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Disruptive Innovation in Mechanical Engineering for Industry Competitiveness

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5–6 October 2017

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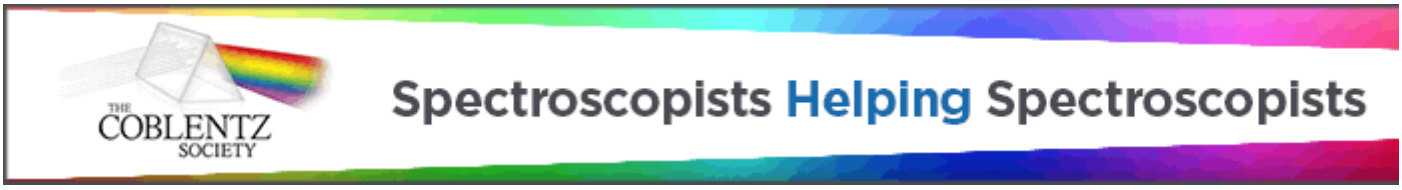

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A Modular Design With Complementary Service Based On PSS Concept: Case Of Mobile Phone

Agus Sutanto[1,a)] and Berry Yuliandra[1)]

[1]*Department of Mechanical Engineering, Universitas Andalas, Kampus Limau Manis, Padang, 25163, Indonesia*

[a)]Corresponding author: berry@ft.unand.ac.id

Abstract. To remain competitive in today's business environment, many enterprises improve the value of their products. One of the currently developing concepts in some literatures is Product-Service Systems (PSS). This concept is an emerging model that enables a tighter integration of both product and service for fulfilling the consumers' needs. How to implement the PSS concept at the design stage is one of the interesting aspects to be researched. Therefore, this paper deals with the implementation of PSS concept by using the modular design method for multi-parts product as well as its complementary service design based on PSS design methodology which generated in the previous study. A mobile phone design is taken as a case for implementing this approach. The Triangularization algorithm is applied as a method to produce the mobile phone modules. Based on the generated modules, the complementary intangible service for the repair activities and its adequate business process is subsequently developed.

INTRODUCTION

The mobile phones which provide a personal communication service and a portable and multi-purposes product is one of the human needs in the information age [1]. A very rapid and dynamic technological development [2], various challenges such as the growing market [3] and multi-variant product [4] has become common characteristics in mobile phone production at the present time. The business environment also pressurizes companies to continuously improve the mobile phone products to remain competitive [5] and consumer demands for the products are becoming increasingly customized [1]. This development shows that technology mastery is no longer enough to ensure competitive advantage. Mobile phone manufacturers need to find alternative sources of added value. One of them is through the addition of complementary services that are integrated with their basic products. A concept called Product-Service System (PSS) can be used to increase added value for mobile phone. This concept is an emerging engineering and business model as well, that provide cohesive delivery of product and services for fulfilling consumers' requirements [6]–[8].

Implementation of the PSS concept in mobile phone market can be found in various literatures. Early example of this implementation can be seen in [6], suggesting GSM network provider to give their new client mobile phone (for free or with reduced price) as a way to accelerate market penetration. Network provider then can made profit from extended features or services of the freely distributed product [8]. Another study also focus on developing integrated product-service roadmap for mobile communications [9]. There is also study on this subject trying to discuss the technical aspects further through development of new PSS design methodology for mobile phone in Indonesian market [10].

The mobile phone marketing in Indonesia is different with market which is described in [6]. There are still two main parties involved: the mobile phone manufacturers and network provider, but these two parties do not have direct partnership and considered as two different entities in marketing scheme. A consumer who buys a mobile phone can afterwards freely choose the network provider he/ she wishes to use. This is a chance to view the development of PSS concept from different perspective, i.e. mobile phones manufacturers' point of view.

Sutanto et al [10] has reviewed the problem in their previous research by generating design concepts for mobile phones using a new PSS design methodology. The methodology integrated product and complementary service

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based on customers' preference. The result was synthesized into two PSS conceptual designs: (1) High specification mobile phone integrated with software upgrade service; and (2) A modular design integrated with the repair service. Between those two, the latter is more profitable because less cost invested in developing high specification mobile phone technology and service. A modular design can also improve PSS performance competitively [11]. Therefore, this paper deals with modular design with complementary repair service in case of mobile phone design in order to implement the proposed PSS conceptual design.

MODULAR DESIGN BASED ON PSS

A module consist of units that structurally independent of one another, but strongly connected and work together as a system [12]. Modularity has been recognized as a means to offer quick, customized, and more complex product and service without having to create totally new designs [13], [14]. While it can be seen as an enabler to integrate flexibility into the design and production technology [15], [16], modularity can also be seen as a way to standardize product-service production [13], [17]. The existing modules need to be standardized to ensure combinability, changeability, and substitutability. These making modularity a promising method to realize product-service platform and family [18].

Various literature has proposed framework to develop modular PSS, as can be seen in [14], [18]–[22]. One thing that should be asks but always seems missing in modular PSS development what kind of PSS that will be offered? The type of PSS offered should be a consideration in determining modularity level to be used. Will modularity be applied to both products and services? Or just for products like conventional modularity but equipped with additional service that only serve as a complement? In the end, negative economic consequences from an over- or under-modularization still must be considered [23].

The PSS classification system can be used to assist in making those decisions. There are three main categories that PSS can be classified into [24]: (1) Product-oriented services, where additional services are added to help products sales. Furthermore, this category subdivided into Product-related service and Advice and consultancy; (2) Use-oriented service, where product still plays central role in business model but the ownership of product stays with provider. Services are provided in the form of product utilization. This category divided into three sub category: Product lease, Product renting or sharing, and Product pooling; (3) Result-oriented service, where services are provided to consumers with no pre-determined product involved. There are also three sub categories for this one: activity management or outsourcing, pay per service unit, and functional result. The conceptual design discussed in this research was developed from mobile phones manufacturers' perspective, which the core business is based on production of communication product. Its basic added value sources lies in product technical knowledge and quality control. This causes modular PSS developed in this research rooted in the first category, especially in Product-related service.

In Product-related service, the provider offers services needed during product use. This cover, for examples: maintenance contracts, financial schemes, consumables supplies, take-back agreements, etc. [24]. Those services can be useful for increasing quality and cost performance, create Unique Selling Points (USP) for manufacturer and new jobs opportunity for society [6], increasing product added value, serve as a basis for innovation strategy, and prolong product lifetime by including activities that can make product last longer and function properly without changing its characteristics, i.e. maintenance [8]. Services also help company to build up direct relations and intensify contact with their consumer [6], [8].

The result of previous research proposed repair service as complimentary service for modular design [10]. This kind of service selected because modular design can help decreasing cycle time of repair service, by decreasing time needed to disassembly/ assembly product during repairing or replacing component. Repair service can help consumer in maintaining their mobile phone functions and prolong its product lifetime. Mobile phone manufacturer can also use repair service as additional revenue to improve their cost performance. The other use of repair service for mobile phone manufacturer is helping in develop innovation strategy by increasing the amount of feedback that can be received from consumers. Repair service also compatible with rapid progress of Information and Communication Technology (ICT). The development of those technology help in increasing service effectiveness and efficiency [6].

METHODOLOGY

Implementing PSS design process in case of mobile phone is conducted by using two parallel steps: (1) Modular design for mobile phone; and (2) Repair service or mobile phone. The modular design is attained by using a method called Triangularization algorithms [25]. These algorithms will produce several modules based on functional relations between parts. Those relationships are modelled in an interactions matrix which its element contains value 0 or 1. Value 0 means no interaction between parts and value 1 means interaction between parts exist. These subsequent algorithms are applied to the interaction matrix with the following steps:

a. Determine Origin Activity (OA) or Destination Activity (DA). An OA is a row of the matrix that does not have value 1 and a DA is a column of the matrix which does not have value 1. If there is no OA or DA, and then proceed to step e below.
b. If OA or DA is found then,
- If a part is an OA, then place it at the leftmost position of the parts order.
- If a part is a DA, then place it at the rightmost position of the parts order.
c. Give mark on OA or DA parts.
d. Delete rows and columns of OA or DA parts from the interaction matrix, and repeat from step a.
e. Find a cycle of the parts interaction.
f. Combine all parts in a cycle into one group.
g. Delete all parts in a cycle from the interaction matrix.
h. Determine a final result according to the combination retrieved in step f and g.

In other hand, the repair service is developed by using different method from the modular design, because product and service have different nature. The product is tangible object while the service is intangible one. The product design approaches cannot be used to design services. The service design cannot be done with engineering characteristics design approach, but it can be approached by design of activities involved in the service provisions. This research uses business process design method to develop repair service. The business process of repair service is developed by using Business Process Diagram (BPD), one of tools in the Unified Modelling Language (UML). The BPD is an extension from of flowchart techniques used to describe activities sequences and effectively to analyse processes and to design activities.

RESULT

The result obtained by using the above mentioned methodology is a mobile phone module with its complementary repair service based on PSS concept.

Generated Mobile Phone Modules

The design of modular mobile phone is developed by using Triangularization algorithms. An interaction matrix constructed from mobile phone parts as an input for Triangularization algorithms. Mobile phone parts that included in interaction matrix can be seen in Table-1. Interaction matrix for mobile phone parts can be seen in Figure-1.

TABLE 1. General parts of a mobile phone [26]

Code	Part Name
A1	Front facial
A2	Back facial
B	Internal facial
C	Ringer
D	Speaker
E	Microphone
F	Vibrator
G	Charging connector
H	Headphone connector
I	Data cable connector
J	Battery
K	Battery connector
L	SIM card connector
M	Memory card connector
N	Camera
O	Camera connector
P	On/ Off switch
Q	Internal antenna
R	Printed Circuit Board (PCB)*
S	PDA
T	Display connector

*) PCB has been equipped with antenna point, Power Frequency Oscillator (PFO), Central Processing Unit (CPU) and various IC

	A1	A2	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
A1	X	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A2	0	X	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B	0	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C	0	0	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
D	0	0	0	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E	0	0	0	0	0	X	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
F	0	1	1	0	0	0	X	0	0	0	0	0	0	0	0	0	0	0	0	0	0
G	0	0	0	0	0	0	0	X	0	0	0	0	0	0	0	0	0	0	1	0	0
H	0	0	0	0	0	0	0	0	X	0	0	0	0	0	0	0	0	0	1	0	0
I	0	0	0	0	0	0	0	0	0	X	0	0	0	0	0	0	0	0	1	0	0
J	0	0	0	0	0	0	0	0	0	0	X	1	0	0	0	0	0	0	0	0	0
K	0	0	0	0	0	0	0	0	0	0	1	X	0	0	0	0	0	0	1	0	0
L	0	0	0	0	0	0	0	0	0	0	0	0	X	0	0	0	0	0	1	0	0
M	0	0	0	0	0	0	0	0	0	0	0	0	0	X	0	0	0	0	1	0	0
N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	X	1	0	0	0	0	0
O	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	X	0	0	1	0	0
P	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	X	0	1	0	0
Q	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	X	0	0	0
R	0	0	0	1	1	1	1	0	1	1	0	0	1	1	0	1	0	1	X	0	1
S	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	X	1
T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	X

FIGURE 1. Interaction matrix for a mobile phone

The final result and parts order from Triangularization algorithms is B-A1-A2-C-D-F-Q-E-R-H-I-L-M-O-N-T-S-K-J-P-G. The final interaction matrix can be seen in Figure-2. The part grouping in the box clusters can be set as proposed modules. If the 'box' only consists of one part, then it is not assigned to any module but stands as a unit. The proposed modules are 'facials', 'core components', 'camera', 'display' and 'power source'. The implication of

these proposed modules is the usage of a non-removable battery because the battery and its connector are joined as a module. The result of the generated modules and the parts list can be seen in Table 2.

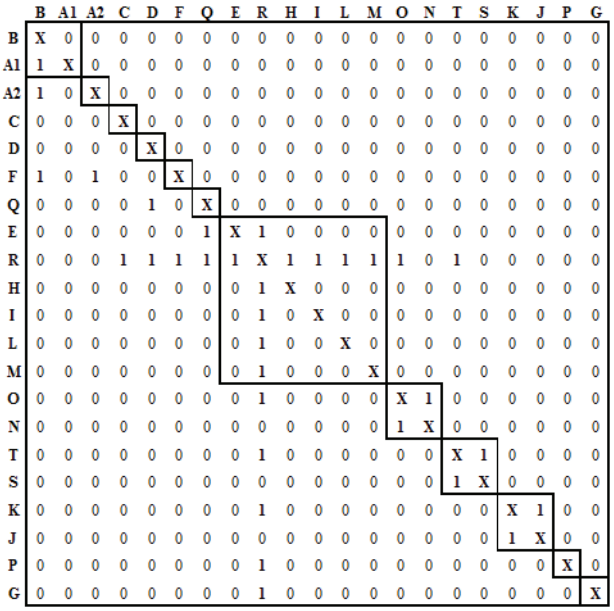

FIGURE 2. Final interaction matrix for mobile phone

TABLE 2. Generated modules for a mobile phone

No.	Module	Parts list
1.	Facials	Front facial Internal facial
2.	Core components	Microphone Headphone connector Data cable connector SIM card connector Memory card connector PCB
3.	Camera	Camera Camera connector
4.	Display	PDA Display connector
5.	Power source	Battery Battery connector

This modular design will facilitate a repair service provision. Assembly or disassembly operations become easier and faster. A damaged module can be removed and replaced with a new one.

Repair Service for Modular Mobile Phone

According to [24], the repair service can be categorized as Product-related service and closely related to the product modularity. In case of mobile phone, the ease of assembly/ disassembly provided by modular design can help in minimizing repair service cycle time. Modular design can also increase the reliability of service outcome.

The repair service model is developed by using a graphical notation for specifying business processes in a Business Process Diagram (BPD). The proposed BPD consists of three pools in designed system namely

'consumer', 'service centre' and 'warehouse'. A service centre pool is divided into a customer service and a maintenance operator line. The proposed business process can be seen in Figure-3. From service provider perspective, three units are needed for the system to run smoothly: customer service, maintenance operator and warehouse. The job descriptions for each unit are shown in Table-3.

TABLE 3. Job description for each unit

Unit	Job description
Customer service	• Receive and process request for repairing from consumers. • Receive payment for repair service.
Maintenance operator	• Check and repair mobile phone damage. • Check availability of mobile phone modules in service centre. • Order the non-available mobile phone modules from warehouse.
Warehouse	• Supply required mobile phone modules to the maintenance operator. • Control inventory level of mobile phone modules.

CONCLUSIONS

According to PSS point of view, a development of conceptual design in case of mobile phone product has produced a modular design incorporate with an intangible repair service. Referring to the modular product design, the Triangularization algorithms have generated a mobile phone module which consists of five modules, namely 'facials', 'core components', 'camera', 'display' and 'power source'. In another case of its complementary product-related service, a Business Process Diagram (BPD) is applied to model the mobile phone repair service activities. The proposed repair service model consists of three main units namely 'customer service', 'maintenance operator' and 'warehouse' as well as the job descriptions of each unit. The future research will consider a remanufacturing scheme for proposed modular design based on PSS concept.

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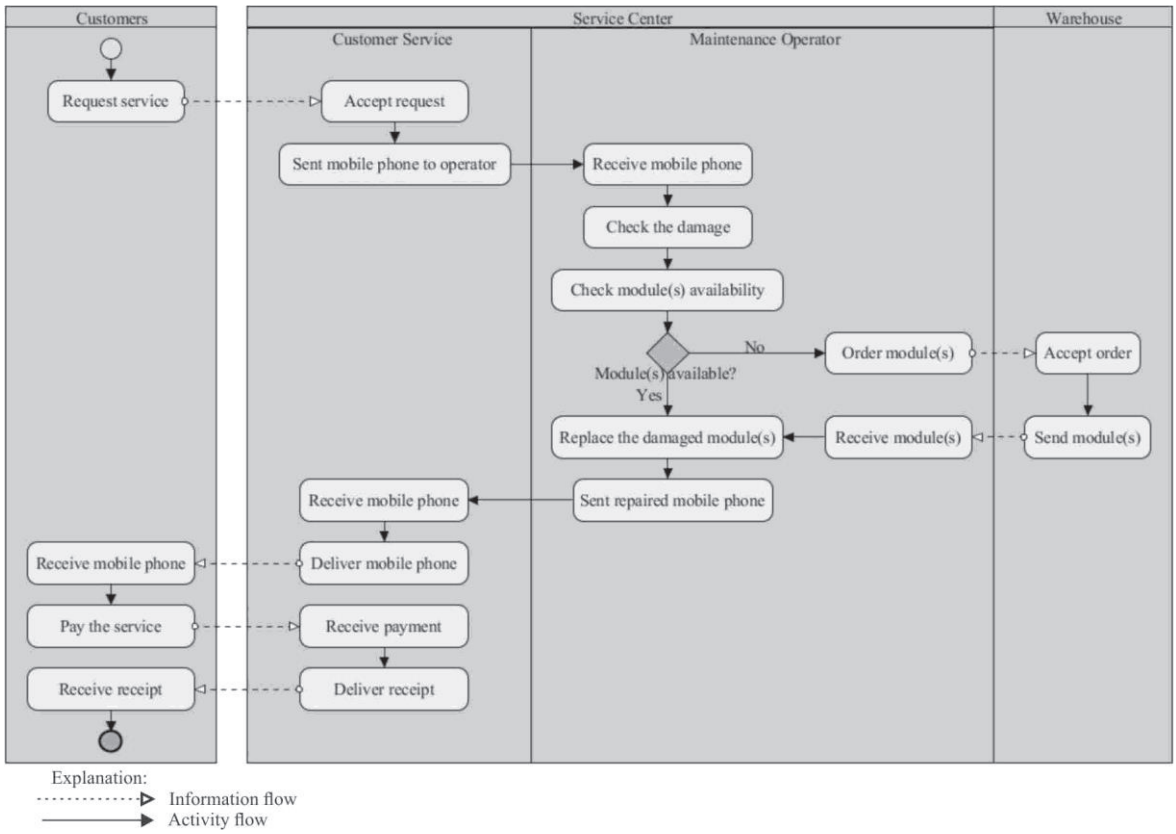

FIGURE 3. Business Process Diagram (BPD) for repair service

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