Future Smart Products Systems Engineering

Julia Kantorovitch
VTT Technical Research Centre of Finland, Finland

INTRODUCTION

The increased availability, robustness, and moderate cost of sensors; the increased capacity of computer chips; and the wide spread of Internet and wireless connectivity are adding a new dimension to models of human living and working.

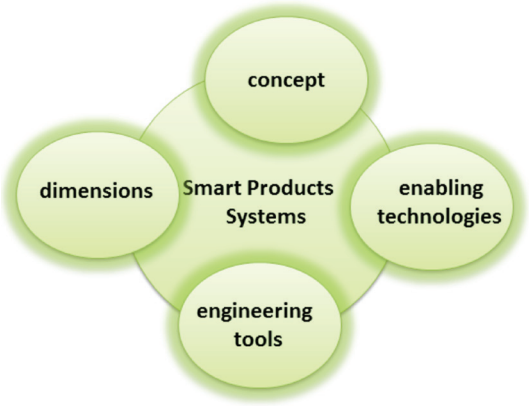
Embedding machine intelligence into the working environment, tools, and processes can make even routine tasks easier. A smart vehicle may eventually suggest using a different type of fuel, knowing the expected temperatures and location of the vehicle during the upcoming trip. Analyzing how a repair procedure is created, a smart vehicle may instruct its owner or technician about the repair procedure, mounting of the snow-chains, or changing the oil. Assembly tools such as a smart wrench may link real-time measurements with actions performed to advise further steps in the assembly process, thanks to the advanced computing and communication technologies available in the surrounding environment and other products.

A combination of several elements brings intelligence to smart products. Sensors measure the environment and the activity of the user, actuators act on the environment or perform functions on behalf of the user, and communication means connect the smart product to other products and the rest of the world. The core of the smart product's intelligence is a knowledge technology combined with the ability to comprehend the user and surrounding environment (i.e. context), coming from reasoning software and intelligent decision rules.

It is widely recognized that additional methods and techniques should be established to meet the needs of the development of future smart products systems. The current research is advancing in several complementary directions, such as 1) clarifying the concept of a smart product from business and technical points of view; 2) implementing various dimensions of smart products systems, including situation awareness, autonomy, and personalization; 3) researching and developing the enabling technologies to implement the functions of smart products; and finally 4) proposing novel support tools to ease the smart product developer's work (see Figure 1).

This article presents a systematic review of existing research in the previously identified domains, providing an analysis of an up-to-date set of technologies that play a critical role in the realization of intelligence and in the sophisticated proactive behavior of smart products. The requirements for the tools facilitating the rapid prototyping of contextual applications and services based on future smart products systems are, in particular, highlighted. The objective of this review is to summarize the existing research in the domain of smart products engineering, to discuss the future trends in the development of smart products systems, and to identify further research needed to ensure the practical execution and success of future smart products systems.

Figure 1. Research direction in the area of smart products engineering



DOI: 10.4018/978-1-4666-5888-2.ch375

BACKGROUND

Smart Product

The 'smart product' as a concept has been investigated by several authors, from various perspectives.

In early 2005, smartness and smart services enabled by connected electronic products were investigated from a business perspective by Allmendinger (Allmendinger & Lombreglia, 2005). Smart services built on top of digital products and related business models are considered mainly in the maintenance context (remote product monitoring and diagnostics).

Later, a more technical approach to framing the requirements and the dimensions of smart products was been taken by Maass (Maass & Filler, 2007; Maass & Varshney, 2008). Smart products have been proposed as characterized by a framework with six general dimensions, namely *situatedness, personalization, adaptiveness, proactivity, business awareness,* and *network capability.* The smart product has been considered from an information point of view, rather than from the point of view of providing the function to its user. A smart product may sell product information from producers, retailers, third party content providers, and online communities. The product has been discussed using a shopping scenario. Multimedia can positively influence a customer's evaluations of products in online shopping situations, which leads to the hypothesis that multimedia contents also support buying decision-making in mobile shopping situations.

The notions of 'simplicity' and 'openness' and the importance of active knowledge in the functioning of smart products have been emphasized by Mühlhäuser (Mühlhäuser, 2007). Active knowledge has been referred to as an enabler for smart products to autonomously interact with the user. Active knowledge about itself, the environment, and users can trigger interaction based on perceived needs, with chosen appropriate modalities for the interaction. Mastering simplicity will be deterministic for digital product success in the future. Better usability will be crucial to differentiate products from their competitors. In fact, we already see this trend, following recent development of the mobile phone market. Openness in product manufacturing, enabling various independent networks of suppliers to participate in the manufacturing process, will enable a complementary bottom-up approach in smart products systems development. From an ICT perspective, this sets the requirements for product self-organization, autonomous functions, and interoperable interfaces in product-to-product interaction.

Later in 2009, the notion of smart products as novel research, combining sensing and semantic technologies to manage proactive knowledge, has been further investigated by the SmartProducts consortium (Sabou et al., 2009; Dadzie et al., 2011; Niskanen & Kantorovitch, 2011). Moreover, a more complete lifecycle-spanning methodology, with tools and platforms to support the construction of smart products systems, has been established, and the definition of a smart product has been further crystalized:

A smart product is an autonomous object that is designed for self-organized embedding into different environments in the course of its life-cycle, and that enables natural product-to-human interaction. Smart products are able to proactively approach the user using sensing, input, and output capabilities of the environment, thus being self-, situational-, and context-aware. The related knowledge and functions can be shared by and distributed among multiple smart products, and emerge over time.

DIMENSIONS OF SMART PRODUCTS RESEARCH

Summarizing the research effort discussed above, there are several major dimensions of smart products to be considered. These dimensions have shaped the research agenda so far and will further drive research innovation in the future:

- **Situation awareness:** The ability to recognize the situation and the context of the user
- **Context capturing:** The ability to sense and interpret captured data
- **Adaptiveness:** The ability to change its own behavior according to the user's tasks and objectives
- **Personalization:** The ability to customize itself according to user needs
- **Proactivity:** The ability to anticipate the user's plans and intentions
- **Business awareness:** The ability to consider the user's goals