Ecosystem for COllaborative Manufacturing PrOceSses – Intra- and Interfactory Integration and AutomaTION
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D7.3 Survey of successful elements with recommendations for COMPOSITION use cases III

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Index:

1 Executive Summary

The *D7.3 "Survey of successful elements with recommendations for COMPOSITION use cases III"* is an update to the Month 24 release of the D7.2 deliverable, *"Survey of successful elements with recommendations for COMPOSITION use cases II"*. It is a public document delivered in the context of WP7, Task 7.1: Survey of Successful Elements in External, Related Initiatives. The aim of Task 7.1 is to identify and undertake an assessment of existing results coming from related projects in order to be reused in COMPOSITON, to be part of the final solution provided by COMPOSITION project.

The present release of the D7.3 document (the last of three), is focused on continuing the work described in D7.1 and D7.2, identifying and assessing results coming from other FoF-11 projects and initiatives identified in the context of Industrial Internet and Digital Automation, mainly FIWARE4Industry and International Data Spaces (previously called Industrial Data Spaces – IDS). Thus, new advances in the last year regarding the International Data Spaces and the FIWARE4Industry initiatives are presented, together with a list of their main features, which can be useful for COMPOSITION. An example of this is the description of the implementation of two additional use cases in COMPOSITION based on both platforms/initiatives.

The document also identifies additional reference architectures for Industrial Internet, which complements those presented in deliverable D7.2.

The deliverable also covers the actions carried out during this last period (September 2018 – August 2019) to co-operate and exploit synergies between FoF-11 projects with the objective of building a common platform for digital automation and share information among projects. Therefore, the different cooperation workshops held to date, and information regarding the delivered reports and documents by the FoF-11 CSA Connected Factories are presented.

Since it is an update of the previous deliverable, several paragraphs in some sections of the second deliverable have been maintained to facilitate reading.

2 Abbreviations and Acronyms

Acronym	Meaning
AII	Alliance of Industrial Internet
CRM	Customer Relationship Management
DoA	Description of Action
EFFRA	European Factory of the Future Research Association
ERP	Enterprise Resource Planning
FoF	Factories of the Future
IDS	International Data Spaces
IIA	Industrial Internet Architecture
IIRA	Industrial Internet Reference Architecture
IOF	Industry Ontology Foundry
JRA	Joint Research Activity
MES	Manufacturing Execution System
MoU	Memorandum of Understanding
NGSI	Next Generation Service Interfaces
PMIC	Power Management Integrated Circuit
RAM	Reference Architecture Model
RAMI 4.0	Reference Architectural Model Industrie 4.0
SCM	Supply Chain Management

3 Introduction

The aim of this deliverable is to update *D7.2 Survey of successful elements with recommendations for COMPOSITION use cases II*, which presented a second analysis and selection of components available in the Fiware4Industry and International Data Space initiatives. It also provided information on the cooperation actions carried out in this last period (September 2018 - August 2019) between the different projects of the FoF-11 2016 call and other existing initiatives relevant for Manufacturing Automation, where COMPOSITION has had a proactive role in the different workshops held, contributing to platform building in Digital automation and contributing to standardisation initiatives.

Seeing the evolution of FIWARE4Industry and the International Data Spaces, and their close cooperation, the main objective has been to continue analysing the solutions provided by these initiatives, be involved in their roadmaps, given the membership of some COMPOSITION partners in them, with the final objective of understanding how these solutions fit in COMPOSITION, mainly for inter-factory purposes, and in particular how to share information in a safe and reliable way. For this purpose, two use cases of COMPOSITON have been carried out based on the solutions provided by these initiatives, interacting directly with reference persons involved in these initiatives.

3.1 Purpose, Context and Scope of this Deliverable

This deliverable is an evolution of D7.2 and comprises and updates the initial assessment of existing results coming from related projects, with the objective of identifying modules or components that can be reused in COMPOSITION. As described in the DoA, the assessment has been done in terms of functionality provided, technology, licence, status, etc. As in the first and second deliverables, the evaluation has been done on ongoing FoF-11 projects and initiatives, but it is important to bear in mind that at the moment, many of the components are not fully accessible for consultancy due privacy policies and licensing types. At the end, the main objective of the liaison and co-operation activities with other projects has been to contribute to platform building in Digital automation.

3.2 Content and Structure of this Deliverable

As for D7.2, the document is structured in three chapters: the first chapter is focused on the FIWARE4Industry and International Data Space initiatives, where some updated information about the evolution of the roadmap is reflected, as well as the description of two Use Cases implemented in COMPOSITION based on these initiatives/platforms. A second chapter describes the cooperative actions carried out with other projects of the FoF-16 call, and finally, the last chapter focuses on conclusions.

4 Fiware4Industry and International Data Spaces

4.1 Fiware4Industry, International Data Spaces and COMPOSITION

As platinum member of the FIWARE foundation, ATOS is contributing to the definition of the FIWARE4Industry reference architecture through the Smart Industry Mission Support Committee. This is a formal body in charge of executing specific tasks to support the FIWARE mission and is constituted by FIWARE members with known competences.

CERTH and ATOS attended the FIWARE Global Summit Meeting in Genoa in May 2019, participating in training workshops related to Industrial Data Spaces and FIWARE, and also providing feedback and requirements for the roadmap of these initiatives.

Moreover, CERTH participates in IDSA's general working group related to Use cases and Requirements. CERTH has introduced a proposed COMPOSITION use case at the IDSA Winter Days in Berlin (December 2018)[1]

CERTH presented an update of the COMPOSITION use case for smart waste management at the 2nd IDSA Global Summit (Bonn - June 2019). In this update, there is an implementation of the IDS connection between fill-level sensor and analytic tools (both implemented in COMPOSITION). Two different approaches have been implemented for this connection. The first approach is a connection based on FIWARE by using the FIWARE Context Broker and the second was a connection by using the IDS Trusted Connector.

In parallel ATOS plays a proactive role in Fiware4Industry to co-operate with the IDSA initiative.

4.1.1 Update on Industrial Data Space

The new version 3 of the IDS Reference Architecture Model (IDS-RAM)[2], published in April 2019, defines safety standards, control and enforcement rules for data usage, and mechanisms for data traceability and data provenance checks. It is an improvement of the IDS RAM described in the D7.2 chapter 4. So, this new version of the IDS-RAM, constitutes the conceptual basis of IDS compliant data exchange between organisation, where the rules and mechanisms for ensuring data sovereignty within data ecosystems are specified. This new version focuses on concepts such as big data, artificial intelligence, the industrial internet of things (IIoT) and blockchain technology, which are the emerging technologies associated with data management, analysis and security. It also focuses on certification, security and governance issues, defining and stipulating security standards, control rules for the use of data and mechanisms to identify the origin of the data and its traceability.

In this new version, the IDS RAM covers Data Usage and Data Access. It is important to differentiate the two concepts, the Access Control and the Usage Control. The Access control provides means to specify and enforce policies about who can access data and how, while the Usage Control extends this to include constraints upon the future usage of data once access has been granted. Therefore, the Usage control policies define conditions, which can be: temporal conditions ("when data must be deleted? After 10 days, 1 hour?"), cardinality constraints ("How many times the data must be used?"), event-defined restrictions ("if the data provider revokes the usage right, any further usage must be inhibited"), purpose of use restrictions ("for which purposes data must be used?, In what kind of devices, tablets, mobiles, PCs? "), etc.

Therefore, when access to a specific resource is required (e.g., a service or a file) the IDS architecture provides a data-centric usage control, which allows to enforce usage restrictions for data after access has been granted. As commented before, the purpose of usage control is to bind policies to data being exchanged and to continuously control how messages may be processed, aggregated, or forwarded to other endpoints. This data-centric perspective allows the user to continuously control data flows, rather than accesses to services. At configuration time, these policies support developers and administrators in setting up correct data flows.

In this context, when specific data is requested there are two different processes: the first one, before accessing the data, is the authorization and it is covered by the Access Control, the second one occurs at runtime, covered by the Usage Control and prevents an unwanted usage of data.

[1] https://www.internationaldataspaces.org/publications/use-case-pitch-certh-alexandros-nizamis/
[2] https://www.internationaldataspaces.org/wp-content/uploads/2019/03/IDS-Reference-Architecture-Model-3.0.pdf

For the IDS-RAM, the Usage Control should be seen as a machine-readable contract, which is expected to be fulfilled by a party. It is a way to track and trace data as it is used within different systems, and to collect evidence of the violation of agreed usage constraints. With that in mind, solutions range from organisational rules or legal contracts to a completely technical enforcement of usage restrictions. Although it is a commonly used solution to solve usage control restrictions with organisational rules, the IDS uses technical enforcement in its documents.

Another remarkable improvement in IDS-RAM is the new Scheme for the Information Layer shown in Figure 1. The IDS Information Layer now refers to the concern hexagon and defines the mandatory elements, making the Important elements of the Information Layer more obvious.

In the context of the IDS, a (digital) Resource is a uniquely identifiable, valuable, digital (i.e., non-physical) commodity that can be traded and exchanged between remote participants using the IDS infrastructure. Therefore, it could be provided by a multiple variety of representations such as: archive, image, media stream, time series of sensor values These are analysed and specified here by applying the "separation of concerns" (SoC) paradigm[3].

In the separation of concerns design principle, only one dimension of a subject matter is considered at a time, and each concern follows a particular, analytical point of view, while other concerns can temporarily be disregarded. The idea of IDS is to apply this principle to information modelling, aiming at a thorough understanding of the domain, and fostering modularity and re-usability of the resulting (sub-) models. This approach allows models to evolve independently of each other, and these models can be updated by different agents at different times.

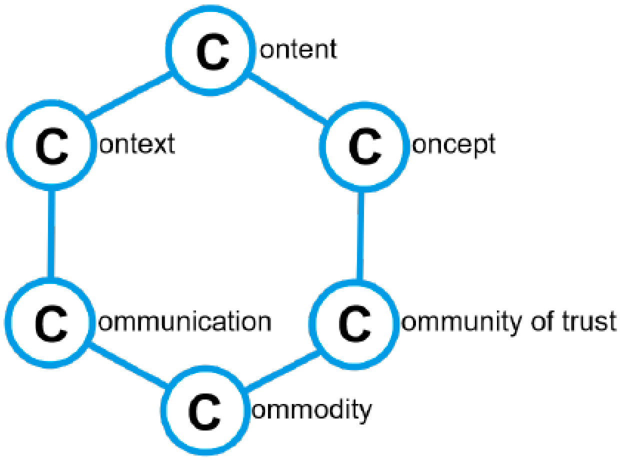


Figure 1: Main concerns C-Hexagon (source: Otto, et al., 2019)

IDS illustrates the main modeling concerns of Digital Resources as a C-Hexagon as shown in Figure 1. Regarding the importance of the aspects, they are located at the different parts of the hexagon, considering the Content the most relevant and putting it at the top of the hexagon. Below this we find the Concept and the Context, the first one allows to interpret the Content, and Context provides relevant information in terms of time, place, or any other relevant context information regarding the real-world entities. Making the Content more relevant and useful for Data Consumers. The other 3 "C"s in the lower part of the hexagon take care of *how* the Content is exchanged through the Communication concern, and in which conditions, which are covered by the Commodity concern. Finally, the Community of Trust concern refers to the distinctive feature of the International Data Spaces being an ecosystem of certified participants and components that exchange and share Digital Resources in accordance with usage policies ensuring data sovereignty.

In addition, IDS identifies and defines different levels of detail for each concern, covering all possible information located in each of them in a structured way (Figure 2).

[3] http://www.cs.utexas.edu/users/EWD/ewd04xx/EWD447.PDF

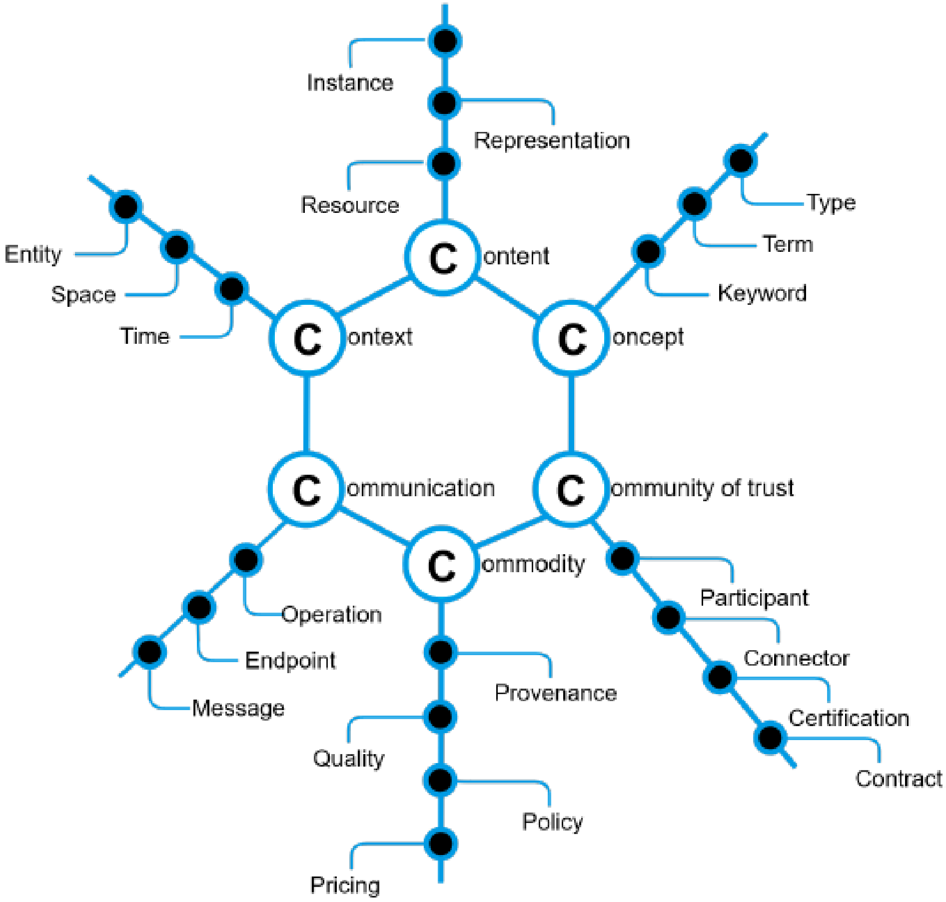


Figure 2: Extended Concern Hexagon - Scheme for Information Layer (source: Otto, et al., 2019)

Summarizing, the 6 "C"s in the Concern Hexagon and their objective mission are:

- CONTENT, deals with the description of a Resource's inherent substance, i.e., its "content" available in any machine- interpretable, binary format.
- CONTEXT, deals with temporal and spatial aspects as well as with real-world entities a Resource's content relates to (intrinsic context)
- CONCEPT, deals with the modeling of the "meaning", annotation, and interpretation of entities introduced by the orthogonal Resource concerns (Content, Context, Communication etc.)
- COMMUNICATION, deals with means to communicate a Resource's content in one of the Representations available
- COMMODITY, helps assess the value and utility of a Resource as an obtainable asset with regard to a client's needs
- COMMUNITY OF TRUST, considers the fundamental requirement of the International Data Spaces for exchanging and sharing digital content between a Data Provider and a Data Consumer in a secure and trusted way, while preserving data sovereignty of the Data Owner.

4.1.1.1 Architecture

The International Data Spaces Association Reference Architecture Model (RAM, version 3.0) still comprises five layers and three cross-cutting perspectives (Otto, et al., 2019, cf. Figure 3).

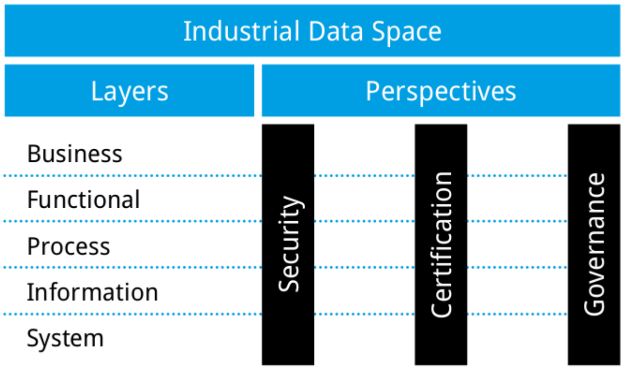


Figure 3: IDS Structure of Reference Architecture Model (Otto, et al., 2019)

The architecture of the "System Layer" which is the most relevant for COMPOSITION and which comprises software components and their interaction has been minimally modified from the previous version as reflected in Figure 4.

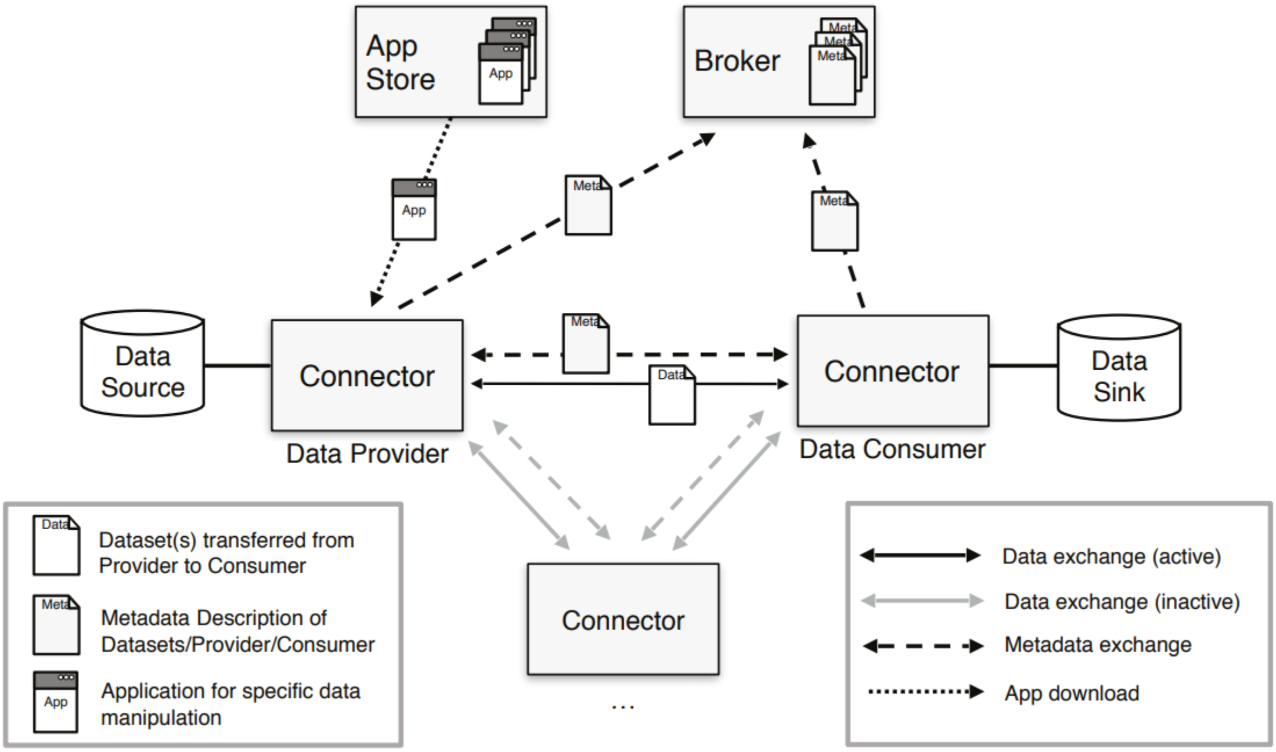


Figure 4: Interaction of components on System Layer (source: Otto, et al., 2019)

4.1.1.2 COMPOSITION-IDS based Use Case for Smart Waste Management

A COMPOSITION use case for the connection of fill-level sensors with the data analytics tools has been developed by CERTH. In this case the IDS Trusted Connector[4] is used and configured/modified for COMPOSITION purposes.

[4] https://industrial-data-space.github.io/trusted-connector-documentation/

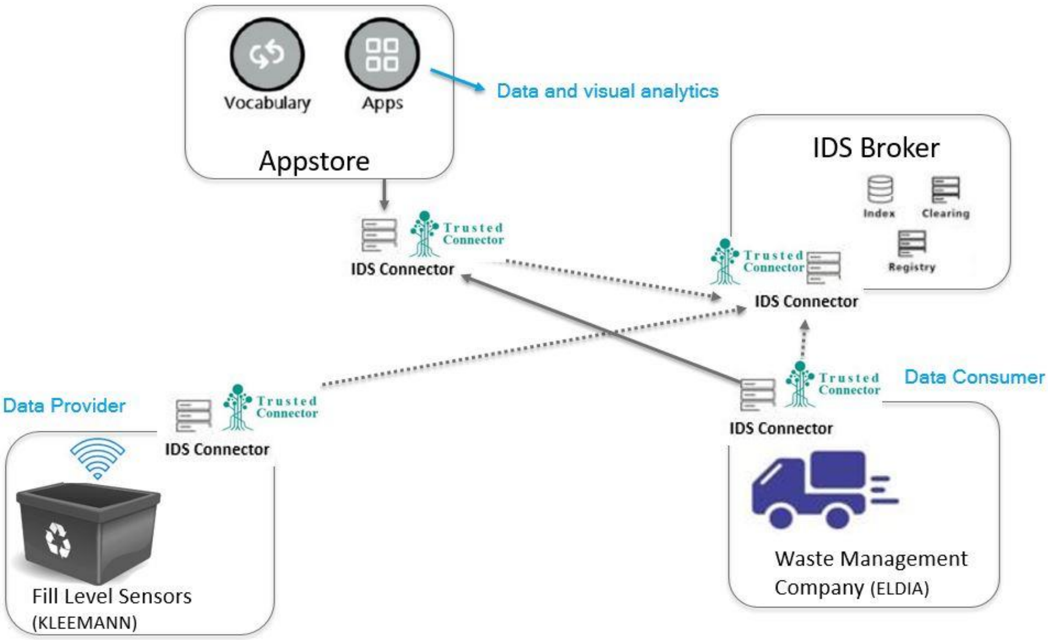


Figure 5: High Level Architecture of COMPOSITION-IDS Waste Management Scenario

In this case, the fill-level sensor at the KLEEMANN premises acts as the Data Provider based on IDS reference architecture. ELDIA is the Data Consumer in this use case, in charge of monitoring and analysing data coming from their customers. The monitoring and analysis of data are provided by apps used by the consumer. (Based on IDS logic connectors, consumers, providers and brokers can be considered apps as well)

The implemented use case uses the following components as the main building blocks:

- **Ultrasonic** sensors for fill-level measurement
- Use of **LoRA** network to get data from sensors at low power consumption
- COMPOSITION **interfaces** for fill-level **monitoring**
- **Trend analysis** methodology from Simulation and Forecasting tool - **SFT** (WP3) and Visual Analytic tool (WP5) for fill-level data **analysis and visualization**
- **IDS connectors** based on **Trusted Connector** for the connection of the above tools and data sources.

Results

The main results of the described implementation are the following:

- Creation of a **solution for smart waste management** based on **IDS infrastructure** and **COMPOSITION components**
- **Real-world connection** of **COMPOSITION** components **with IDS** ecosystem. As soon as an IDS ecosystem is set up, the COMPOSITION/IDS implementation can be effortlessly available to this data space
- The IDS environment would **increase the visibility of COMPOSITION** components and the project outcomes in a large community of data scientists and industrial domain participants
- The use of IDS infrastructure enables the **secure data exchange** over IDS and **reduces** the **effort** to **connect** to **IoT devices** and **analytics** tools.

Short demonstration of the back-end connection

The figures below are added as proof of the above-mentioned mini demo about COMPOSITION-IDS based Use Case for Smart Waste Management. They demonstrate the connection set-up and the deployment of necessary containers/apps as they are presented in the IDS official user interface.

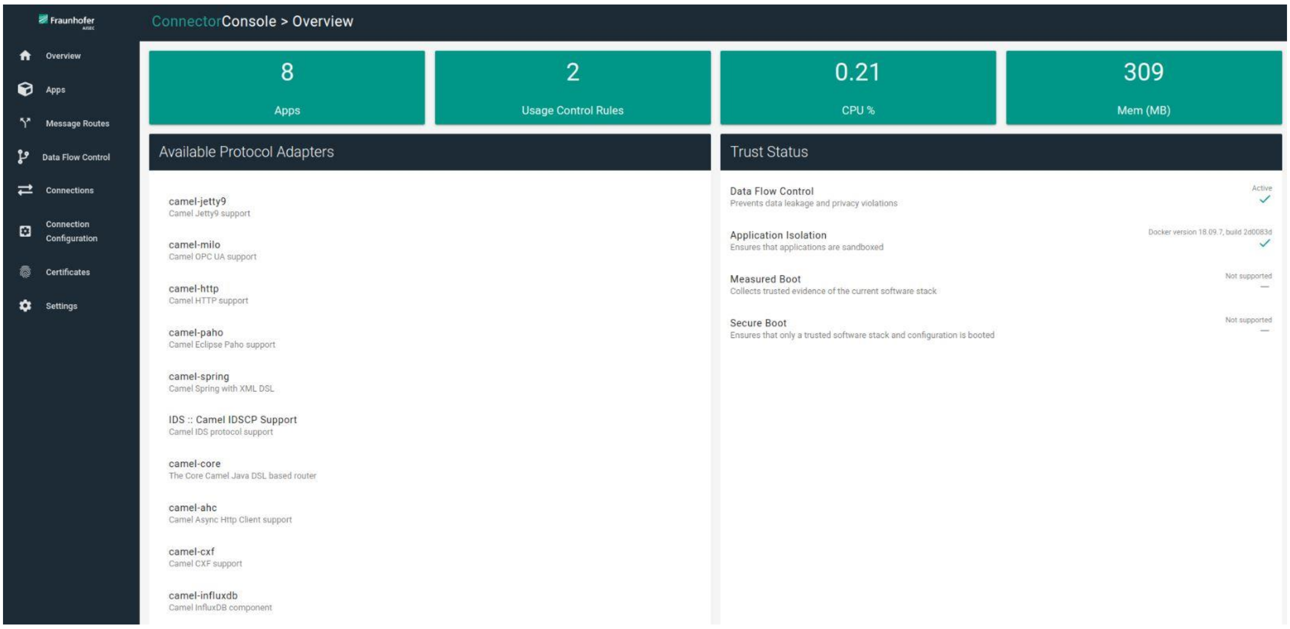


Figure 6: IDS Console Overview

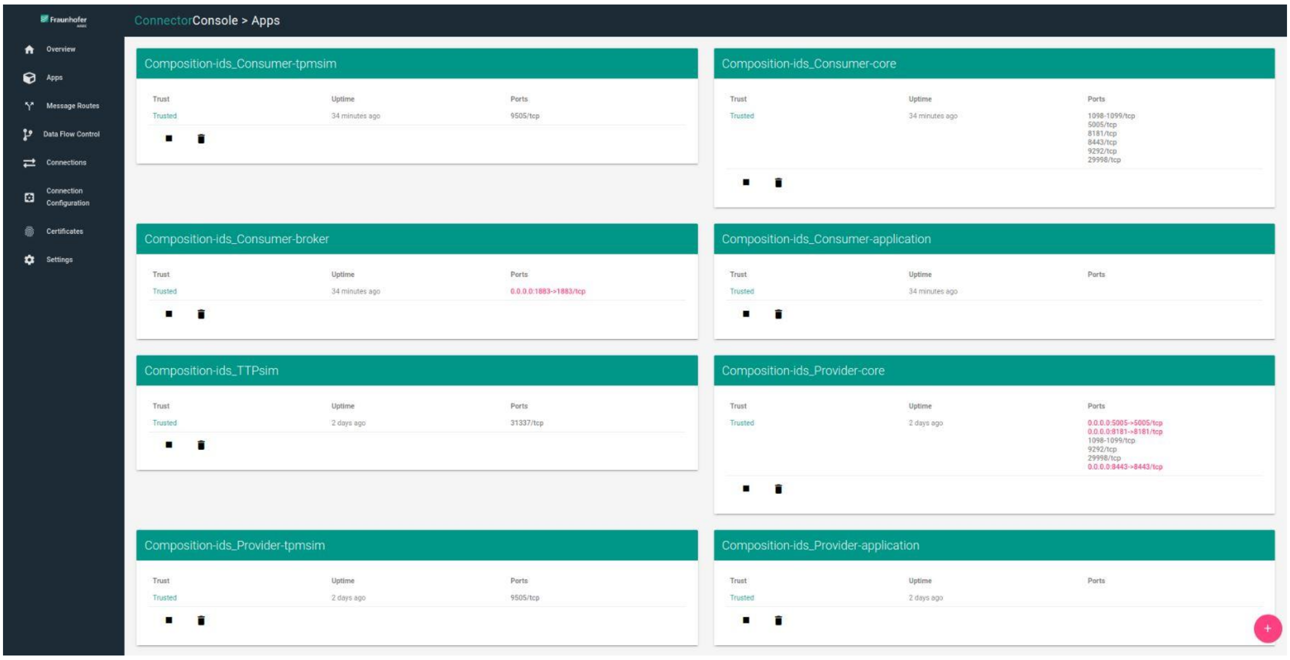


Figure 7: COMPOSITION-IDS Apps View in IDS Console

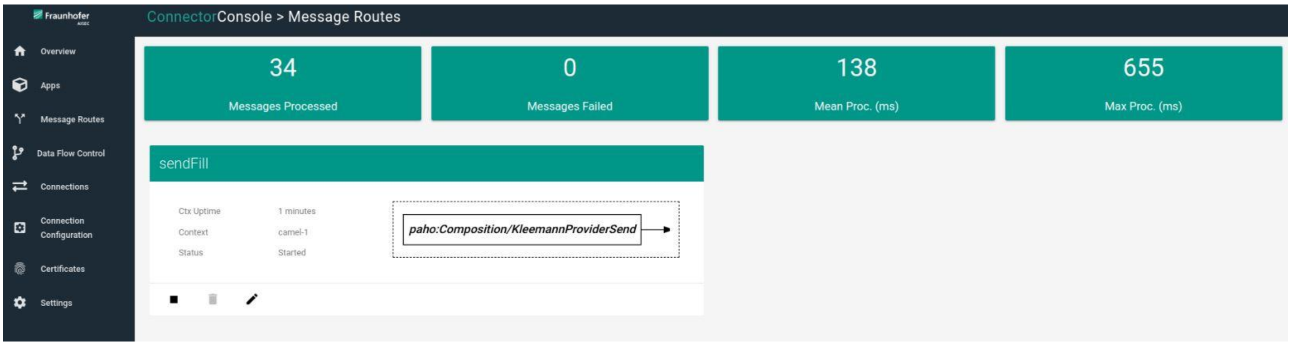


Figure 8: Messages Routes set-up for Data Provider's Fill-level Sensor in IDS Console

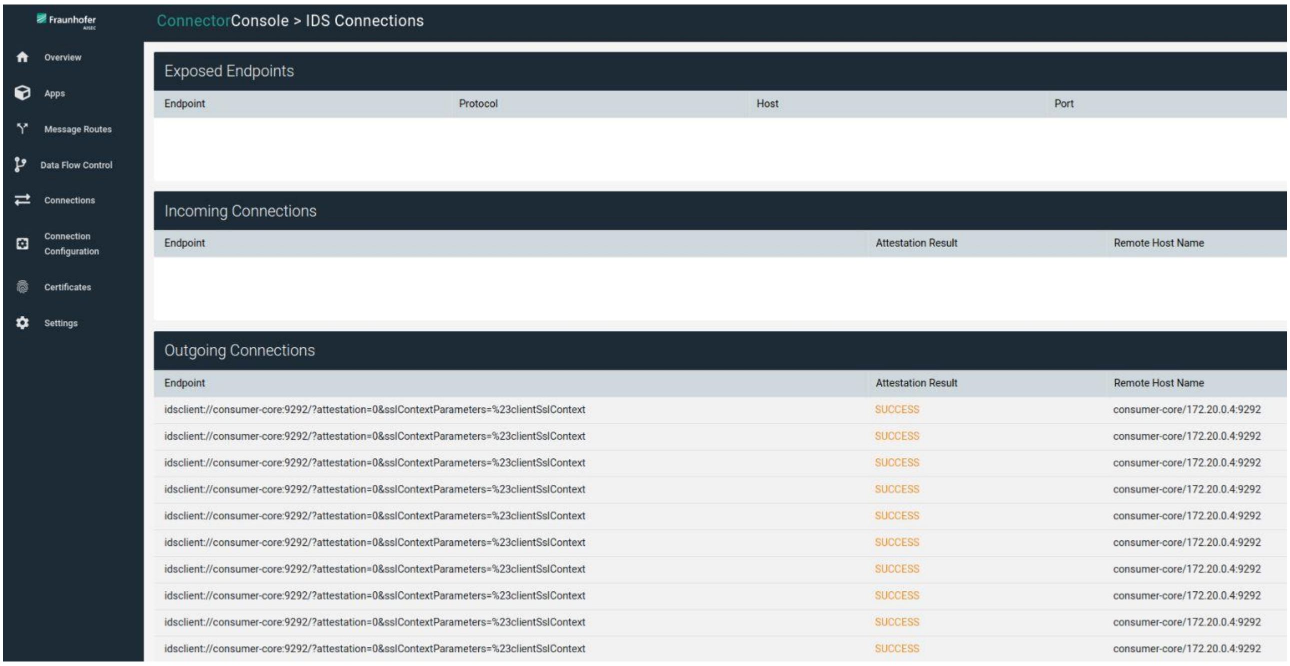


Figure 9: Connections Example Logs in IDS Console

4.1.2 The FIWARE4Industry Reference Architecture

The objective is to have a community driving FIWARE Technology for Smart Industries. For this purpose, FIWARE has defined the FIWARE4Industry Reference Architecture (Figure 10), which is compliant with existing industry architectures such as the Reference Architecture Model Industrie 4.0, the International Data Spaces Reference Architecture Model or the Industrial Internet Consortium Reference Architecture.

The main objectives of FIWARE4Industry are to transform Big Data into Knowledge, Unleashing the potential of right-time Open Data, enhancing the Data Economy and ensure Data Sovereignty. For this, an action plan covering several actions has been defined:

- Deliver a Position Paper at the next FIWARE Summit in Berlin in October 2019
- Identify, Pursue and Reinforce Smart Industry Strategic Alliances, aligning FIWARE with standards and reference architectures – RAMI & Asset Administrative Shell Analysis
- Develop, Experiment and Validate “powered by FIWARE” reference implementations & solutions in Smart Factory, Smart Product and Smart Supply Chain

Regarding technology, the main objectives of the FIWARE4Industry are:

- Data Sharing, covering technologies for building Federated Industrial Data Spaces, allowing Data Sovereignty and Data Usage control
- Edge Computing runtimes, covering technologies for Edge Computing orchestration and for Edge Computing advanced features (complex event process, AI hardware support, etc.)
- Intelligent Digital Twins, providing technologies for creating and operating Digital Twins and make them intelligent: sensing, cognition, AI
- Artificial Intelligence for Smart Industry, identify and provide AI technology for Smart Industry
- Robotics/Manufacturing Devices – Technology for managing Robots, Cyber Physical Systems (CPS) and Manufacturing Devices (ROS, OPC-UA) – Technology for Communication between CPS – Technology for autonomous control of CPS.

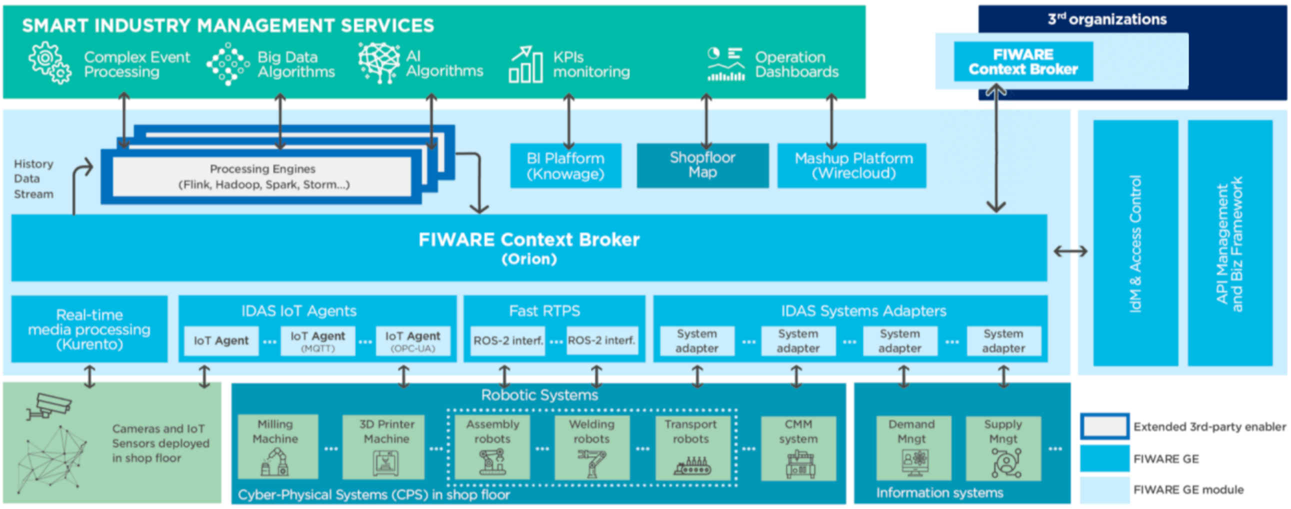


Figure 10: The FIWARE4Industry Reference Architecture (source: FIWARE, 2019)

The current FIWARE4Industry Reference Architecture is composed by several Generic Enablers (GEs) covering specific functionalities. The most relevant components are:

- Orion Context Broker which is the main component of the platform and integrates information from machines and sensors in the shop floor, breaking information silos. Ii is in charge also for distributing the context information between the different layers
- At the Southbound, there are the IDAS IoT Agents in charge of connecting sensors, handling multiple IoT protocols. OPC- UA IoT Agents bring alignment with RAMI 4.0
- Processing engines for processing historical data (e.g., Hadoop or Flink) to extract insights or derive smart actions
- Complex Event Processing (CEP), advanced AI or machine learning functions that can be implemented on top of Apache Flink or other Processing engines
- Generic Enabler Wirecloud web mashup framework to have Operational dashboards
- Generic Enabler Knowage for KPI monitoring, Reporting and BI functions.

4.1.2.1 COMPOSITION-FIWARE based Use Case for Smart Waste Management

A COMPOSITION use case for the connection of fill level sensors with the data analytics tools similar with the IDS one has been developed by CERTH. The following figure depicts the alignment of COMPOSITION use case for Smart Waste Management with FIWARE Architecture. The red boxes highlight the parts from FIWARE that used or configured or implemented for the implementation of this example use case.

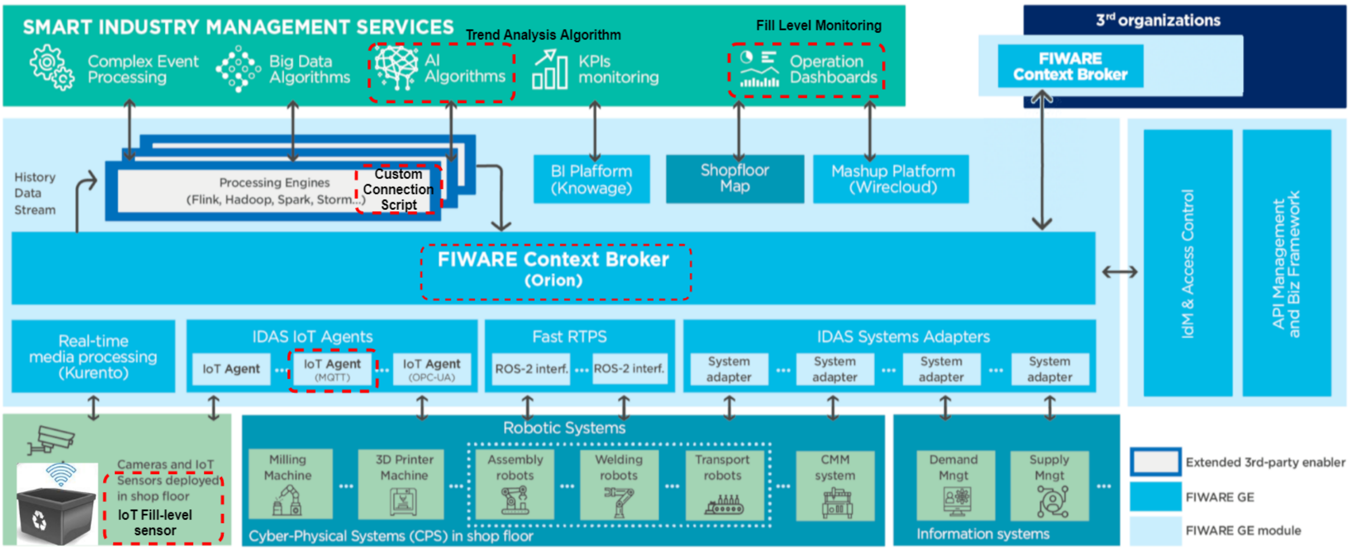


Figure 11: COMPOSITION Use Case Alignment in FIWARE Architecture

The implemented use case uses the following components as the main building blocks:

- **Ultrasonic** sensors for fill-level measurement
- Use of **LoRA** network to get data from sensors at low power consumption
- COMPOSITION **interfaces** for fill-level **monitoring**
- **Trend analysis** methodology from Simulation and Forecasting tool - **SFT** (WP3) and Visual Analytic tool (WP5) for fill-level data **analysis and visualization**
- **IDAS IoT Agent (MQTT)** from **FIWARE** and **FIWARE Context Broker (Orion)** for the connection of the above tools with the data sources and the data source management
- A simple **custom script connecting the analytic tools to** the data available in the FIWARE Context Broker **database.**

Results

The main results of the described implementation are similar to the IDS case as listed below:

- Creation of a **solution for smart waste management** based on **FIWARE components** and **COMPOSITION components**
- **In practice alignment** of **COMPOSITION** components **with FIWARE** architecture
- The **use of FIWARE** components would **increase the visibility of COMPOSITION** components and the project outcomes in a large community of data scientists and industrial domain participants
- The **use of FIWARE** infrastructure **reduces** the **effort** to **connect** to **IoT devices** and **analytics** tools and provides a more **standardised** and **wide-used implementation** for the **connection of third parties with the project**'s software and hardware solutions.

The Figure 12 below is added as proof of the above-mentioned mini demo about COMPOSITION-FIWARE based Use Case for Smart Waste Management. It demonstrates the connection set-up of the back-end. In contrast with the IDS case where there is a user interface for monitoring of the connection, in FIWARE it is available only by using console logs. In the console output, there are messages related to the usage of Orion Context Broker and IoT Agent from FIWARE. A fill-level measurement is shown in the screenshot as well.

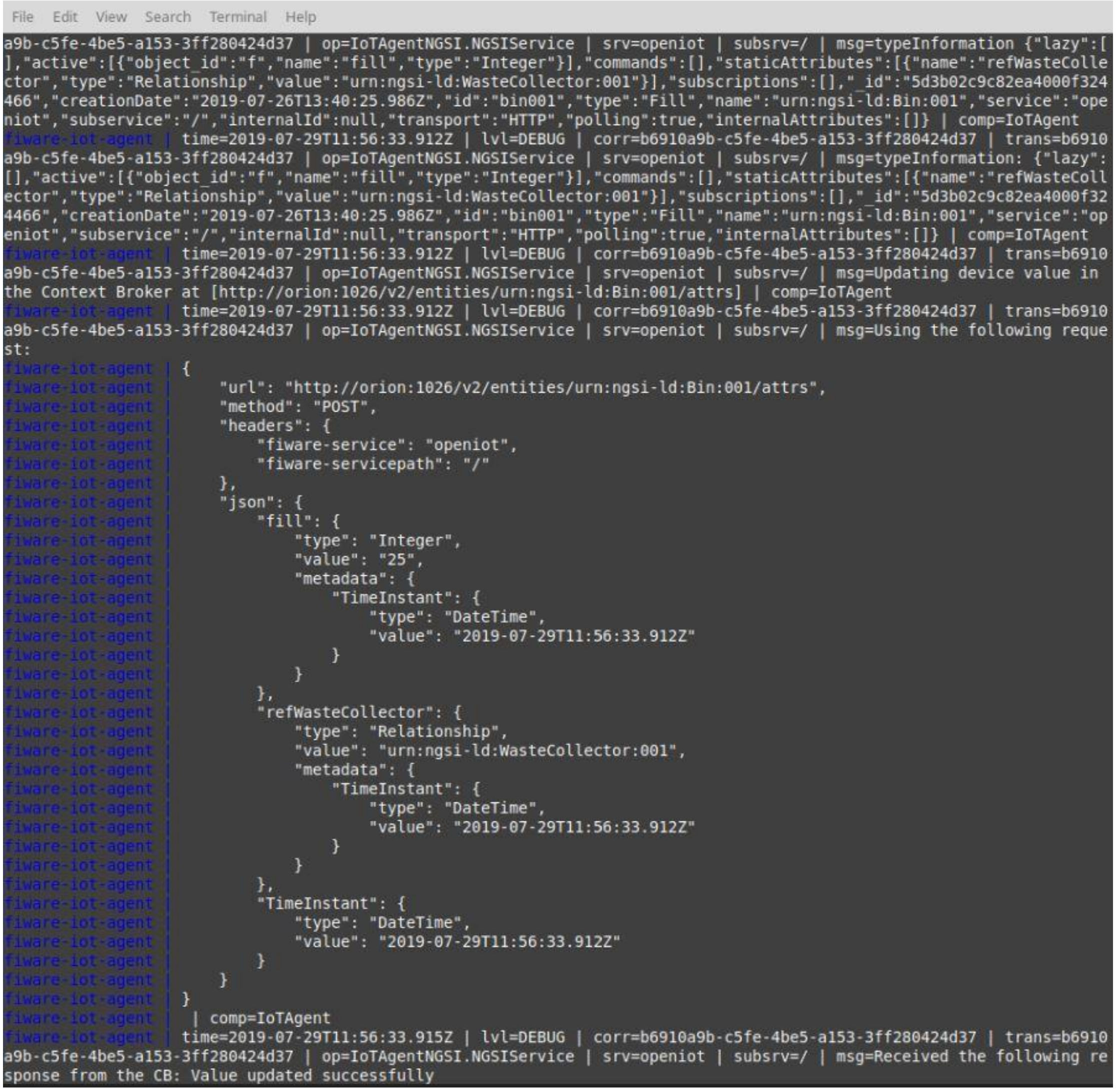


Figure 12: Demonstration of FIWARE Context Broker and IoT Agent Usage

5 Initiatives on Smart Industry and Collaborative Manufacturing and Logistics

This section summarises the cooperative activities carried out with other organisations working on smart industry, collaborative manufacturing and logistics in the last period (September 2018 – August 2019). Special, focus is put on collaboration with projects of the FoF-11 call, with the aim of exploiting synergies and increasing the impact of the initiative on platform building in Digital Automation.

5.1 FoF-11 Projects Cooperation

The FoF-11-2016 topic focused on Digital Automation was the origin of eleven funded projects, 10 RIAs and 1 CSA. In the table below is a FoF-11 project list:

#	Project Name	Coordinator	Type
1	AUTOWARE	SOFTWARE QUALITY SYSTEMS SA	Factory Automation
2	DAEDALUS	SYNESIS SCARL	Factory Automation
3	DISRUPT	CENTRO RICERCHE FIAT SCPA	Factory Automation
4	FAR-EDGE	ENGINEERING – INGEGNERIA INFORMATICA SPA	Factory Automation
5	SAFIRE	X/OPEN COMPANY LTD	Factory Automation
6	ScalABLE4.0	INESC TEC	Factory Automation
7	COMPOSITION	FRAUNHOFER FIT	Collaboration
8	DIGICOR	FRAUNHOFER IPA	Collaboration
9	NIMBLE	SALZBURG RESEARCH FORSCHUNGSGESELLSCHAFT MBH	Collaboration
10	vf-OS	INFORMATION CATALYST FOR ENTERPRISE LTD	Collaboration
11	ConnectedFactories	EUROPEAN FACTORIES OF THE FUTURE RESEARCH ASSOCIATION AISBL	CSA

Table 1: FoF-11 Projects

There is an initiative led by the ConnectedFactories project (CSA) to foster collaboration among the ten FoF-11 projects. This CSA is led by EFFRA (http://www.effra.eu/). In the following sections there is a description of the activities done by COMPOSITION in this collaboration framework until M36. It is noted that COMPOSITION is in closer contact with the projects listed as type “Collaboration”.

5.1.1 FoF-11 Projects Synergies

The ConnectedFactories CSA project has brought together FoF and especially FoF-11 projects, and it has provided results on the digital mapping framework, glossary, reference structure and architecture and digital platforms. Those results and the involvement of COMPOSITION until M24 have been reported in *D7.2 Survey of successful elements with recommendations for COMPOSITION use cases II*.

The four FoF-11 projects DIGICOR, NIMBLE, vfOS and COMPOSITION have collaborated on various topics, such as business models, use cases, evaluation KPIs and dissemination activities. For the scope of this deliverable, it is of interest to focus on the results of these efforts and especially the outcomes of the COMPOSITION project, as they have been also provided on the EFFRA Innovation Portal. It is reminded that the main goal of the Portal is to share information with everyone who is interested in EU funded R&D results and among the projects.

The COMPOSITION project is presented on the EFFRA Innovation Portal with a public profile. It can be found as a result of a search effort with keywords such as collaborative manufacturing or automation and, of course, as an FoF-2016-11 project. The maintenance of the information on the portal is a joint effort led by the Coordinator and the Dissemination Manager, in cooperation with all members of the consortium.

The COMPOSITION consortium has directly interacted with EFFRA and has submitted a recommendation for including a Lessons Learned section in the Innovation Portal. This recommendation has been accepted by EFFRA and a section on “Use Case Requirements and Lessons Learned” has been added. It is the consortium’s intention to communicate as much as possible with the Factories of the Future community and with whoever is interested in the fruits of the European Union's Horizon 2020 Framework Programme for Research and Innovation.

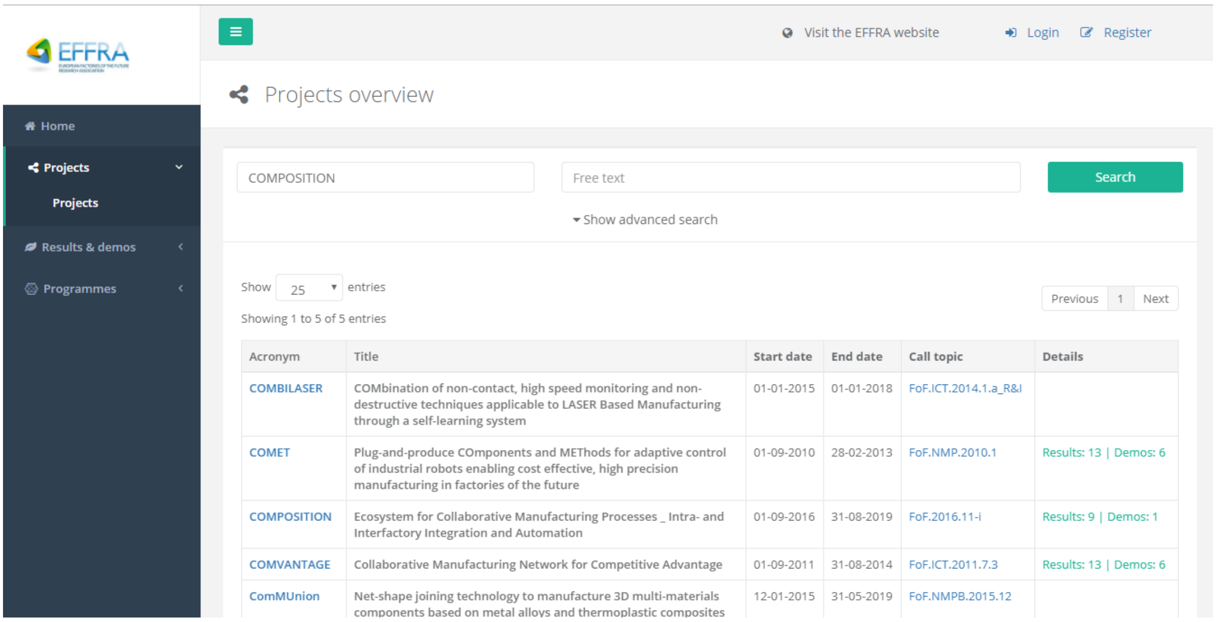


Figure 13: EFFRA search results

Navigating through the Portal, there is first a public ***Summary*** and some ***More information*** about the project including the website, duration, start date, end date, participants, budget. In addition to this introductory information, results that have already been published by the consortium in public deliverables are available in the ***Results*** section. It should be noted that this is continuously updated, in order to offer the possibility to the research community and general public to benefit from the project's findings. The same goes for the ***Demonstrators***, as COMPOSITION progresses.

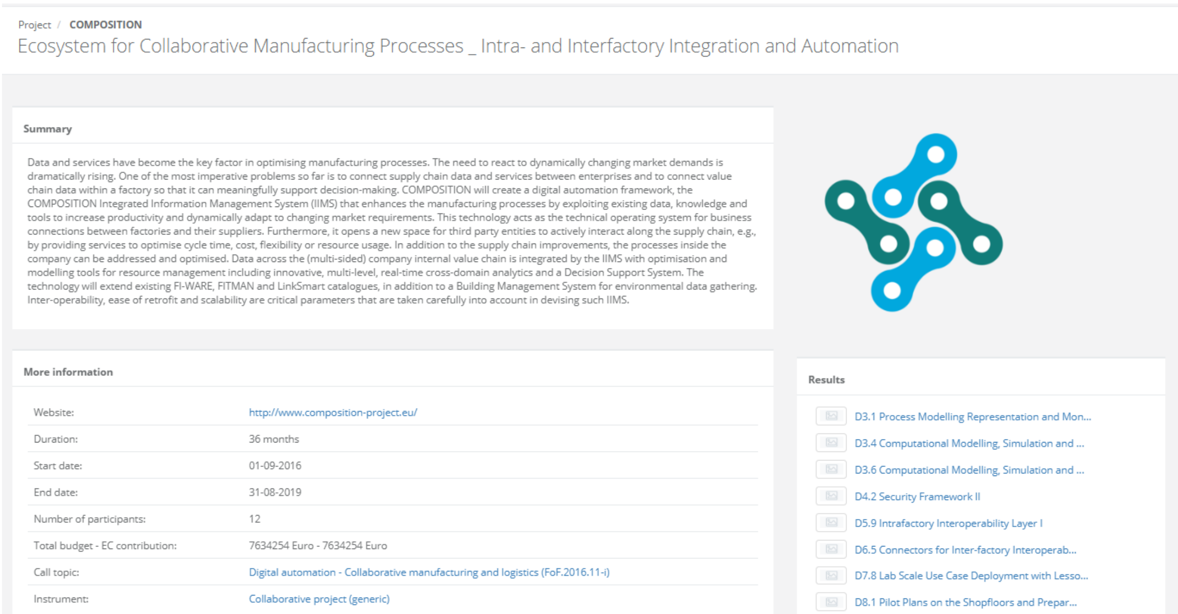


Figure 14: COMPOSITION Introductory information

The essentials of the project are followed by its ***Characteristics***. It should be mentioned that as the project advances, the information available in the characteristics part is continuously updated and enriched in collaboration with the responsible partners.

The first part is actually the ***Significant Innovations, Use Case Requirements and Lessons Learned***, which is the newest addition to the EFFRA Innovation Portal.

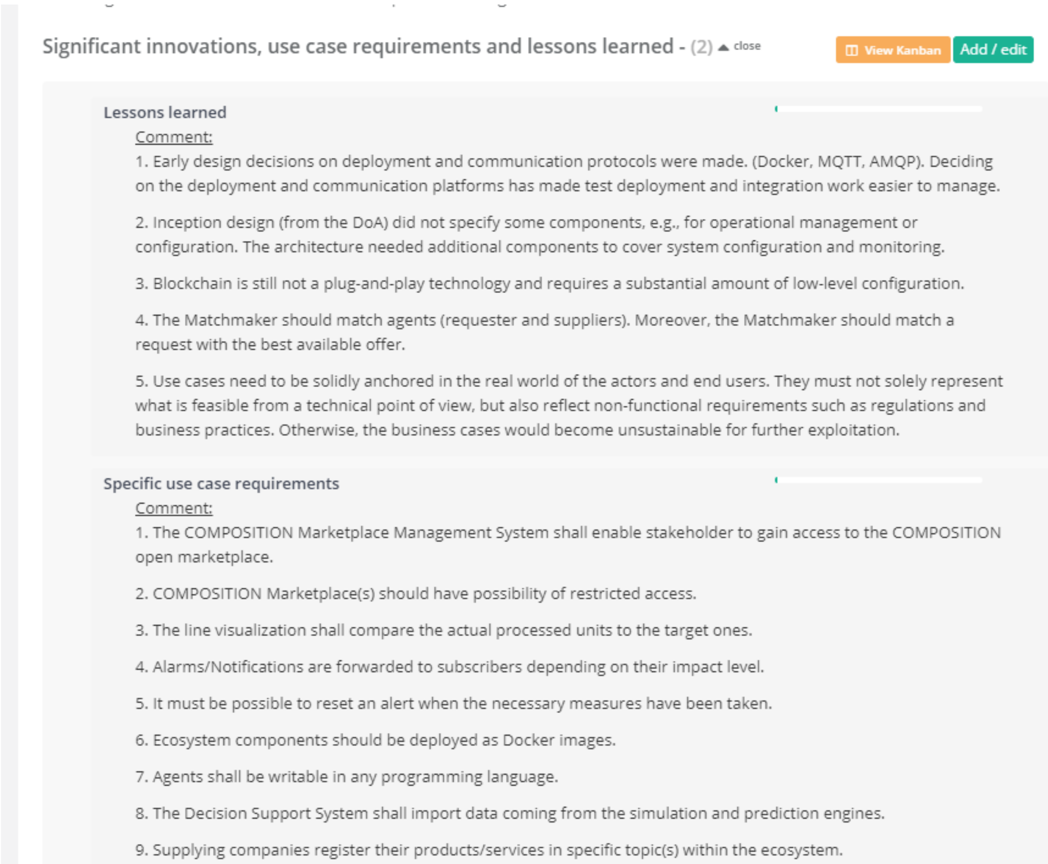


Figure 15: COMPOSITION Significant Innovations, Use Case Requirements and Lessons Learned

The second part is ***Added Value and Impact***, formerly ***Challenges*** and it is devoted to the ones that COMPOSITION faces and attempts to solve, following the specific approach that has been set up by the technology providers and end users and which is continuously monitored. The sectors discussed cover two aspects; the *economic sustainability, a*ddressing economic performance across the supply chain, and resource efficiency in manufacturing, including addressing the end-of-life of products, and *environmental sustainability, r*educing the consumption of energy, while increasing the usage of renewable energy, as well as optimising the exploitation of materials in manufacturing processes, together with the co-evolution of products-processes-production systems. It also contains a section on *social* sustainability.

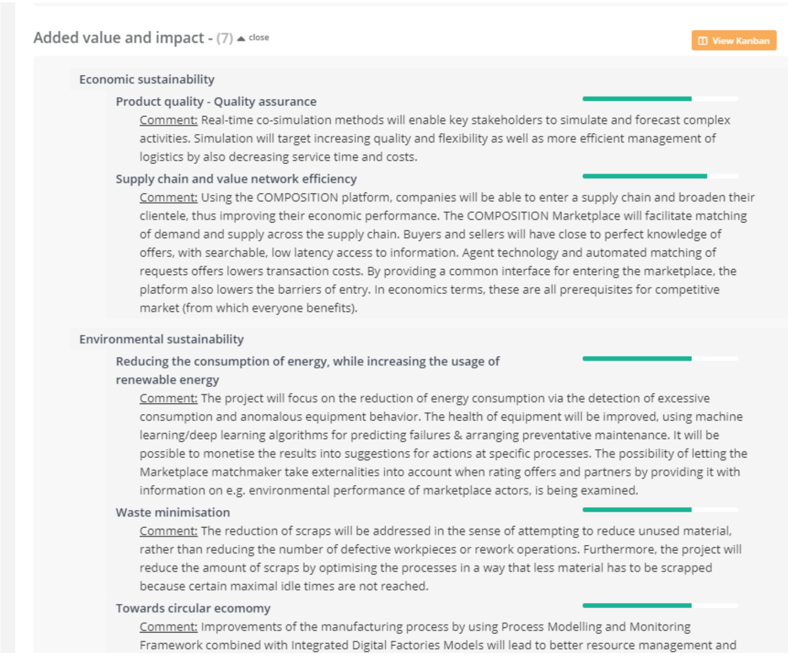


Figure 16: COMPOSITION Added Value and Impact section

In the next part, the ***Technologies and enablers*** used in the COMPOSITION project are presented and described. The four sectors that have been chosen at the present state are “Advanced manufacturing processes”, “Mechatronics for advanced manufacturing systems”, “Information and communication technologies” and “Manufacturing strategies”.

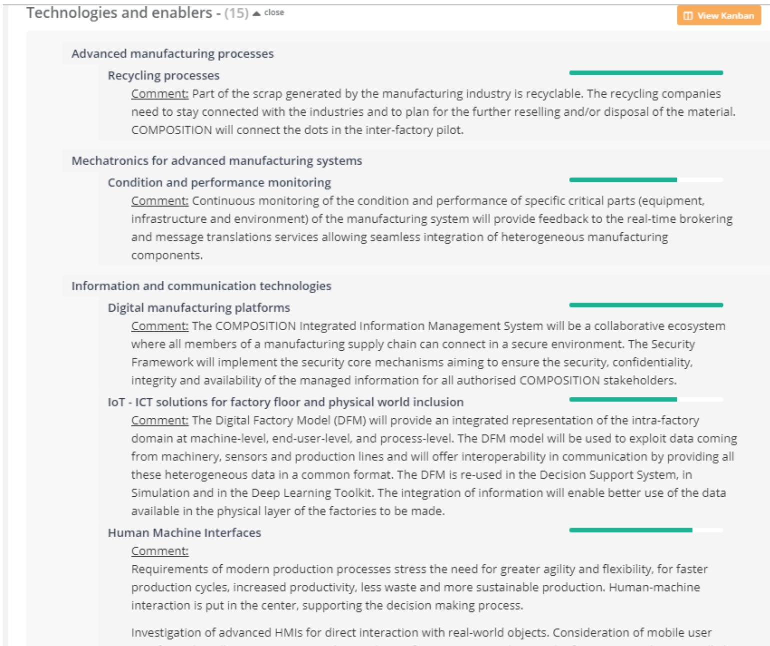


Figure 17: COMPOSITION Technologies and enablers section

An addition to the Portal is also the ***Digitisation pathways*** section. As mentioned in the EFFRA website “The ConnectedFactories project explores pathways to the digital integration and interoperability of manufacturing systems and processes and the benefits this will bring.” The COMPOSITION project describes its journey along the applicable pathways: Hyperconnected Factories, Autonomous Smart Factories.

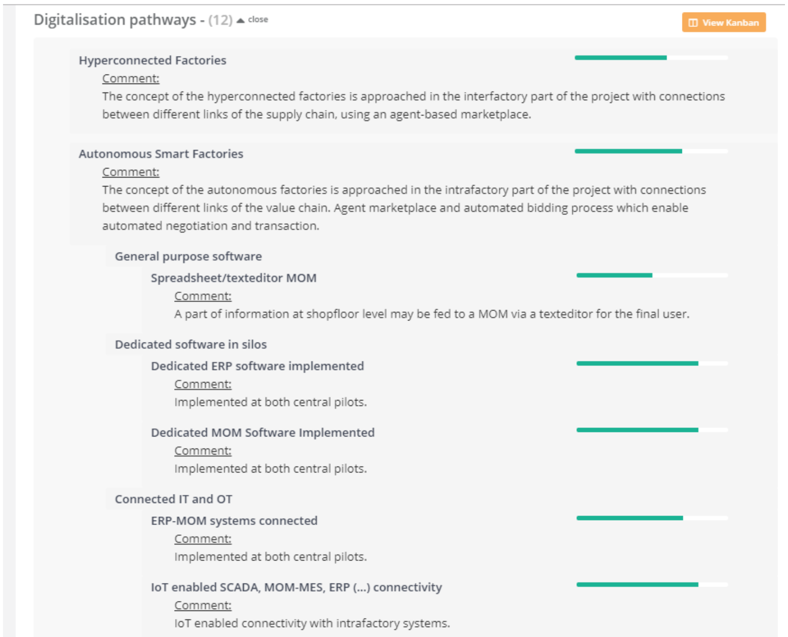
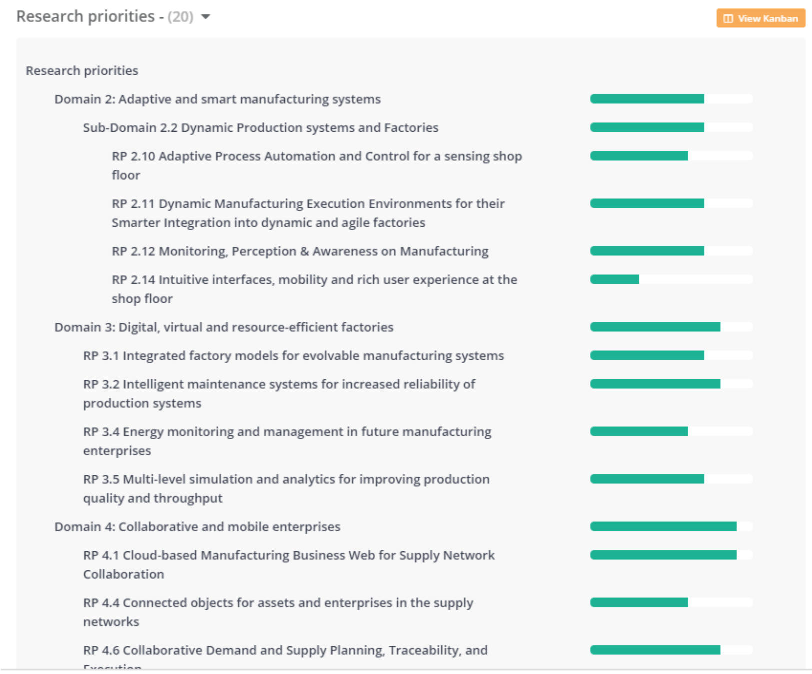


Figure 18: COMPOSITION Digitalisation pathways section

Moreover, the project is described as active in three specific domains of ***ICT Performance Characteristics***. The partners have developed solutions addressing the areas of "Data communication and interoperability", "Cybersecurity" and "Scalability".



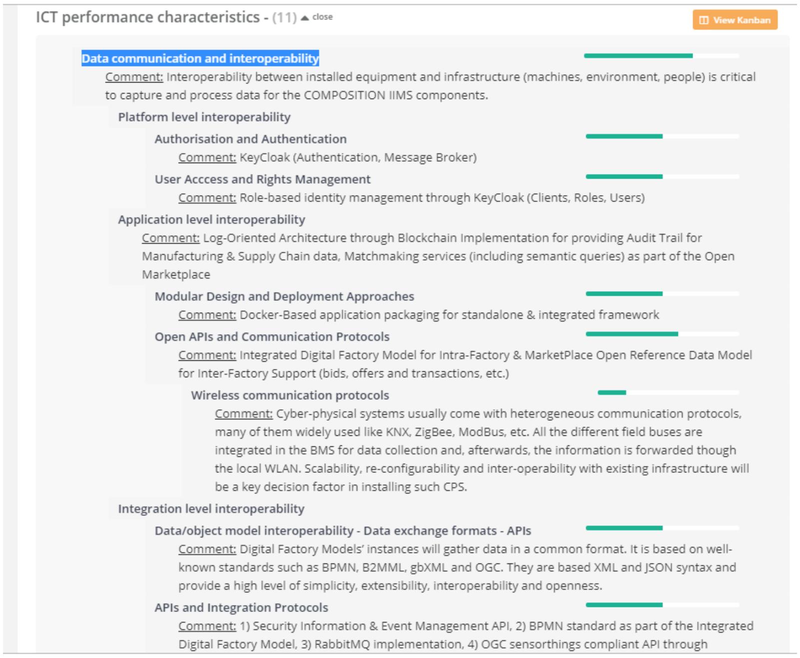


Figure 19: COMPOSITION ICT Performance Characteristics section

The two final sections are ***Standards, standardisation and regulation*** and ***Business model aspects***. The COMPOSITION project has also contributed to those, as indicated also in Figure 20 to highlight standardisation activities that the partners are involved in and Business model aspects of digital platform deployment.

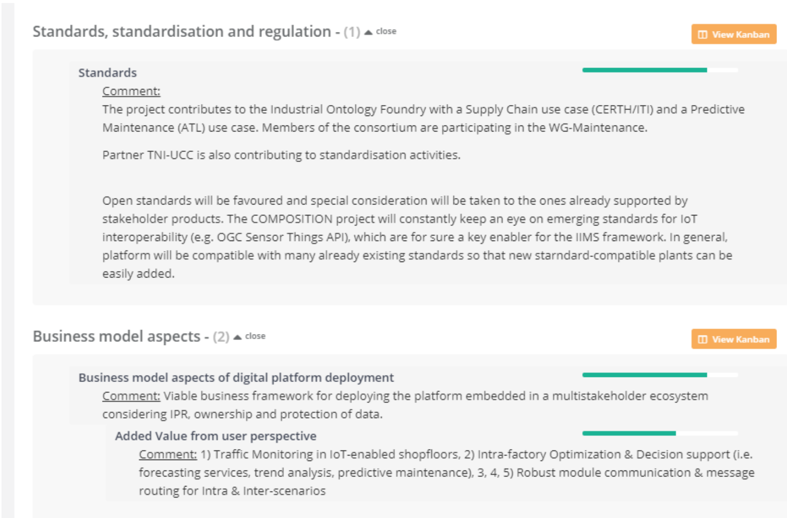


Figure 20: COMPOSITION *Standards, standardisation and regulation* and *Business model aspects* sections

It should be mentioned that three partners of the consortium are active members of the Association. Hence, it is of importance also to them to share the outcomes and advancements of the project with this community and the public. Moreover, as mentioned above, the information in the EFFRA portal is continuously revisited throughout the lifetime of COMPOSITION.

5.1.1.1 Standardisation

Based on COMPOSITON objectives, a new standardization entity has been identified and contributed from the project in addition to the initiatives identified and analysed based on COMPOSITION requirements in D7.2. These initiatives cover ***Communications Protocol Standards, Sensor Protocol Standards***, especially the ***EnABLES JRA 3 – Simulation Tools for Power Module Sizing***, and the ***Industrial Ontologies Foundry (IOF). Of this last initiative*** CERTH and ATL are members and they contribute in

Supply Chain and Predictive Maintenance use cases, respectively. Moreover, ATL is a member of the Maintenance Working Group and is in collaboration with the members of the Working Group for the definition of use cases related to predictive maintenance.

European Materials Modelling Council (EMMC)

The mission of the EMMC is to bring materials modelling closer to the demands of industry. A new collaborative and integrative approach will bring materials modelling benefits to manufacturers. The EMMC Marketplace is a digital European hub to ease the access of industry to materials modelling and data repositories, development of the translator's role and function, training and validation of software. The EMMC enhances the interaction and collaboration between all stakeholders engaged in different types of materials modelling, including discrete and continuum modellers, software owners, translators and manufacturers.

To support the activities of EMMC, CERTH has followed some of their activities and deploy the Collaborative Manufacturing Services Ontology of COMPOSITION to EMMC repository (https://emmc.info/taxonda/collaborative-manufacturing-services-ontology/) in order to publish results from the project related to manufacturing ontologies that can be adopted by EMMC.

5.1.2 Workshops and Joint Events

During this third period (September 2018 – August 2019) several Workshops have been held:

- **25th-27th September 2018** in Funchal, Portugal - Connected Smart Factories - Showcasing Recent Developments in the Smart Manufacturing Arena

  The conference brought together industrial representatives from the digital manufacturing and IoT domain alongside the researchers to discuss the ongoing developments in the broad area of Connected Smart Factories. COMPOSITION co-organised the workshop "Connected Smart Factories", together with NIMBLE, DIGICOR and vf-OS. The workshop covered different aspects of smart manufacturing, with the common vision to contribute towards a Connected Smart Factory platform in Europe. It was composed of 19 presentations organised into the four thematic sessions and was attended by 38 participants, who actively contributed towards the discussions during each of the presentation.

  COMPOSITION participation: FIT, ISMB

- **17th October 2018** in Brussels, Belgium - Workshop on Security and Manufacturing

  DG Connect, EFFRA and ECSO co-organised a workshop on Security and Manufacturing on 17 October in Brussels. COMPOSITION presented the security framework implemented in the project and shared experiences around cybersecurity and blockchain with other attendees.

  COMPOSITION participation: ATOS

- **21th-22th November 2018** in Torino, Italy - Innovation and Networking Days

  ICT Community, Academia, Research and Industry, Public administrators

  The Innovation and Networking Days allow Innovators from industry, research and public administration to meet, share, network and discuss different facets of a broad topic that, in this edition, was how Information and Communication Technologies can support environmental sustainability of production, products and services.

  As an example of collaboration activities, eFactory coordinator Usman Wajid gave a talk about the new project and participated in the collaborative workshop sessions.

  COMPOSITION participation: ISMB, FIT, KLE, TNI-UCC

- **4th-6th December 2018** in Vienna, Austria - ICT 2018

  ICT Community – Industry

  ICT 2018 focused on the European Union's priorities in the digital transformation of society and industry. The collective which includes the projects COMPOSITION, Nimble, Digicor and vf-OS together with EFFRA, under ConnectedFactories, has organised a Networking event/Workshop on "Digital Manufacturing Platforms & Connected Factories".

  COMPOSITION participation: FIT, ATL, CERTH, KLE, TNI-UCC, CNET

- **19th March 2019** in Brussels, Belgium - EFFRA General Assembly

The EFFRA General Assembly brought together Project representatives, EFFRA members, associated PPPs and representatives of the Commission and Policy makers.

COMPOSITION participation: ATL, ISMB/LINKS, ATOS

- **15th May 2019** joint webinar, online

  COMPOSITION united with DIGICOR, NIMBLE, vf-OS and EFFRA to give the free webinar "Future Manufacturing Pathways in Europe". It presented the Hyperconnected factories & Pathways concept and showed how the four projects transformed user needs into solutions and stories.

  COMPOSITION participation: ATL, FIT

- **22th-23th May 2019** in Brussels, Belgium - FoF Community Days

  The two-day event included brokerage sessions for the upcoming FoF 2020 calls followed by parallel sessions highlighting the project results, demonstrators and their impact, covering a broad spectrum of technologies and applications. COMPOSITION gave a talk about project outcomes in the session "Digital platforms and hyperconnected Factories".

  COMPOSITION participation: ATL, FIT, NXW, ATOS

- **4th June 2019** in Rome, Italy, KET4DF at CAiSE 2019

  COMPOSITION, along with Z-Bre4k, UPTIME and FIRST projects supported the organisation of the 1st International Workshop on Key Enabling Technologies for Digital Factories. It was held in conjunction with CAiSE 2019. The goal of this workshop was to offer high quality research papers and presentations focused on technologies for Industry 4.0, with specific reference to digital factories and smart manufacturing.

  COMPOSITION participation: ATL, ISMB/LINKS

- **25th-26th June 2019** in Bonn, Germany - IDSA 2nd Summit

  Participants: Technical Managers, R&D managers, Developers, SMEs, Business Consultants, CEOs, CIOs, COOs and CTOs from industrial and software sectors, Academics and Researchers, EC members.

  The IDSA 2nd summit is a two-days event dedicated to creation of international data spaces. The event contains presentations, use case pitches, interaction sessions, booths and networking activities. CERTH presents COMPOSITION/Smart waste management use case pitch.

  COMPOSITION participation: CERTH

5.1.3 Further Planned Collaborative Activities with FoF-11-2016 Projects

The collaboration of COMPOSITION and the other three "Collaborative manufacturing and logistics" projects DIGICOR, NIMBLE and vf-OS has led to the joint follow-up project eFactory, which is funded under DT-ICT-07-2018. eFactory aims at pursuing the efforts of the four projects by realising a federated smart factory ecosystem, initially by interlinking the four smart factory platforms through an open and interoperable Data Spine. The federation of the four base platforms will be complemented by industrial platforms, collaboration tools and smart factory systems, specifically selected to support connected factories in lot-size-one manufacturing. The federated eFactory platform will deliver added value and reduce the barrier to innovation by providing seamless access to services and solutions that are currently dispersed. eFactory has started in January 2019 with close collaboration in terms of parallel activities with the ongoing FoF-11-2016 projects. eFactory will continue until December 2022.

Moreover, the DT-ICT-07-2018 projects eFactory, QU4LITY and ZDMP are already in collaboration and they are going to stay connected in order to define synergies and mainly complementarities. Partners of COMPOSITION (ATOS, Kleemann, Nextworks and Atlantis) are members of the eFactory and QU4LITY consortia and thus facilitate the interactions.

Additionally, it is envisaged that EFFRA will continue to work on the concepts of the ConnectedFactories capitalising on the experience gained from the CSA.

5.2 FoF-11 CSA Connected Factories

In the period between September 2018 and August 2019, EFFRA and the CSA Connected Factories have produced some material (deliverables, reports, etc.) and held some workshops. This is a summary of the main outputs produced:

- ConnectedFactories published the v12.0 of the Structured Glossary associated to the digital mapping framework on the EFFRA Innovation Portal. (described in subchapter 0)
- As mentioned in section 5.1.2, ConnectedFactories CSA was one of the co-organisers of the Networking session held in December 2018 at the ICT2018 in Vienna. COMPOSITION, DIGICOR, NIMBLE, vf-OS and ConnectedFactories presented the status and vision and collected feedback about the goals and objectives of representatives of industry and R&D. Furthermore, with the addition of eFactory, QU4LITY and ZDMP, the group of collaborating projects offered a free webinar, which is available on YouTube (https://www.youtube.com/watch?v=5_XvNOTUFls&feature=youtu.be).
- COMPOSITION has provided feedback to ConnectedFactories about the video the latter produced on “Pathways to digitalisation of manufacturing”. This collaboration has been expanded into providing material and suggestions to the CSA on the EFFRA Portal and on the video for “HyperconnectedFactories” which is being currently finalised and will soon be released on the ConnectedFactories website.
- In the last year, EFFRA has also published monthly newsletters, indicating the different activities in which they have been working or participated.

5.3 Other Initiatives

From September 2018 to August 2019, several memorandums of understanding (MoU’s) and collaboration agreements between the different Industrial IoT initiatives have been carried out. For instance, FIWARE has signed a MoU with the International Data Spaces Association (IDSA - Germany) and with the Industrial Value Chain Initiative (IVI - Japan) and has already established relations with the Industrial Internet Consortium (IIC - US). In the same way FIWARE has already started discussions with the Platform Industrie 4.0 (Germany) focusing on the implementation approach for the AAS (Asset Administration Shell) based on the NGSI-LD standard developed by FIWARE.

In addition to the initiatives presented in D7.2, the reference architecture model RAMI4.0, the Industrial Internet Reference Architecture (IIRA) and the Industrial Value Chain Initiative, there are some other emerging initiatives of which we can highlight the Industrial Internet Architecture (IIA) by the Alliance of Industrial Internet in China.

The first version of this Architecture was presented in August 2016, endeavouring to identify all the technologies, logical layers and activities related to Industrial Internet Architecture in AII (Figure 21).

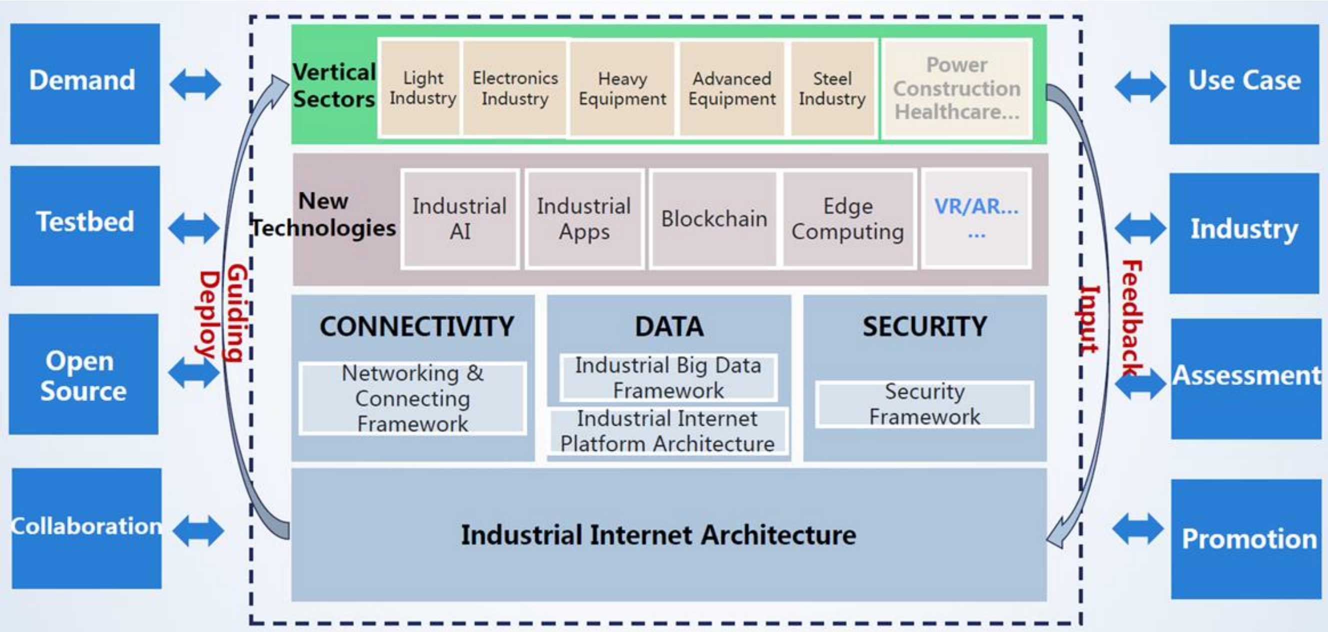


Figure 21: Industrial Value Chain Reference Architecture (source: Xiaohui, et al, 2018)

The core of industrial internet is the data-driven intelligence that is based on overall interconnection. For both, industry perspective and Internet perspective, network, data and security are their common foundation and common support. Therefore, as reflected in Figure 22, IIA (Xiaohui, et al, 2018) is based on these three main pillars:

- CONNECTIVITY is the basis, the basis for the data collection, transmission, exchanging, including the network interconnection system. Main responsibility is the seamless delivery of information data between the production system units, and between the entities of the production systems and business systems with the ubiquitous and interconnected network infrastructure. Also supporting production models with features of real-time sensing and collaborative interaction between them
- DATA is the core, data flow and data intelligence in the whole lifecycle of the product, including functional modules such as data collection and exchange, integrated processing, modelling and analysis, decision optimization, feedback and control. It can provide analytics of the production site, information of the collaborative enterprises, and customer needs through collection and exchange of massive data. This pillar is based on the use of technologies such as edge computing, cloud-based big data computing and Artificial Intelligence (AI)
- SECURITY is a prerequisite, ensuring the running of the industrial internet system, providing mechanisms for the protection of networks and data in industrial internet, including equipment and network security based on a comprehensive security management. So, the main objective is to protect network infrastructure and system software from internal and external attacks and preventing unauthorized access to data.

Based on the three pillars, the IIA identifies three different optimization loops in the industrial Internet to achieve intelligent industrial development:

- Equipment operation optimization, in charge of optimizing the equipment and its operation based on real time sensing and edge computing, with the objective of developing smart machines and flexible production lines based on dynamic adjustment of the machines and equipment
- Enterprise management optimization oriented to production operation optimization. This focuses on integrated processing and big data modelling analysis based on information system data, manufacturing execution system data, and control system data. To realize dynamic optimization and adjustment of production operation management and generate intelligent production models for various scenarios
- Ecosystem optimization, oriented to enterprise collaboration, user interaction and optimization of products and services. This loop focuses on the integration and analysis based on supply chain

data, user requirement data and product and service data, to produce new models like network-based networking collaboration and personalized customization.

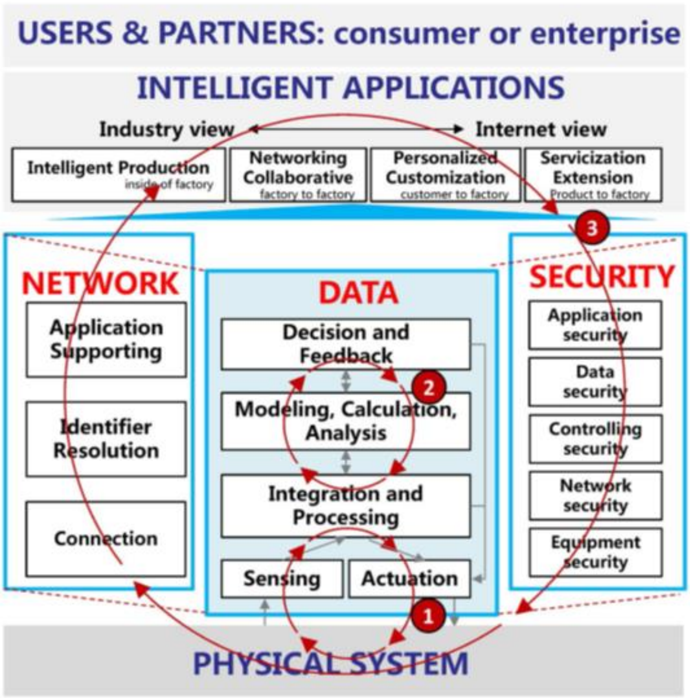


Figure 22: Industrial Value Chain Reference Architecture (source: Xiaohui, et al, 2018)

The IIA, also describes the Connectivity Framework of the Industrial Internet (Figure 23), based on two separated networks:

- Factory Internal Network, which connects industrial equipment, PLCs, products, enterprise Datacentre and Servers
- Factory External Network, which supports the scenarios with low latency, high reliability and customization.

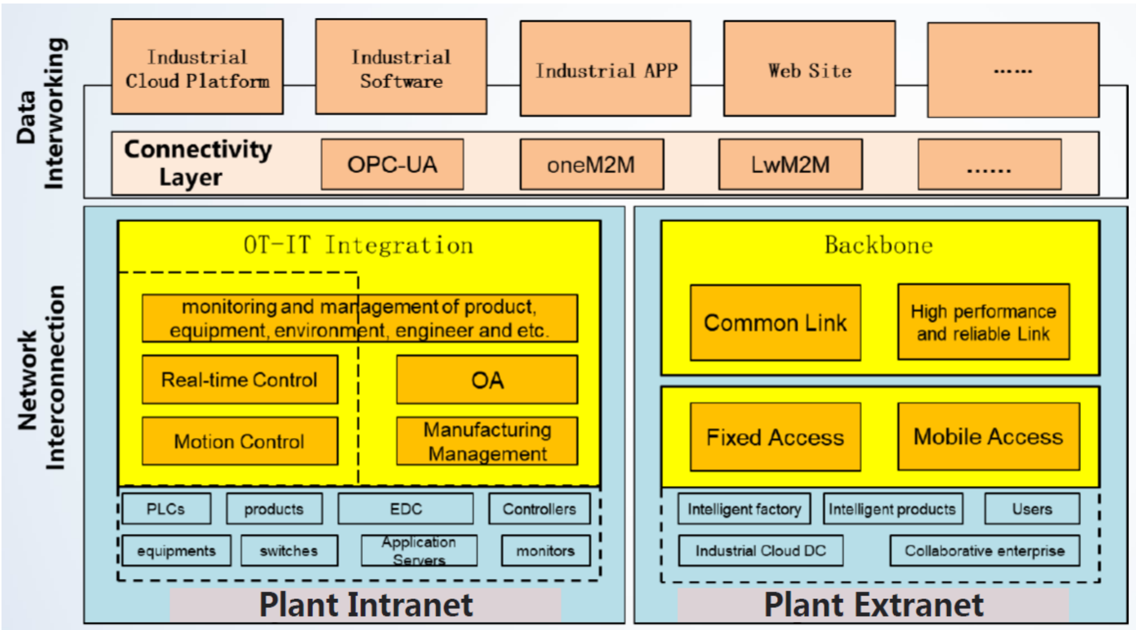


Figure 23: Connectivity Framework of Industrial Internet (source: Xiaohui, et al, 2018)

The second pillar, the data system of the Industrial Internet, covers all the data generated during the different phases throughout the life of the product, covering the design phase, production phase, management phase and service phase of industry. This pillar also covers the Industrial big data analytics with intelligent functions including description, diagnostics, prediction, decision making and control. IIA Industrial big data is divided into three types:

- Onsite equipment data, which comes from industrial production line equipment, machines and products, mostly collected by sensors, devices and instruments, as well as the industrial control system, including equipment operation data and production environment data
- Production management data, which is generated by traditional information management systems, such as SCM, CRM, ERP and MES
- External data. which includes information and data from Internet market, environment, customers, governments, supply chains and another factory external environment.

From the functional perspective, the industrial internet's big data architecture consists of four layers and five parts, which are data acquisition and exchange, data pre-processing and storage, data modelling, data analysis, and the data driven decision-making and control applications, as shown in Figure 24.

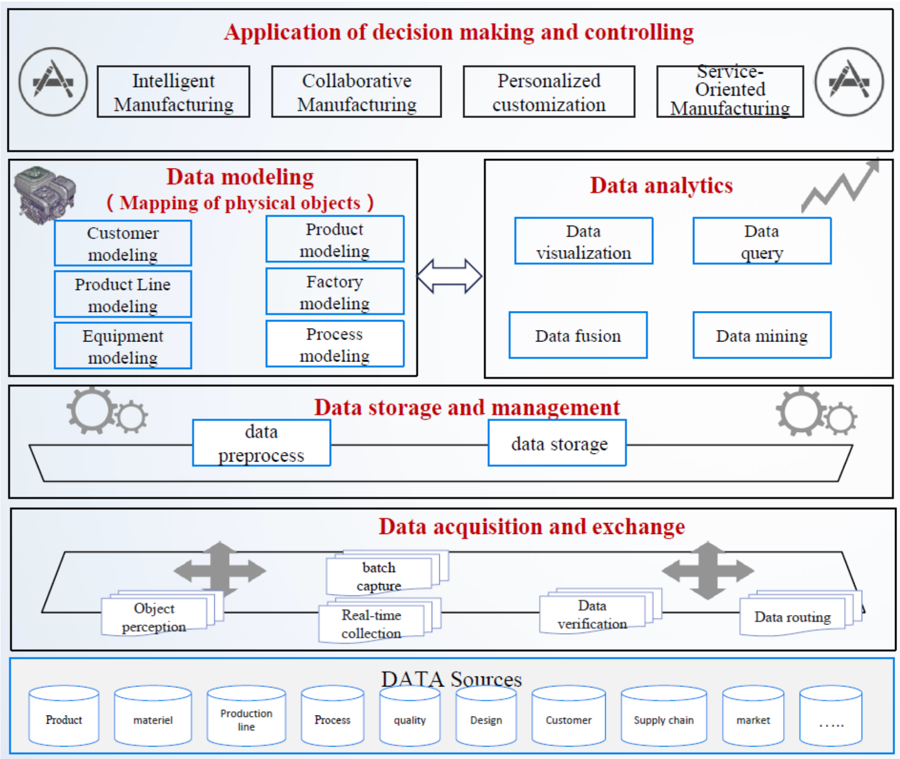


Figure 24: Industrial Internet Big Data Architecture Layers (source: Xiaohui, et al, 2018)

The IIA, defines the Industrial Internet of Things Platform as a service system that is based on the needs of digitalization, networking and intelligence in manufacturing. It builds a service system based on mass data collection, aggregation and analysis, and supports the making of connections, flexible supply and efficient allocation of manufacturing resources. For this it identifies and provides mechanisms for covering the following main trends:

- Data integration across layers and parts
- Data process with assistant of the edge
- Data integration management in the cloud
- Advanced data analytics
- Data visualization as analytic tools

All these functionalities are distributed and covered by three functional layers reflected in Figure 25, which are:

- Application layer – Formed to meet different industries and verticals, different scenarios of industrial SaaS and industrial APP for the final value of industrial Internet
- Platform layer – Responsible for building a scalable Open Cloud Operating System on the common PaaS with big data processing, industrial data analysis, and industrial microservices
- Edge layer – Responsible for building a data foundation for industrial Internet platform through a wide range of in-depth data acquisition, as well as heterogeneous data protocol conversion and edge computing,

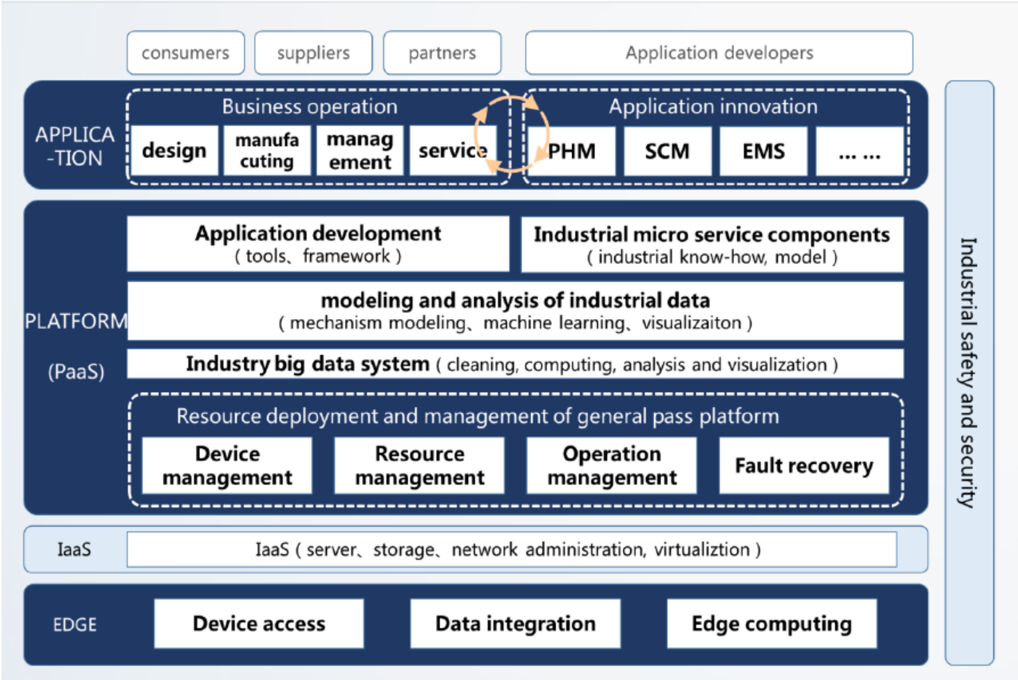


Figure 25: Industrial Internet of Things Platform (source: Xiaohui, et al, 2018)

Finally, the third pillar, which covers the Security of the Industrial Internet, is analysed via the IIA from two perspectives:

- Industry, the security mainly refers to guaranteeing the continuity and reliability of intelligent production, focusing on the security of intelligent equipment, industrial control devices and systems
- Internet, to ensure the running of customization, network-based collaboration, service-oriented extension and other industrial internet applications so as to provide continuous service capability and prevent the leakage of important data, focusing on industrial application security, network security, industrial data security and service security of intelligent products.

Therefore, the IIA defines an Industrial Internet Security System framework with five parts as shown in Figure 26, in the Protection object Viewpoint: device security, network security, control security, application security and data security. In addition, the IIA also defines two more Viewpoints which are the Protection Measurement Viewpoint and the Protection Management Viewpoint.

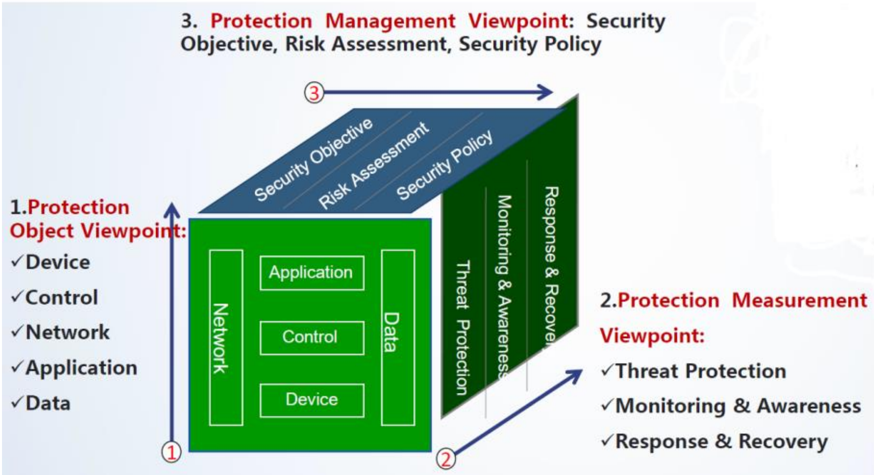


Figure 26: Industrial Internet Security System framework (source: Xiaohui, et al, 2018)

The Working Group JTG2 from the Industrial Internet consortium (IIC) in charge to work on the convergence between RAMI and IIRA and together with people from the Alliance of Industrial Internet China on identifying convergences between IIRA and the IIA (Figure 27).

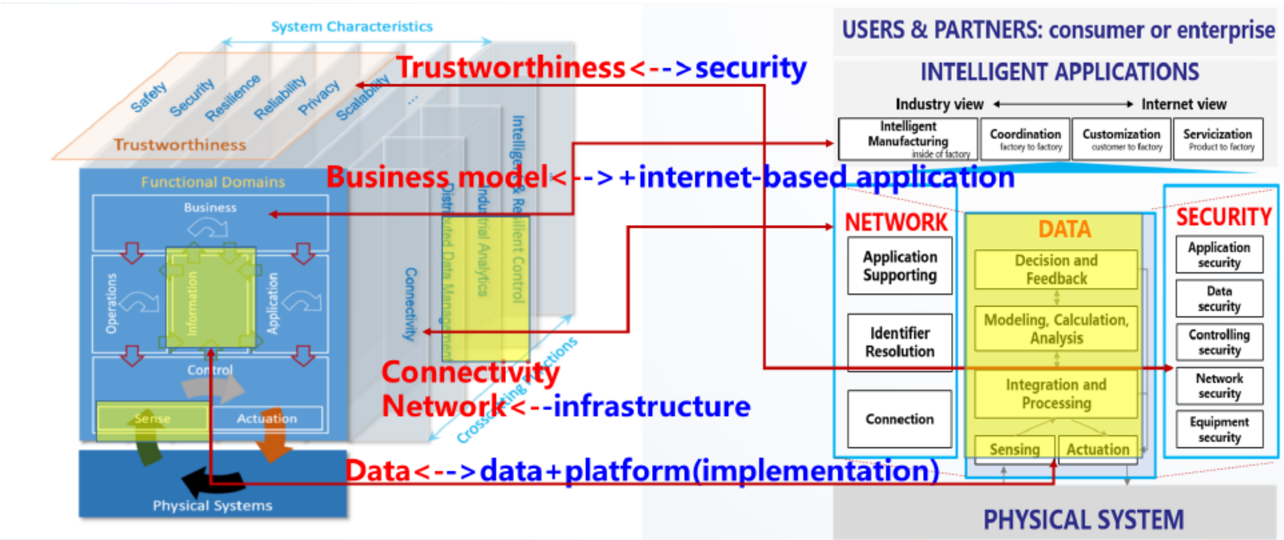


Figure 27: Convergence between IIRA and IIA (source: Xinhao Jiang, 2018)

Another identified project that can be taken as reference by COMPOSITION is:

- The European research project BIG-IoT (BIG-IoT, 2018) intends to set up a digital Marketplace allowing companies to monetize their data resources and services. Interoperability is ensured by leveraging a uniform, standard Web of Things API (W3C, 2018).

6 Conclusions

Deliverable D7.3 is the last of three deliverables which provides detailed information about ongoing initiatives such as FIWARE4Industry and International Data Spaces, together with joint actions carried out with these initiatives in order to take advantage of existing components or solutions that can be reused in COMPOSITION project to solve some of the project requirements.

The document also provides a detailed description of the work carried out during the third year (September 2018 – August 2019) in cooperation with the other ten FoF-11 Projects with the objective of achieving a common platform for digital automation.

From the point of view of COMPOSITION, the planned tasks and actions for the third year have been fulfilled, incorporating IDS open source solution into COMPOSITION as well as the solution provided by FIWARE, thanks to the monitoring of the evolution of these platforms as well as the involvement of COMPOSITION in their roadmaps. Similarly, there has been a remarkable and proactive role of COMPOSITON with other projects and initiatives, where collaboration efforts were focused on clustering activities in scope of the other FoF-11-2016 projects, EFFRA and ConnectedFactories. As such, COMPOSITION gave talks at two EFFRA community events and acted as example for the EFFRA HyperconnectedFactories video. Special collaboration happened with the projects DIGICOR, NIMBLE and vf-OS, which resulted in two jointly organised conference workshops and one joint webinar. Finally, the four initiatives have begun to integrate parts of each project into a joint platform as main objective of the eFactory[5] project. Together with eFactory, the joint webinar was funded in collaboration with DT-ICT-07-2018 projects; namely QU4LITY and ZDMP.

[5] https://www.efactory-project.eu/

7 Tables and Figures

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