Proactive Customers Integration as Drivers of an Integrated Food Chain

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1. Introduction

Competitiveness of European Small and Medium sized Enterprises (SME) in the global marketplace is correlated to and determined by diverse factors. However, specifically SME's ability to satisfy explicit and implicit customer requirements as well as to proactively integrate them as a driver of complex business networks is a key success factor. Although this seems to be the most obvious economic principle, it is hard to be achieved in complex networks of small actors, including vertical and horizontal supply chain dimensions, especially due to self-organisation of single network entities in relation to the continuous and dynamic adjustment of the overall network. Moreover, dynamically changing customer needs, evolving requirements (e.g. legislative demands, technology enablers) and process disturbances (e.g. delivery deviations, incompatibility of supplied semi-finished products) need to be handled.

A promising opportunity for proactive customer integration is envisaged by promoting the usage of Intelligent Networked Devices such as enhanced RFID-based systems, for the usage in dynamic networks as specifically represented by food chain scenarios. It is considered that Intelligent Networked Devices are enabling highly flexible and dynamic business interconnections to react dynamically and agile as well as to enable just-in-time exchange of knowledge and experience among Large Enterprises (LEs), SMEs and customers.

To approach such a vision and to realise an important step towards an "Integrated Real Time Enterprise", having customers as drivers, it need to be explored how to enable the interaction of diverse actors in the integrated enterprise, specifically including customers as an integral part of these complex relationships, while focusing on the usage of "Networked Devices Enabled Intelligence" to realise distributed and asynchronous control of business processes. Although most actors in the food chain are already using "networked devices" (e.g. mobile phone, PDA, mobile scanner, notebooks) they are generally neither easily interconnected nor interoperable, often missing the required ICT related environment and infrastructure. Therefore, the realisation of the following aspects is considered as prerequisite before being able to implement a networked devices enabled intelligence:

- new interaction models and patterns for the real time enterprise, reflecting logical models for an optimal customer integration,
- an innovative architecture, supporting distributed as well as asynchronous interaction,
- software applications, mainly driven by events in the distributed workflow and
- a decentralised and self-evolving approach for assuring security and trust as well as supporting a customer oriented privacy of data.

These aspects are further detailed in the following chapters, focusing on problems related to a “real time food chain”, since such an SME driven integrated enterprise application scenario is considered as one of the most critical scenarios from both technical and organisational/ business points of view, due to its high complexity and requested flexibility.

2. Decentralised Coordination of Tasks in the Food Chain

For a decentralised coordination of tasks in the food chain, also small and micro enterprises as well as customers need to be enabled to actively play their role in the chain management. They might even need to become a focal point for a massively decentralised coordination of a “real time food chain”, which is able to continuously evolve/extent itself and to easily interface with existing systems. Therefore, key aspects for enabling the realisation of a solution need to be identified and systematically structured in accordance to both organisational and technological dimension as presented in the following Figure 1. Organisational and Technological Dimension for a Decentralised Coordination of Tasks in the Food Chain.1.

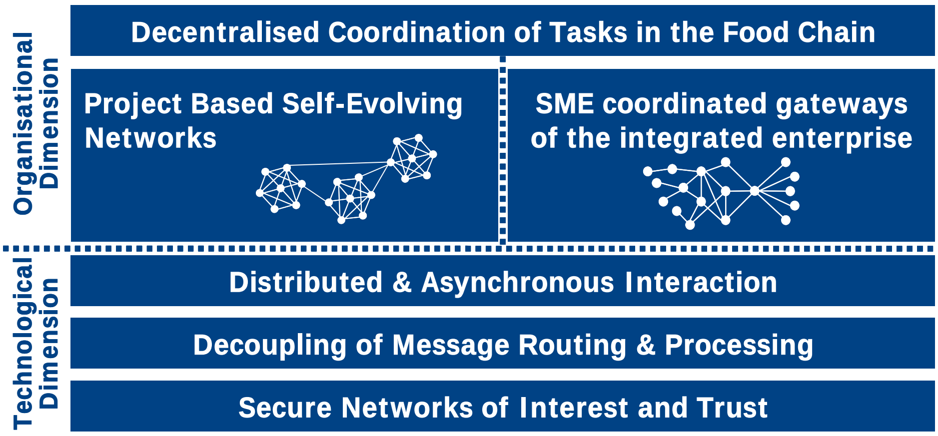

Figure 1. Organisational and Technological Dimension for a Decentralised Coordination of Tasks in the Food Chain.

In reference to the organisational dimension, specifically customers and the public audience have different perceptions of potentials and threats of massively distributed networked devices, such as enhanced RFID-based systems (e.g. concerns w.r.t. security, privacy, radiation, health, environment). Those concerns are jeopardising the establishment and acceptance of RFID supported solutions in food chains, especially when bringing RFID tags in the customer’s home. However, to overcome especially customer concerns w.r.t. such applications, technology impact of potential solutions need to be explained, envisaged benefits for the customer need to be validated and customers need to be trained on how to handle potential risks of upcoming solutions.

To enable the realisation of new solutions, research is needed to find appropriate methodologies for modelling complex interaction patterns within distributed business networks, while addressing supply chain integration as well as managing chronological changing composition of actors and context of business processes in the integrated enterprise. Such new interaction models may be based on different structures within the integrated enterprise, while determining the transition from the technological to the organisational dimension. As a basis for elaboration of SME driven scenarios, especially two interaction reference models (basic SME-driven integrated enterprise structures) are proposed as baselines and incubators for application and business specific software, services and applications development.

- **SME coordinated gateways of the integrated enterprise:** Network of ‘n’ customers and ‘n’ suppliers, while coordinated by an SME, which acts as a gateway between customers and suppliers (e.g. retailers at different “gateways” in the food chain). Basically, it is a continuous and repeated interaction of the coordinating SME with a known set of suppliers and mainly a larger amount of same customers or consumers while those are generally remaining anonymous. The interaction is widely based on not articulated requirements with infrequent and unsystematic procedures for collecting customer’s requirements and feedback. Major objective is to enable SMEs to realise a distributed ICT supported coordination of their supplier interaction (independent of supplier specific legacy systems) as well as to realise at least an unidirectional communication with their customers, to specifically broadcast target group oriented product/ service information.
- **Project based self-evolving networks:** Basically consisting of one customer which is supplied by 1 to n SME(s). In general there is an intense interaction in one project of known actors, between SME and customer as well as in between SMEs. It is based on explicitly defined and agreed requirements (e.g. supply of food for large events). Major objective is to enable all actors in a sub-network to add participants as well as to initiate and realise decentralised and asynchronous coordination.

In reference to the technological dimension major obstacles within distributed and dynamic business networks are connected towards guaranteeing security and establishing trust between nodes in open and distributed networks. Within the scope of network complexity, it is a key challenge to assure, on the one hand, an integrated homogeneous infrastructure and, on the other, capability of existing legacy systems to support dynamic adjustments (e.g. dynamic change in usage of specific devices, distributed user profile management on multi-layer access principles, roaming in decentralised networks, RFID based process event management and integration of existing security enabling devices), assuring connectivity of nodes and sub-networks, while decoupling message routing and processing. On top of that, it is necessary to address how to distribute and utilise intelligence within the network [1] and in accordance to each node’s characteristics (e.g. performance, connectivity, storage, self-sufficiency) for distributed and asynchronous interaction.
Innovations to ease the presented obstacles w.r.t. the organisational and technological dimension are specifically relevant for consumer oriented industries, since consumers can make real selections in between the supply by the high amount of small and micro enterprises, while these SME type suppliers have only a little impact on the overall food supply chain and its integrated business networks in the scope to improve their competitiveness.

3. Networked Devices Enabled Intelligence

The decentralised coordination of tasks in the food chain as well as the distributed control of underlying complex networks is realised in the physical world by a large amount of actors. In classical terms, the SME actors are generally independent, having defined personal interfaces to the rest of the supply chain. Over the past decades, specifically this underlying supply chain dramatically improved concerning efficiency and effectiveness, spanning globally distributed networks of actors, representing an integrated enterprise, in terms of horizontally as well as vertically integrated chains. This was feasible, due to strategic and often large players, which had the power in the network to establish and operate centralised systems or combinations of such large scale systems for network coordination. In such “realisation instances” of the integrated enterprise, the impact of taking benefit was therefore also remaining with the large players, resulting in their advantage in terms of flexibility of deliveries, control on balancing supply and demand as well as defining requirements on product characteristics and origin.

3.1 Key Enabling Technologies

When aiming at supporting SME type actors in providing ICT enabled added-value services to their customers and for optimising the food chain control, a key enabler are Intelligent Networked Devices, providing their own computing capability, while nowadays becoming more advanced and less expensive, and can be combined with an increasing number of other devices [2]. Furthermore, especially RFID and GNSS technology can be considered as key add-on when realising added value services based on Intelligent Networked devices available or likely to be massively introduced within the next 3-5 years.

- Radio Frequency Identification (RFID) enhanced devices based on e.g. Near Field Communication, Action Activated Tags or Smart Tags.
- Global Navigation Satellite Systems (GNSS) technology, aiming at the realisation of location based services as well as application specific data transmission via satellites (e.g. publish/subscribe based functionality).

Nowadays, RFID tags are already widely applied in e.g. theft protection (retail, cars), item identification (supply chain), lifestyle products (access, sports), security (transponder based identification, payment authorisation), animal identification (pets, livestock), production/ environment monitoring (temperature, pressure, thresholds) or even as action activated tags in the “Smart Diaper”. Constant struggle to be addressed w.r.t. especially passive tags are costs, transmission range and functionality, while currently new functionality is approaching (i.e. security, extra memory and sensors) [3, 4] and the amount of tags which can be read in parallel and the cost benefit ratio is continuously improving [5,6].
However, key challenge to be further addressed in research will be to shift the focus from reading/writing single to many tags as well as from passive to active tags, while the latter has to be characterised rather as systems or massively distributed devices than as unique items. The introduction of RFID also faces new challenges on technological as well as organisational level, requiring new and intelligent approaches for device management and auto-ID infrastructures. Moreover, the combination of tags, intelligence, readers and writers with the product, the equipment, the infrastructure or the “human operator” need to be carefully analysed and planned in accordance to the application scenario, as individually required for a specific interaction model (e.g. to enable the processing of information, generation of an event or authorisation of an interaction). While specifically the combination of the tag itself with additional devices (e.g. mobile telephones, PDA) enables new interaction paradigms (e.g. NFC enabled interaction like touch & go, confirm, connect or explore [7, 8]).
GNSS technology respectively the GNSS satellite infrastructure was until recently based upon GPS (USA) but now also GLONASS (Russia) is available free of charge and GALILEO (Europe) is underway. These independent but compatible infrastructures enormously increase the application potential of GNSS services. Accurate and real-time position and time information can dramatically increases the quality and relevance of all sorts of commercial services, while this development and related products are in the market introduction phase or even still under development. However, of great importance is the fact that first applications, such as those realised in car navigation or tracking & tracing market (e.g. tracking and tracing of road vehicles to prevent theft and to improve logistics efficiency), have created a wide supplier base of GNSS components and intelligent user equipment – so the basic elements are there (infrastructure and user electronics) to boost the location based service business. While the availability of accurate

and regular time & place information has a major impact on the realisation of new interaction models within the food chain, especially for offering added-value services to the customers, facilitating the provision of ICT services at the right time and the right place. Also triggering of activities in the workflow can be supported by generating events, based on the specific location of actors in the food chain.

On the longer term, indoor positioning techniques will come into play, which are currently being developed and will come to the market in a number of years time [9]. These indoor positioning techniques could contribute to many food chain processes like delivery control or workflow management, even including heterogeneous distributed actors along the supply chain.

3.2 The Concept of Ambient Intelligence Solutions

RFID and GNSS technology highly facilitates the implementation of implicit inputs and outputs to an ICT system, disburdening the user from activities which are not directly related to the business process execution. Therefore, the interaction with ICT systems can focus to a higher degree on added value tasks enabling a transparent user support [10] defines 'transparency', if an activity of a user is experienced without breakdowns). This implicit inputs and outputs from and to the ambience, processes or infrastructure enables an important add on to the envisaged multimodal interaction with mobile devices, while highly facilitating the usage of such devices (e.g. avoiding tedious log-in procedures, repeated identification of individual preferences, combining explicit inputs with additional semantics related to the current situation of the process or the user). Moreover, RIFD and GNSS will drastically facilitate to collect added value knowledge on the human operator (e.g. location, context, intention), the (process) environment in which the human operator is working and its interaction with its environment as well as the ICT system itself and its interaction with the environment. Therefore, the RFID and GNSS technologies are providing a key prerequisite to implement an Ambient Intelligence (AmI) technology based solution in accordance to its definition as presented in [11]. An AmI solution is aiming at greater user-friendliness, more efficient service support, user-empowerment, and support for human interactions [12]. Thus, implementing AmI based solutions for surrounding people with electronic environments, sensitive and responsive to their wishes.

For the implementation of such AmI based solutions in an SME environment, the SME end-user, representing "non-experts in AmI technology", need to be enabled to identify most appropriate AmI technologies for a human centred business improvement [13], even before a technical realisation can be taken into account. First methodologies and technological solutions are available [14] aiming to support SMEs as well as consultancy and ICT providers.

3.3 Evolving Requirements towards Networked Devices Enabled Intelligence Solutions

To realise highly decentralised and asynchronous interaction of loosely coupled actors, while even aiming at the realisation of evolving end-user networks (e.g. based on contract, location, schedule) along the workflow in the food chain, there is a need for a new dimension of interaction to be supported by added-value services, which cannot be based neither on static large scale systems, due to evolving infrastructures and devices, nor on predefined systems functionality, due to heterogeneity of actors and impossibility to achieve an accepted overall system governance or central authority for system maintenance and change.

Therefore, the shift in the characteristics from classical solutions to the envisaged solutions which are based on a networked devices enabled intelligence, realising AmI solutions is presented in the following Table 1. Basic differences between classical solutions and envisaged solutions based on networked devices enabled intelligence.1. This comparison is quite general, not aiming at a holistic characterisation of the solutions or a full coverage of all possible solutions available in the market, nor reflecting the continuous innovation and migration of "classical solutions" towards the "internet of things/objects". The key objective is the identification of the most typical description of some key quality characteristics (on the basis of ISO 9126), trying to polarise basic solution alternatives as basis for the resulting key requirements to be taken into account when aiming at the development of the development environment for "solutions based on networked devices enabled intelligence".

Table 1. Basic differences between classical solutions and envisaged solutions based on networked devices enabled intelligence.

Characteristics	Classical Solutions	Solutions based on networked devices enabled intelligence
Amount of Functionality	Agreed and defined between actors.	Specific individual w.r.t. the actors/ group of actors and continuously evolving over time.
Location of Functionality	Centralised in large scale systems.	Decentralised, partly mobile and possibly defined at runtime.
Usability	General user interfaces based on profiles or user groups generally not customised to individual user preferences.	Highly customisable, even by users themselves, enabling context based user interfaces taking into account implicit inputs from ambience.
Portability	Limited due to platform specific implementations.	Solutions are aiming at supporting diverse platforms as well as dynamic and distributed operation.
Maintenance	Fixed relation of maintenance supplier and solutions.	Open environment, enabling ICT suppliers to maintain solutions from other ICT suppliers.
Interfaces	Static, explicitly defined, not self explanatory.	Dynamic, based on ontology, self explanatory.
Middleware	Client-Server relation.	Publish-Subscribe relation of peers.
Infrastructure	Agreed and defined infrastructure and devices in the overall system.	Evolving infrastructure and continuously changing devices.
Performance	High performance Servers and Clients.	High performance of servers and centralised not mobile hardware. Limited and highly restricted performance of mobile, distributed devices.
Efficiency	Often not optimised relation on server and client side (i.e. server to low and client to high performance).	Available ICT devices and infrastructure are generally requiring an optimisation of the performance/usage ratio.
Availability	Immediate and parallel processing of requests for a synchronous interaction.	Processing in accordance to available performance and queuing of requests, required to enable disconnected operation and asynchronous processing.
Security	Centralised, application specific user management or trust centres with defined roles	Built-in security (i.e. in devices) and evolving communities of trust with dynamic roles, based on interacting peers and groups.
Privacy	Group and role based interaction with centralised data storage, not necessarily requiring the distributed processing of content.	Profile based and individual interaction with centralised and often decentralised data storage, requiring mobile processing of content.
Governance	If managed carefully well defined strategy and policy for use of the IT.	Independent strategies and policies likely.

These characteristics were further grouped in accordance to the ICT related environment and infrastructure required for developing a “Networked Devices Enabled Intelligence” as presented in the next chapter.

4. Envisaged Solution

4.1 Key Technical Characteristics of the Envisaged Solution

Based on the assumption, that a combination of RFID and GNSS with mobile devices like mobile phones, PDA, displays, touch screens, digital pens and wearable input/ output devices will enable the realisation of solutions based on networked devices enabled intelligence, the characteristics as presented in Table 1. Basic differences between classical solutions and envisaged solutions based on networked devices enabled intelligence.1 were grouped in the following activity fields for realising the required solutions:

- Enterprise Architecture Development:
  For supporting the operation and usage of mobile and distributed devices like enhanced RFID based systems, an architectural approach is required which is enabling the realisation of a distributed solution, allowing the operation on heterogeneous platforms, facilitating asynchronous processing, supporting publish-subscribe relation of peers, enabling the evolution of the infrastructure & devices, supporting the execution of logically units of functionality with different physical entities of the system as well as enabling the reuse and combination of existing and new system functionality.
- Business Oriented Intelligent Agents:
  The asynchronous interaction in a distributed network of actors with limited online connection of autonomous peers is quickly suffering of the inability to exchange information in the moment when the end-user is operating his device. This would immediately lead to a breakdown of ‘experiencing an activity’. It is envisaged, that business oriented intelligent agents could fill the gap w.r.t. the user input and its perception of the required system/device functionality and reaction time. The objective is to disburden the user based on defined business rules, context based system behaviour and available resources/ system performance.
- Trust, Security and Privacy:
  Due to the basic risks of RFID and GNSS based solutions as well as potential data losses w.r.t. malfunction or theft of mobile devices, it need to be aimed at a provision of Privacy Enhancing Technologies (PET) with both technical solutions for agent & middleware security, authentication, authorisation and trust as well as appropriate interaction paradigms for user/ customer centric interfaces.
- Interaction Models:
  When aiming at the realisation of an interconnected and interoperable solution in the food supply chain, several SME type actors need to be empowered to somehow jointly implement an appropriate solution. Generally they are neither experienced with new technologies, nor having vast experience in process innovation approaches. Therefore, it is envisaged that the elaboration of reusable and widely applicable interaction models for supply chains will directly facilitate the process analysis and ICT specification. (e.g. with respect to amount and location of functionality, system usability, performance, efficiency, availability and governance).

The key areas as presented above are put into relation to the overall system aspects as presented in the following Figure 2. Key Technical Characteristics in relation to overall system aspects.2.

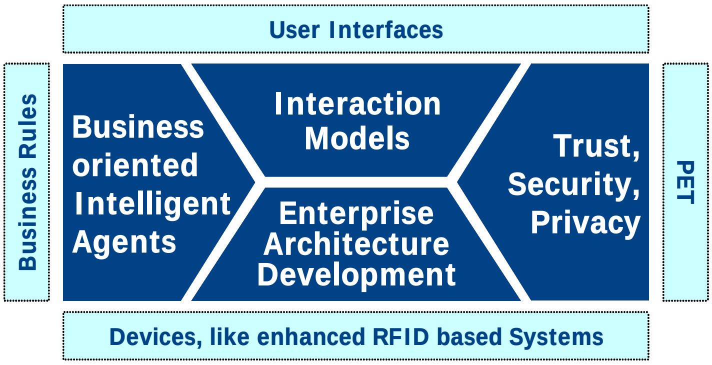

Figure 2. Key Technical Characteristics in relation to overall system aspects.

4.2 Envisaged ICT Environment and Infrastructure

To serve the needs for an appropriate system architecture, a combination of an event driven (EDA) with a service oriented architecture (SOA), based on an enterprise service bus infrastructure, realising basic services, is envisaged as a highly appropriate combination for solutions based on networked devices enabled intelligence.

To complement this with user centred and context based functionality, event-driven agents based on a multi-agent architecture and integration framework for agents (realising an intermediary for agents with services) can support the asynchronous and decentralised interaction of the actors in the food chain. It is also expected, that this approach will highly facilitate the integration and further usage of existing legacy systems and service providers.

For a decentralised approach for security & trust, realising novel security services – security and trust need to be addressed amongst network centric systems, involving the integration of embedded devices, information processing, and communication. This needs to support a diverse set of requirements, reflecting different kinds of heterogeneous systems. A promising approach for realising an appropriate security framework is the consideration of MILS (Multiple Independent Levels of Security/ Safety/ Separation), which is an architectural approach designed to build scalable systems appropriate for the Information Assurance needs of both commercial and government systems.

Furthermore, the main assumption is that the massively distributed networked devices in combination with EDA & SOA will offer new opportunities to ‘integrate the customer in the integrated enterprise’, by allowing new interaction patterns among different actors in the enterprise, also including customers. Therefore, it is considered as a key prerequisite, to analyse the actual interaction patterns in the food chain, aiming at a fully understanding why the interactions are organized the way they are. Each pattern represents a 'best' balance between (a) highest expectations of actors on interaction benefits and (b) real interaction systems where limitations in technology, economics, legal conditions, etc. limit the exploitation of potentials to full extent.

Therefore, such interaction patterns can serve as a kind of user requirements specification for realising generic interaction services, while the services at lower layers are likely to be even cross-sectorial (see next section). Potential services have to be further analysed and several of such generic services have to be developed, especially those which are being most appropriate to prove concepts and demonstrate the new interaction patterns benefits.

4.3 Service Structure

As explained above, key approach for realising a networked devices enabled intelligence is to develop generic services (i.e. basic services, event-processing agents, security services and generic interaction services) for supporting typical, while still generic, Interaction Models. However, they need to be explicitly validated in the scope of business cases. To facilitate this, a grouping into three types of services is recommended: (1) generic services which are envisaged to be applicable for diverse application scenarios, (2) general elements of services which would serve as templates/libraries for further adaptation in specific services, and (3) specific services highly adapted to the specific needs of an application scenario.
However, to transfer such generic services to specific application scenarios, additional integration effort is required, for finally realising customised interaction services, providing specific functionality/ features within a business process.

4.4 Methodology

Accompanying to the development of technological solutions, emphasis shall also be put on the elaboration of a methodology to provide an innovative approach on how to realise the usage of networked enabled intelligence for proactive customer integration, addressing both technological and organisational aspects related to the envisaged four key solutions as described before.
Such a methodology need especially to target at end-users within an integrated enterprise [15], addressing SME type organisations and their customers, but also providing methodological approaches for larger organisations in the food chain like actors as retailers, distributors or logistics providers to facilitate the realisation of systems, able to support massively distributed networked devices. Therefore, such a methodology need to cover guidelines on different issues such as:

- how to combine different services to provide customised interaction services for specific application scenarios.
- how to set up the services for a specific environment,
- how to design, evaluate and implement the right architecture for an integrated enterprise, supporting massively distributed networked devices,
- how to customise event-processing agents according to the specific needs of actors and organisational issues in the integrated enterprise,
- how to adopt the security services in an integrated enterprise, based on a sound security framework,
- how to develop new different generic/ customised services within different application scenarios in integrated enterprises,

Such a methodology need to serve as guideline for actors (or an integrated enterprise) intending to introduce new services, especially providing a practical guideline for introduction of innovated customised interaction services.

5. Conclusions

The presented concept is aiming at the realisation of a holistic approach allowing an effective utilisation of a networked devices enabled intelligence for customer integration. However, specifically in the food industry, most companies are SMEs and are often reluctant to use innovative technologies within their integrated enterprises. One of the crucial barriers for the technology end-users is that trust between companies is not mediated appropriately by existing technologies and solution design.

Specifically the new interaction models need to drive the solution design and the evolution of the solution characteristics need to be analysed, taking into account the organisational as well as the technological dimension of a potential solution. The design of the ICT environment, infrastructure and service structure need to reflect the software application requirements like e.g. decentralised versus centralised applications or supporting broadcasting as well as communication. Therefore, the analysis of interaction models within the business processes need to clearly identify the actors behaviour in reference to e.g. synchronous or asynchronous interaction and identifying constraints related to connected and disconnected end-user interaction with the ICT solution. On the top of that, methodological guidelines are required for supporting the realisation of solutions based on a networked devices enabled intelligence.

The presented approach and concept is elaborated in the scope of an EU-funded project “CuteLoop – Customer in the Loop: Using Networked Devices enabled Intelligence for Proactive Customers Integration as Drivers of Integrated Enterprise”, grant agreement nr. 216420. The CuteLoop project was just started and it is funded in the scope of the Information and Communication Technology (ICT) domain in the Seventh Framework Programme of the European Community. It is carried out by an international consortium from France, Germany, Luxembourg, Portugal, The Netherlands and UK. Since the project is just started, first implementations and results of test and validation are still to be realised. The consortium will continuously present the progress via its website (http://www.cuteloop.eu) and is already involved in the CERP and AITPL clusters of European research projects.

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