



Contents lists available at ScienceDirect

CIRP Annals - Manufacturing Technology

journal homepage: <http://ees.elsevier.com/cirp/default.asp>



Enhancing products and services using smart appliance networks

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ARTICLE INFO

Article history:

Submitted by K. Iwata

Keywords:

Information
Mass customization
Smart appliance

ABSTRACT

The Internet of things (IoT) plays important roles in the servitization of manufacturing, especially in B2B businesses. This discussion addresses the potential of IoT in B2C businesses for the domain of consumer electronics. It presents an analytical example of 600 users' smart appliance logs combined with responses to a questionnaire survey on their lifestyles to clarify consumers' daily behaviors. This study examines the log data format which might be used for the design of new products, maintenance, or services. Finally, simulation results demonstrate how smart appliance data are expected to be useful for mass customization or creation of new services.

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1. Introduction

Recently, IoT is widely anticipated for use in enhancing product value and creating new services for customers using real-time log data from Internet-linked products [1]. For example, Komatsu Ltd., a manufacturing and sales company, embeds GPS and various sensors in their construction equipment such as dump trucks and shovel vehicles [2]. Thereby, they can monitor the locations and conditions of their products around the world in real time. Such log data enable them to provide new services such as supplying fuel or replacement parts before their product develops some malfunction. Simultaneously, the monitoring system enables them to predict demand in markets for construction or mining around the world. As these examples demonstrate, the servitization of manufacturing using IoT is attracting attention in recent studies of product-service systems.

The servitization of manufacturing also has become more important in business-to-consumer (B2C) businesses, such as automotive, mobile telephone, and consumer electronics industries. In those industries, IoT is expected to enhance product value for customers to cope with the commoditization of products. It is also expected to create a direct channel for services from manufacturers to customers. Nevertheless, it remains difficult for many consumer product companies to change their business model from pure product sales to a 'product as a service' business model. Given that background, this paper presents a specific examination of the consumer electronics industry and discusses underlying challenges posed by the use of IoT data.

1.1. Impact of IoT on the consumer electronics industry

In the consumer electronics industry, the concept of 'smart appliances', which assumes that home appliances are connected to the Internet [3], has emerged around 2000. The term 'smart appliance' is now used widely in hopes of making a user's life smart through the use of intelligent home appliance systems. Actually, home energy management systems (HEMS) using Internet-linked appliances or electric equipment have become widely used in recent years as an elemental technology supporting smart grids [4]. Some smart appliances such as Internet-linked televisions and air conditioners are becoming popular recently. During this decade, some consumer electronics companies such as Panasonic, Samsung, and LG Electronics have introduced various smart appliances including microwave ovens, refrigerators or washing machines that are connected to the Internet. However, it is not usual for many consumers that all home appliances such as microwave ovens or refrigerators for routine housekeeping tasks be connected to the Internet. Innovative changes of consumers' everyday life must be created using such smart appliances with a good business eco-system.

1.2. Current challenges in smart appliance networks

Fig. 1 displays some potential applications of a smart appliance network in which log data of smart appliances are used for various purposes including information services, maintenance, mass customization or design of new products based on analysis of user behaviors. Although the smart appliance network offers many possibilities to enhance servitization of manufacturing, providers must overcome some challenges to realize a network from technological and business model perspectives.

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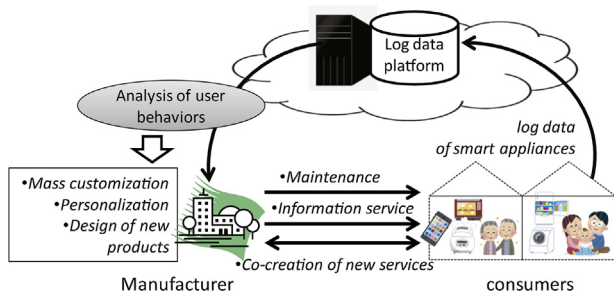


Fig. 1. Potential applications of smart appliance networks.

Through discussions with practitioners of consumer electronics companies and IoT experts, the authors believe that current challenges include, but are not limited to, the following problems.

1. Secure data-handling system to manage personal data
2. Secure and efficient home network environment
3. Design of IoT data format used for various purposes
4. Modeling of consumer behaviors using IoT data
5. Utilization of IoT data for product design or customization
6. Creation of a new business model including attractive services
7. Design of interactive human interface for better usability
8. Co-creation of new services with customers using IoT data

Although all technological problems above are important, we especially examine 3, 4 and 5 in this study because it has been less discussed as an underlying problem of the utilization of acquired IoT data. Fundamentally, the authors argue that IoT data of home appliances might be used not only for ascertaining the device status (as device-log data). The data might also be used for elucidation of user behaviors (as life-log data). Moreover, it is important to elucidate the lifestyles behind log data. Through understanding various user lifestyles, manufacturers will acquire more opportunities to enhance their products and to create new services. However, the IoT data format is not usually well designed for human behavior analysis. Therefore this paper presents discussion of which kind of log data format is useful for additional purposes such as the design of products, maintenance or new services. The following section introduces examples of smart appliance log data used to clarify customers' daily behaviors with a combined lifestyle survey.

2. Analysis of smart appliance log data

Through research collaboration between AIST and Panasonic Corp., the authors specifically examine how user lifestyles can be clarified from log data. Therefore, we administered a questionnaire survey to classify lifestyles of actual users [5]. The survey was administered via Internet in February 2015 in Japan, with responses received from 2928 users of washing machines, microwave ovens, refrigerators, rice cookers, air conditioners or IH cooking heaters. To broaden the sample further, we conducted a survey of 1030 normal consumers simultaneously. The questionnaire was designed to elucidate consumers' lifestyles based on the authors' previous studies [6]. Twenty-seven questionnaire items included demographic information, daily behaviors including household affairs, health condition, consumption patterns, and personality traits with regard to the BIG 5 factors.

By conducting factor analysis of selected 21 question items for all participants (2537 male, 1421 female), we extracted five factors (maximum-likelihood method, Promax rotation with Kaiser normalization). The factor score (Bartlett score) of each factor for each participant was normalized to 1, 2, 3, 4, or 5 (top 20% highest factor participants are rated as 5, average 3). Table 1 presents characteristics of five lifestyle factors (A-E) and averaged factor score of 537 users who used at least one certain smart appliances (microwave oven, refrigerator, washing machine, and rice cooker) capable of logging usage information during October

Table 1 Lifestyle factors and averaged factor score.

Lifestyle factor	Characteristics of lifestyles	Avg. factor score of 537 selected users with (SD)
A. Fulfilling life and conscious consumption	Choosing items that are good for health even if they are expensive; conscious about health care	3.41 (1.35)
B. Passion for cleanliness	Laundry and housework every day; passionate about cleanliness	2.95 (1.45)
C. Active life	Extroverted personality; inclination to try new items	3.40 (1.41)
D. Anxious about daily life and health	Busy; anxious about health and daily life; readily make changes	3.18 (1.35)
E. Planned and economical consumption	Purchase inexpensive items; maintain a household accounts book; save money on electricity	3.08 (1.42)

2012 through July 2015. Those 537 users show higher average scores in factor A (3.41) and C (3.40) than overall (3958 respondents) average score (3.0). These results suggest that the smart appliance users might be more conscious about health care and have openness to new experiences or items.

2.1. Analysis of log data with lifestyle factors

Table 2 presents the categories of the acquired log in each smart appliance. Fig. 2 presents ratios of 135 users who had used certain functions of the microwave oven. To clarify how usage patterns of those appliances differ according to their lifestyles, we categorized users into high (factor score is 4 or 5) and low groups (1, 2, or 3) with respect to each of five factors using a normalized factor score. Results show that the 'High factor B' group who are passionate about cleanliness tend to use the self-cleaning function or defrosting and cooking at once functions. However, the steamed food menu is used more often by the 'High factor C' group, who are active at trying new items.

Fig. 3 presents the ratios of 173 users who had used certain functions of the rice cooker at least once during the period: brown

Table 2 Sample of acquired log data from selected smart appliances.

Product	Acquired log categories (abstract)
Microwave oven	Number of used functions or menus (defrosting, toast, fry, boil, soup, self-cleaning, etc.)
Refrigerator	Number of door openings (refrigerating room/freezer room) -hour, weekly
Washing machine	Number of using function (fresh freezing, etc.)
Rice cooker	Number of use setting courses (automatic, quickly, premium-house cleaning, drum-cleaning, 40 °C washing, bath water use, etc.), start time
	Number of selected cooking functions, rice type (white, brown, mixed-grain, etc.), cooking preference (firm, soft, etc.), keep-warm times

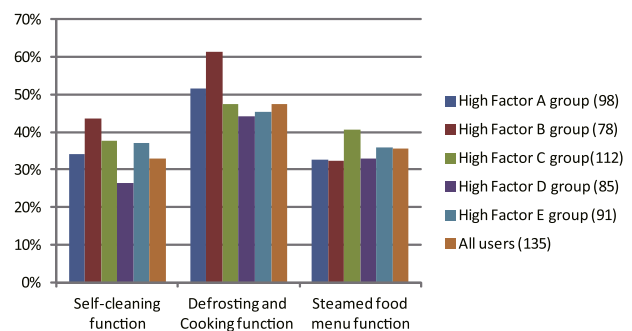


Fig. 2. Usage of microwave oven functions with lifestyle.

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