SemProM—Dissemination and Impact

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Abstract In the SemProM project "Products Keep a Diary" smart labels give products a memory and support intelligent logistics. Within the ICT 2020 research program of the German Federal Ministry of Education and Research the Innovation Alliance "Digital Product Memory" (IA DPM) is developing key technologies for the Internet of Things in the cooperative project SemProM. Through the use of integrated sensors, relations in the production process become transparent and supply chains as well as environmental influences traceable. The producer is supported and the consumer better informed about the product.

1 Lead Project in the Innovation Alliance "Digital Product Memory"

ICT-supported logistics and services related to high-value products, starting from the initial consult and covering everything from maintenance and repair to recycling, has become a key success factor in many sectors. To remain competitive in the global markets, manufacturing and trading companies find they are more and more dependent on the ability to capture and track a product together with all its relevant lifecycle data.

As part of the Innovation Alliance "Digital Product Memory" of the Federal Ministry of Education and Research, the research and industry technology cooperation "SemProM—Semantic Product Memory" aimed at the development of the next generation of mobile, embedded, and wireless elements.

While the research activities of the Federal Ministry of Economics and Technology within the High-Tech Strategy for Germany of the Federal Government focus on the "Internet of Services" by means of the program iD2010 (see Heuser and Wahlster 2011, and, for example, the THESEUS research program[1]), the SemProM project addresses fundamental challenges in building the complementary

[1] www.theseus-programm.de.

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Fig. 1 German Federal Ministry of Education and Research (*left*) and German Aerospace Center Project Management Agency (*right*)

"Internet of Things", one pillar of the Federal Ministry of Education and Research program ICT 2020.

Already applying the upcoming generation of active sensor nodes, the SemProM project aimed far beyond commercializing existing RFID technologies.

In the sense of an "Internet of Things" it will be possible to capture all operational and logistical product data and to exchange it with the users, other products, and the immediate environment. The industrial partners thereby guarantee technological leadership and an implementation and standardization of results relevant to real-life applications. Opening up several lead markets—pharmaceuticals and the health sector, retail and logistics, automotive and mechanical engineering—SemProM has a strong cross-sectional character in ICT key areas like software systems and knowledge technologies.

The SemProM project was designed as a three-year initiative. The network plan was set up in summer 2007 defining ten subprojects with a total of 131 work packages. Within the seven research groups a total of about 164 person years were allocated. The project started February 1, 2008 and ended January 31, 2011.

The SemProM consortium consisted of seven partners, integrating research, large-scale industry and SME:

- **Research:**
  - German Research Center for Artificial Intelligence GmbH, Kaiserslautern, Saarbrücken, Bremen (DFKI, Main Contractor)
- **Large-scale industry:**
  - BMW Forschung und Technik GmbH, Munich
  - Deutsche Post DHL, Bonn
  - SAP AG, Walldorf
  - Siemens AG, Munich
- **SME:**
  - 7 × 4 Pharma GmbH, Merzig
  - GLOBUS SB-Warenhaus Holding GmbH & Co. KG, St. Wendel (associated partner)

The cooperative project SemProM was funded by the German Federal Ministry of Education and Research (BMBF, Fig. 1 (left), grant no. 01IA08002) and additionally financed by the industrial and SME partners. Up to 2011, 16.46 million € was allocated to the project. The research centers received a 95 % funding, while the industrial partners contributed 50 % of their costs. The industrial and SME partners

Table 1 Funding and investment

BMBF Funding, 01.02.2008–31.01.2011	16.46 Mio. €
Industrial Investment, 01.02.2008–31.08.2011	46.12 Mio. €

invested 9.32 million € as shared cost co-funding and additionally 36.8 million € in various spin-off and follow-up activities (Table 1).

The project was controlled by the German Aerospace Center (DLR) Project Management Agency, Berlin (Fig. 1 (right)).

2 Project Plan, Management and Organization Structure

SEMPROM's project plan described on 262 pages the goals, content, structure and organization of the undertaking. The course of the project was structured into four phases: an initial definition phase was followed by three milestones at the end of every project year. The project plan comprises detailed descriptions of every work package including duration and personnel allocation as well as input–output relations. Furthermore network plans, a Gantt chart and checklists as indicators for fulfillment of the milestones were included.

The project was divided into five Project Fields (PF), each of them subdivided into Subprojects (SP) and Work Packages (WP):

- PF I: Capturing and Processing (SP 1 and 2)
- PF II: Modeling, Storage, Recall (SP 3, 4, and 5)
- PF III: Multimodal Interaction with a Digital Product Memory (SP 6 and 7)
- PF IV: System Integration (SP 8 and 9)
- PF V: Management, Organization, Public Relations, Documentation (SP 10)

The SEMPROM project was jointly managed by the Scientific Management, the SEMPROM Steering Committee and the Group of Module Managers (Fig. 2). The Scientific Management organized, coordinated and supervised the project and evaluated the progress of the implementation in close contact with the funding agency.

The assignment of the SEMPROM Steering Committee was to support the Scientific Management in ensuring the scientific excellence of the work. The SEMPROM Steering Committee consisted of seven project partner leaders to adjust the project plan to new scientific results or trends in the research area and to react immediately to problems that arose in the development and implementation process. A total of nine meetings was held. Within the SEMPROM Steering Committee there were assigned responsibilities for subprojects.

The main task of the Group of Module Managers was to tie together and bundle the distributed development capabilities. In the meetings of the Group of Module Managers all important decisions concerning interface definitions, offline data flow, delivery schedules, and integration cycles were prepared, discussed and communicated. The implementation process was tightly monitored and supervised. It also provided contact points for the Scientific Management and gave feedback to the SEMPROM Steering Committee.

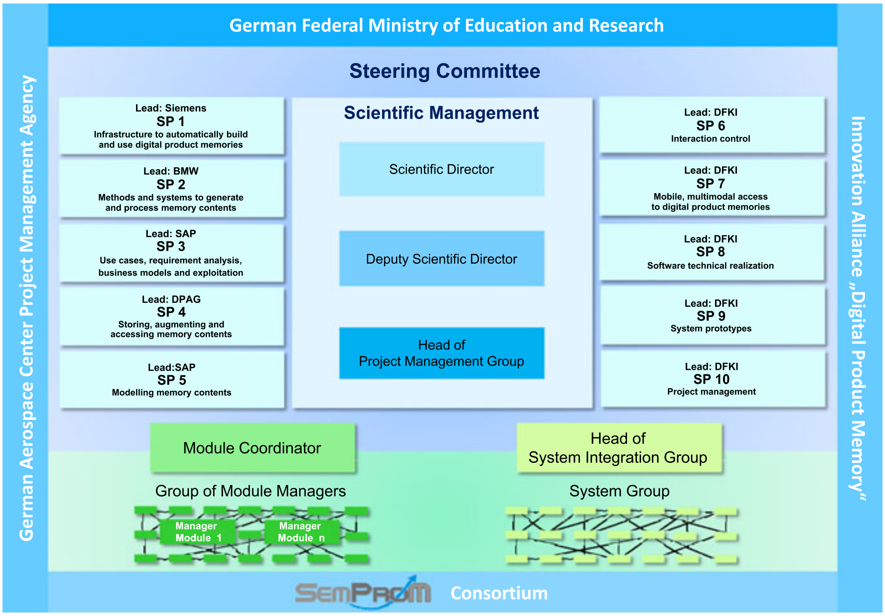

Fig. 2 The management structure of the SEMPROM project

Besides numerous bilateral and multilateral workshops, 23 large project meetings were held to discuss the scientific matters, to finetune details of the realization process, and to synchronize the intermodule communication (Table 2).

BMBF and DLR were informed in three annual milestone review meetings about the progress of the project (Table 3). During these large project meetings the results achieved as well as the ongoing and planned work were presented. In the accompanying demonstration sessions the current SEMPROM systems were shown and industrial SEMPROM spin-offs of the partners were first presented.

3 Building Integrated System Prototypes

The realization of full-fledged prototype systems for various application scenarios constituted an integral part of the research and development activities within the SEMPROM project. These experimental investigations and the experience gained in building large-scale prototypes laid the foundation for a gradual evolution of an integrated framework for semantic product memories. A comprehensive set of SEMPROM use cases was addressed, with a specific focus on the following five areas of application: manufacturing, maintenance, logistics, retail and end-users. The overall SEMPROM framework is demonstrated in industrial pilot use in selected target branches, covering industrial automation and automotive sector, logistics services, health care, and retail, and taking into account the consumer as well.

Table 2 Project internal workshops

Date	Topic
08.09.2008–09.09.2008	Middleware (Nuremberg)
23.09.2008	Project coordination (Saarbrücken)
20.10.2008	Demonstrator “Retail” (St. Wendel)
30.09.2008–02.10.2008	Module coordination (Zurich/Regensdorf)
27.10.2008–28.10.2008	System prototypes (Kaiserslautern)
07.11.2008	Pharma scenario (Saarbrücken)
28.11.2008–29.11.2008	Interaction and dialog management (Munich)
01.12.2008–02.12.2008	Data format and middleware (Dresden)
17.12.2008	Demonstrator planning “Tag der Forschung” and CeBIT (Saarbrücken)
14.01.2009	User analysis (Saarbrücken)
15.01.2009	Demonstrator planning “Tag der Forschung” and CeBIT (Saarbrücken)
21.01.2009	Coordination CeBIT questionnaire (Kaiserslautern)
19.02.2009–20.02.2009	Robot interaction (Kaiserslautern)
19.03.2009	Module coordination (Bonn-Troisdorf)
28.05.2009	Memory architecture (Walldorf)
15.07.2009	Demonstrator systems (Kaiserslautern)
01.09.2009	Integrated demonstrator Hannover Messe (Troisdorf)
07.09.2009	Integrated demonstrator CeBIT (Munich)
08.10.2009–09.10.2009	Module coordination (Nuremberg)
20.10.2009	Scenario “New German eID Card” (Saarbrücken)
28.10.2009	Integrated demonstrator CeBIT (Saarbrücken)
23.03.2010–24.03.2010	Module coordination (Nuremberg)
27.07.2010	Workshop “Novel Memory Structures” (Dresden)

Table 3 Project steering and review meetings

Date	Topic
14.04.2008–16.04.2008	Internal kick-off (Saarbrücken)
14.04.2008	Steering meeting (Saarbrücken)
18.09.2008	Steering meeting (Berlin)
12.12.2008	Steering meeting (Munich)
20.03.2009	Review meeting (Bonn-Troisdorf)
20.03.2009	Steering meeting (Bonn-Troisdorf)
07.10.2009	Steering meeting (Nuremberg)
15.01.2010	Steering meeting (conference call)
22.03.2010	Review meeting (Nuremberg)
22.03.2010	Steering meeting (Nuremberg)
14.06.2010	Steering meeting (Berlin)
02.09.2010	Steering meeting (Saarbrücken)
26.01.2011	Review meeting (Unterschleißheim)

During the course of the collaborative project, integrated SEMPROM installations were set up in a number of living labs at different partner sites:

- SAP Research *Future Factory*, Dresden;
- Siemens *SmartAutomation* facility in Nuremberg;
- DFKI *SmartFactory*^{KL} at DFKI Kaiserslautern;
- Deutsche Post DHL logistics group *DHL Innovation Center* located in Troisdorf, near Bonn;
- SAP Research *Future Retail Center* (FRC) in Regensdorf, near Zurich;
- DFKI *Innovative Retail Lab* (IRL), which was installed in St. Wendel in the head office of the German chain store GLOBUS SB-Warenhaus Holding;
- DFKI *Smart Kitchen*, the Ambient Assisted Living (AAL) open-plan kitchen at DFKI Saarbrücken.

The DFKI *Smart Kitchen* is used in particular to realize sample use cases related to health care aspects in close cooperation with 7 × 4 Pharma (Brandherm et al. 2010, 2013).

From each of these permanent installations, transportable modules were made available as well. These SEMPROM subsystems in combination with other mobile demonstrators, including in particular the mobile autonomous dual-arm AILA robot (Lemburg et al. 2011, 2013) from DFKI Bremen and BMW's experimental vehicle, provide a modular construction kit that can be used to build up integrated system demonstrations for complex scenarios with interoperable SEMPROM utilization.

Following an iterative process for carrying out the research work, such integrated SEMPROM set-ups served two main purposes:

- Experimental test set-up for collaborative development during system integration
- Collective demonstration of interoperable SEMPROM installations for illustrative presentation of project results

A first integrated SEMPROM demonstration system was prepared for the CeBIT 2009 trade fair. The overall scenario combined in particular decentralized process control in industrial production using distributed manufacturing modules from three industrial partners (Stephan et al. 2010, 2013) with the idea of continuous and detailed assessment of an item's carbon footprint along the supply chain (Kröner et al. 2010; Ulrich et al. 2013). In 2010, the latest demonstrator modules covering most of the use cases were employed for two complementary large-scale installations at CeBIT 2010 and Hannover Messe 2010. For CeBIT 2010, the main focus was on personal shopping support and use cases related to automobiles (Kröner et al. 2011a; Kahl et al. 2013). The complex Hannover Messe scenario concentrated primarily on industrial production and logistics (Brandherm and Kröner 2011).

The fully integrated installations aimed at a convincing demonstration of the manifold applications of a digital product memory and the prospects of the SEMPROM approach. A key requirement for the conception of a complex SEMPROM scenario is a deliberate storyline that links distinct use cases together. Characteristic features of our integrated prototype installations include:

- Several stations illustrate how a DPM supports communication across application domains, users, and/or processes. With respect to the general goals of an integrated prototype, usually different stations were realized by different project partners with expertise in different application domains (e.g., manufacturing, logistics).
- Variable elements illustrate how a DPM supports communication in open scenarios, where the details of changes between stations cannot be predicted. Typically, such elements are combined with an opportunity for the user to interact with the running process, e.g., by creating obstacles.
- Objects allow for human–computer interaction. This addresses novel opportunities for interacting with objects as well as IT systems that arise from extending an artifact with a DPM. Here, a common approach was to define a "focus object", which the user accompanies through a process across the various stations, where the digital data link is exploited in different ways for interaction support.
- The DPM is emphasized in its role as connecting element. Thus, in general, the user can inspect the DPM of selected products and especially of the focus object at any time, which allows for exploring the aggregation of information in a DPM as one of its most prominent features.
- Individual memory contents illustrate the new role of future products. Due to variations on the way through the different stations and variable user interactions, the focus object's memory contents are typically unique. This demonstrates on the one side new production concepts such as lot-size-one production, and shows on the other side how different a product's lifecycle actually may be.

Subsets of these characteristics were realized in several application scenarios, each of them comprising several use cases of a DPM. The complex scenarios intentionally share selected use cases such as the SEMPROM Browser or provide story-driven connections, which allow for chaining scenarios to even more complex settings—and thus for reflecting to some extent the diversity of real-world scenarios a product might be exposed to during its journey through the supply chain.

In parallel, from a technical point of view, these scenarios reflect the complexity and heterogeneity typical for today's broad range of solutions in areas such as automated identification, process automation, and user support. Various implementations of SEMPROM middleware and architecture components were developed, which are tailored to the specific requirements of existing hardware and software ecosystems employed in radically differing application domains such as logistics and retail. These implementations illustrate not only the technical feasibility of a migration of DPM technology with today's technology landscape, but also how domain- and platform-independent DPM technology such as the Container API and Format can open "closed loops" typically implemented in existing infrastructure.

4 Project External Cooperation

The SEMPROM project was integrated in a context of related research activities. One important goal of the project consisted in identifying synergies and initiating the interchange of ideas between those activities. In the first place, here the Innovation Alliance “Digital Product Memory” comprising the three BMBF-funded cooperative projects SemProM, ADiWa and Aletheia has to be mentioned. Based on their thematic conjunction a close organizational cooperation was established.

The projects together aimed at opening up the potential of the “Internet of Things” new technologies for a wide range of applications and to advance the convergence to the “Internet of Services”. In joint workshops the common points and interests as well as distinctions were discussed and identified to clearly distinguish the projects and their use cases.

SemProM primarily stores data about single objects in digital product memories. SemProM focusses on how to capture information in the Internet of Things, distribute it across process borders, and represent and apply this information. In the sense of an Internet of Things single objects store their history and are able to communicate with each other.

Aletheia stands for a universal interface integrating different information sources to allow for accessing comprehensive knowledge about products. Next to involving single entities, here the focus is on recognition, representation and use of typical characteristics of entire categories of products.

ADiWa uses the potential of the Internet of Things to model and adapt business processes by analyzing especially automated real-time recognition and processing of dynamic information. Here, ADiWa partly builds on results of SemProM.

A monthly conference call was established where the projects informed each other about the ongoing work and planned activities. As a result a common demonstrator was presented at CeBIT 2010.

The evaluation regarding the joint use of results was essential. This was implemented, e.g., in ADiWa and SemProM with regard to the use of the RWIP middleware. In the development of the requirements for the business case framework, partners of all three projects of the Innovation Alliance were available for interviews. A further substantial discussion on the common approach towards standardization activities within the Innovation Alliance took place.

Aiming at sustainable project results there is ongoing work even after the end of the project, to formalize the representation of object data stored in SemProMs. To this end, the SemProM container format was developed. This in turn was the basis to start a collaboration with the W3C Council in the third year of the project to advance the standardization of the object description language in a W3C “Object Memory Modeling” Incubator Group.[2]

During the term of the project a similar subject matter as in SemProM was addressed in the SmartProducts project initiated by the EU.[3] With this project, an exchange of information took place to raise synergies in the research (see Kröner et al. 2011b).

Based on special topics of the work packages, research collaborations with various universities, mainly as studies and diploma and master theses, were carried out:

[2] www.w3.org/2005/Incubator/omm/.

[3] www.smartproducts-project.eu.

Table 4 Project external meetings

Date	Topic
29.04.2008	Official kick-off of the Innovation Alliance “Digital Product Memory”, “SEMPROM: Products Keep a Diary”, in the presence of German Federal Minister of Education and Research Prof. Dr. Annette Schavan and Minister President of Saarland Peter Müller (Saarbrücken)
06.07.2009	Workshop “Use Cases for the New German eID Card” with T-Labs (Darmstadt)
04.08.2009	Meeting of the Innovation Alliance “Digital Product Memory” (Saarbrücken)
19.08.2009	Presentation “Products Keep a Diary: Overview and Project Status SEMPROM” (ADIWA conference call)
02.09.2009	Workshop “Use Cases for the New German eID Card” with T-Labs (St. Wendel)
06.10.2009	Meeting of the Innovation Alliance “Digital Product Memory” (Nuremberg)
03.12.2009	Workshop with SmartProducts (Saarbrücken)
27.01.2010	Workshop “Use Cases for the New German eID Card” with FhG FOKUS (Berlin)
22.02.2010	Workshop “The Digital Product Memory in the E-Health Area of Application” with T-Systems (Saarbrücken)
10.03.2010	Workshop “Digital Lifelogs & Mobile Books” with Blackbetty Mobilmedia GmbH and Satzweiss.com GmbH (Saarbrücken)
15.03.2010	Workshop “Integration of SEMPROM Events in CEP” with ADIWA (Saarbrücken)
30.06.2010	Workshop “Deployment of the New German eID Card” and “Privacy Protection in SEMPROM” with Bundesdruckerei (Saarbrücken)
04.11.2010	Workshop “Storage Concepts for the Digital Product Memory” with SmartProducts (conference call)
10.12.2010	EIT-ICT Labs Workshops “Digital Lifelogs in Everyday Environments” (Saarbrücken)

Researchers of the SEMPROM project worked together, for example, with the Chair for Materials Handling, Material Flow, Logistics of the Technical University Munich, the Chair of Computer Networks and Communication Systems of the Friedrich Alexander University Erlangen-Nuremberg, the Reinhold-Würth-Hochschule Heilbronn as well as with the Technical University Kaiserslautern, the Universities of Applied Sciences Coburg and Cologne and the Steinbeis-Hochschule in Berlin. In addition, a collaboration with the Fraunhofer Institute for Secure Information Technology (SIT), was used to strengthen expertise in security aspects.

The success of the scientific cooperation with external bodies is reflected in the international implementation of a Digital Object Memories workshop series (DOMe).[4] Here, approaches and solutions resulting from the SEMPROM project are discussed with experts from all over the world.

[4] www.dfki.de/dome-workshop/.

Fig. 3 The SemProm logo (*left*) and the SemProm technology logo (*right*)

5 Project Results and Impact

SemProm developed semantic technologies for the development and exchange of digital product memories. These are used for the adaptation of modular production processes, user assistance via a multimodal mobile interface, as well as for the control of robots. The SemProm technology of the digital product memories led to a paradigm shift in production, logistics, trade, maintenance and robotics. Projects, products and processes using SemProm technology are requested to show the corresponding SemProm logo (Fig. 3). SemProm is a so-far-unique contribution to the Internet of Things with the revolutionary concept of semantic product memories. SemProm provides a basis for numerous innovations in two open and four company-specific living labs, which are supported by over 20 industrial companies: SAP Research *Future Factory*, Siemens *SmartAutomation*, DFKI *SmartFactory*$^{\mathbf{KL}}$, *DHL Innovation Center*, SAP Research *Future Retail Center*, and DFKI *Innovative Retail Lab*.

The good cooperation within the project consortium contributed significantly to the fact that all project milestones could be achieved in due time and completely. The outstanding results with regard to the software implementation were presented with great success to the industry, as at CeBIT and Hannover Messe.

Through the cooperation and the common focus of important know-how carriers, a leading scientific position could be achieved, documented in numerous scientific papers and lectures. While the research partners made important contributions to the implemented prototypical solutions, the transfer of the results is being carried out in concrete product development together with technology partners.

Comprehensive and sustainable results for SemProm are the following:

- Cross-industrial effects of the digital product memory from production to logistics until the end-user were illustrated by demonstrator systems at CeBIT, Hannover Messe, and Euro-Id amongst others.
- The project results were made tangible for customers and the public in corporate innovation centres, the so-called living labs of SAP, Siemens, DHL and DFKI.
- R&D work in SemProm has so far resulted in 9 patent applications; a direct exploitation of the results—e.g., novel mechanisms for integrity monitoring in logistic chains—is the subject of 3 new spin-off companies.
- A global internet standardization for product memories (OMM) was introduced by the German consortium in the W3C.
- There was a multiplier effect by employing the SemProm results in already 13 other projects.

The creation of a universal memory solution over the entire lifecycle of a product and the application of digital product memories in open loops required semantic technologies to ensure interoperability, i.e., the transition of (proprietary) ad hoc data formats ("island solutions") to an ontology-based semantic data format. To do this, as one central conceptual result of SEMPROM, a layer model for cross-technology semantic communication with digital product memories was developed.

With the completion of the SEMPROM project, the following scientifically relevant results are available:

- Cross-domain set up and use of digital memories.
- Comprehensive infrastructure for processing sensor data.
- Comprehensive infrastructure for the processing of and access to digital product memories.
- Multimodal user interfaces for accessing the digital product memory.
- Integrated solutions to finegrained information communication over the entire lifecycle of a product (open-loop).
- Bridging the semantic gap in the perception of robots.
- Secure, role- and right-based access in the Internet of Things.
- For the first time, SEMPROM established an application of the new German identity card (neuer Personalausweis, nPA) for the protection of digital product memories, this being the first fully realized use case for the nPA in the Internet of Things.
- At international conferences on the Internet of Things and the Semantic Web, SEMPROM gained very positive feedback in the scientific community through best paper awards and keynotes.
- Basic principles for the standardization of digital product memories were laid down. These will be further pursued in the W3C Incubator Group "Object Memory Modeling."

SEMPROM system-based value-added services, as well as benefits and product potential, have been shown in different application domains:

- Added value through personal information about the product
  - Quality assurance through confirmation of intake (compliance), intake notes, recognition of pharmacological interactions
- Added value through automatic understanding of scenery and objects
  - Autonomous action, e.g., detection of "expired" products
- Added value through personalization of products
  - Access security and identity verification with the nPA, combinations of personal information and services building on that
- Added value through object-centric interaction
  - Placement of product knowledge through dynamic consultation dialogs, shopping advice
- Added value through products as information carriers
  - Transport of selected personal data, detection of object interactions on the basis of rule knowledge

In the interaction of the user with the digital product memory, the product does not only become the means of communication and the key for retrieving information but also the observer of its user.

A further core task in SEMPROM included the design of a detailed overall architecture that combines the various detailed concepts in a coherent way. This included in particular the support and control of interface arrangements.

For the research and development activities within the project, the implementation of efficient demonstrator systems was one of the central objectives. An essential added value of the SEMPROM system consists in the support for open systems—either by bridging technology gaps in the area of smart label technology, or by explicitly supporting transfer and continuation of data recording in open processes with changing user groups. Demonstrator systems of SEMPROM need to implement this statement technically and communicate it through appropriate application scenarios. Thus, the benefits of system prototypes for the project are defined among other things as follows:

- by proving the technical functionality of the SEMPROM architectural approach and the SEMPROM platforms;
- by ensuring the development of practicable DPM solutions through the integration of real-world use cases, and
- through the highly illustrative character of the system prototypes, which presented the research results convincingly and with public impact.

Solutions to the challenges that arise because of the shortening of product lifecycles and the increasing individualization of products evolve in the area of the "Internet of Things." Especially Auto-ID technologies such as bar code and RFID (Radio Frequency Identification) are increasingly finding their way into production and logistics systems and bridge the gap between physical streams of goods and the data flow. Based on such enabler technologies, the concept of so-called "Digital Product Memories" represents a holistic and flexible approach to link together digital information and physical objects. Digital product memories conceptually go beyond existing Auto-ID approaches and include the organization of object-related information in a memory-like structure. Digital product memories can be built from various information, such as sensor information from the environment or parameters of a process that the physical object has undergone. Digital product memories build on the scientific and conceptual basis of the work done in SEMPROM.

In the context of using digital product memories in production processes, the key task consists not only in showing operational reliability, but in particular in identifying the potential of added values that can be associated with the application of DPM in factory processes.

Specifically, it has been shown in SEMPROM that digital product memories can contribute to an improved process monitoring at the level of the individual product and allow a reduction of complexity of control systems by a decentralized parameterization of processes. In addition, evidence has been provided that digital product memories can be employed for cross-domain information exchange in production and logistics processes and, based on this, they allow new degrees of freedom in the planning and engineering of modular system concepts.

Further results are:

- SOA-based platform for the development of distributed solutions;
- an infrastructure for intelligent product memories;
- an interaction of innovative autonomous systems with DPMs;
- interaction of intelligent transport containers with environmental systems;
- identification of user intentions in the vehicle;
- weekly medication blister with integrated sensors;
- user-centered evaluation of the multimodal interface;
- technical evaluation of the digital product memory;
- business case framework, cost–benefit analysis, market potential analysis.

Public Relations Public and media interest in the SEMPROM project was very intense, the feedback very positive. SEMPROM was presented at several major events:

- Official kick-off of the Innovation Alliance "Digital Product Memory", "SEMPROM: Products Keep a Diary", in the presence of German Federal Minister of Education and Research Prof. Dr. Annette Schavan and Minister President of Saarland Peter Müller at DFKI Saarbrücken, April 29, 2008; 3rd National IT Summit ("IT-Gipfel"), November 20, 2008, Darmstadt;
- CeBIT 2009, 2010, and 2011;
- Hannover Messe 2009, 2010, and 2011;
- "Day of Research" ("Tag der Forschung"), February 05, 2009, Darmstadt;
- "Selected Landmark in the Land of Ideas 2009" ("Ort der Ideen") at *Innovative Retail Lab* in St. Wendel, May 18, 2009;
- Visit of German Federal President Christian Wulff and Minister President of Saarland Peter Müller at DFKI Saarbrücken, May 17, 2011.

The project was presented to representatives of a large number of leading companies in various application fields, like Bosch Rexroth AG, Deutsche Telekom/T-Labs, Metris Systems, Wacom Europe GmbH, Adam Opel GmbH, AGT, Intel Labs/Intel Corporation, T-Systems, Keiper GmbH, Abacus alpha GmbH, Perma-Cryo-Technologie GmbH, as well as to researchers and politicians exponents such as, for example, Prof. Dr. Jürgen Mlynek, president of Helmholtz-Gemeinschaft, John Dalli, European Commissioner for Health and Consumer Policy, Dr. Jorgo Chatzimarkakis (MEP), Prof. Tsui (Hong Kong Polytechnic University), amongst others.

6 Conclusion

SEMPROM and the concrete work and results of the involved research groups in SEMPROM have helped substantially to push forward in its technological development the Internet of Things as a central component of the High-Tech Strategy of the Federal Government, and with the digital product memory to provide a trendsetting technology for the industrial powerhouse Germany along the entire value chain.

Table 5 Overall results in figures

Economic results	
Number of patent applications	9
Number of spin-off companies founded	3
Number of spin-off products developed	10
Number of projects using SEMPROM technology	13
Number of internal prototypes and demonstrators	99
Number of new jobs beyond funding	56
Scientific results	
Number of scientific publications in journals	22
Number of accepted conference papers	47
Number of keynote lectures	60
Number of additional conference talks	18
Number of additional workshop talks	10
Number of additional other talks	6
Number of organized workshops	10
Number of completed degrees (bachelor, master's, diploma)	23
Number of completed PhD theses	6
Public relations	
Number of printed articles	33
Number of TV programs	8
Number of radio programs	1
Number of online presentations	67

Exploiting the results of the SEMPROM project, Germany can consequently use its strengths and expand, what has made it the "supplier of the world" in production, trade and business processes.

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