structural issues that must be addressed for businesses to benefit. One of the most critical obstacles is the

[5]Icons made by Freepik from www.flaticon.com

vertical silos' model that shapes today's IoT, which hampers developers – *due to the lack of interoperability and openness* – to produce new added value across multiple platforms (data is "siloed" in a unique system, cloud, domain, and stays there). Several organisations and standardization fora have understood this critical challenge and started to build up consortia and IoT initiatives to address it.

The Open Group was among the first ones with the *IoT Work Group* established in 2010 [1]. More recent initiatives are, for example, the *Web of Things* initiative at W3C that aims to create open ecosystems based upon open standards, including identification, discovery and interoperation of services across platforms; the *Alliance for IoT Innovation* (AIOTI) launched by the EU with the aim of strengthening links and building new relationships between the different IoT players (industries, SMEs, startups); the *Open Platform 3.0*™ at The Open Group that focuses more on organization applications and practices; the *OneM2M global standards* initiative that involves eight standards bodies for M2M communications; or still the *IEEE IoT* initiative.

Although most of those initiatives promote various types of standards and specific technology enablers, they all share the same vision about relying as much as possible on open and interoperable standards to foster open ecosystems and unlock the commercial potential of the IoT. While in the US, IoT ecosystems are created around big, multinational players such as Apple or Google, the EU's strength is rather in smaller and agile companies. Several past EU initiatives gave rise to a multitude of IoT platforms in various domains [2] (e.g., OpenIoT cloud platform, BUTLER, FI-WARE, etc.).

Despite these efforts, it is a key challenge for the EU to turn those initial IoT platforms into economically viable entities and ecosystems. This is the current focus and goal of the H2020 ICT30 R&I Programme that is composed of two support action projects and seven R&I projects. In this chapter (in the next two sections), we briefly introduce the vision, objectives and building blocks underlying one of these projects named bIoTope (standing for *Building an IoT OPen innovation Ecosystem for connected smart objects*), along with a brief overview of the smart city pilots that will be developed.

9.3.1 Building Blocks Underlying the bIoTope Project

This section provides a brief overview of key building blocks that underlie the bIoTope ecosystem, namely *(i)* IoT standards that will be used as interoperability enablers across various IoT platforms, and *(ii)* context-aware services

(CoaaS) that provide systems with reasoning capabilities that allow them to react appropriately to new situations.

9.3.2 O-MI and O-DF Standards

Primary goal of bIoTope is to enable companies to easily create new IoT systems and rapidly harness available information using advanced Systems-of-Systems (SoS) capabilities for Connected Smart Objects. To this end, bIoTope takes full advantage of messaging standards developed and officially published by The Open Group, notably the Open Messaging Interface (O-MI) and Open Data Format (O-DF) [3, 4] standards.

Those standards emerged out of past EU FP6-FP7 projects, where real-life industrial applications required the collection and management of product instance-level information for many domains involving heavy and personal vehicles, household equipment, etc.

Based on the needs of those real-life applications, and as no existing standards could be identified that would fulfil those requirements without extensive modification or extensions, the partner consortia started the specification of new IoT interoperability standards. O-MI provides a generic Open API for implementing RESTful IoT information system, also using other underlying protocols than HTTP as illustrated in Figure 9.3.

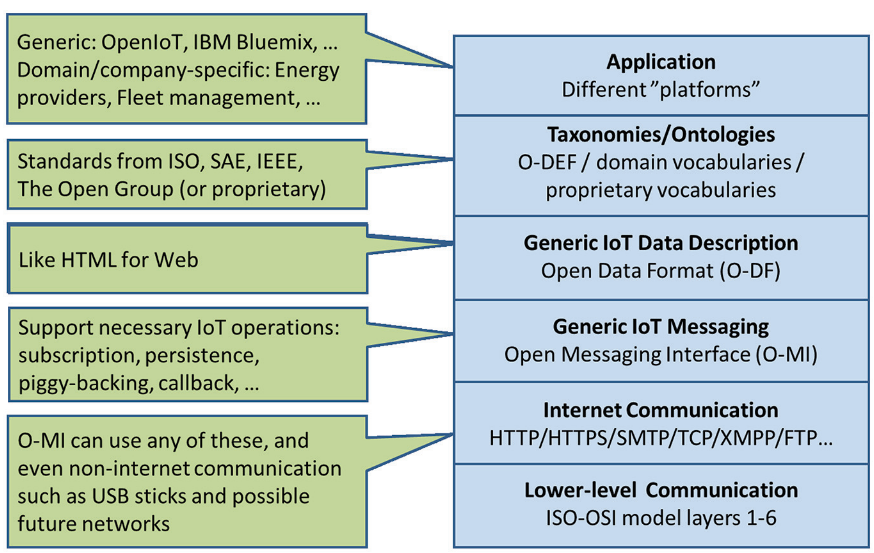

Figure 9.3 Positioning of O-MI and O-DF in IoT protocol stack.

O-DF provides a generic content description model for Objects in the IoT that can be extended with more specific vocabularies (e.g., using domain-specific ontology vocabularies).

In the same way as HTTP can be used for transporting payloads in formats other than HTML, O-MI can be used for transporting payloads also in other formats than O-DF [5].

When used together, O-MI and O-DF provide the necessary tools for "any" IoT information systems to interoperate successfully in ad hoc manners, which is necessary also for dealing with context.

9.3.3 Context-as-a-Service

Context awareness and provisioning (i.e., CoaaS) is a key feature of bIoTope ecosystem. CoaaS will be providing relevant, dependable, trustworthy real-time and historical context to bIoTope services, pilots, platforms and applications through open APIs. Context is defined as "any information that can characterise a situation of an entity" [6]. Tremendous opportunities and challenges exist in implementing and organizing such context-aware systems on different scales, ranging from context-aware printing; context-aware enterprises that respond with agility to an understanding of physical circumstances; context-aware toys that interact with children aware of their age, abilities, parental constraints, context-aware parking areas that tell drivers where to go, to context-aware road intersections that warn drivers of dangerous situations [7].

Context awareness R&D efforts in bIoTope focus on a powerful theoretical framework that enables domain-agnostic representation of context, reasoning about and validation of context. Very little research has been done on context- and situation-prediction [8]. Solid theoretical methods including Particle and Kalman filters, Bayesian Networks, machine learning and Dempster-Shafer theory, Markov models and Reinforcement learning underpin CoaaS. Computationally efficient context fusion from multiple heterogeneous IoT sources is very much a fundamental challenge that is also being addressed in bIoTope. The CoaaS will therefore provide run-time support for advanced context-awareness through context prediction, proactive adaptation, privacy and UI awareness, and personalisation that will lead to the emergence of intelligent, user and object-driven and user-centric services. Our context service components will be open, O-MI/O-DF compliant and, most importantly, scalable.

9.3.4 bIoTope Large-Scale Pilots

Two categories of pilots will be developed in bIoTope to validate the effectiveness of the bIoTope SoS ecosystem for IoT, namely:

- *Domain-specific pilots*: ensure industrial impact through customer networks of bIoTope partners addressing electric car charging stations, self-managing buildings and smart air quality;
- *Cross-domain smart city pilots*: provide proofs-of-concept of IoT system composition and interoperability scenarios in smart city environments (Helsinki, Brussels region, Grand Lyon) including smart metering, shared electric vehicles, smart lighting, etc., as illustrated in Figure 9.4.

9.4 INTER-IoT: Interoperability of Heterogeneous IoT Platforms

INTER-IoT project aims at the design, implementation and experimentation of an open cross-layer framework and associated methodology and tools to enable voluntary interoperability among heterogeneous IoT platforms. The proposal will allow effective and efficient development of adaptive, smart IoT applications and services atop different heterogeneous IoT platforms, spanning single and/or multiple application domains. The project will be tested in two application domains: port transportation and logistics and mobile health; additionally, it will be validated in a cross-domain use case.

Most current existing sensor networks and IoT device deployments work as independent entities of homogenous elements that serve a specific purpose, and are isolated from "the rest of the world". In a few cases where heterogeneous elements are integrated, this is done either at device or network level, and focused mostly on unidirectional gathering of information [9]. A multi-layered approach to integrate heterogeneous IoT devices, networks, platforms, services and data will allow heterogeneous elements to cooperate seamlessly to share information, infrastructures and services as in a homogenous scenario [10].

9.4.1 Open Interoperability

Lack of interoperability causes major technological and business issues such as impossibility to plug non-interoperable IoT devices into heterogeneous IoT platforms, impossibility to develop IoT applications exploiting

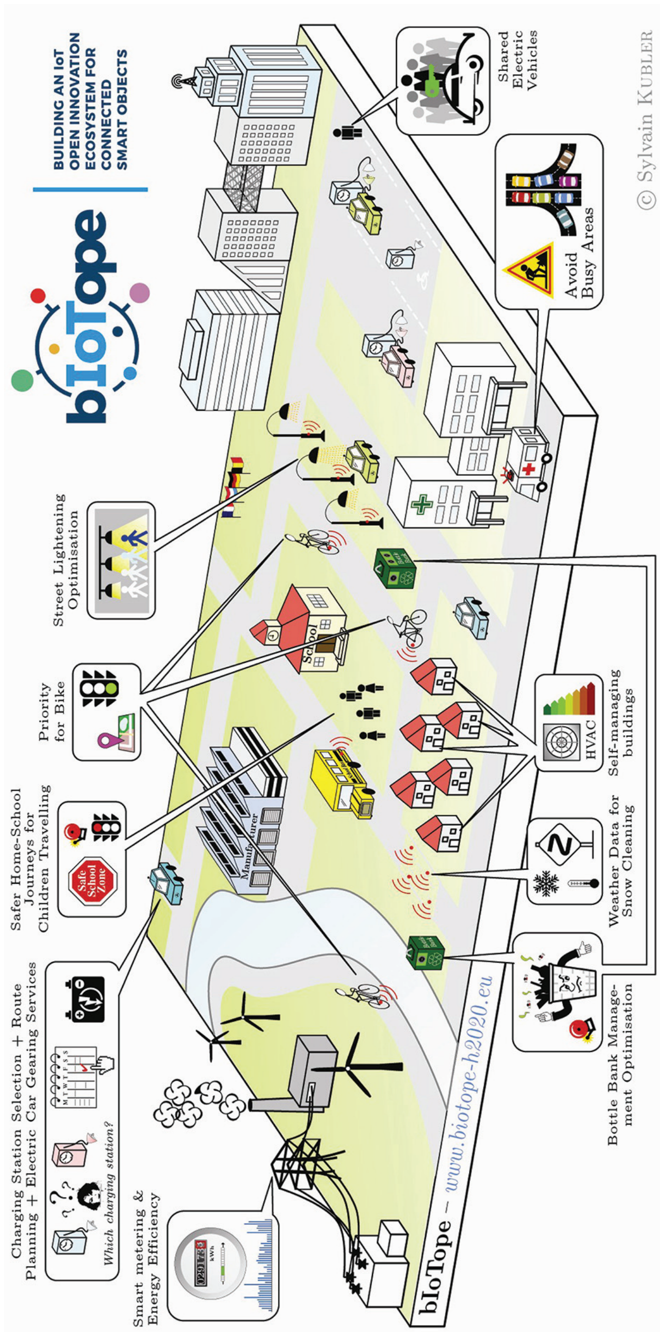

Figure 9.4 Overview of the bIoTope large-scale pilots to be implemented in the bIoTope project.

multiple platforms in homogeneous and/or cross domains, slowness of IoT technology introduction at a large-scale, discouragement in adopting IoT technology, increase of costs, scarce reusability of technical solutions, and user dissatisfaction [11].

The main goal of the INTER-IoT project is to comprehensively address lack of interoperability in the IoT realm by proposing a full-fledged approach facilitating "voluntary interoperability" at any level of IoT platforms and across any IoT application domain, thus guaranteeing a seamless integration of heterogeneous IoT technology [11].

INTER-IoT aims to provide open interoperability, which delivers on the promise of enabling vendors and developers to interact and interoperate, without interfering with anyone's ability to compete by delivering a superior product and experience.

In the absence of global IoT standards, the INTER-IoT project will support and make it easy for any company to design IoT devices, smart objects, and/or services and get them to the market quickly, thus creating new IoT interoperable ecosystems.

The solution adopted by INTER-IoT will include three main products or outcomes (see Figure 9.5):

- **INTER-LAYER**: methods and tools for providing interoperability among and across each layer (virtual gateways/devices, network, middleware, application services, data and semantics) of IoT platforms. Specifically, we will explore real/virtual gateways [13] for device-to-device communication, virtual switches based on SDN for network-to-network interconnection, super middleware for middleware-to-middleware integration, service broker for the orchestration of the service layer and a semantics mediator for data and semantics interoperability [14].
- **INTER-FW**: a global framework (based on an interoperable meta-architecture and meta-data model) for programming and managing interoperable IoT platforms, including an API to access INTER-LAYER components and allow the creation of an ecosystem of IoT applications and services.
- **INTER-METH**: an engineering methodology based on CASE (Computer Aided Software Engineering) tool for systematically driving the integration/interconnection of heterogeneous non-interoperable IoT platforms.

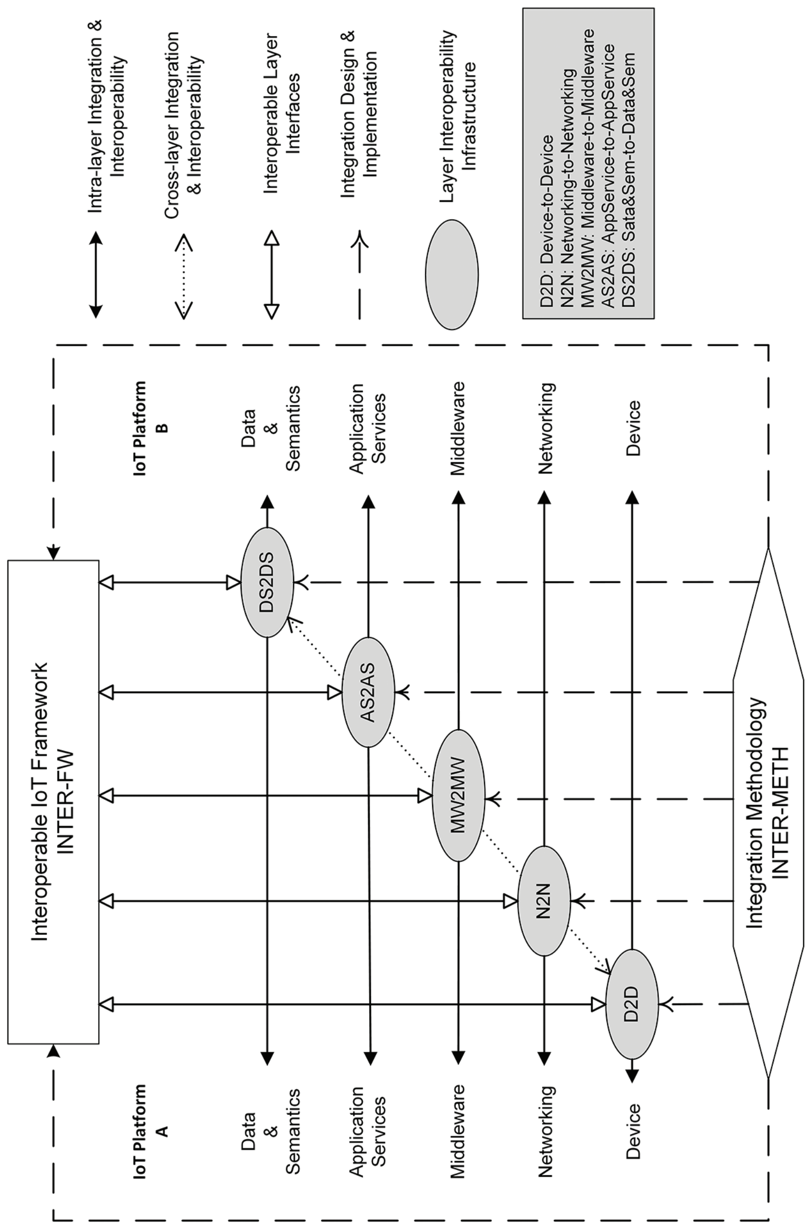

Figure 9.5 INTER-IoT abstract architecture associating INTER-IoT products.

9.4.2 Use-Case Driven

The INTER-IoT approach will be use case-driven, implemented and tested in three realistic large-scale pilots:

- **INTER-LogP**: will be designed and built to specifically accommodate the communication and processing needs of moving vehicles and cargo items (being conceived as moving things according to the IoT paradigm), e.g., by seamless and secure integration of various vehicle telematics solutions as well as mobile devices serving as retrofitting equipment. It will work over smart containers (i.e., reefers and IMOs[6]), trucks and different infrastructures, allowing exchange of information associated with the operations and movements of containers inside the terminal.
- **INTER-Health**: aims at developing an innovative, open integrated m-Health IoT platform for humans monitoring in a decentralized way and in mobility. The integrated platform, derived from existing platforms (i.e., e-Care Tilab platform and BodyCloud) [15], will be open to be further enhanced by integrating new subsystems by using the INTER-IoT approach.
- **INTER-DOMAIN**: a cross-domain pilot involving IoT platforms from different application domains, including transport and logistics but extendable to other domains.

9.5 symbIoTe: Symbiosis of Smart Objects Across IoT Environments

The IoT is evolving around a plethora of vertical platforms, each specifically suited to a given scenario and often adopting proprietary communications, device and resource control protocols.

The emerging need for cross-domain IoT applications and services highlights the necessity of interoperability across IoT platforms for a unified and secure sharing of and access to sensing/actuating resources.

symbIoTe (Symbiosis of smart objects across IoT environments) steps into this landscape to devise an interoperability framework across existing and future IoT platforms.

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[6] IMO containers are used to transport safely dangerous goods, available at http://www.imo.org

The framework will enable the discovery and sharing of resources for rapid cross-platform application development and will facilitate the blending of next generation of smart objects with surrounding environments.

9.5.1 The Vision

symbIoTe aims at introducing IoT platform federations, provisioning of domain-specific enablers, sharing of IoT resources and new business models in the IoT landscape.

Vertical IoT solutions focus on specific activities of everyday life, but are restricted to the ecosystem that can be created around a single platform (see "Closed Private" IoT Business models in [16]). Through *federations*, multiple IoT solutions can collaborate so as to i) provide cross-domain solutions, and ii) share IoT resources and the respective measurements in locations originally out of their reach.

For the co-creation of cross-domain solutions it is important that expertise in a certain domain by existing solutions is exploited. To achieve this, current IoT solution providers should wrap and offer their domain-specific platforms in a "Sensing as a Service" manner [17]. This way, important and useful information with respect to a single domain can be provided to third parties, in the form of a *domain-specific enabler*, typically after some pre-processing and aggregation.

To deal with the increasing complexity of IoT systems and reduce the deployment costs, collocated platforms can choose to be cooperative by opening up the access to their resources to third parties and by implementing generic high-level APIs. In addition, they may choose to collaborate by *sharing the common physical resources* in a coordinated way.

Putting the technical details aside, the federations among IoT solution providers need to be supported by the *appropriate business models* in order to be viable. While basic literature on IoT business models is arising [18], the horizontal integration in federations deserves more specific considerations since the current IoT value chain includes more stakeholders like infrastructure providers, IoT platform providers, Cloud operators, ISPs and application developers.

9.5.2 The Technical Approach

symbIoTe builds around a hierarchical IoT stack connecting smart objects and IoT gateways within smart spaces with the Cloud. Smart spaces share the available local resources, while platform services running in the Cloud should enable federations and open up northbound interfaces to third parties. The architecture comprises four layered domains, as depicted in Figure 9.6.

The *Application Domain* offers a high-level API for a unified view on different platforms to enable cooperation and support cross-platform discovery and management of IoT resources, as well as data acquisition and actuation in accordance with platform-specific business rules.

The *Cloud Domain* hosts the Cloud-based building blocks of specific platforms. To enable platform federations and sharing of resources, a symbIoTe interworking interface will be defined and implemented for the exchange of information between two collaborating IoT platforms.

The *Smart Space Domain* comprises smart objects, IoT gateways as well as local computing and storage resources. To enable dynamic sensor discovery and configuration, as well as dynamic sharing of the wireless medium, symbIoTe introduces the symbIoTe middleware which will expose a standardized API for resource discovery and configuration within a smart space, and implement a sensor-discovery protocol for a simplified integration of sensors with platforms hosted in particular smart space domains.

The *Device Domain* spans over heterogeneous devices, which should be capable to dynamically blend with the surrounding environment and get discovered by the symbIoTe middleware. Smart objects can be configured on the fly to be integrated with different IoT platforms hosted within the smart space, preventing the lock-in to specific IoT platforms.

9.5.3 The Use Cases

symbIoTe use cases are targeting typical daily environments to assist people seamlessly while performing their daily activities. The diversity of the considered environments is ideal to showcase platform interoperability.

Smart residence will enable automatic discovery and configuration of devices in homes and offices as well as sharing of available resources between collocated platforms. The basic idea is to exploit local resources and dynamic service composition to manage and access functions across any available device.

Smart campus will develop campus-wide smart services across various platforms with a focus on collaboration services which utilize indoor navigation and room/equipment booking. In addition, it will enable "eduroam-like" IoT services for visiting students and staff and showcase device roaming across IoT domains.

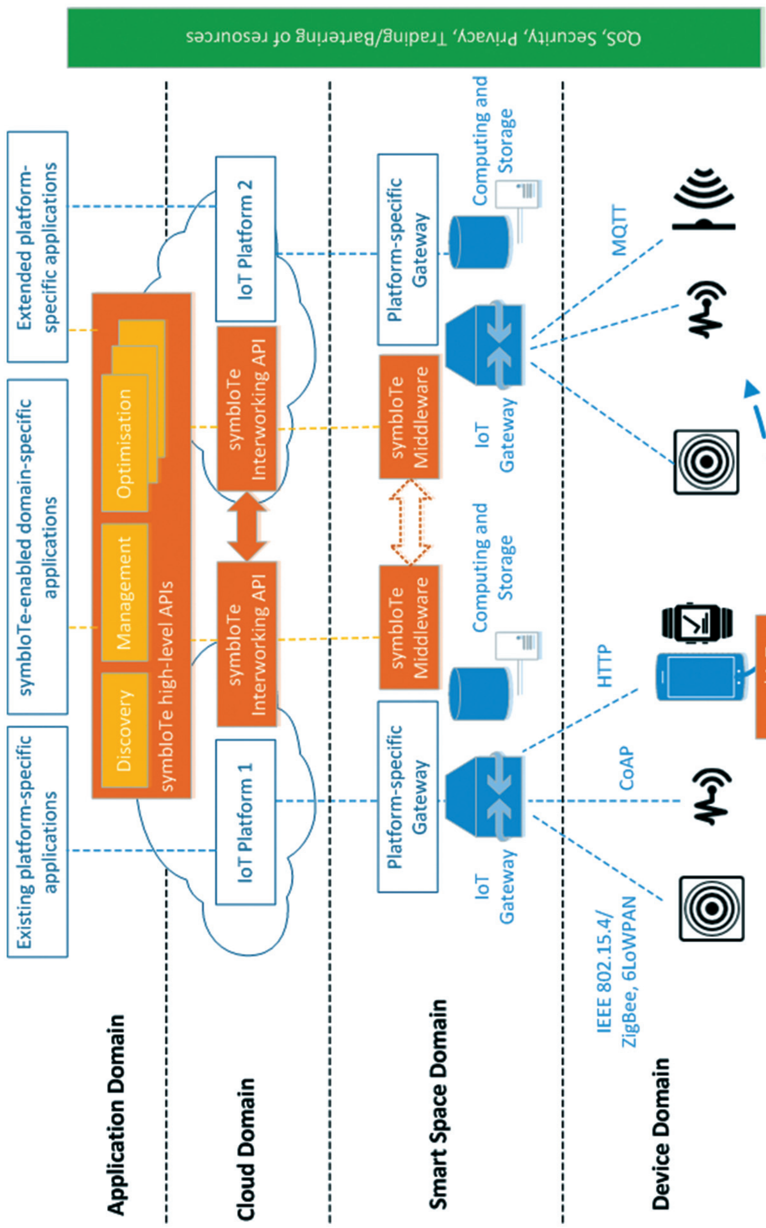

Figure 9.6 The symbIoTe high-level architecture.

Smart stadium will enable indoor location services while supporting strict security and privacy policies. The goal is to link digital and physical worlds so as to create a unique experience for stadium visitors.

Smart Mobility and Ecological Routing will bring together existing city-wide air quality measurement infrastructures with wearable air quality sensors to predict the total emission levels commuters are exposed to. A domain specific enabler will offer a service for the calculation of the ecologically preferable routes for motorists, bicyclists and pedestrians.

Smart Yachting will automate the information processes between a boat and the mainland, to allow i) users on a boat to identify automatically the territorial services and ii) the port authorities to automatically send various land information to the boat, e.g., during the mooring phase.

9.6 TagItSmart

The IoT is about connecting objects, things, and devices, billions of them. What is still out of reach due to technological limitations and the cost of deployment are mass market products: a carton of milk, a package of steak, a basket of apples, a book, a CD etc. Today, these products are identified by printed tags (such as barcodes or QR codes). These codes relate to the product they tag, not to the unique unit/object that holds the tag. Once attached to an object, tags are usually static and the information they provide does not change, regardless of the state or events happening in the immediate environment of that product.

9.6.1 Vision

Leveraging the features of functional codes (such as QR codes printed using functional inks) to change according to the context changes of each tagged product together with wide availability of smart phones that can capture/record/transmit these codes we can create context sensors for mass market products and convert mass market products into connected mass market products with unique identity that can report on their environment.

This opens up possibilities for a whole new range of services to be created and consumed by the user, and for the user. The outcome will be the creation of an almost infrastructure-less IoT framework applicable in multiple industry sectors.

$$\text{Funcational ink} + \text{optical tags} + \text{crowd sourced smartphone}$$
$$= \textbf{IoT for mass market products}$$

9.6.2 Objectives

The overall objective of TagItSmart is to create a set of tools and enabling technologies integrated into a platform with open interfaces enabling users across the value chain to fully exploit the power of condition-dependent functional codes to connect mass market products with the digital world across multiple application sectors.

TagItSmart will define a framework, enabling technologies and the tools required to design and exploit functional codes across multiple application sectors in a secure and reliable manner. The project will leverage clearly identified and well established catalysts (i.e., functional inks, printed circuit NFC, smartphones pervasiveness and cloud computing) to enable inclusion of any mass market product into the world of connected objects.

Functional inks and printed NFCs will be used to create functional codes which will provide sensing capabilities to the objects they are attached to. Product manufacturers, shopping centres, supply chain providers and other stakeholders from different sectors will be able to leverage the framework to easily and automatically produce and deploy these codes according to their needs and the properties they need to observe and track. Functional

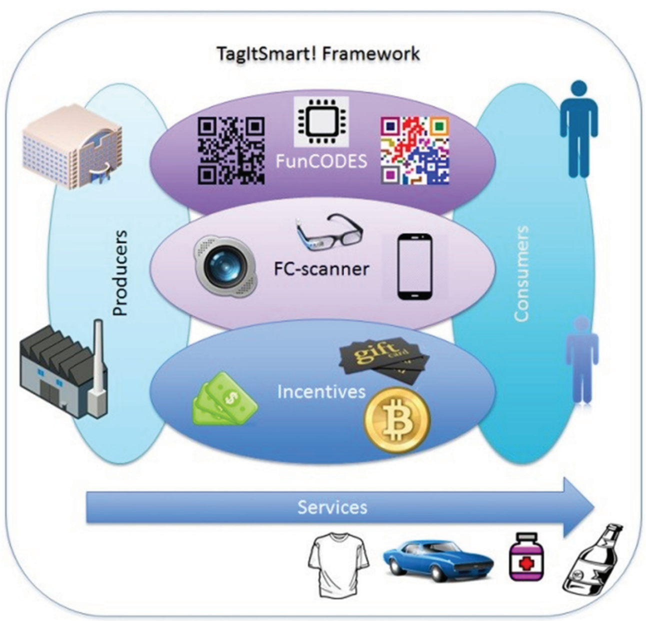

Figure 9.7 TagItSmart concept overview.

codes scanners (fixed and provided by existing infrastructure, or supported by participatory engagement of consumers) will be used to obtain data from functional codes throughout the product lifecycle.

9.6.3 The Approach

The following are the main characteristics of the TagItSmart project's approach and methodology:

1. Leverage and re-use the existing solutions, components, architectures, communities, ecosystems, do not build from scratch.
2. Build open systems, use open source and interact with other relevant initiatives and ecosystems identified in collaboration with the community.
3. Start building a community and an ecosystem immediately from the beginning of the project.
4. Use co-creation methodology to specify new use cases, listen and be agile to react on the input.
5. Pilot solutions early. Involve community in evaluation. Iterate.
6. Use open calls to address new use cases and extend TagItSmart Functionality.
7. Aim to create commercial opportunities already during the project.

9.6.4 Industry Impact

Consumers will be able to get additional assurance about authenticity of the product, information about the way the item in hands was handled, transported etc. as well as to receive other services and incentives provided by manufacturers, retailers and third party service providers.

Manufacturers will be able to track individual items they manufactured throughout the product lifetime, thus offering insights into how the item is being handled, used and finally disposed of as well as enabling them to interact directly with the consumers.

Retailers will be able to monitor individual items on the shelves, improve logistics and supply chain and offer new services to consumers.

Developers will be able to build applications and services on top of the open API and provide them to consumers whenever a tagged product is scanned.

The TagItSmart project includes two open calls for the third parties willing to build new components for TagItSmart framework as well as new services leveraging the provided open API. For this activity, a budget of €1.2 million has been allocated.

9.6.5 Use Cases

The TagItSmart project plans to address at least the following 5 use cases.

1. **"Digital Beer"**: Digital beer is a product that is marked with functional codes, during its production and distribution using the TagItSmart platform. For the digital beer, the TagItSmart enables item-level control, lifecycle management, digital engagement and authenticity control. The functional codes' sensing capabilities make it possible to track products internal and external conditions throughout the lifecycle.
2. **"Lifecycle and Consumer Engagement"**: This use case will implement a system that allows full lifecycle management of every fast-moving consumer good (FMCG) that motivates and helps companies and citizens to recycle their waste items, overcoming the current limits.
3. **"Brand protection"**: Brand protection is a serious issue that matters to manufacturers of both high value products such as high fashion textiles and accessories, and low value products manufacturers like Aspirin. This use case reveals a simple but powerful method for authenticity checking that could either act as a stand-alone security platform or as an added feature to other TagItSmart use cases.
4. **"Supply Chain and Dynamic Pricing"**: This use case provides consumers with the capacity to check the time elapsed from when the product is packaged, and the conditions in which it is stored and transported to the shelf, on top of other basic product information. The products can at the same time be priced dynamically reflecting the goods condition, eliminating the end consumers' doubt about the quality or the price of a product.
5. **"Home Service"**: This is a use case for a new business model. By moving the value downstream along the supply chain, the retailer acts as a service provider or as a trusted 3rd party. Additional services on top of the traditional after-sale services can be provided to customers, making them better enjoy the services and products, improving their satisfaction level.

9.7 Vicinity

VICINITY – "Interoperability as a Service for the IoT: a bottom-up approach" [20]

The VICINITY project will build and demonstrate a platform and ecosystem for IoT infrastructures that will offer "Interoperability as a Service".

The platform aims to be device and standard agnostic, and will rely on a decentralised and user-centric approach. VICINITY aims to retain full control of the ownership and distribution of data across the different IoT domains.

VICINITY introduced the concept of virtual neighbourhood, where users can share the access to their smart objects without losing the control over them. A virtual neighbourhood will be a part of an IoT infrastructure that offers decentralised interoperability and will release the vendor locks that are present in the current IoT ecosystems.

New independent value added services across IoT domains may benefit from the availability of the vast amount of data in semantic formats that are generated by IoT assets.

9.7.1 Challenges

The lack of integration across different disciplines, vendors and standards prevents exploitation of the huge potential in successful large-scale IoT implementations.

It is difficult to control the data flow and privacy settings within a virtual neighbourhood consisting of IoT devices, and it creates both social and technological barriers, which affects the development of new value-added services.

Identifying, configuring, managing and updating information concerning the IoT ecosystem demands technical expertice, which makes it less feasable for the smaller stakeholders, and ultimately may lead to slow adoption rate among the users that may be in the most need – especially within the eHealth and assisted living domain. This is however also something that influence smart home appliances and green energy implementations, as well as how smart home systems are tied in with transportation and the nearby surroundings.

9.7.2 VICINITY Solution

VICINITY presents a virtual neighbourhood concept. A decentralized approach resembling a social network will be used. The users are allowed to configure installations and integrate standards according to the preferred services, as well as being able to fully control their desired level of privacy.

Data exchange between different devices is handled through the VICINITY open interoperability gateway, which reduce the need for having a technical background in order to exploit to the VICINITY ecosystem.

An API will allow for easy development of an adapter to the platform. Once an IoT infrastructure is integrated, its owner can simply manage the access to his/her IoT data and controls using the VICINITY neighbourhood manager (VNM).

Connecting to detected IoT infrastructures is handled by the open VICINITY auto discovery device. The device will automatically discover the smart objects. These devices will appear in a device catalogue, and will allow the users to manage access rules for the discovered smart objects.

9.7.3 Demonstration and Impact

VICINITY will provide an IoT platform that can connect islands that were previously isolated, and will allow integration of end-users and creation of new business models. VICINITY will pave the way for large-scale demonstration of the applicability of the solution in different use cases that implement and demonstrate different value-added services on top of the VICINITY platform.

The first use case will be a smart energy micro-grid that is enabled by municipal buildings (Enercoutim, PT). The VICINITY value-added services will provide users with information on potential energy savings and thereby increase awareness of the contributors.

The second use case will show how to combine infrastructure from different domains: a Smart Grid ecosystem will be combined with an Assisted Living use case (Tiny Mesh, NO).

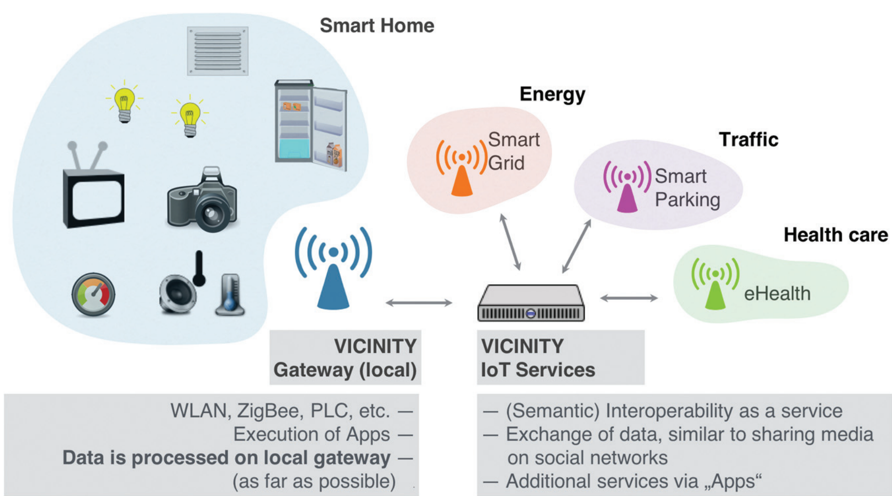

Figure 9.8 VICINITY overview.

The third use case will be eHealth (GNOMON, GR) which looks at the specific needs and constraints of eHealth. Value-added services will include the detection of abnormal events, and the possible finding and clustering of similar patients based on data mining.

The final use case will show how a large number of data sources from different domains can be combined in an intelligent parking application (Hafenstrom, NO). This will use data from booking, heating management and health status while considering how users canbe incentivised to use the application.

VICINTY is open and welcomes the participation of further interested consumers, integrators and developers of value-added services.

9.8 Be-IoT

The vision of Be-IoT is to build a broad and vibrant ecosystem for the overall project IoT-EPI increases the collaboration of the research and innovation projects within the overall initiative, generates economic impact through new innovative business models and creates trust in the IoT by transparent information about societal challenges such as privacy and security implications.

SMEs have been set to take on a very important role as a focus group in Europe, since SMEs are at the heart of innovation in the economy. They play a vital role with their capacities to generate new ideas and quickly transform these into business. Their importance is illustrated in the Small Business Act (SBA) and also reflected in the Horizon2020 industrial leadership mission, which states that Europe needs innovative SMEs to create growth and jobs. Their importance and needed support to create new business is reflected in the Be-IoT project.

Be-IoT is establishing a structure for supporting the development of standardized IoT technologies and disseminating those with the goal to derive use case applications and business models and to create societal acceptance of IoT applications across Europe.

Be-IoT project builds the bridge between IoT-EPI and relevant stakeholders (e.g., potential customers such as European SMEs as well as larger corporations, entrepreneurs and developers, but also researchers, policy makers and investors) and thus expand the ecosystem massively.

The main goal of the Be-IoT project is to build an adopter's ecosystem focussing on developers, entrepreneurs and end-users.

Innovation activities such as idea challenges, business model challenges and hackathons create awareness and make sure a variety of end-user interests will be taken into account when building the platforms.

Idea challenges and business model challenges derive specific business opportunities. Best practices and use cases will be derived from these and implementation will be pursued, in collaboration with both investors and SMEs.

The project will work on stimulating the platform adoption by hosting idea and business challenges and hackathons, while setting the ground for upcoming business building activities by creating awareness and also by facilitating and fostering societal acceptance (e.g., by running a variety of innovation, communication to the businesses and to the public and dissemination activities).

9.9 UNIFY-IoT

UNIFY-IoT objectives are to stimulate the collaboration between IoT projects, between the potential IoT platforms and support these in sustaining the IoT ecosystems developed by focusing on complementary actions, e.g., fostering and stimulating acceptance of IoT technology as well as the means to understand and overcome obstacles for deployment and value creation.

UNIFY-IoT is the "working partner" of the Alliance for IoT Innovation (AIOTI) and the IoT European Research Cluster (IERC) by coordinating and supporting the activities on innovation ecosystems, IoT standardisation, policy issues, research and innovation.

The overall concept underpinning UNIFY-IoT is to stimulate strategic cooperation and cross project support between the projects and potential

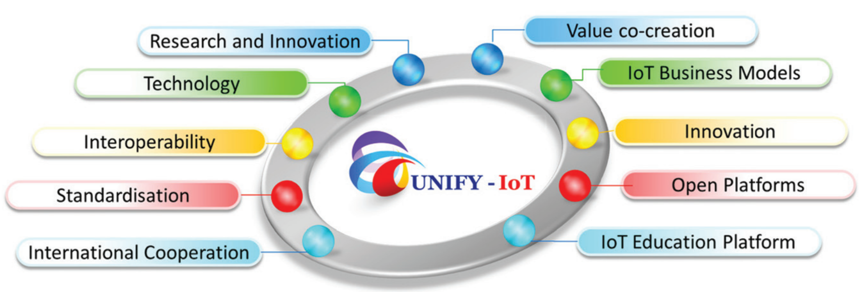

Figure 9.9 UNIFY-IoT activities overview.

platforms that will be used, conceived and developed under IoT-EPI. UNIFY-IoT aim is to:

- Identify new research and innovation mechanisms
- Derive joint exploitation strategies on how to make successful ecosystems emerge;
- Involve and coordinate the cooperation with the AIOTI, ECSEL JTI, cyber-physical stakeholders;
- Give input on and support extend the international cooperation
- Respond to the societal challenges for Europe.

The main activities are focusing on:

- **Value co-creation** – bringing together the various stakeholders in the IoT ecosystem to work towards a mutually agreed outcome using IoT interoperable solutions and evaluate the value co-creation by analysing the results of the projects.
- **IoT Business Models** – surveying and analysing existing business models related to IoT: from specific deployment in case of process optimisation in a company, to, at the opposite, providing a technological element to the open markets, and produce a taxonomy of business models.
- **Innovation Support** – analysing existing IoT platform deployments and analyses at the innovation and other activities of those deployments. It assesses the relative success of the platform adoptions and identifies common innovation activities in the most successful platforms.
- **IoT Open platforms concepts** – building upon on the open platforms activity chain started by the IERC an combine it with other initiative documenting project outcomes.
- **IoT Education platform** – interacting with stakeholders to identify opportunities for interaction between IoT platforms and education institutions to ensure that future graduates are conversant with emerging IoT platforms and the opportunities they present. UNIFY-IoT is leveraging the knowledge process supporting the emergence of an IoT Curricula and education platform in Europe.
- **Standardisation Support** – sensing the global trends in term of interoperability and de-facto standards, and interacts with standardisation bodies including ETSI and CEN/CENELEC to systematise de facto standards emerging from the IoT-EPI projects. The project is cooperating closely with the working group on standardisation of the AIOTI to ensure a coordinated approach to standardisation.

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