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Smart products are everywhere   smartphones, smart appliances, smart cars. Several building blocks have been evolving over the past few years that enable conversations between such products and humans. IT specialists call this network the "Internet of Things."

As an example, the Object Memory Model (OMM) language with embedded Ontology Web Language (OWL) expressions was designed for use by applications to process the content of information stored by these products instead of simply presenting the information to humans. By building actuators, sensors, and radio modules for web connectivity directly into products or their packaging, we can create "event recorders" that record the life histories of products   similar in concept to the black box that records flight data on airplanes and that can be retrieved and analyzed.

The SemProM (short for Semantic Product Memory) consortium has been evaluating how the Internet of Things affects various production and supply chain processes. The consortium is one component of the KT-2020 research program of the German Federal Ministry of Education and Research.

Based on all these pioneering efforts, it is not futuristic to envision a digital journal that various products "write" and to use that journal to facilitate a wide range of consumer decisions, commerce, logistics, safety recalls, and other traceable actions.

To illustrate this concept   have outlined below and in Figure 9-1 the "diary" of an order of chocolates. With minor changes, you could apply the same

concepts to a box of frozen pizza or a tub of ice cream. Later will apply similar concepts to other groceries and to pharmaceutical products.

In the Smart Factory

The chocolate factory receives an order for assorted luxury pralines from a chocolate store will call Althaus. The factory order management system initializes the semantic memories of the boxes in which the pralines will be packaged. On the shop floor the memories guide each filling station as to the kind of pralines to put in each box and how to position them in the box.

This digital system is fundamentally different from the traditional manufacturing flow where the bill of material drives most of the production, and customization is usually one of the last steps. Here the semantic product memory guides the flow across conveyor belts and filling stations in the factory.
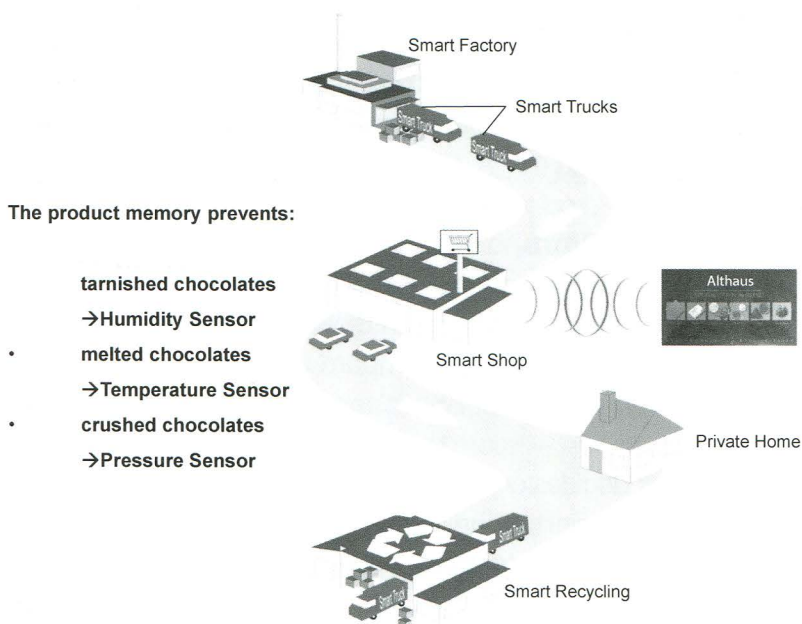

Smart Factory

Smart Trucks

The product memory prevents:

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

Smart Shop

Althaus

Private Home

Smart Recycling

Figure 9-1· The digital diary of an order of chocolates

In the Smart Delivery Truck

These expensive pralines justify the costs of shipping via temperature-controlled trucks that logistics providers increasingly provide. DHL, for example, offers its Smart Sensor packages that combine a sensor with a passive ultra-high frequency (UHF) radio frequency identification (RFID) transponder which allows authorized personnel to read the temperature data without having to open the shipment. DHL also offers services like COLDCHAIN, which provides temperature control, security, and handling for life sciences and healthcare products.

In addition, the chocolate package contains a "black box" that frequently has its own temperature sensors. If the truck were to get too hot, these sensors can "complain" via machine-to-machine communication to the truck's refrigeration system to increase the cooling.

When the shipment arrives, the Althaus storeowner opens the secure delivery box with the PIN/TAN authentication he or she has been provided by the factory. He or she may find that the pressure sensor of the boxes in the order has been triggered. In that case, instead of accepting crushed chocolates, the storeowner can decide to return that box to the factory.

In the Smart Retail Store

The semantic product memory on the boxes allows a consumer to perform a side-by-side comparison on digital signage in the Althaus store. Specifically, it allows her to compare calories, freshness, and other product features.

Once the consumer decides on a product, its box updates the electronic shopping list on her smartphone. The cashier-less checkout station then reads the relevant contents of the semantic product memory. BMW and DFKI have developed a car key fob that also doubles as an electronic payment device in our innovative retail lab (IRL).

In the Consumer's Smart Car

BMW and other automakers increasingly offer temperature-controlled storage space in the central console or glove compartment. The car's indoor sensors detect the praline box and read its semantic product memory. They then help recommend the ideal air conditioning setting and the best navigation route home to avoid a temperature violation for the pralines.

At the Consumer's Smart Home

In the customer's home, smartphones enabled by NFC can continue to monitor the humidity, temperature, and pressure sensors of the praline box. As an added benefit for customers with diabetes, medical devices like the Medivox system from Kohl Pharma Group can read the semantic product memory and warn them to take their medication before eating a praline. NFC readers and health apps on smartphones can also warn patients with food allergies that there are traces of nuts in the pralines.

In the Smart Recycling Plant

The consumer discards the box in the garbage, and the waste pickup service brings it to the recycling plant. At the plant the automatic sorting module recognizes the embedded black box, and a robotic gripper communicates with the product memory to locate its position. It then separates the black box from the rest of the box so the electronics can be recycled.

Now let's look at two other products   one with somewhat less elaborate packaging, and one with more   and see how they can tell their "life stories."

A black box like the one we just described would not be feasible for a pack of frozen spinach or a bag of lettuce. However take a look at Iglo's packages of its creamed spinach, Rahm-Spinat. (Iglo,

formerly a division of the giant corporation Unilever is one of Europe's leading frozen food makers.) Below the expiration date is a uniquely engraved set of codes. Enter those codes on Iglo's website, and you receive information about the farmer who grew the spinach, the region where the farm is located, the date it was packed, and other pertinent details. Not only is this information important for traceability during recalls, it also provides transparency to the consumer on the Iglo supply chain. Indeed, search social media sites, and you can find consumer compliments and complaints about the spinach with the specific codes included.

In another industry   pharmaceuticals   opportunities for smart packaging are even greater Smart blister packs with printed electronics embedded in a thin plastic foil can monitor when a pill is taken out of its packaging. Not only can this help with dosage management, it also helps in monitoring for tampering. Worldwide sales of counterfeit medicines could exceed US$75 billion in 2013, a 90% rise in five years.[135] Going further smart tags on packs permit reverse audits, known as "pedigree" in the industry. They also enable precise tracking, so the origin and destination of even the smallest package can be known at all times.

There are also packages that can verbally convey prescription instructions to patients. The City University in London has found that 25% of fully sighted consumers either cannot read or have difficulty reading these instructions. That number jumps dramatically to almost 75% for partially sighted people.[136] To address this problem, the German company Wipak Walsrode came out with a "TalkPack" that includes a pen reader that can speak aloud instructions encoded on the packaging. Along these same lines, some packages are embedded with NFC tags that can be read by mobile phones and played back orally Also available is packaging with large scrolling instructions in glowing images.

As you can see, semantic product memories promise to reshape how products are manufactured, shipped, sold, consumed, traced, and recycled. Each product leads an interesting life, and if we listen carefully to it, it can help us to redefine our businesses and our lives in many fascinating ways.

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