

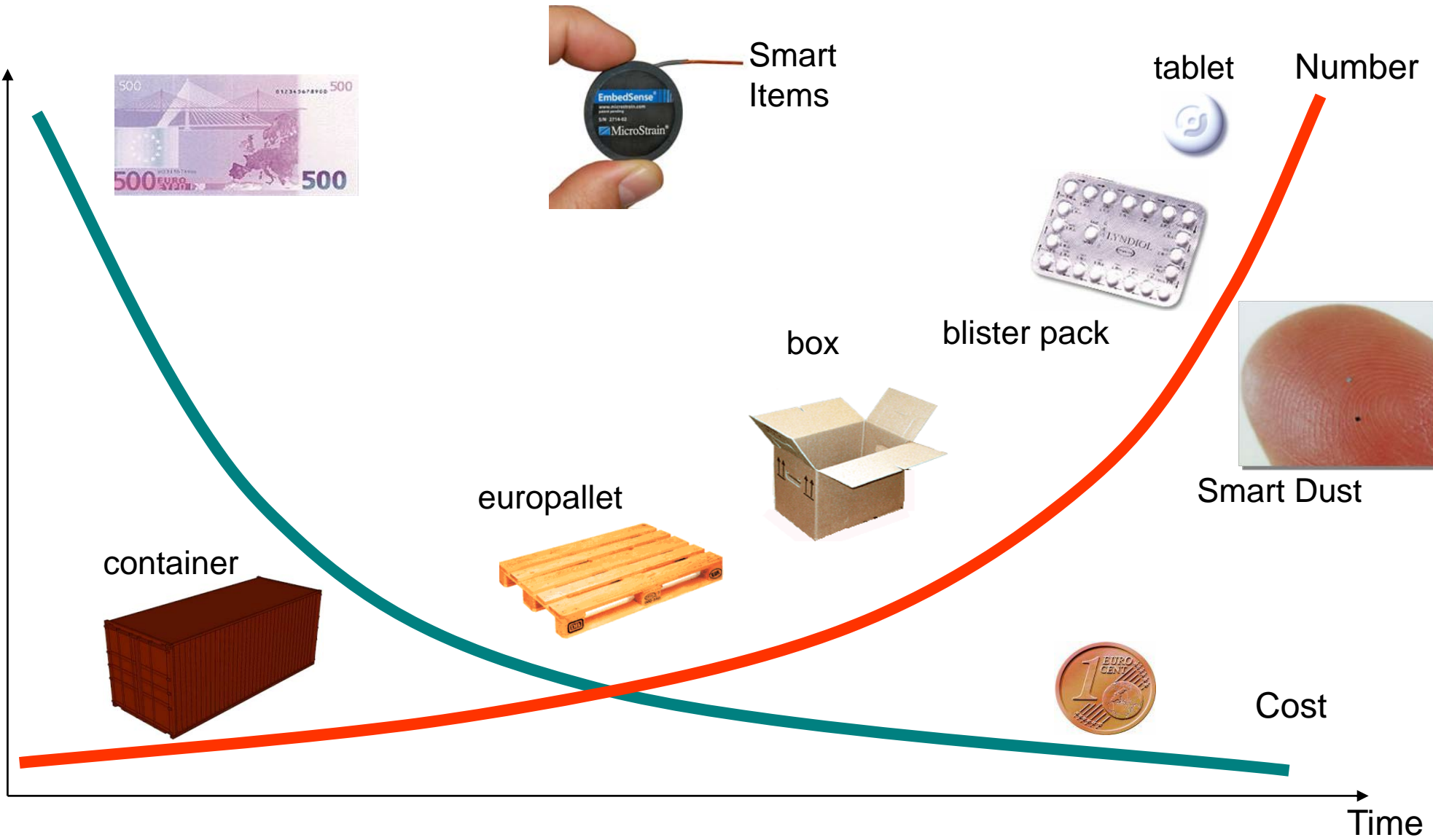
Semantic Product Memories: Digital Lifelogs for Smart Products

Wolfgang Wahlster



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Saarbrücken, Kaiserslautern, Bremen, Berlin
Phone: +49 (681) 302-5252/4162
Email: wahlster@dfki.de
WWW: <http://www.dfki.de/~wahlster>

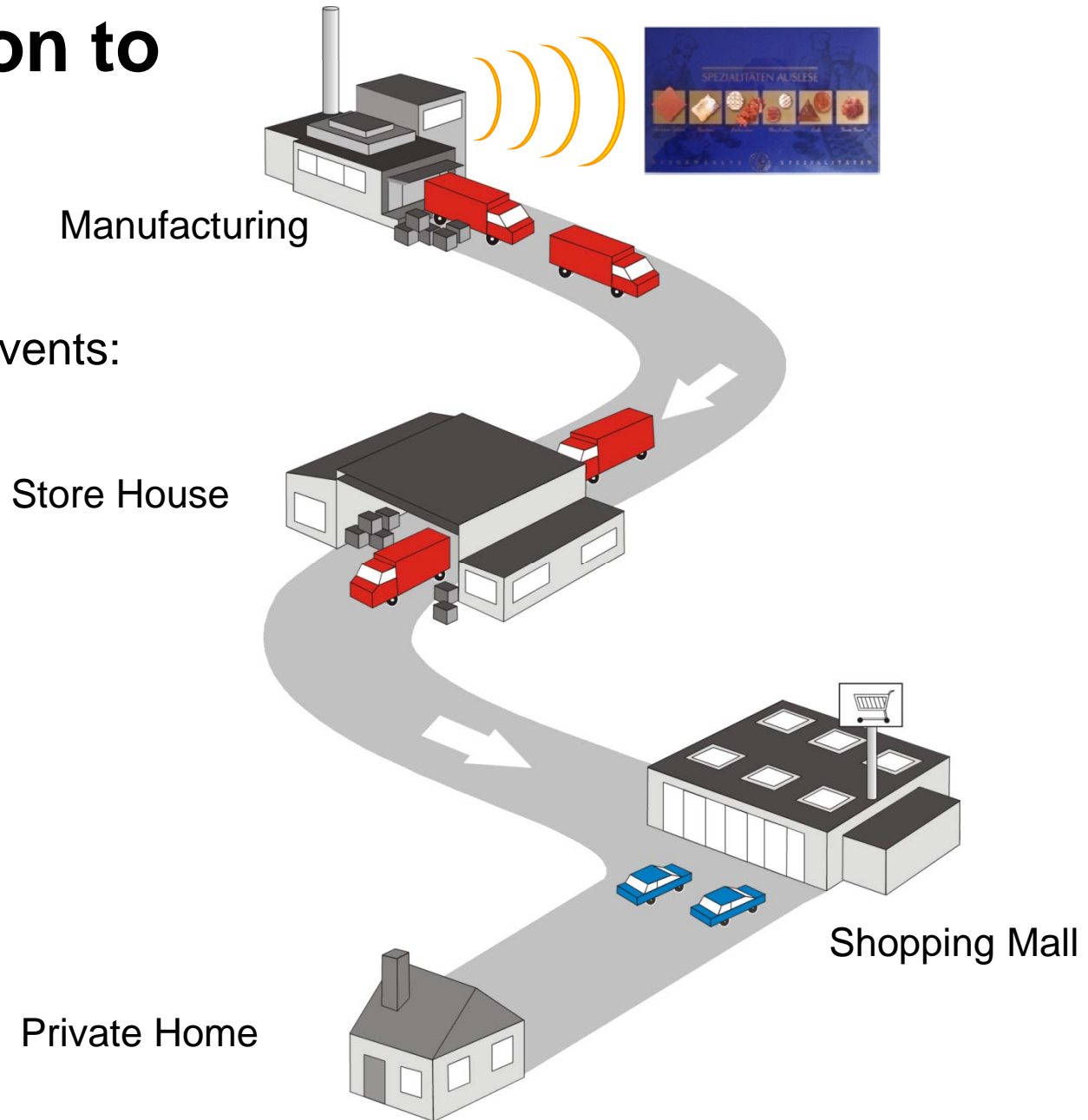
From RFID to Smart Sensor Items



The Semantic Product Memory: From Production to Consumption

The product memory prevents:

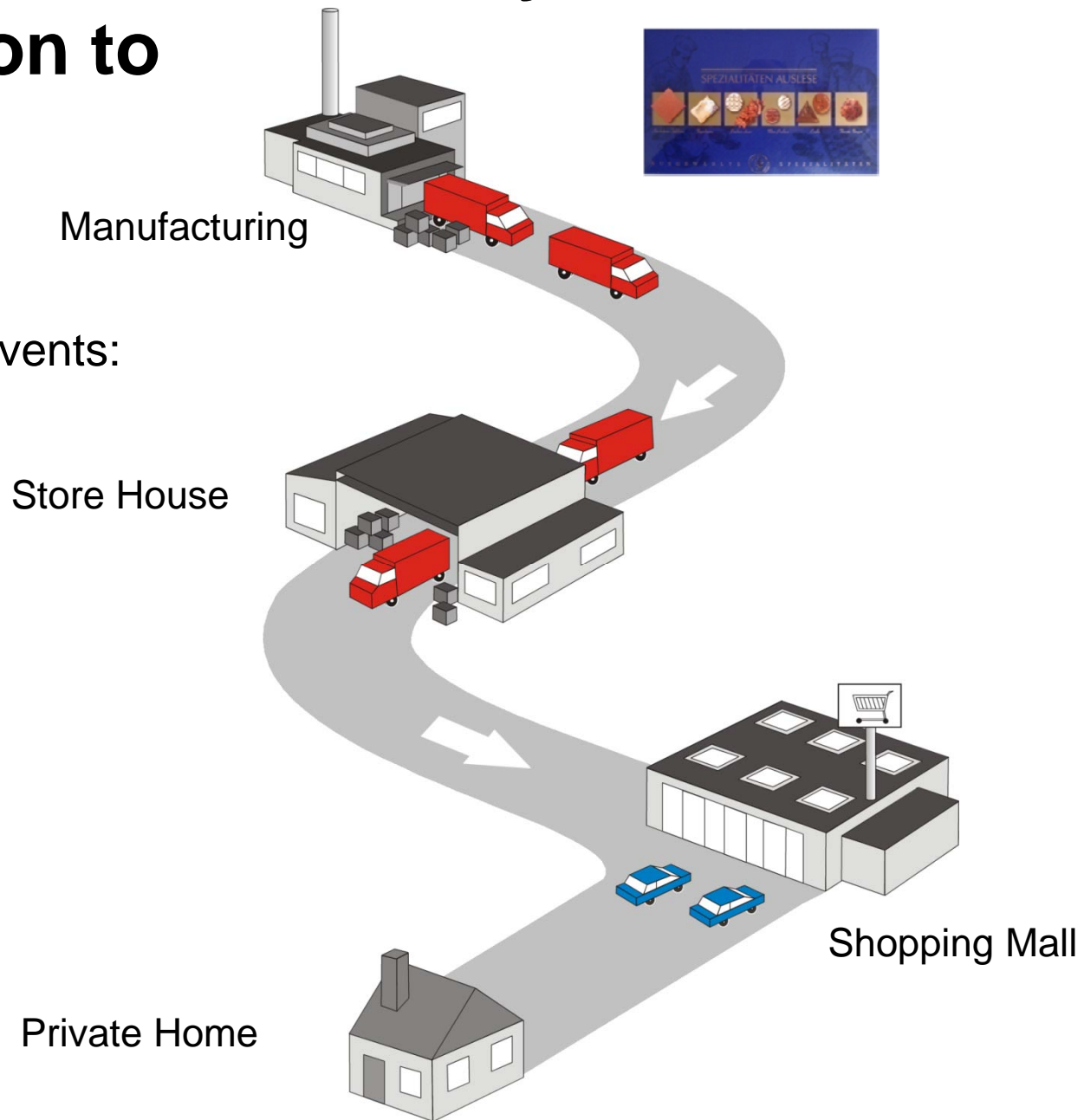
- tarnished chocolates
→ Humidity Sensor
- melted chocolates
→ Temperature Sensor
- crushed chocolates
→ Pressure Sensor



The Semantic Product Memory: From Production to Consumption

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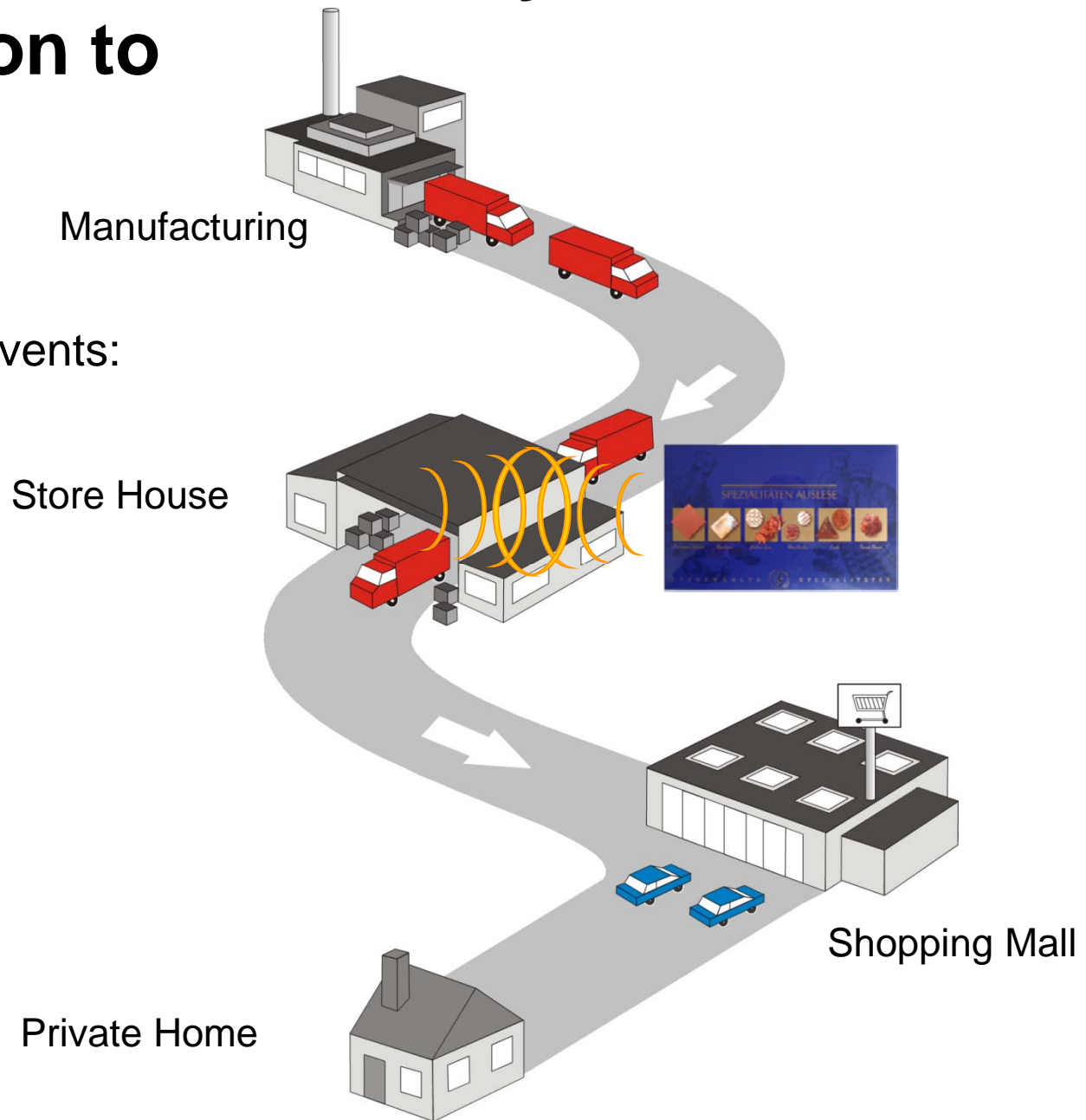
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The Semantic Product Memory: From Production to Consumption

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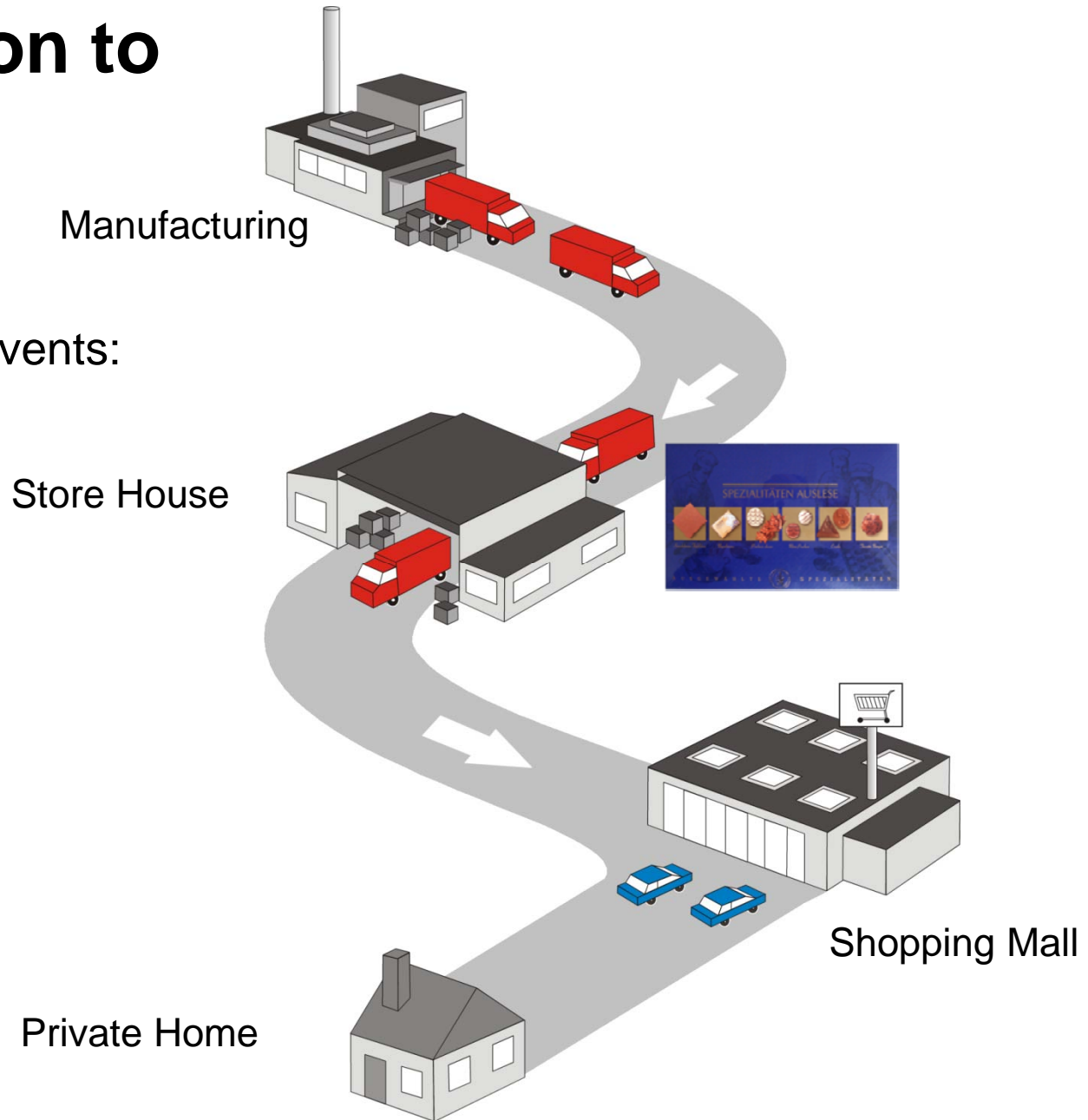
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The Semantic Product Memory: From Production to Consumption

The product memory prevents:

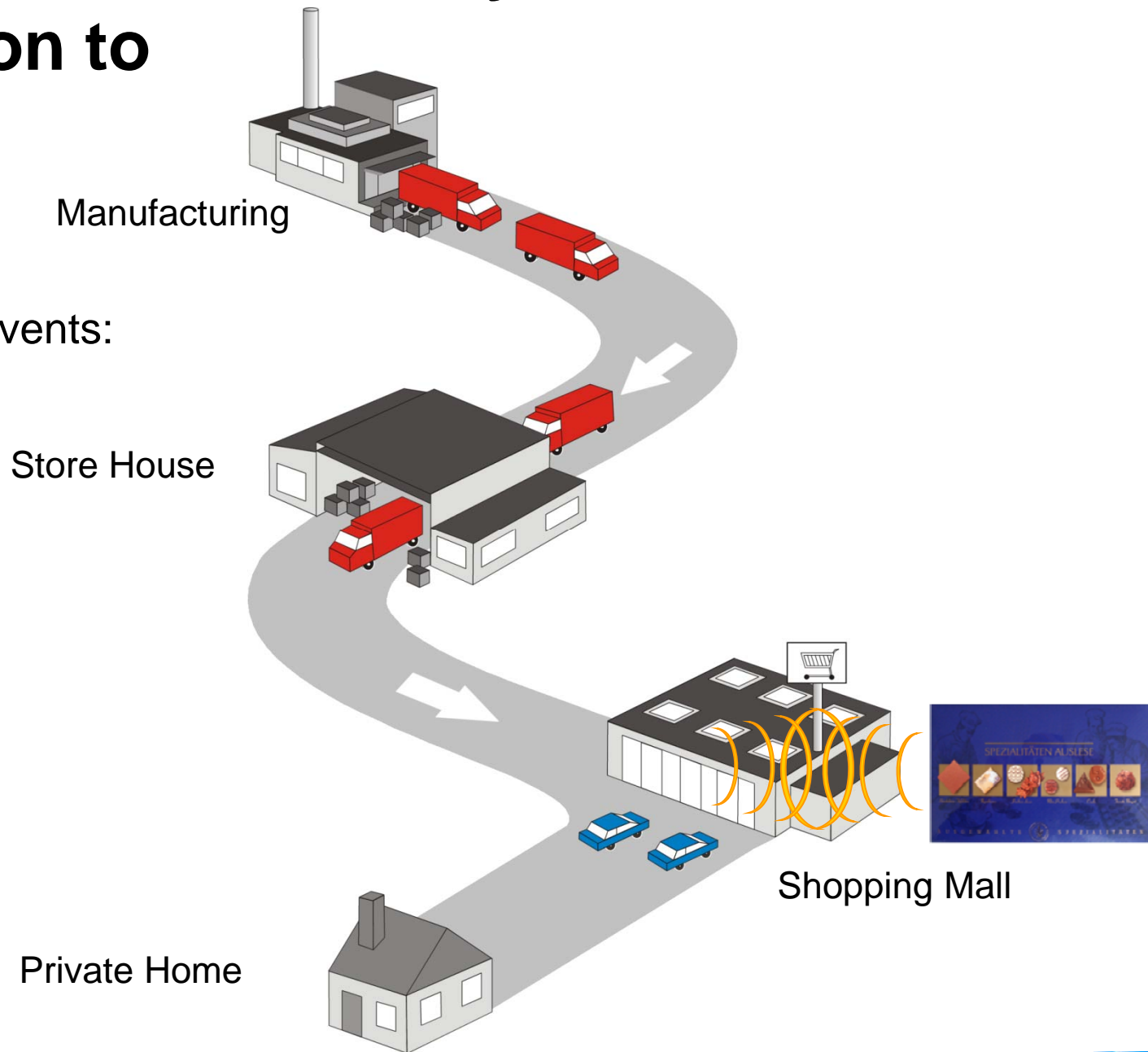
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The Semantic Product Memory: From Production to Consumption

The product memory prevents:

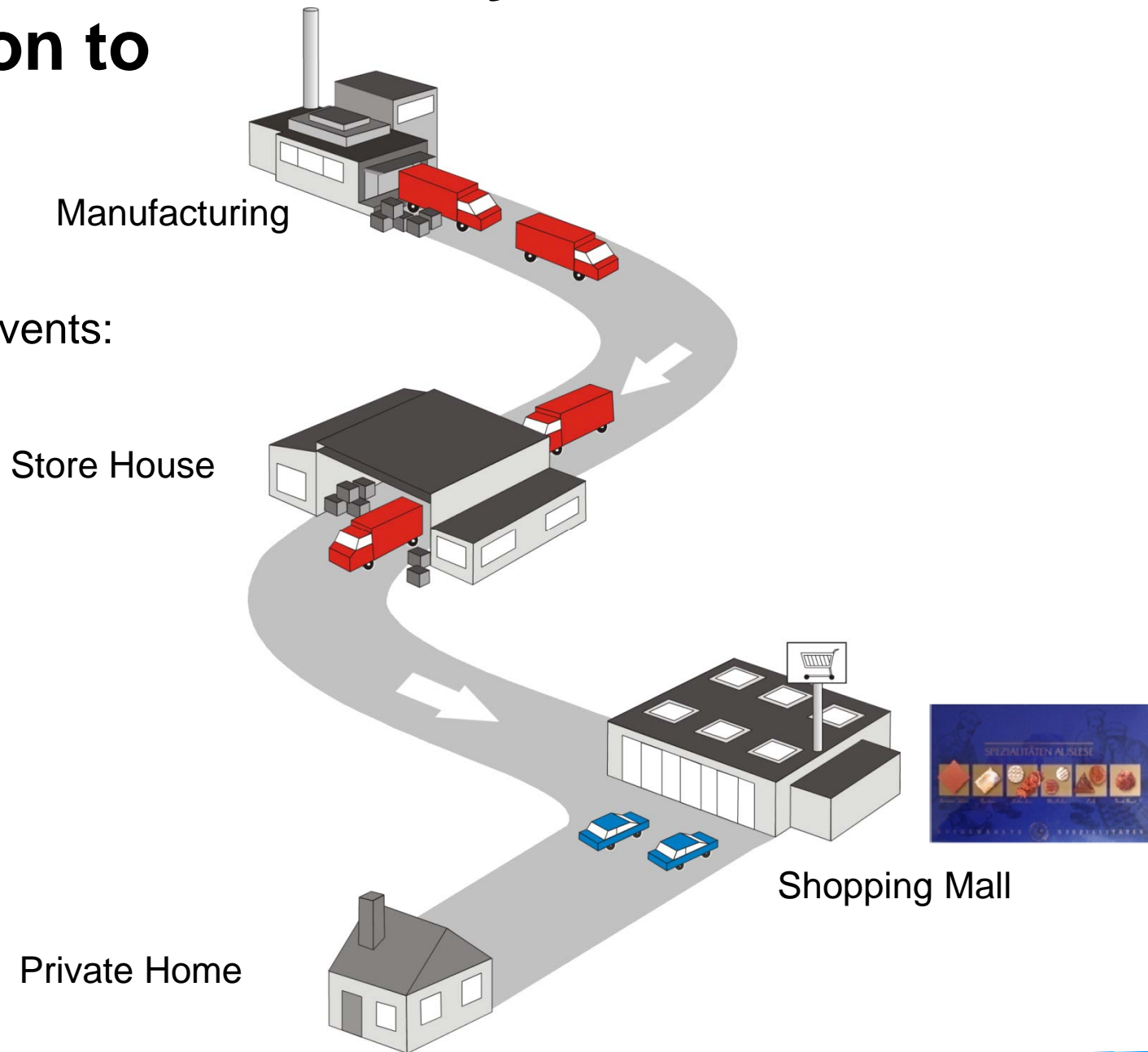
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The Semantic Product Memory: From Production to Consumption

The product memory prevents:

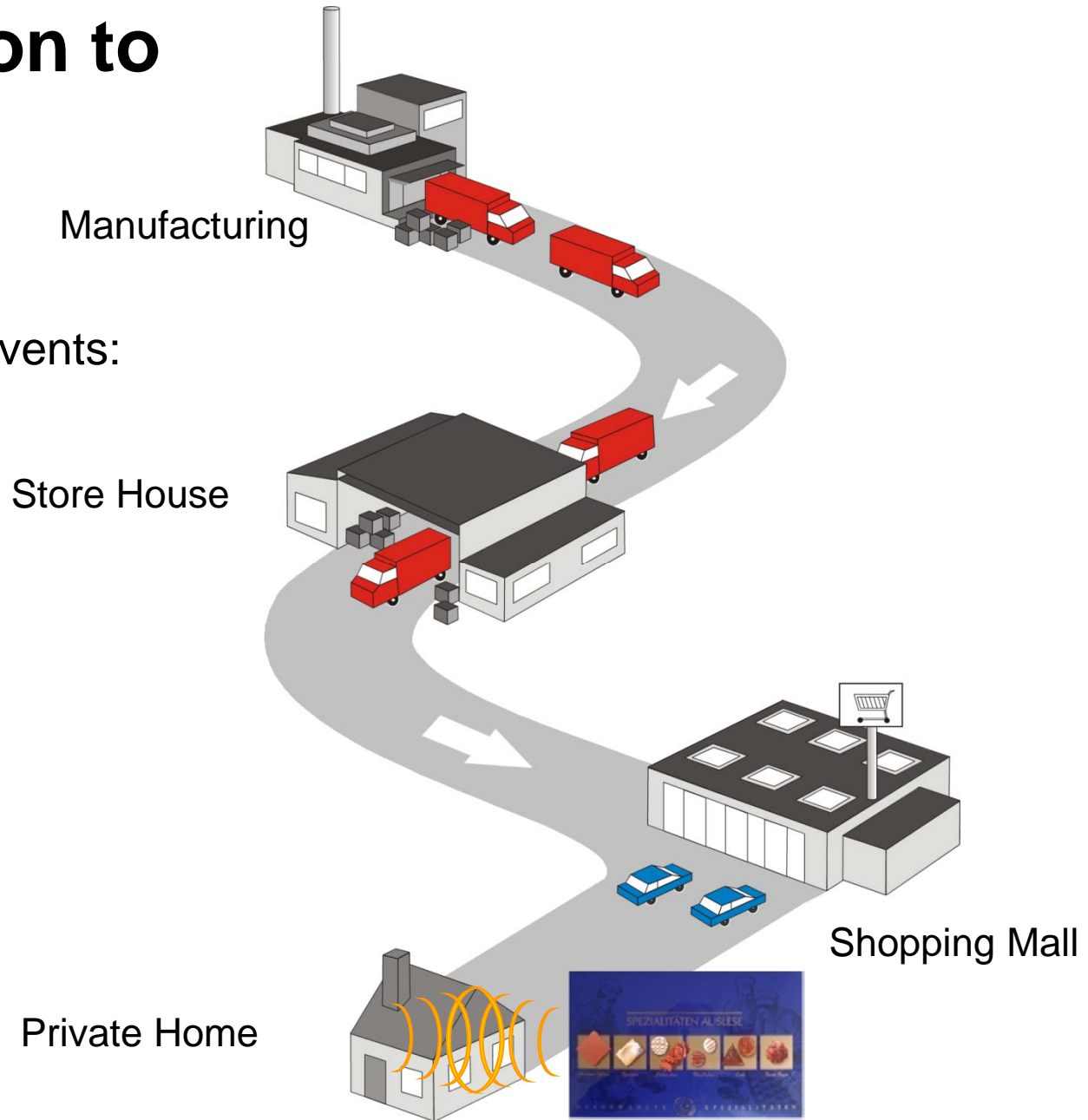
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→ Temperature Sensor
- crushed chocolates
→ Pressure Sensor



The Semantic Product Memory: From Production to Consumption

The product memory prevents:

- tarnished chocolates
→ **Humidity Sensor**
- melted chocolates
→ **Temperature Sensor**
- crushed chocolates
→ **Pressure Sensor**



Products with Integrated Dynamic Digital Storage, Sensing, and Wireless Communication Capabilities

⇒ The product as an information container

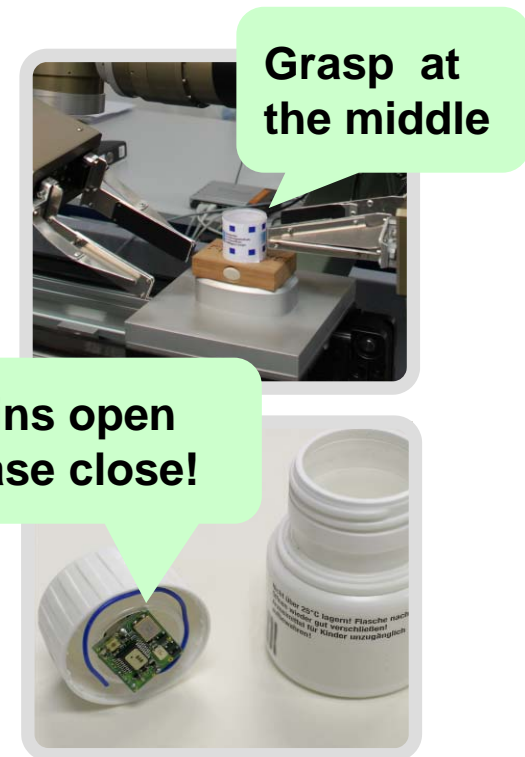
The product carries information across the complete supply chain and its lifecycle.

⇒ The product as an agent

The product affects its environment

⇒ The product as an observer

The product monitors itself and its environment



SemProM: Semantic Product Memories From Manufacturing to Retail and After-Sales



SPONSORED BY THE



Federal Ministry
of Education
and Research

Semantic Product Memory

SemProM

Products keep a diary



SemProM

BMW Group
Forschung und Technik



Funded by BMBF in the ICT 2020 Programme

Funding Volume: 16,4 Mio. Euro

Director and PI: W. Wahlster (DFKI)

Duration: 2008-2011

Deutsche Post



SIEMENS

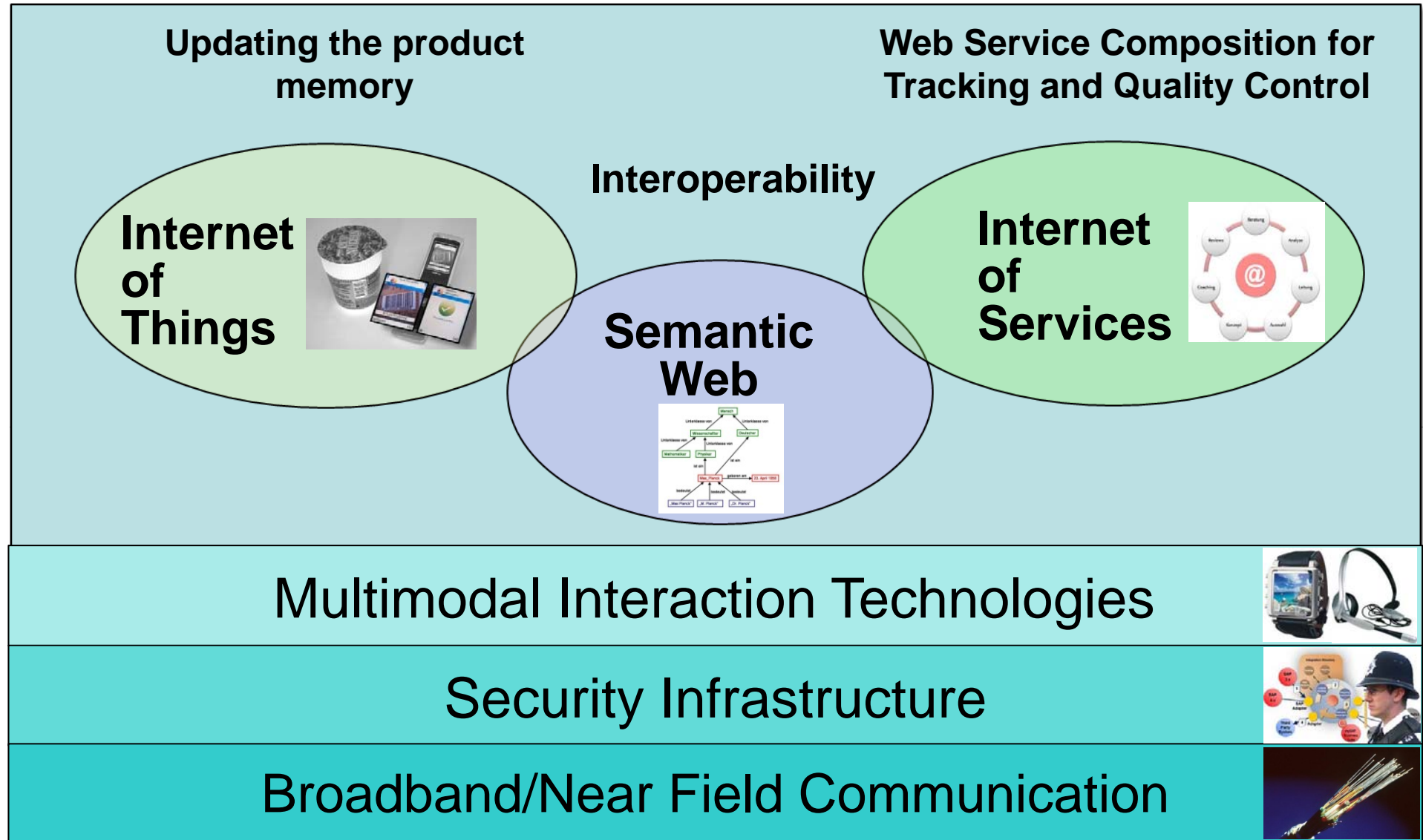
7x4Pharma



Outline of the Talk

- 1. From Lifelogs of People to Lifelogs of Things**
- 2. Today's Product Tracking Systems**
- 3. The SmartFactory: Initializing SemProM**
- 4. SemProM's Architecture and Representation
Format**
- 5. Ambient Shopping Assistance based on SemProM**
- 6. Conclusions**

The Semantic Web of Things and Services as the Platform for Product Lifelogs



SemProM: Ontology-based Interpretation of a Black Box Log for Cars



Using semantic technologies
to ensure inter-
operability and end user access
to the product memory.



The Semantic Product Memory Serving the Consumer

Access to the product memory via NFC-enabled Smartphone:

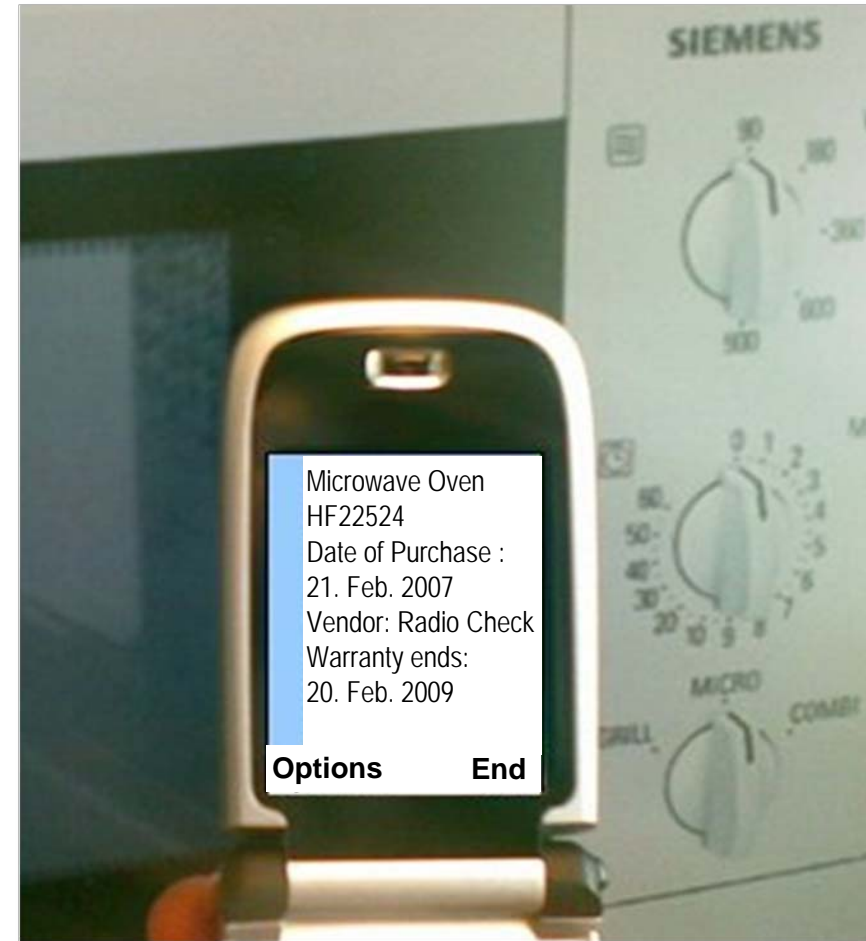
User Manual

Warranty Data

Date of Purchase

Operating Data

Maintenance Data



LifeLog Research at DFKI: 2003 -2011



Specter: Personal Journals as LifeLog:

<http://www.dfki.de/specter/>

BMBF: 2003-2005



SharedLife: Sharing LifeLogs

<http://sharedlife.dfki.uni-sb.de/>

BMBF: 2006-2008

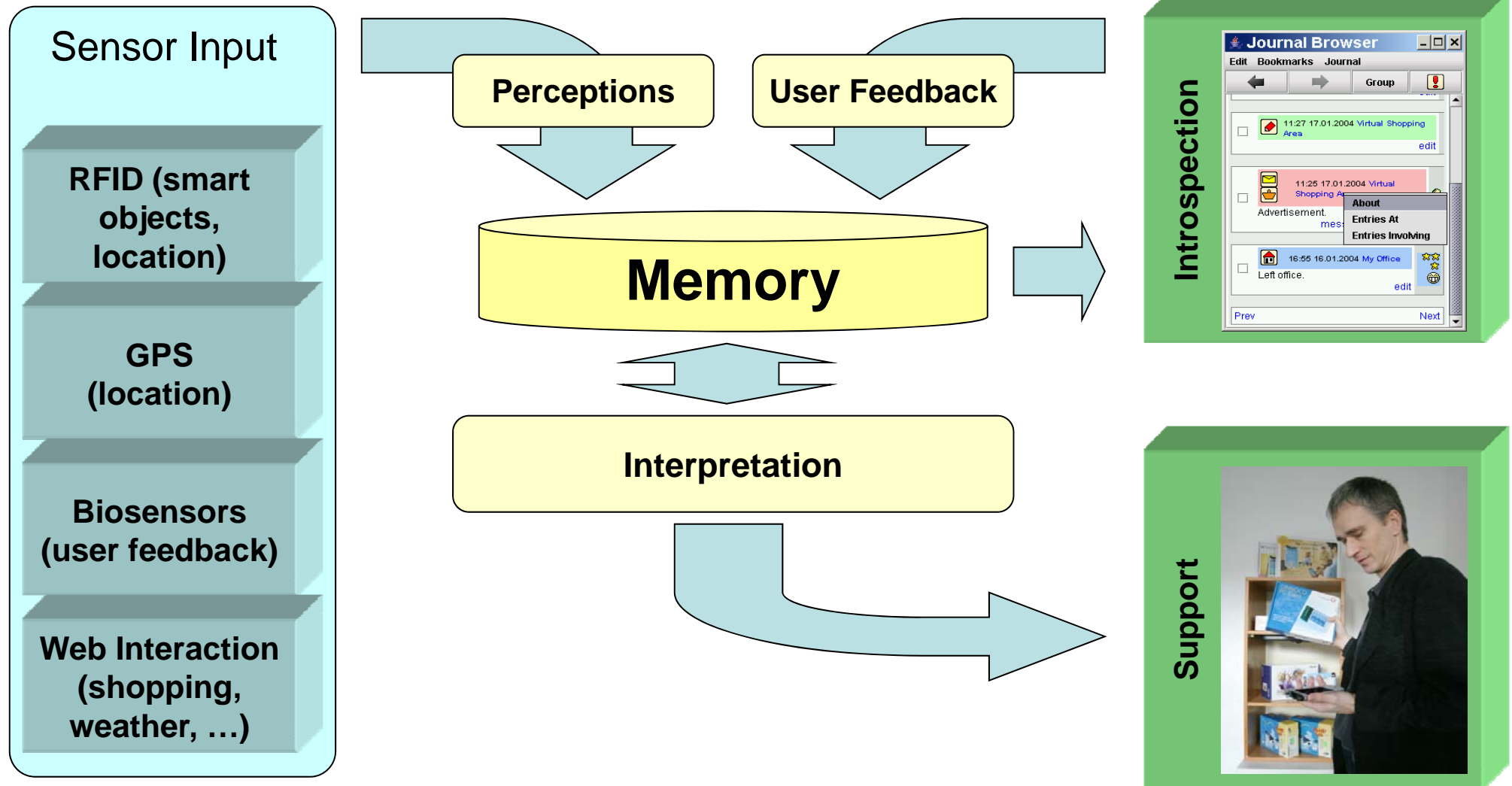


SemProm: Semantic Product Memory – LifeLog for Objects

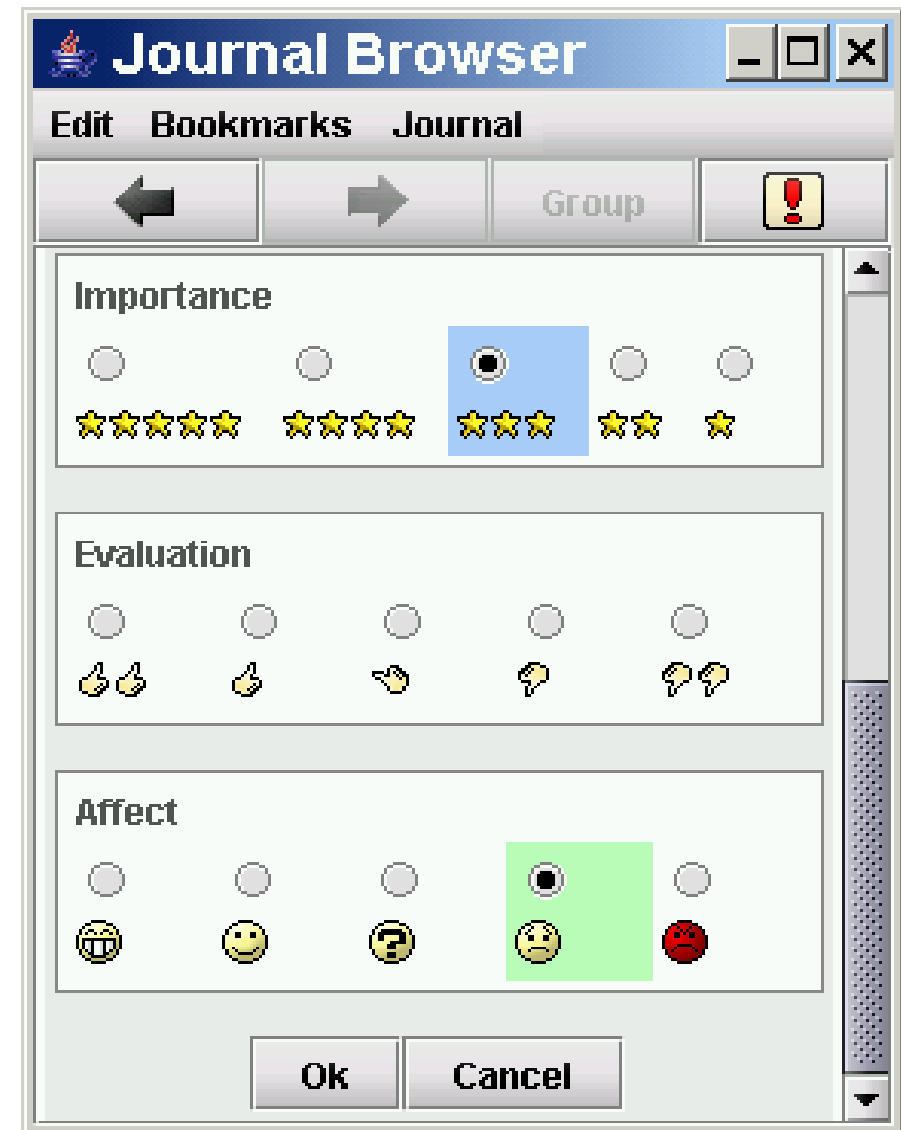
<http://www.semprom.de/>

BMBF: 2008 - 2011

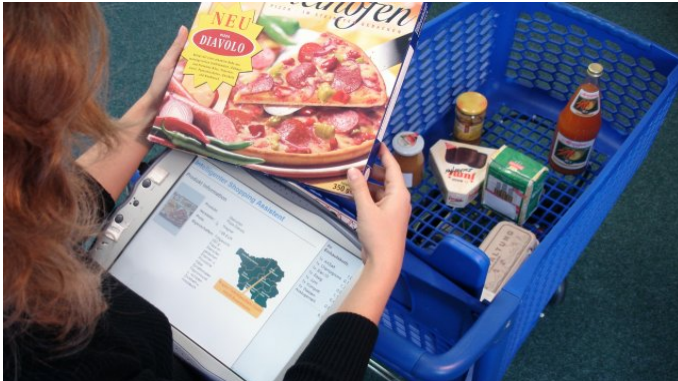
The Personal Journal: Augmenting Memory



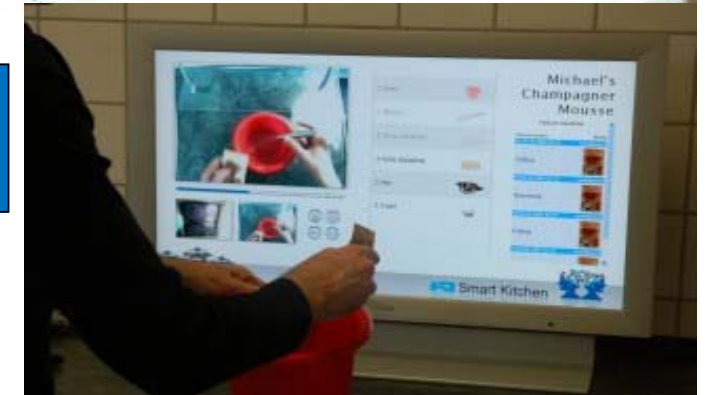
Reflection and Introspection – A Journal Browser



Building Personal Digital Memories from an Instrumented Environment's Perceptions



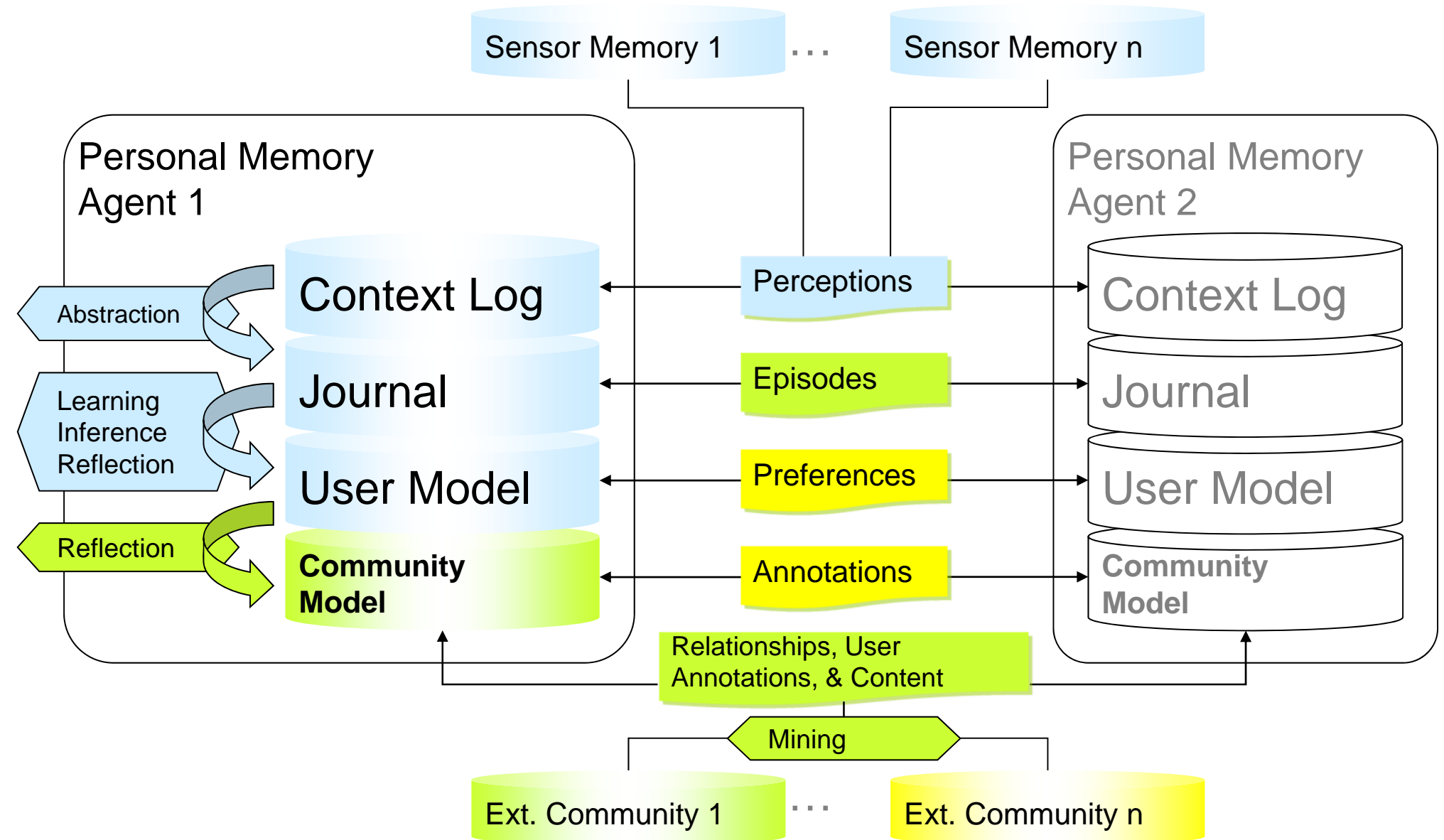
Grocery Shopping



Cooking

Personal Digital Memories

SharedLife : Sharing Personal Digital Memories



Simple Product Memories for Food Traceability

**Your Internet Code knows
every spinach field !**




**A laser marker is used to mark each
icy spinach package with an
individual code**

**Your spinach was harvested
at the field “Sea View”
by farmer Jim Miller and
was packaged on Monday,
14 September 2009.
Jim has a contract with Iglo
since 1992....**



Domino's Pizza Tracker for the Complete Order Status Order, Prep, Bake, Box, Deliver

Used by 75% of online customers



SUN 9:05 AM

[ESPAÑOL](#)

[ORDER](#) [MENU](#) [COUPONS](#) [LOCATIONS](#) [SEE LOCAL OFFERINGS](#)

PIZZA TRACKER

You've got 30 minutes and you've got Domino's coming your way. The delivery experts at Domino's have specifically engineered the Pizza Tracker to keep you up to date on the status of your order from the moment it's prepared to the second it leaves our store for delivery. Now, you got tracking where no tracking has ever gone before.

ORDER PLACED

PREP

BAKE

BOX

DELIVERY

1

2

3

4

5

PATENT PENDING

© 2008 Domino's

ENTER YOUR PHONE NUMBER* EXT.

☐ I AGREE TO ONLY TRACK MY OWN ORDERS AND TO THE [TERMS & CONDITIONS](#)
*Only available at participating locations

TRACK YOUR ORDER

☐ REMEMBER ME

DOMINO'S // PIZZA TRACKER

Peter Hackett made my Pizza, it's all messed up.

Tracking of Processes as a Consumer Obsession

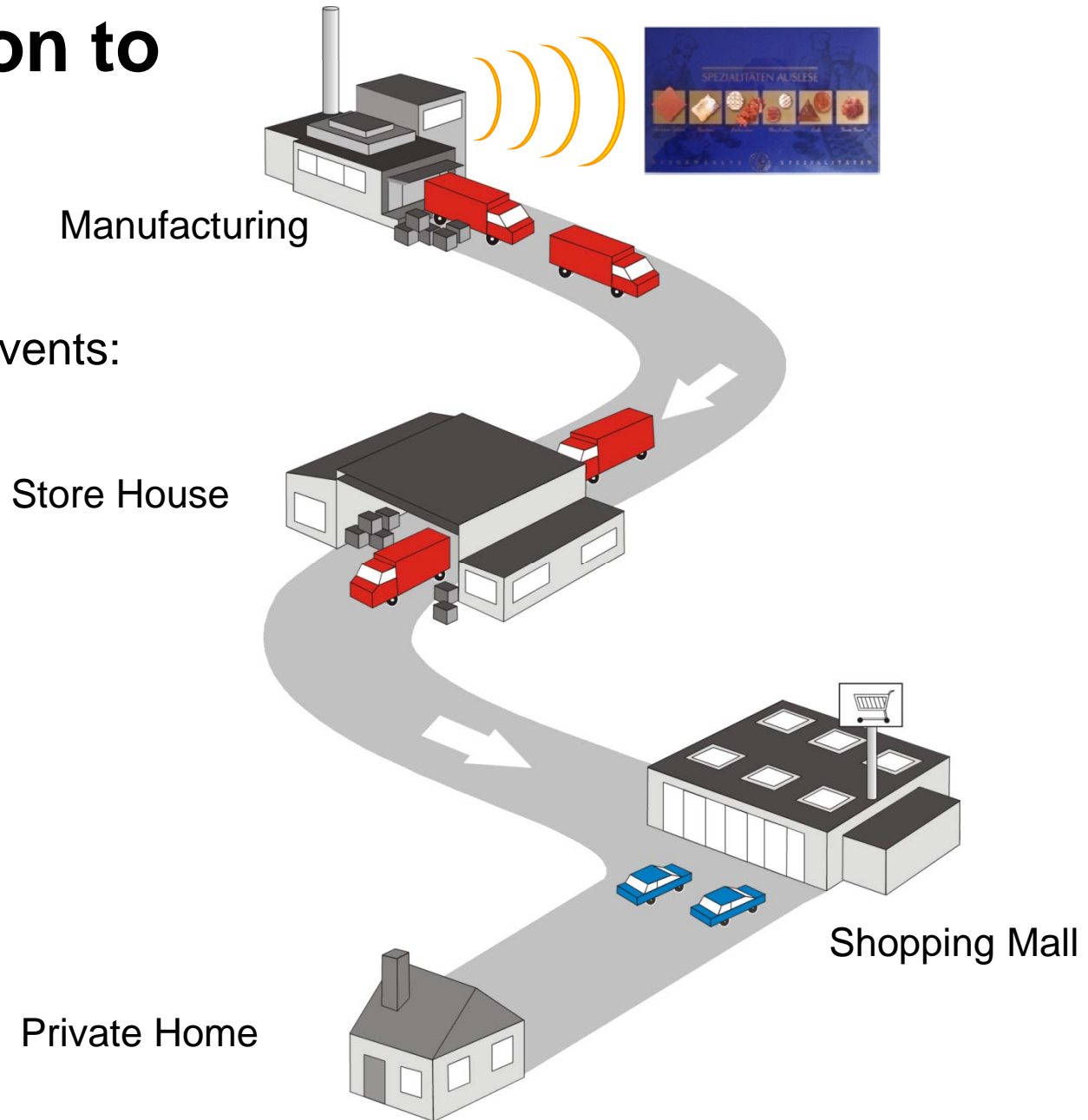
America is becoming a nation of **track-a-holics**. We want to go online and track the whereabouts of everything we order — or do. It's sometimes because we need to know, but often it's simply because we want to know...Customers want some sense of control.

By Bruce Horovitz, USA TODAY, 27 July 2009

The Semantic Product Memory: From Production to Consumption

The product memory prevents:

- tarnished chocolates
→ Humidity Sensor
- melted chocolates
→ Temperature Sensor
- crushed chocolates
→ Pressure Sensor



DFKI's Living Lab for AI and Automation

The SmartFactory: Producing Bottled Soap in Dispensers



The SmartFactory Shop Floor: Wireless, RFID-, Sensor- and Service-based Architecture

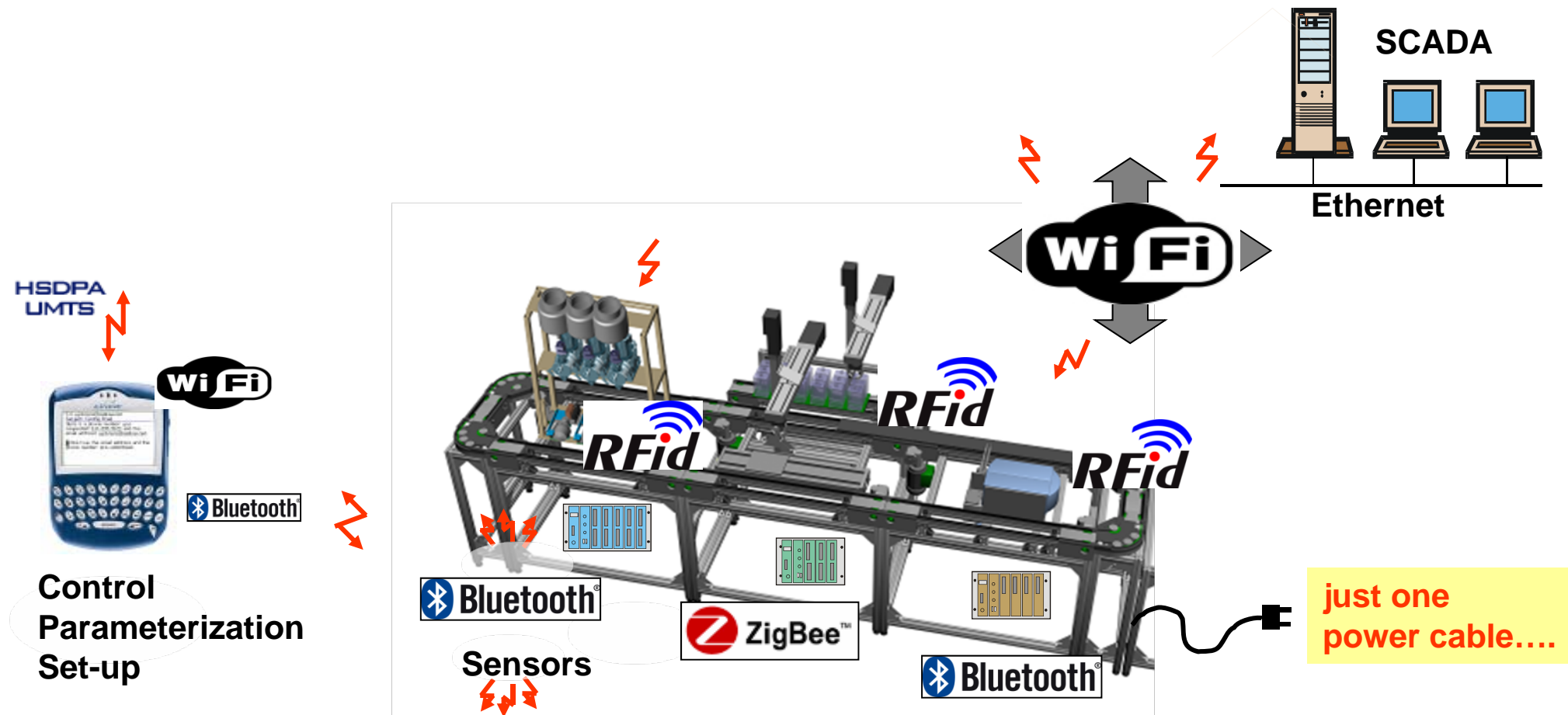
continuous flow process
colored soap production

discrete handling process
bottling, handling, labeling, QC, packaging...



Live Webcam: <http://www.smartfactory.de/webcam.de.html>

The SmartFactory as a Wireless and Sensor-based Factory for SemProM



From Bits and Bytes to Semantics on the Job Floor

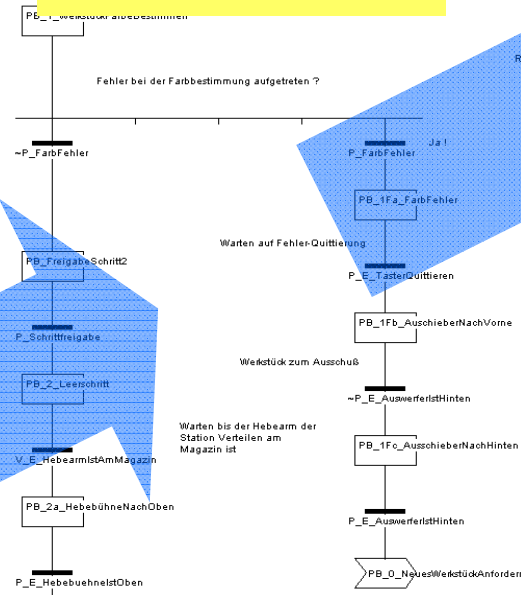
driven by
Electrical Engineering

driven by
Software Engineering

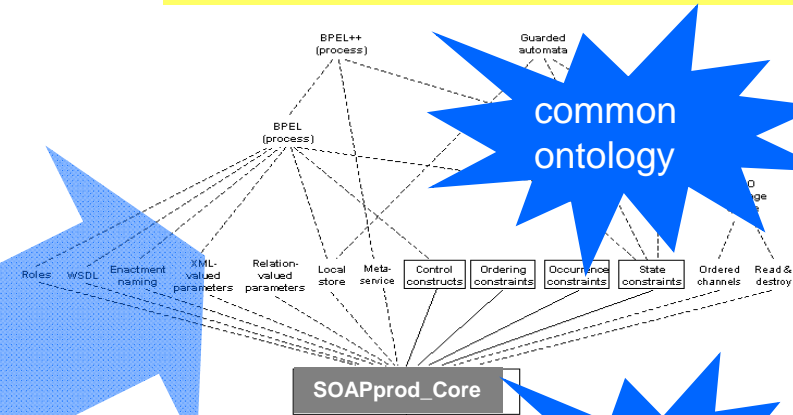
Via functions

From bits and bytes

Antrieb einschalten		
U	E_FERN	;Antrieb auf Fern
UN	E_STOER	;keine Störung
UN	E_NOTAUS	;Not Aus nicht bet.
U|		
UN	HAND	;nicht Hand-PLS
U	AUTO_EIN	;Auto-EIN Befehl
O		
U	HAND	;Hand-PLS
U|		
O	HAND_EIN	;Hand-EIN-Befehl PLS
O	A_EIN	;Selbsthaltung
J		
=	A_EIN	;Antrieb EIN
BE		



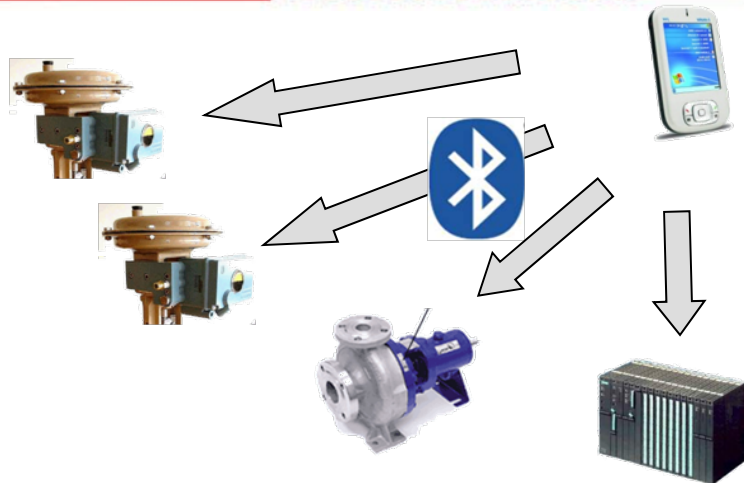
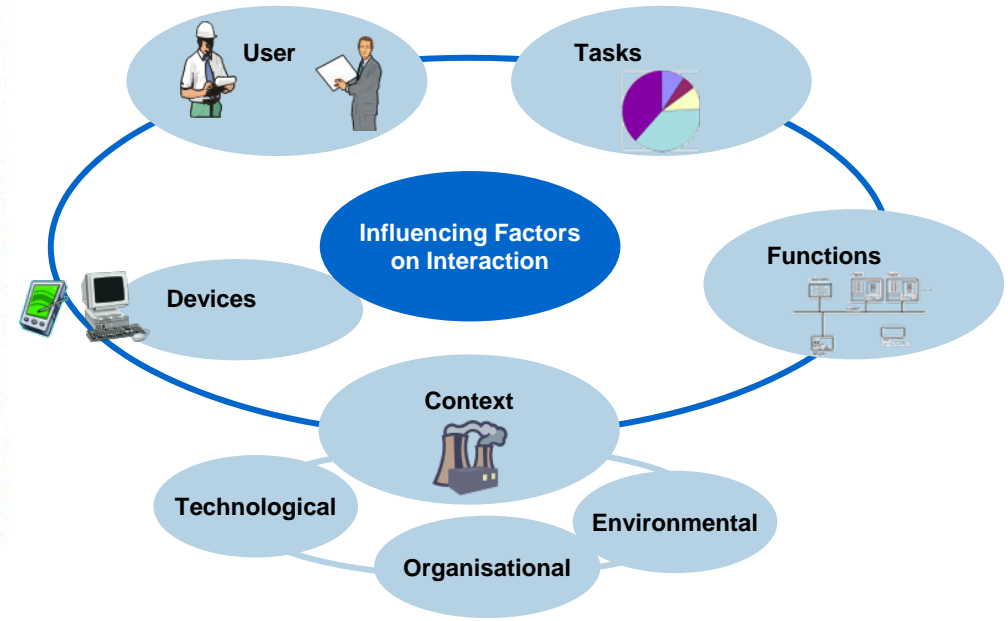
To semantic services



knowledge based

Semantic Technologies
driven by

NFC-enabled Smartphones as Universal Interaction Devices for Future Manufacturing and Accessing SemProM

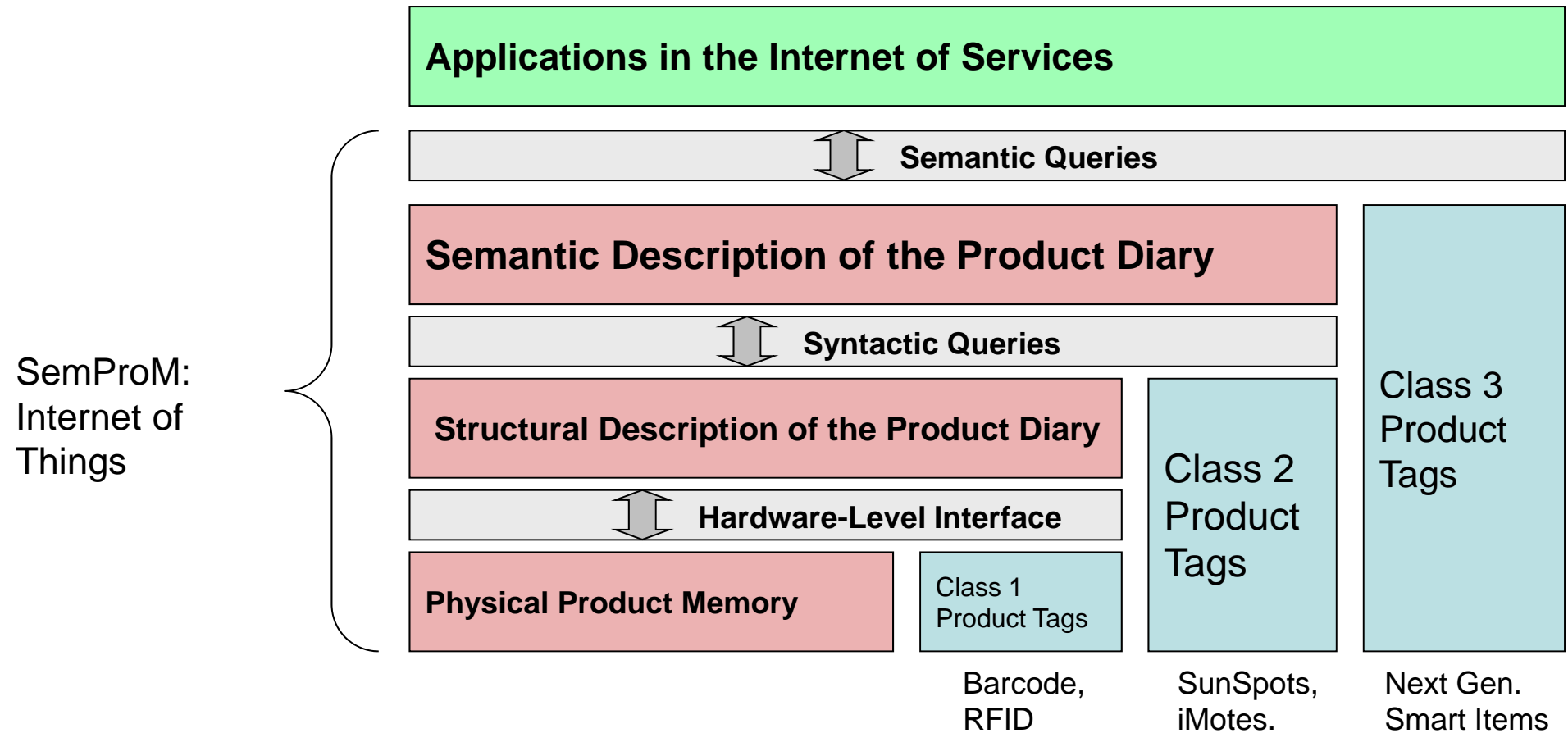


Future Manufacturing in DFKI's SmartFactory



See **Exhibition Booth A18**: Guided Tour during the Break after my talk, Demonstrations of a section of the SmartFactory till Thursday afternoon

The Layered SemProM-Architecture

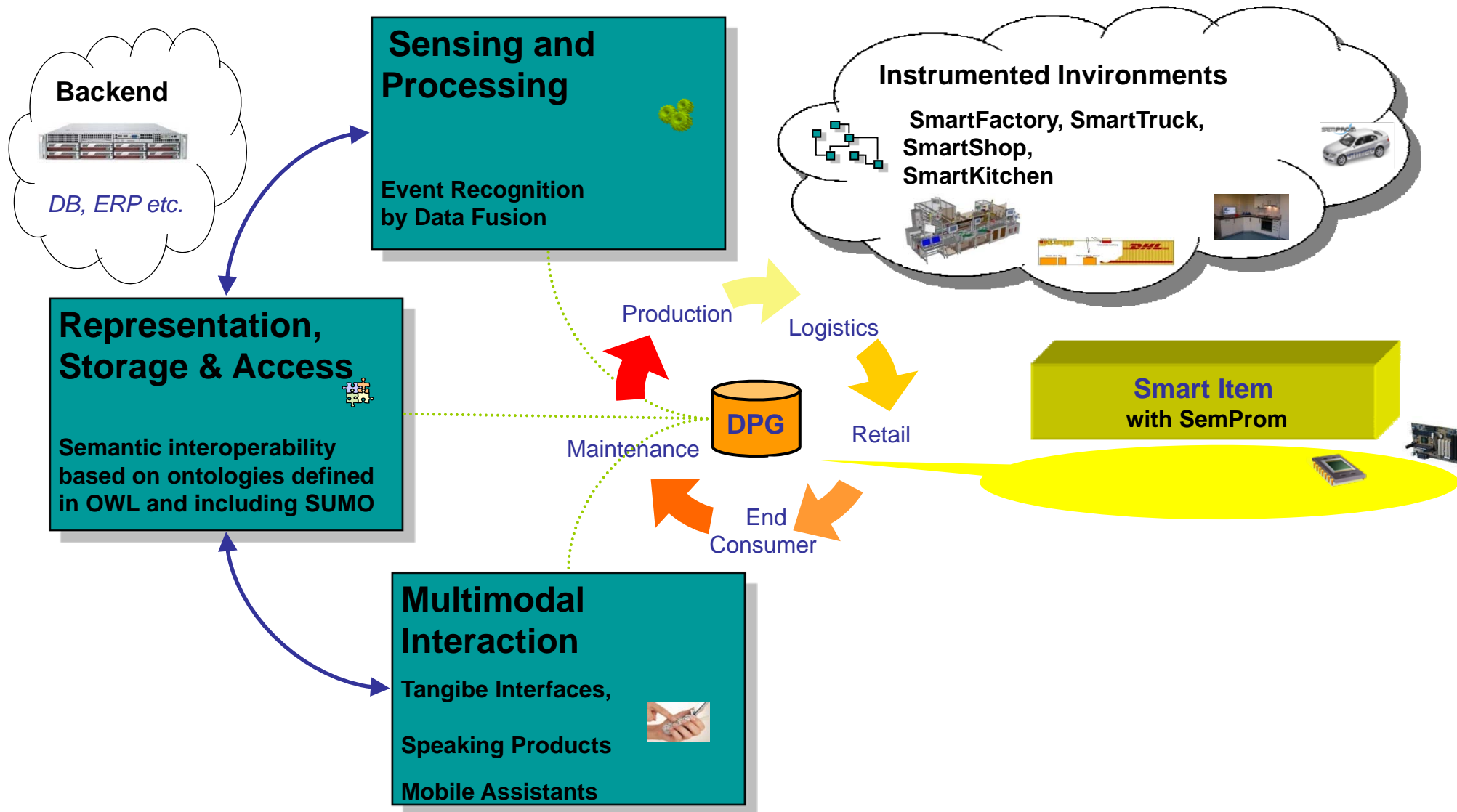


Class1: No information processing on the product, only identification and reference to storage

Class 2: Collection of sensor data and storage on the product, communication with other tags

Class 3: Semantic integration of data and semantic query processing on product data

Three SemProm Components



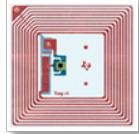
Tracking the Temperature History of a Frozen Pizza for the Semantic Product Memory



In the shop

Freezer with frozen pizza

- RFID tag



Cool Box

- with sensor node
- Temperature Sensor
- Light Sensor



Kitchen Worktop

- RFID reader
- Touch screen

at home



Sun SPOT:
(Small Programmable
Object Technology)

from the shop to the home

Shopping Cart

- RFID reader
- UMPC



in the shop

Fridge

- RFID reader
- Touch screen



at home

The Structure of the Semantic Product Memory

Time Stamp	Data Link	Data Interpretation
$T_{\text{freezer-1}}$	.../temp/_32	TEMPERATURE
T_{freezer}	.../event/pizza_out_of_freezer	EVENT
T_{Cart}	.../event/pizza_in_cart	EVENT
$T_{\text{Cart}+1}$	.../temp/4	TEMPERATURE
(...)	.../temp/2	TEMPERATURE
$T_{\text{Cool_box-closed}}$	.../event/box_closed	EVENT
$T_{\text{Cool_box-closed}}$ till $T_{\text{Cool_box-removed}}$	.../temp/xx	TEMPERATURE
$T_{\text{cool_box-removed}}$	.../event/box_removed	EVENT
$T_{\text{cool box_removed}}$ till $T_{\text{box_recognized}}$	.../temp/xx	TEMPERATURE
$T_{\text{box_recognized}}$	.../event/box_in_kitchen_detected	EVENT
$T_{\text{box_recognized}}$ bis $T_{\text{pizza_on_work_top}}$	.../temp/xx	TEMPERATURE
$T_{\text{pizza_on_work_top}}$	.../event/pizza_removed	EVENT
$T_{\text{pizza_in_fridge}}$	.../event/pizza_in_fridge	EVENT
$T_{\text{pizza_in_fridge}}$ bis T_{NOW}	.../temp/xx	TEMPERATURE

Example for the Semantic Product Memory

HTML Output for http://oms.sb.dfki.de/m/Pizza_04?cmd=query

RESULTS for 'Pizza_04':

Type	Value
ID	61
Link	http://www.dfki.de/pizza/converter/event.php?timestampstart=2008-04-24T10%3a27%3a00%2b00%3a00&type=ITEM_PRODUCED&provider=PRODUCER
Hash	---
Certificate	
Datatype	application/xml
Purpose	http://www.dfki.de/pizza/ontologies/oms_purpose.owl#Event
Timestamp	2008-04-24T10:27:00+00:00
Status	VALID

Type	Value
ID	62
Link	http://www.dfki.de/pizza/converter/key_value.php?timestamp=2008-04-24T10%3A27%3A01%2B00%3A00&value=-18&unit=celsius
Hash	---
Certificate	
Datatype	application/xml
Purpose	http://www.dfki.de/pizza/ontologies/oms_purpose.owl#Temperature
Timestamp	2008-04-24T10:27:01+00:00
Status	VALID

Example for the Semantic Product Memory

XML Output for: http://oms.sb.dfki.de/m/Pizza_04?cmd=query

```
<?xml version="1.0" encoding="utf-8" ?>
<oms xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLocation=
"omi_query.xsd">
<oms-instance name="Pizza_04" from="1" to="0" of="0">
  <omi>
    <id>61</id>
    <link>
http://www.dfki.de/pizza/converter/event.php?timestampstart=2008-04-24T10%3a27%3a00%2b00%3a00&type=ITEM\_PRODUCED&provider=PRODUCER</link>
    <hash>---</hash>

    <certificate></certificate>
    <datatype>application/xml</datatype>
    <purpose>http://www.dfki.de/pizza/ontologies/oms\_purpose.owl#Event</purpose>
    <timestamp>2008-04-24T10:27:00+00:00</timestamp>
    <status>valid</status>
  </omi>
  <omi>

    <id>62</id>
    <link>
http://www.dfki.de/pizza/converter/key\_value.php?timestamp=2008-04-24T10%3a27%3a01%2b00%3a00&value=-18&unit=celsius</link>
    <hash>---</hash>
    <certificate></certificate>
    <datatype>application/xml</datatype>
    <purpose>http://www.dfki.de/pizza/ontologies/oms\_purpose.owl#Temperature
</purpose>

    <timestamp>2008-04-24T10:27:01+00:00</timestamp>
    <status>valid</status>
  </omi>
</oms-instance>
```

The Memory Format of SemProM

Design Goals:

- Separation of physical data format and semantics
- Contents are typed and thus externally recognizable
- Various contents in different representation formats can be combined
- Minimal storage requirements of the meta-data structures

Realization:

- 1 SemProM Header at the beginning of each SemProM
- 1..n SemProM Blocks
 - SemProM Blocks consist of a Block Header and Block-Data
 - Block Data encodes data in a flexible format

SemProM Header

Block Header

Block Data

Block Header

Block Data

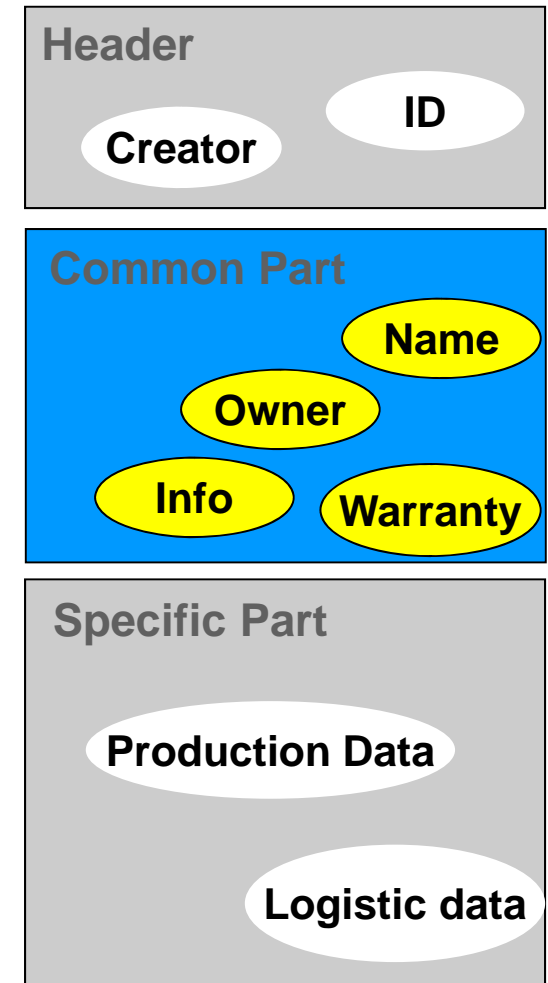
Block Header

Block Data

The General Part of the Semantic Product Memory

Includes only contents that are relevant for almost all phases of the product life cycle:

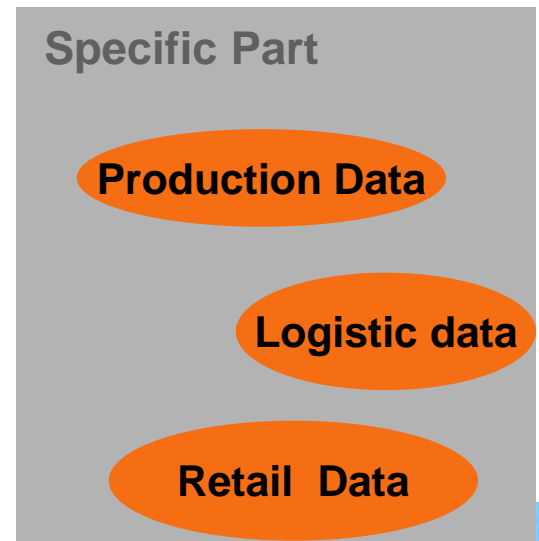
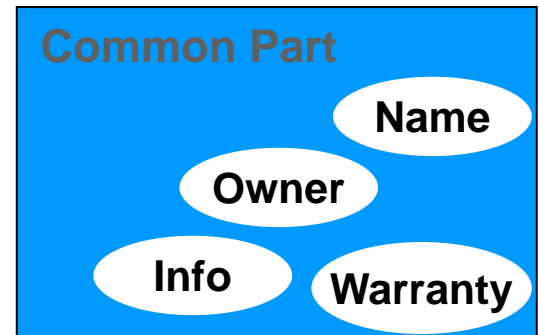
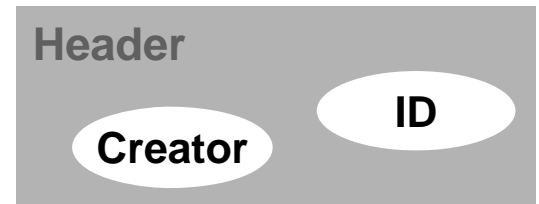
- Header (with ID and name)
- Event log (EventLog)
- List of product names (ProductHistory)
- List of owners (OwnerHistory)
- List of inherited „parent“ and „child“ memories
- Keyword list for syntactic matching and search
- Product information (ProductInfo)
- Warranty information
- List of norms, standards and certificates (CertificateList)



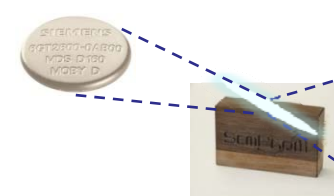
The Specific Part of the Semantic Product Memory

Each manufacturer, logistics company, retailer, maintenance company and consumer can store any number of blocks with any information

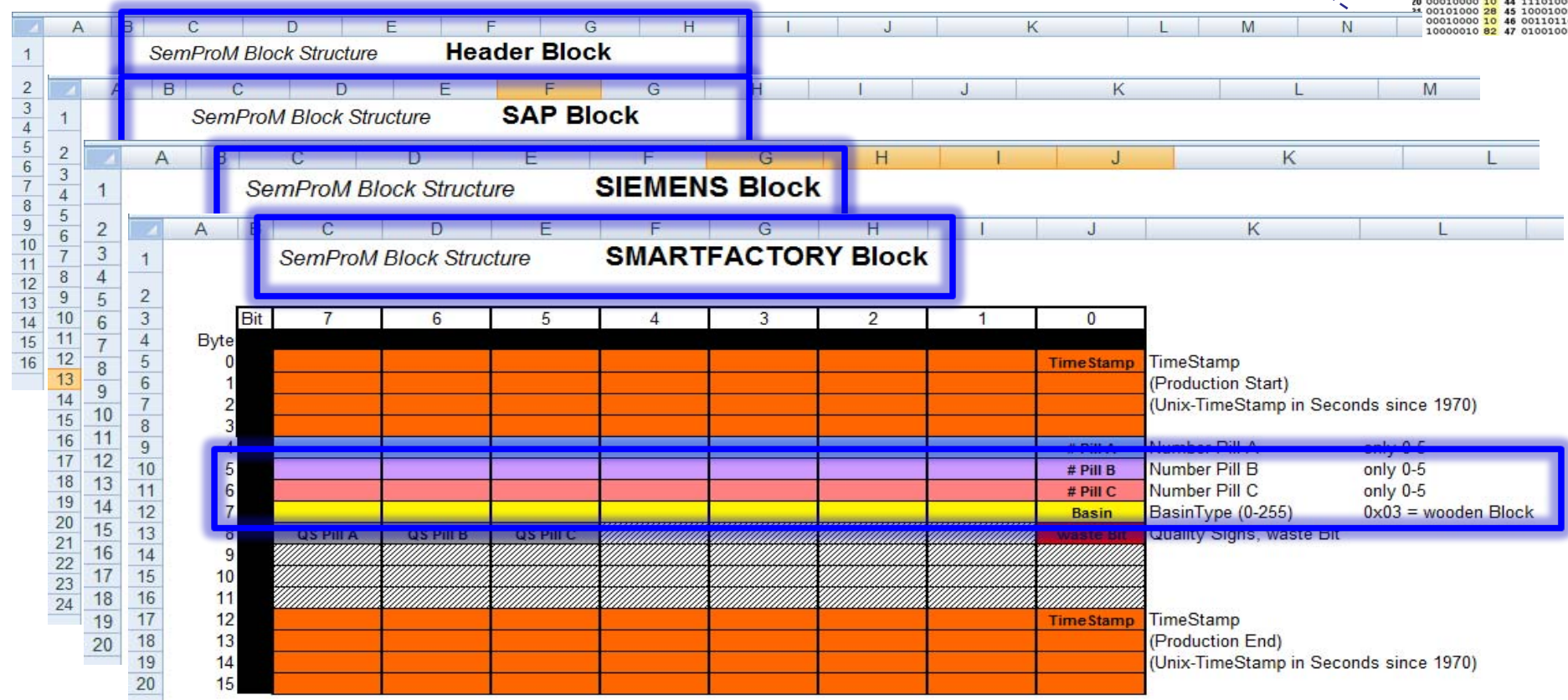
- Header (with ID, name and type)
- Creator of the block
- Detailed list of events (eventList)
- Keyword list for search
- Scheme for proprietary content representation
- Any proprietary content



Binary Data Structure on the SemProM Chip of the Product



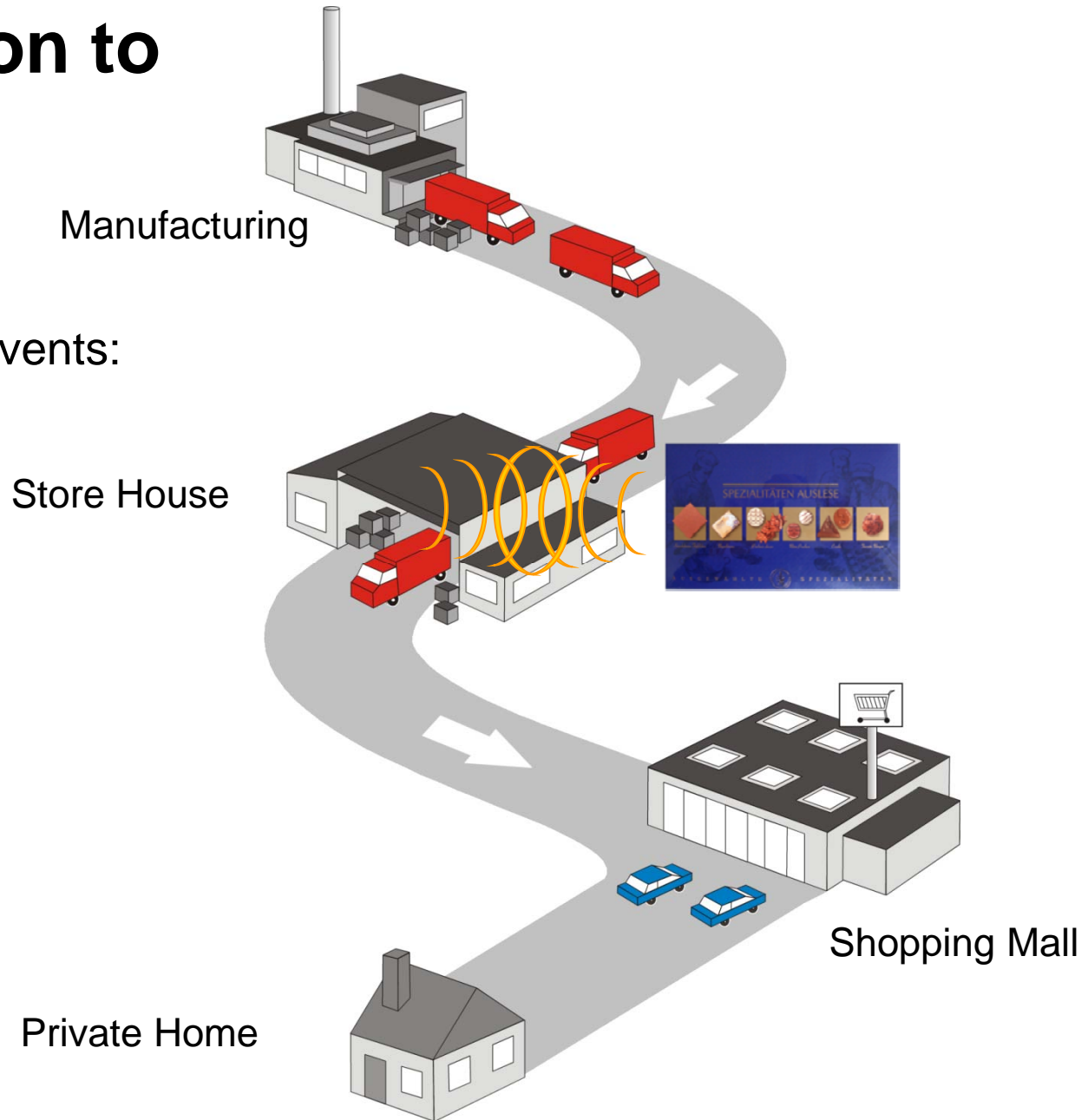
30	11100111	E7	24	10000010	82	48	11100111	E7
31	10001001	89	25	10000010	82	48	10001001	89
32	00110110	36	26	00000000	00	50	00110110	36
33	01001001	49	27	00000000	00	51	01001001	49
34	00000010	02	28	11101000	E8	52	00000010	03
35	00110000	30	29	10001001	89	53	00000001	01
36	01110101	75	30	00110110	36	54	00000010	02
37	01010000	50	31	01001001	49	55	00000011	03
38	00010100	14	32	11100111	E7	56	10100001	A1
39	00110010	32	33	10001001	89	57	00000000	00
40	00000000	00	34	00110110	36	58	00000000	00
41	00000000	00	35	01001001	49	59	00000000	00



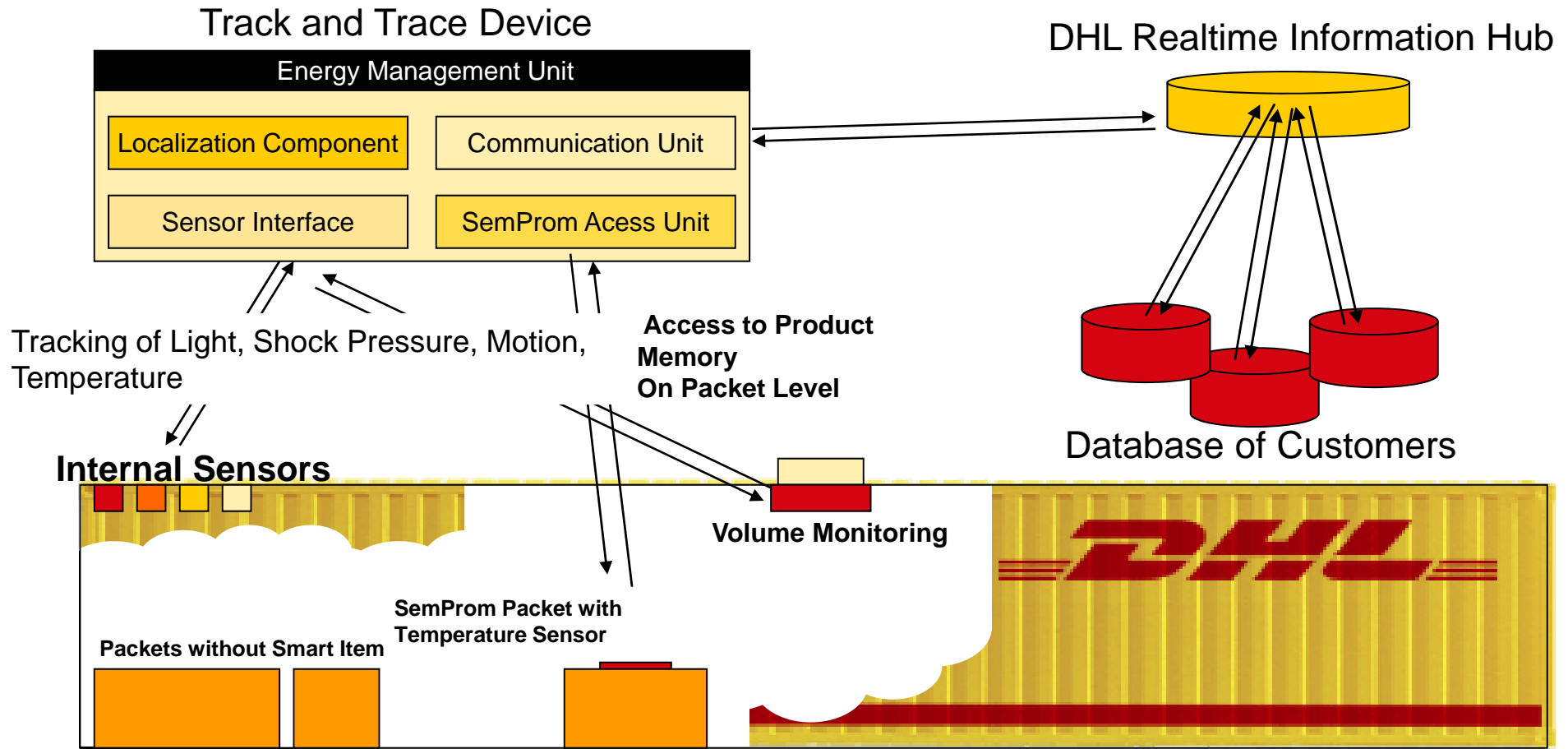
The Semantic Product Memory: From Production to Consumption

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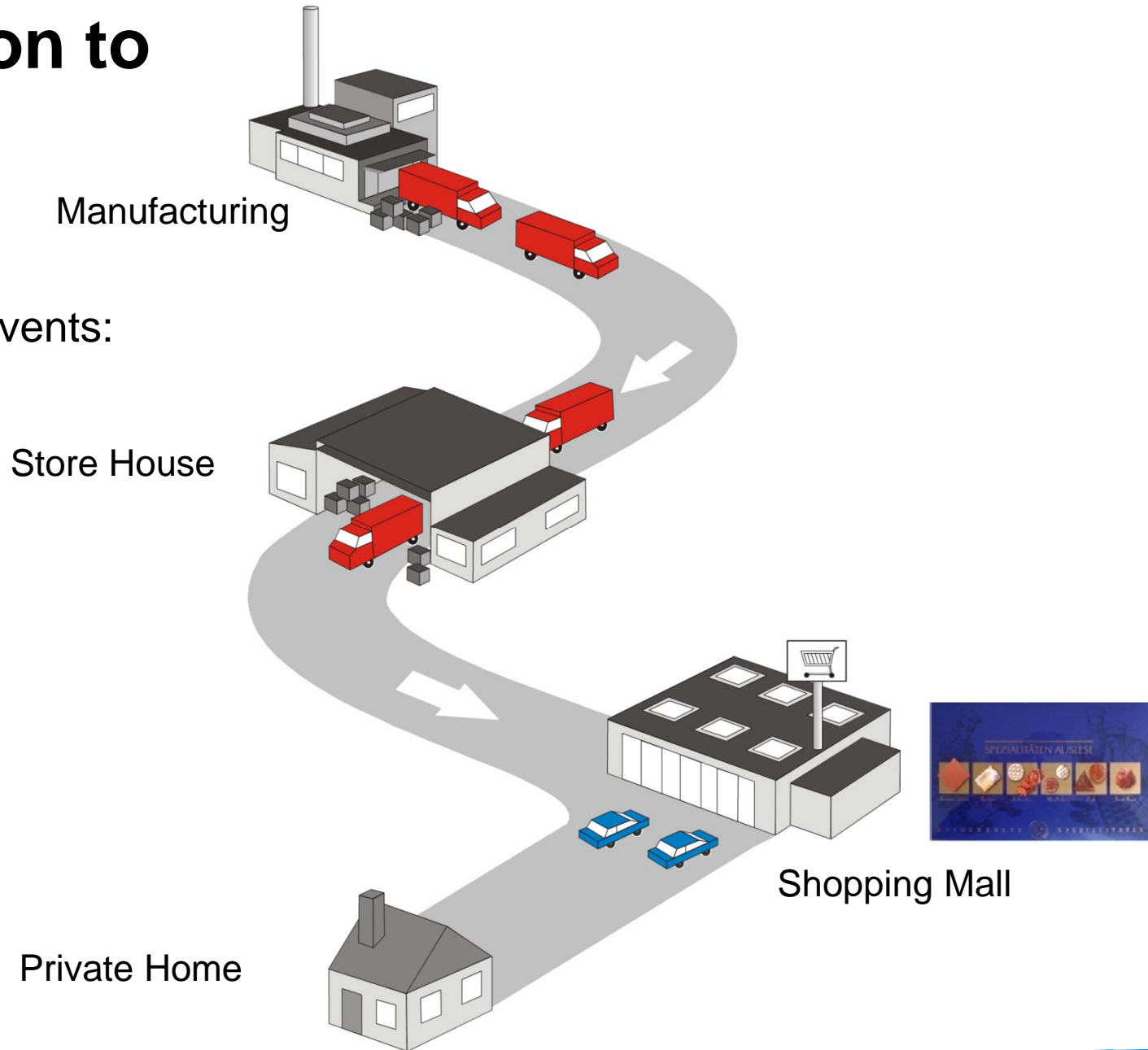
SemProm in the logistics chain



The Semantic Product Memory: From Production to Consumption

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→ Pressure Sensor



The Innovative Retail Laboratory (IRL) of DFKI sponsored by the Globus Hypermarket Chain



Research Topics

- Personalized Shopping Assistance
- Semantic Product Memories
- Intelligent Intralogistics
- Ambient Retail Intelligence

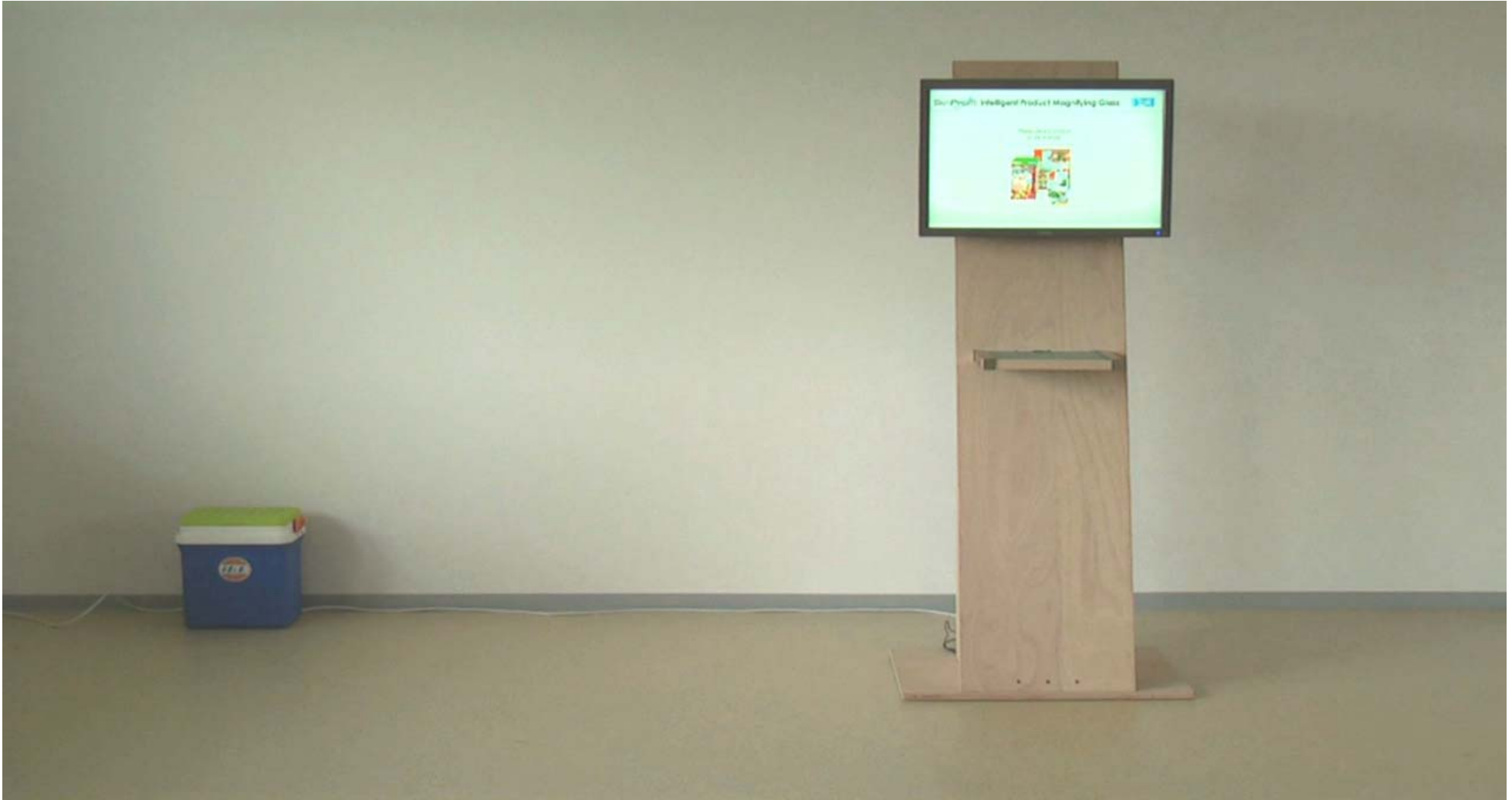
- more than 90 malls in Germany and Eastern Europe
- more than 4 Billion Euro Revenues
- No. 1 in customer service innovation in Germany

Sponsorship by Globus: 1.5 Million Euro, 500 sqm free lab space at Globus headquarters in St. Wendel, Germany, and an endowed chair for **Antonio Krüger**, „AI for Retail Intelligence“.

Composition and Synchronization of a Smart Shopping List with the iPhone



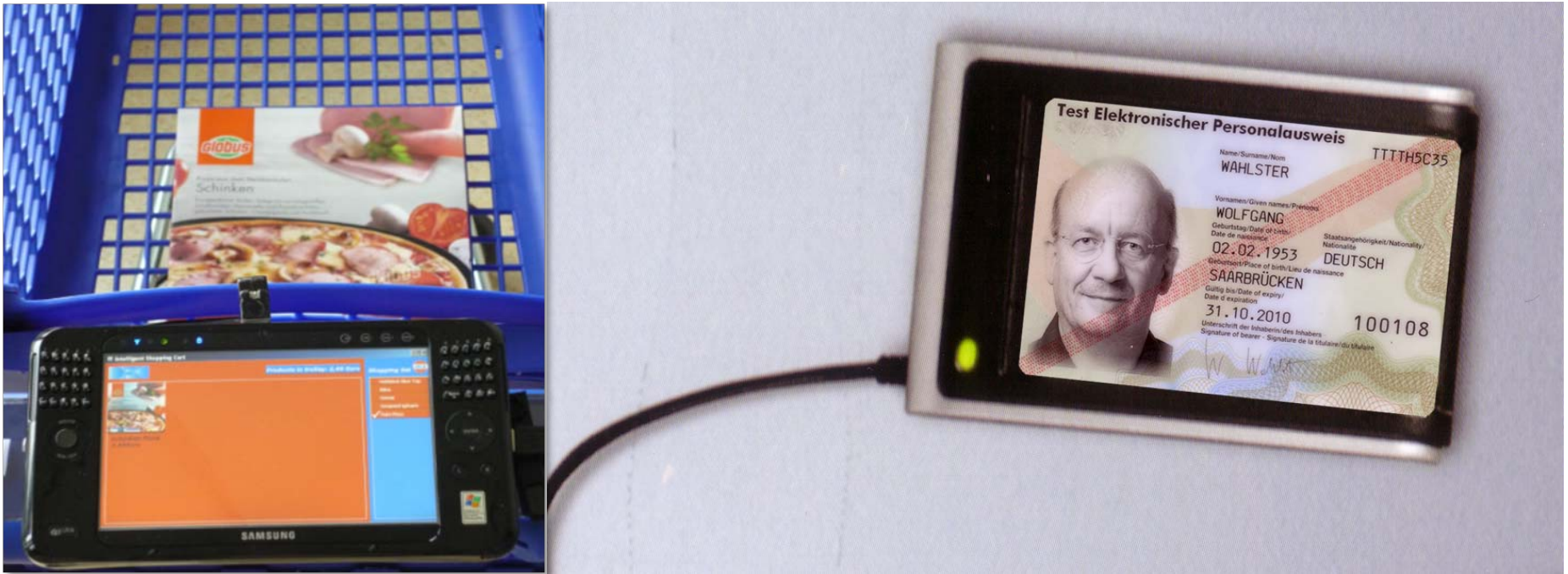
The Intelligent Product Magnifying Glass: Ingredients, Food Additives (E Numbers) and Allergens



Browsing the Semantic Product Memory at the Fridge's Display at the Customer's Home



Secure Role-based Access to SemProm using the new German National Smart ID Card



**Filtering of the visualized content of SemProm
based on the personal security profile and
privileges of the user**

Acknowledgements

This talk is based on joined work with the following members of DFKI:

Detlef Zühlke,
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Jörg Baus,
Gerrit Kahl,
Michael Schmitz,
Tim Schwartz
Antonio Krüger
Alexander Kröner,
Christoph Stahl,
Michael Schneider,
Dominik Heckmann

The work is sponsored by the German Federal Ministry for Education and Research (BMBF)

Conclusions

A **semantic product memory** stores a diary of an individual physical object in a persistent way on an embedded sensor system that is networked by wireless communication to a smart environment.

We showed how such embedded **“black box” event recorders** can transform everyday objects into **smart products**.

We showed how consumers of smart products can access their **lifelogs** by NFC-enabled smartphones using SemProM's browser and track the complete history of a product.

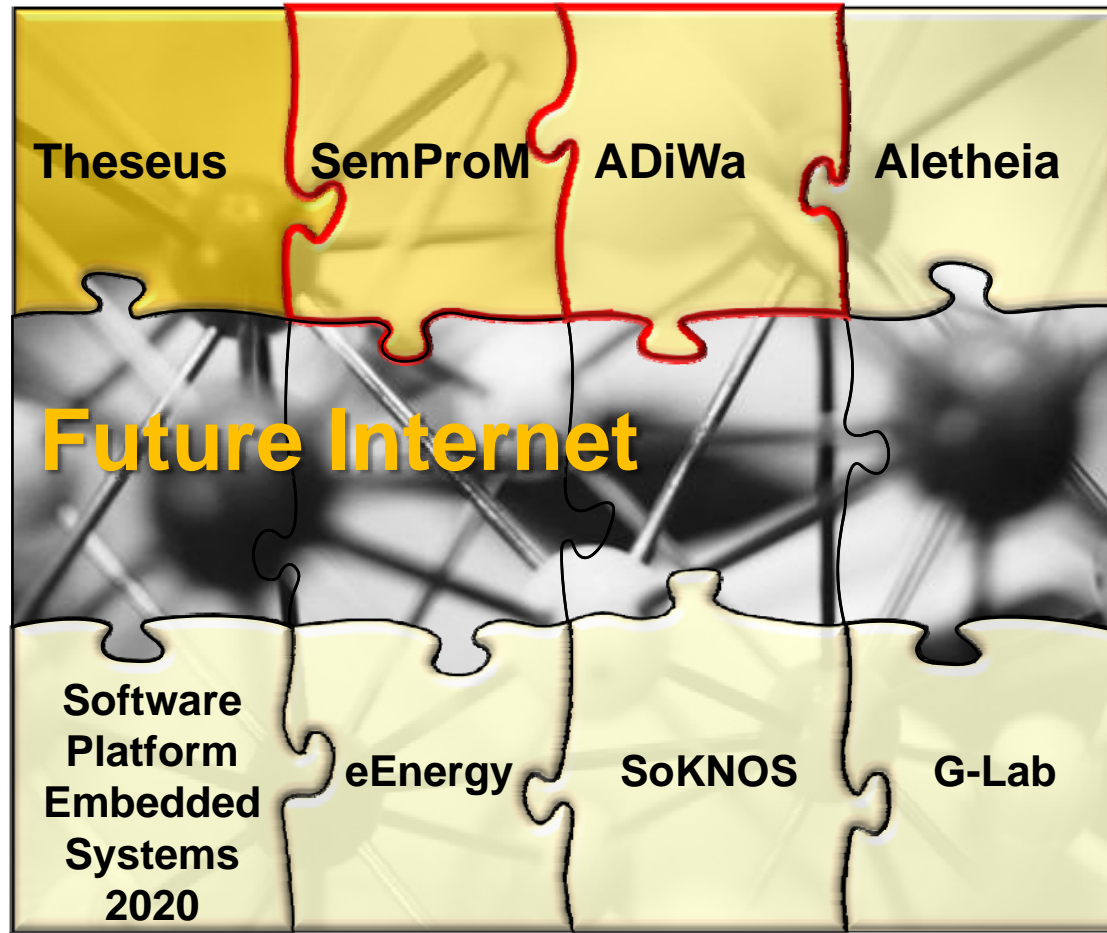
Conclusions

SemProM is the German flagship project towards the **Internet of Things**.

SemProM is based on **ontologies, semantic web services, sensor fusion, event recognition, multimodal and tangible interfaces** and contributes to AI and Automation.

SemProM has shown that the **interoperability** needed for product memories can be achieved by using **semantic technologies** developed in AI

Future Internet Research in Germany



Thank you very much
for your attention.

