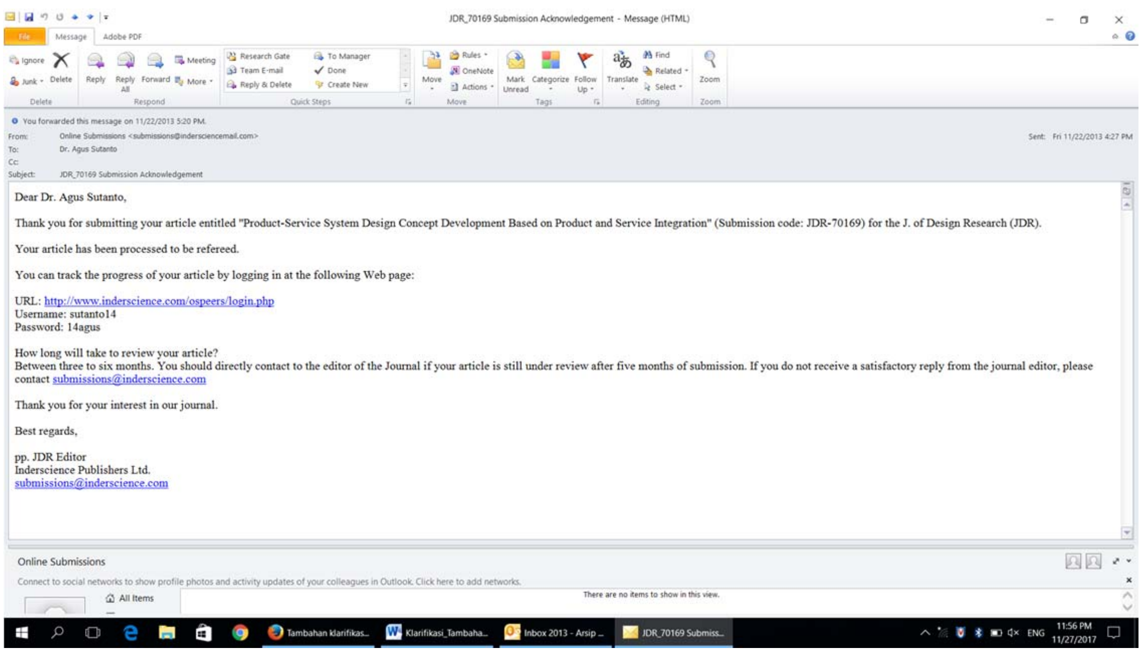
Kronologis Proses Pemasukan (Submission) Artikel hingga Terbit (Published) pada Publisher Inderscience

Judul artikel : Product-Service System Design Concept Development Based on Product and Service Integration
Jurnal : Journal Design of Research (JDR)/ Penerbit Inderscience
SJR : 0,3 (Quartil Q2 sejak 2013 bidang Engineering hinga sekarang)
http://www.scimagojr.com/journalsearch.php?q=5900152897&tip=sid&clean=0
Submitted : 22 November 2013
Review report : 10 Januari 2014
Revise version : 24 Maret 2014
Post Review : 25 Mai 2014
Accepted : 27 Mei 2014
Published : Februari 2015 (Vol. 13 No.1 Tahun 2015)

KRONOLOGIS SEBAGAI BERIKUT:

1. Email pemberitahuan tertanggal 22 November 2013 (**Gambar 1**) dari editor Journal of Design Research (JDR) bahwa artikel sudah dikirim (submitted). *Original paper* diberikan pada **Lampiran A.**


JDR_70169 Submission Acknowledgement - Message (HTML)

You forwarded this message on 11/22/2013 5:20 PM.
From: Online Submissions <submissions@inderscienceemail.com>
To: Dr. Agus Sutanto
Cc:
Subject: JDR_70169 Submission Acknowledgement
Sent: Fri 11/22/2013 4:27 PM

Dear Dr. Agus Sutanto,

Thank you for submitting your article entitled "Product-Service System Design Concept Development Based on Product and Service Integration" (Submission code: JDR-70169) for the J. of Design Research (JDR).

Your article has been processed to be refereed.

You can track the progress of your article by logging in at the following Web page:

URL: http://www.inderscience.com/ospeers/login.php
Username: sutanto14
Password: 14agus

How long will take to review your article?
Between three to six months. You should directly contact to the editor of the Journal if your article is still under review after five months of submission. If you do not receive a satisfactory reply from the journal editor, please contact submissions@inderscience.com

Thank you for your interest in our journal.

Best regards,

pp. JDR Editor
Inderscience Publishers Ltd.
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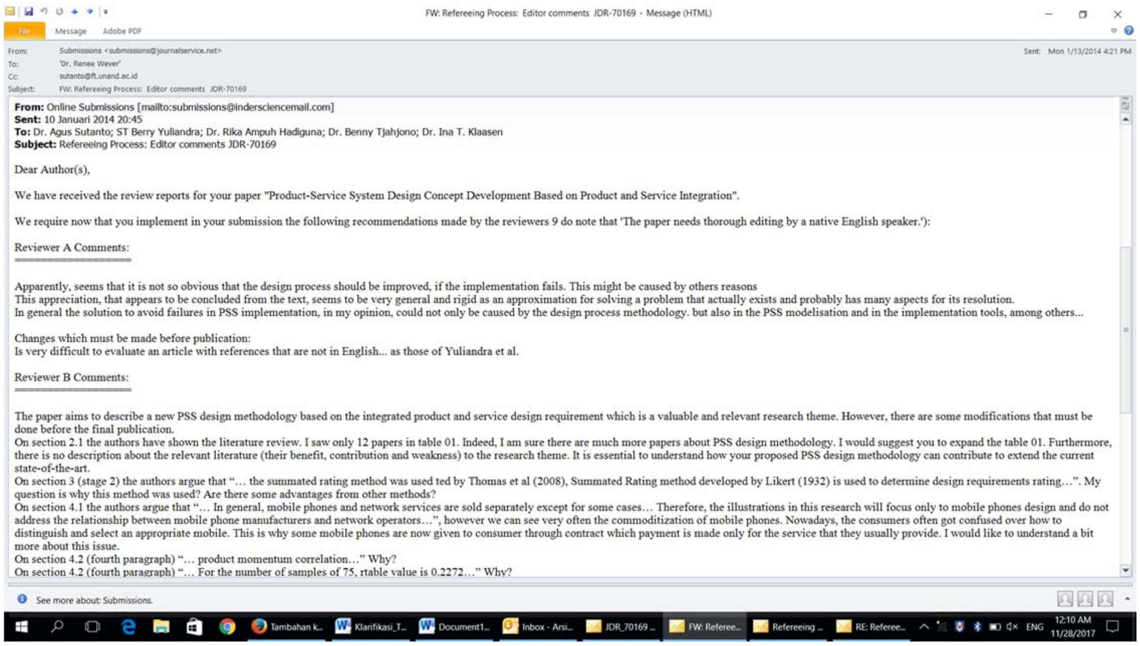
Gambar 1. Email Author's original Submission

2. Email pemberitahuan tertanggal dari 10 Januari 2014 dari Editor Journal of Design Research (**Gambar 2**) tentang hasil review dari 2 orang Reviewer.



FW: Refereeing Process: Editor comments JDR-70169 - Message (HTML)

From: Submissions <submissions@journalservice.net>
To: 'Dr. Renee Wever'
Cc: sutanto@ft.unand.ac.id
Subject: FW: Refereeing Process: Editor comments JDR-70169
Sent: Mon 1/13/2014 4:21 PM

From: Online Submissions [mailto:submissions@inderscienceemail.com]
Sent: 10 Januari 2014 20:45
To: Dr. Agus Sutanto; ST Berry Yuliandra; Dr. Rika Ampuh Hadiguna; Dr. Benny Tjahjono; Dr. Ina T. Klaasen
Subject: Refereeing Process: Editor comments JDR-70169

Dear Author(s),

We have received the review reports for your paper "Product-Service System Design Concept Development Based on Product and Service Integration".

We require now that you implement in your submission the following recommendations made by the reviewers 9 do note that 'The paper needs thorough editing by a native English speaker.'):

Reviewer A Comments:

Apparently, seems that it is not so obvious that the design process should be improved, if the implementation fails. This might be caused by others reasons
This appreciation, that appears to be concluded from the text, seems to be very general and rigid as an approximation for solving a problem that actually exists and probably has many aspects for its resolution.
In general the solution to avoid failures in PSS implementation, in my opinion, could not only be caused by the design process methodology. but also in the PSS modelisation and in the implementation tools, among others...

Changes which must be made before publication:
Is very difficult to evaluate an article with references that are not in English... as those of Yuliandra et al.

Reviewer B Comments:

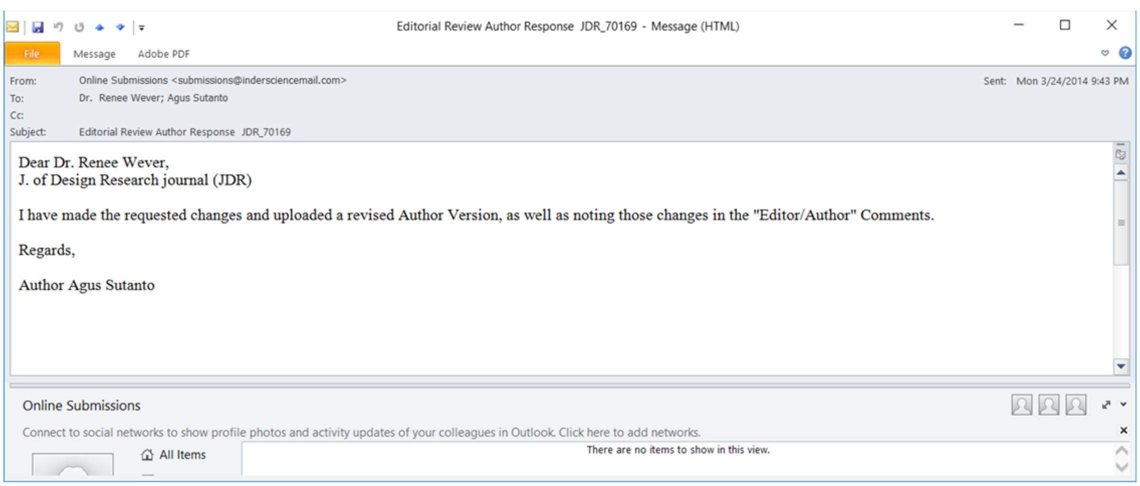
The paper aims to describe a new PSS design methodology based on the integrated product and service design requirement which is a valuable and relevant research theme. However, there are some modifications that must be done before the final publication.
On section 2.1 the authors have shown the literature review. I saw only 12 papers in table 01. Indeed, I am sure there are much more papers about PSS design methodology. I would suggest you to expand the table 01. Furthermore, there is no description about the relevant literature (their benefit, contribution and weakness) to the research theme. It is essential to understand how your proposed PSS design methodology can contribute to extend the current state-of-the-art.
On section 3 (stage 2) the authors argue that "… the summated rating method was used ted by Thomas et al (2008), Summated Rating method developed by Likert (1932) is used to determine design requirements rating…". My question is why this method was used? Are there some advantages from other methods?
On section 4.1 the authors argue that "… In general, mobile phones and network services are sold separately except for some cases… Therefore, the illustrations in this research will focus only to mobile phones design and do not address the relationship between mobile phone manufacturers and network operators…", however we can see very often the commoditization of mobile phones. Nowadays, the consumers often got confused over how to distinguish and select an appropriate mobile. This is why some mobile phones are now given to consumer through contract which payment is made only for the service that they usually provide. I would like to understand a bit more about this issue.
On section 4.2 (fourth paragraph) "… product momentum correlation…" Why?
On section 4.2 (fourth paragraph) "… For the number of samples of 75, rtable value is 0.2272…" Why?

See more about: Submissions.

Gambar 2. Komentar 2 orang reviewer

3. Pengiriman "*Summary of Modification*" untuk menjawab hasil review dua reviewer **(Lampiran B)** ke dalam sistem jurnal yang bersangkutan. Kemudian diikuti dengan membuat serta mengirim "revised Author Version" kedalam sistem jurnal tersebut **(Terlampir C)**

4. Email pemberitahuan kepada Editor per tanggal 24 Maret 2014 bahwa perbaikan (a revise author version) sudah dilakukan (**Gambar 3**)



Editorial Review Author Response JDR_70169 - Message (HTML)

From: Online Submissions <submissions@inderscienceemail.com>
To: Dr. Renee Wever; Agus Sutanto
Cc:
Subject: Editorial Review Author Response JDR_70169
Sent: Mon 3/24/2014 9:43 PM

Dear Dr. Renee Wever,
J. of Design Research journal (JDR)

I have made the requested changes and uploaded a revised Author Version, as well as noting those changes in the "Editor/Author" Comments.

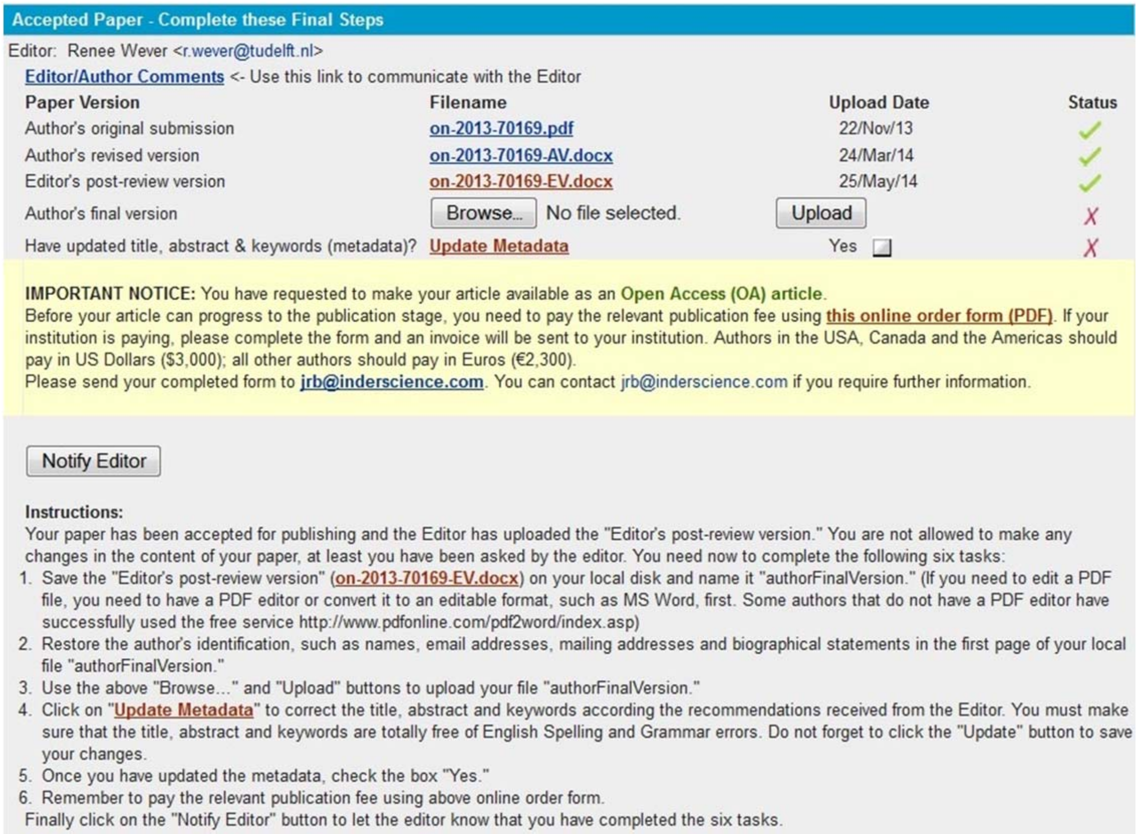
Regards,

Author Agus Sutanto

Online Submissions

Gambar 3. Author's revised version

5. Penyampaian post review vesion per tanggal 25 Mai 2014 (bukti **Gambar 4**, bukti ini merupakan dialog anatar Author dan Editor yang disediakan oleh publisher. Pada Gambar ini terlihat juga kronologis proses submitted- revisi – post revisi)



Accepted Paper - Complete these Final Steps

Editor: Renee Wever <r.wever@tudelft.nl>

Editor/Author Comments <- Use this link to communicate with the Editor

Paper Version	Filename	Upload Date	Status
Author's original submission	on-2013-70169.pdf	22/Nov/13	✓
Author's revised version	on-2013-70169-AV.docx	24/Mar/14	✓
Editor's post-review version	on-2013-70169-EV.docx	25/May/14	✓
Author's final version	Browse... No file selected.	Upload	✗
Have updated title, abstract & keywords (metadata)?	Update Metadata	Yes ☐	✗

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Please send your completed form to jrb@inderscience.com. You can contact jrb@inderscience.com if you require further information.

Notify Editor

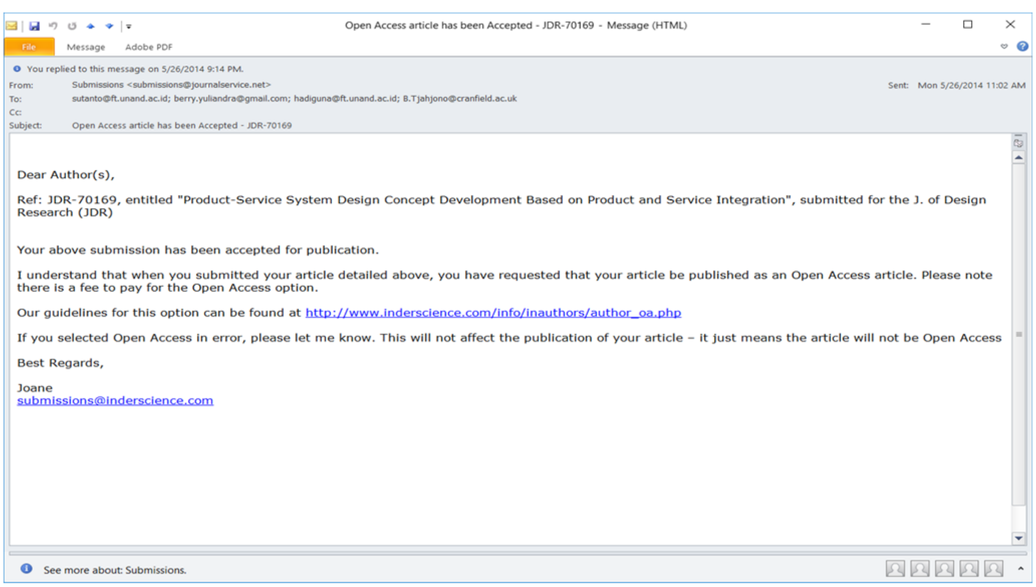
Instructions:
Your paper has been accepted for publishing and the Editor has uploaded the "Editor's post-review version." You are not allowed to make any changes in the content of your paper, at least you have been asked by the editor. You need now to complete the following six tasks:

1. Save the "Editor's post-review version" (on-2013-70169-EV.docx) on your local disk and name it "authorFinalVersion." (If you need to edit a PDF file, you need to have a PDF editor or convert it to an editable format, such as MS Word, first. Some authors that do not have a PDF editor have successfully used the free service http://www.pdfonline.com/pdf2word/index.asp)
2. Restore the author's identification, such as names, email addresses, mailing addresses and biographical statements in the first page of your local file "authorFinalVersion."
3. Use the above "Browse..." and "Upload" buttons to upload your file "authorFinalVersion."
4. Click on "Update Metadata" to correct the title, abstract and keywords according the recommendations received from the Editor. You must make sure that the title, abstract and keywords are totally free of English Spelling and Grammar errors. Do not forget to click the "Update" button to save your changes.
5. Once you have updated the metadata, check the box "Yes."
6. Remember to pay the relevant publication fee using above online order form.

Finally click on the "Notify Editor" button to let the editor know that you have completed the six tasks.

Gambar 4. Dialog antara Author dan Editor, dimana proses sebagian proses kronologis pemasukkan artikel, pemasukkan revisi, dan *post-review* dapat dilihat

6. Email pemberitahuan dari Editor per tanggal 26 Mei 2014 bahwa karya ilmiah diterima **(Gambar 5).** Pada Email juga diperingatkan, bila penulis mencontreng **Open Access** (Jurnal secara default tertutup terhadap akses, tetapi bila Author Open Acess artinya ia memilih hanya artikelnya bebas dibaca maka dikenai fee tambahan sebesar $ 3000**),** bila hal tersebut hanya error, maka maka hal itu tidak berdampak kepada proses publikasi.



Open Access article has been Accepted - JDR-70169 - Message (HTML)

File Message Adobe PDF

You replied to this message on 5/26/2014 9:14 PM.

From: Submissions <submissions@journalservice.net> Sent: Mon 5/26/2014 11:02 AM
To: sutanto@ft.unand.ac.id; berry.yuliandra@gmail.com; hadiguna@ft.unand.ac.id; B.Tjahjono@cranfield.ac.uk
Cc:
Subject: Open Access article has been Accepted - JDR-70169

Dear Author(s),

Ref: JDR-70169, entitled "Product-Service System Design Concept Development Based on Product and Service Integration", submitted for the J. of Design Research (JDR)

Your above submission has been accepted for publication.

I understand that when you submitted your article detailed above, you have requested that your article be published as an Open Access article. Please note there is a fee to pay for the Open Access option.

Our guidelines for this option can be found at http://www.inderscience.com/info/inauthors/author_oa.php

If you selected Open Access in error, please let me know. This will not affect the publication of your article – it just means the article will not be Open Access

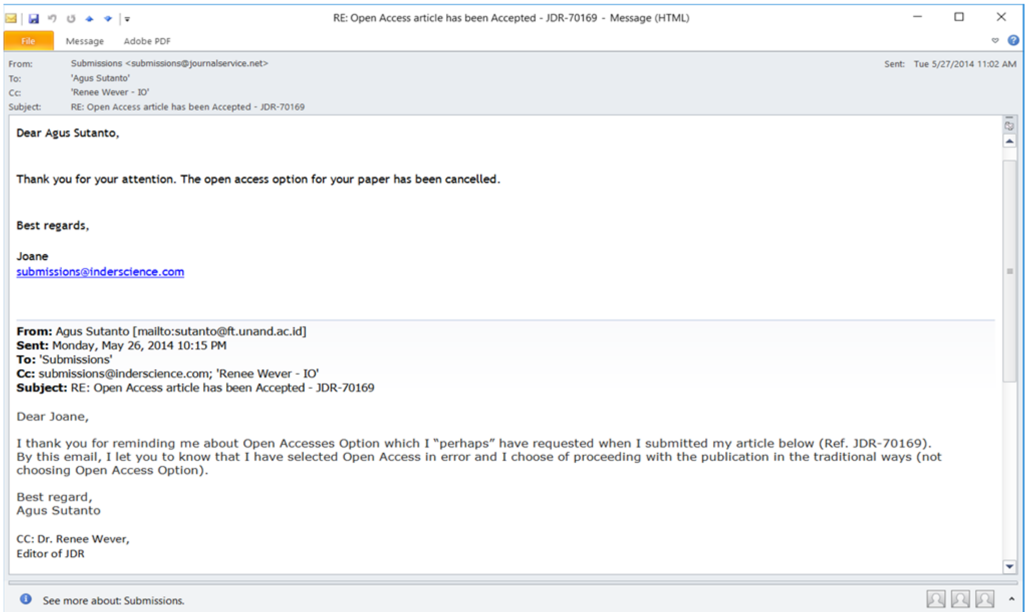
Best Regards,

Joane
submissions@inderscience.com

See more about: Submissions.

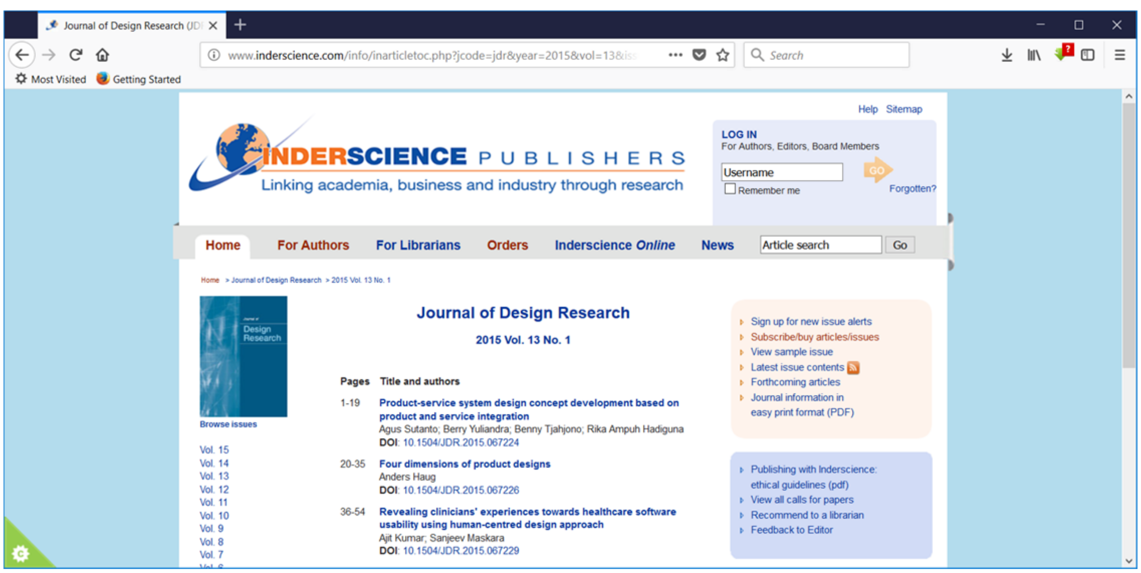
Gambar 5. Artikel diterima

7. Email pemberitahuan penulis bahwa contrengan Open Access adalah kesalahan (error) penulis dan penulis menginginkan karya ilmiah **tidak Open Access** (**Gambar 6**)



Gambar 6. Email Penulis terhadap kekeliruan contreng Open Access

8. Karya ilmiah dipublish pada Journal Design Research (Scimago, Q2 bidang Engineering) Februari 2015 Vol. 13 No. 1 (**Gambar 7**)



Gambar 7. Artikel diterbitkan pada bulan Februari 2015 (Vol. 13 No.1 hal. 1-19)

LAMPIRAN A

PAPER DENGAN VERSI PERTAMA KALI DIKIRIM (ORIGINAL VERSION)

Judul artikel	: Product-Service System Design Concept Development Based on Product and Service Integration
Jurnal	: Journal Design of Research (JDR)/ Penerbit Inderscience
Hal	: 20 halaman
SJR	: 0,3 (Quartil Q2 sejak 2013 bidang Engineering hinga sekarang) http://www.scimagojr.com/journalsearch.php?q=5900152897&tip=sid&clean=0

Submitted	: 22 November 2013
Review report	: 10 Januari 2014
Revise version	: 24 Maret 2014
Post Review	: 25 Mai 2014
Accepted	: 27 Mei 2014
Published	: Februari 2015 (Vol. 13 No.1 Tahun 2015)

Product-service system design concept development based on product and service integration

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Abstract: Today's business environment is characterized by a higher level of competition that has forced companies to improve their competitiveness. One possible way that can be taken into account is to offer more added values by providing solutions in order to satisfy the consumers. The concept of Product-Service Systems (PSS) that integrates products and services to meet consumer needs provides a solution for this problem. This research aims to provide new PSS design methodology based on integrated product and service design requirements. The process consists of three stages: the identification of design requirements, the determination of design requirements rating and the integration of product and service design requirement in order to develop a PSS design concept. A mobile phone development case is used as an illustration to test the developed model. Results suggest developing modular mobile phone with high specification component supported by mobile phone repair and software upgrade service.

Keywords: product-service system; added values; design concept; design requirements; consumer needs; PSS design methodology; integration; mobile phone; product concept; service concept

1. Introduction

Due to various changes in the global environment, businesses nowadays exist in a highly competitive market. Consumer demand for products is becoming increasingly complex and customized (Morelli, 2002). Increasing awareness of the quality of the product by the consumer, tight competition among developed countries with developing countries, and markets trend towards globalization are some examples of the changes in the global business environment (Lay *et al*, 2010). Product differentiation can be considered as a solution to this problem. However, advances in information and communication technology, that makes every people from different companies and countries more connected to each other, indicates nearly equal of technology mastery among various competing companies. Therefore, product differentiation becomes increasingly difficult to do in this business environment (Tan *et al*, 2007).

Feinberg (2001) states that customer satisfaction will be a determinant factor in business competition, if the product in the market is slightly differentiated. To be able to survive in the global competition, the company should improve its competitiveness by focusing on the customer satisfaction. One possible way is to offer added values to the product, which can be done by changing the business paradigm from product-oriented into the providing solutions and service-based economy (Geng *et al*, 2010). As noted by Shikata *et al* (2013), it is difficult for manufacturing companies nowadays to succeed by selling only product. This approach can extend the functionality offered by the company to the consumer. Concept of Product-Service Systems (PSS) that integrates products and services can accommodate this condition. Product and service integration can lead to better value proposition, revenue generation opportunities and sustainable customer value (Roy and Cheruvu, 2009).

Although PSS offers various benefits through increasing added value, but the analysis conducted by the Sustainable Product Development Network (SusProNet) showed that the PSS application is not always a win-win solution and still has questionable sustainability. Even in certain case, it failed or just gave a slight profit margin (Tukker, 2004). To avoid failure of the PSS implementation, the design process needs to be improved. By this way, the implementation of PSS concept will be enhanced (Yuliandra et al, 2013a).

This research aims to provide new PSS design methodology based on integrated product and service design requirements. Customer preferences will become basis for the requirements. The integration process will be focused on product-oriented service; it means services that will consider in this research only product-related services. This integration is expected to initiates the company transition from product-oriented to service-based economy and improve their competitive capabilities through synergizing the product and the services offered.

2. State of the Art

2.1 Product-Service Systems Concept

PSS can be defined as the integration between products and services to generate higher added value and fulfil the specific needs of consumers (Goedkoop et al, 1999; Mont, 2000; Erkoyuncu et al, 2009; Chirumalla et al, 2011; Wallin and Kihlander, 2012). In the context of PSS, a product is a tangible commodity manufactured to be sold, while a service is an activity with economic value often done on commercial basis. Combinations of products and services can expand the functionality offered to consumers, both in terms of improving the quality of products and services as well as reducing the total cost (Goedkoop et al, 1999).

Increasing of the added value is obtained by expanding the product utility and services during the period of use (Tan et al, 2007). Business strategy was developed with a holistic approach to link economic, environmental and social aspects (Mateu et al, 2012). Hence, it can be said that the concept of PSS has closely related with the concept of sustainability.

The relation between product and service in terms of the sustainability dimensions can be described as follows:

- In term of *the economic dimension* means the integration of products and services will bring new functionality to be offered, open wide opportunities for products and service customization as well as improve product quality and customer satisfaction (Goedkoop et al, 1999). Furthermore, it will expand the market for producers, increase the company's reputation from the consumer point of view (Wimmer and Kang, 2006) and can reduce the cost of investment and production (Goedkoop et al, 1999; Wimmer and Kang, 2006).

- In term of *the environment dimension* shows the integration of products and services will reduce material waste by shifting the company's business than just selling products to providing functionality (Mont, 2002; Maussang et al, 2006). In addition, combination of products and services that complement each other in providing the needs of the consumers can reduce energy consumption and use of aggregate material. This is due to some values offered has been replaced by intangible services activity.
- In term of the *social dimension* shows the integration of service activities in manufacturing companies will expand the employment. This integration will also affect the consumption patterns in society so it can reduce the impact of the rebound effect. However, the relationship between the PSS concept with the social aspect is reciprocity. This is due to the effectiveness implementation of PSS also requires a corresponding social structures (such as social infrastructure, community structure and organizational layout) (Mont, 2000).

2.2 Design Approach In Product-Service Systems

Design aspect has a critical role in the efficiency, visibility and usability of PSS (Morelli, 2002). McAloone and Andreasen (2004) found that design in PSS ideally combine various disciplines by considering the product life cycle and consumer acceptance. The same opinion is expressed by Mont and Plepys (2003) that the PSS design should be able to connect the consumer perceptions and behaviour as well as the concept of sustainability development. Moreover, the collaboration between product (tangible) and services (intangible) in order to generate higher added value is also necessary to be considered for PSS design. Therefore, the design process of products and services in the PSS should not be conducted separately to maximize the potential profit of the resulting design (Yuliandra et al, 2013a). Design requirement is determined before the design process done and it is based on the perspective of products and services. Both perspective of requirements are then processed together to generate the optimal PSS design.

PSS design methodology has been widely discussed in the literature. Literature study conducted by Vasantha et al (2012) showed that the design process to integrate products and services into primary goal is often discussed in the literature. Based on this view, several literatures that discussed design methodology for PSS has been collected to be reviewed.

Some PSS design methodology that appeared in the literature can be seen in Table 1.

Table 1. PSS design methodologies in literature

References	**Description**
Geng et al (2010), Geng et al (2011)	Determined critical design parameter for PSS conceptual design by translating customer requirements (CRs) into Product-related Engineering characteristics (P-ECs) and Service-related Engineering Characteristic (S-ECs).
Maussang et al (2006), Maussang et al (2007), Maussang et al (2009)	Integrated product and service design to develop PSS based on functional analysis concept.
Hara et al (2007), Hara et al (2009), Kimita et al (2010)	Using service engineering concept to design product and create more added value by enhanced services.
Ericson, et al (2009), Chen and Li (2010)	Support designers to develop PSS with TRIZ design methodology.
Lee and Kim (2010)	Create more added values to product offering by service function development using functional modelling concept.
Kim et al (2010)	PSS Concept Generation Support System (PSS CGSS) to support development of new PSS business model

The main drawback of these methodologies is not well grounded in determining the design requirements. This is a fatal weakness for PSS design should be developed based on the needs of consumers, given that the primary goal is to meet the needs of consumers PSS. Therefore, the need for a clear framework in determining the requirement list for a development process that was more focused and has a strong foundation.

Muller et al (2010) has developed a checklist of criteria to determine the needs of PSS design. The criteria checklist can serve as a basis for developing a PSS design methodology. Through clear criteria in determining the needs of consumers, PSS design process will be able to reflect the consumer needs in a better way with more systematic measures and structured.

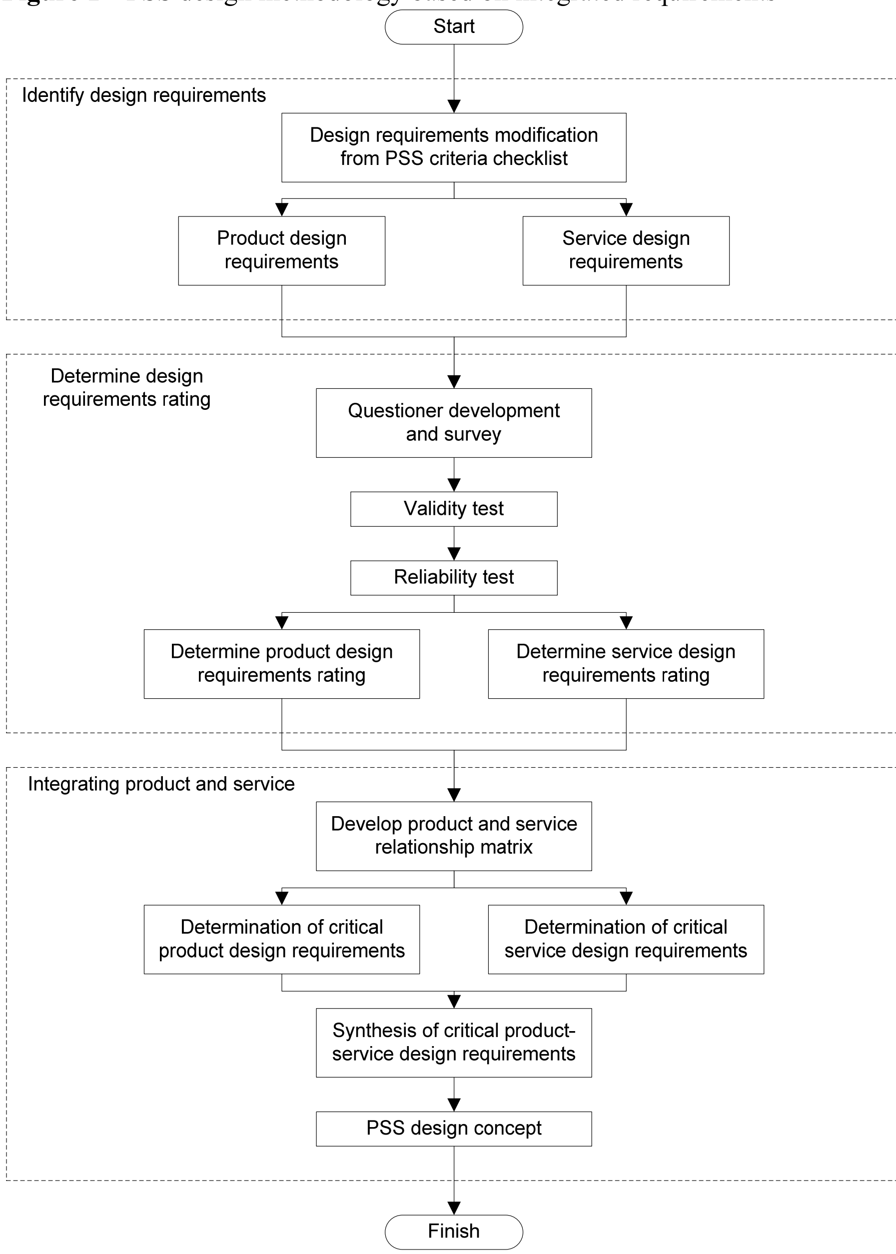
3. PSS Design Methodology

In this research, PSS categories are a main consideration in designing the PSS model. This is because different groups of PSS categories will have different characteristics and thus they have different design needs. PSS design methodology in this research is designing for Product-oriented PSS classification developed by Tukker (2004). Integration process is focused on the Product-Oriented Service. This category can be considered as an early stage for company to adopt the concept of PSS which still have traditionally product-oriented paradigm to service-based economy. The model will facilitate the adoption of the PSS concept for established companies or companies which still applying the traditional approach.

A methodology for product and service integration suggested by this research (Figure 1) consists of three stages as follow:

- **Stage 1** is to identify design requirements. This stage aims to determine the PSS core requirements for design products and services. This criterion is general in nature and divided into product and service criteria. The PSS criteria checklist developed by Muller et al (2010), especially technical artefacts and service criteria can be used as a basis for this stage.
- **Stage 2** is to determine design requirements rating. A survey is conducted to rate various design requirements for a product which reflect the customer interest. As noted by Thomas et al (2008), characteristic of product and service component can be systematically derived on the basis of customer requirements. The Summated Rating method developed by Likert (1932) can be used to determine design requirements rating.
- **Stage 3** is to integrate product and service design requirements. This stage aims to generate PSS design concepts from product and service requirements in order to fulfil customer satisfactions. Product and service relationship matrix can be used for this purposed.

Figure 1 PSS design methodology based on integrated requirements



4. Case Study

A mobile phone design case been chosen for testing the developed methodology. This section provides the explanations related to the mobile phone design, the product-service integrated design for mobile phone and the result analysis.

4.1 Mobile Phone Design

The mobile phone design has various challenges to be considered to ensure marketing success. These challenges may come from external as well as internal perspectives. The challenge from external marketing perspective is slightly different technological mastery level from the competing manufacturers. This causes at least two problems namely the lack of products variation and the shorter product life cycles. Meanwhile, from the perspective of the mobile phone design process problems also emerged. Mobile phone design has evolved into a series of communication, knowledge and new innovative entertainment features (Ling et al, 2007 and Ziefle et al, 2006). This actually makes the design more complicated and reduces the usability level of mobile phones (Ling et al, 2007).

The mobile phone industry in Indonesia involves two main parties, the mobile phone manufacturer and network operator. In general, mobile phones and network services are sold separately except for some cases. A consumer who buys a mobile phone can freely choose which network provider they will use. Therefore, the illustrations in this research will focus only to mobile phone design and does not address the relationship between mobile phone manufacturers and network operators. Product oriented service design will be focused on producing a better product and product support service by mobile phone manufacturers. To test and provide an explanation regarding the use of models that have been developed, illustrative case study of product oriented service design development for consumers in West Sumatra, Indonesia is used.

4.2 Product-Service Integrated Design for Mobile Phone Product

As already noted in Section 3, development activities begins with the identification of design requirements. This stage is done by using a PSS checklist criteria developed by Muller et al (2010), particularly the technical artefact and service criteria. Technical artefact criteria are related to the physical form of a mobile phone which will be designed. Service criteria are connected with the characteristics of the services support offered by the manufacturers. Checklist criteria from Muller et al (2010) are modified to make design requirements appropriate for mobile phone. Design requirement for mobile phone can be seen in Table 2.

Table 2 Product and service design requirements for mobile phone

Muller et al, 2010	Modified Requirements for mobile phone	Code
Technical Artefacts		
Main function	Telecommunication network support technology	P1
Related products/ artefacts	Supporting device	P2
Interfaces	Mobile phone display	P3
Related activities	Camera feature	P4
Related service offers	Internet connectivity	P5
Availability	Battery durability	P6
Robustness	Mobile phone robustness	P7
Flexibility	Connectivity with other media	P8
Safety	Mobile phone safety	P9
Input, throughput, output	Type of keypad	P10
	Processing unit specification	P11
	Sound quality	P12
Required quantity	Single or multi-card hybrid phones	P13
Design for X requirements	Ease of assembly/ disassembly	P14
Ownership and "user ship"	Type of battery	P15
Qualification level of user	Ease of use	P16
Cost	Mobile phone price	P17
Location of product operation	Ease of handling	P18
Service		
Required resources	Ease of repair	S1
Related activities	Duration of product delivery	S2
Estimated result	Reliability of service result	S3
Required information	Early warning system	S4
Facultative services	Product upgrade	S5
Additional services	Diagnosis and repair	S6
Supplemental services	Product warranty	S7
Location of service applications	Availability of service centre	S8

The second stage is to determine critical design requirement using Summated Rating Method developed by Likert (1932). This method uses assessment from respondents. In order to determine the importance level for each requirement, the respondents are selected from the societies who really understand the object under study (in this case a mobile phone). Assessment is done through surveys and respondents selected through the following two criteria:

1. At minimum, respondent's level education is Bachelor.
2. Respondents had used mobile phones for five years.

Seventy-five respondents rate each of design requirements. Each design requirement is transformed into a question of the requirement function in order not to confuse the respondent. As an example:

Design requirement	:	Telecommunication network support technology
Questionnaire question	:	"How important is a mobile phone with the high internet speed for you?"
Description	:	Type of telecommunication network support technology (2G, 3G and 4G) has significant effect to internet speed level.

Rating scales used are listed in Table 3.

Table 3 Rating scale used

Order	Scale	Description
S_1	1	Very not necessary/ very unimportant
S_2	2	Less needed/ less important
S_3	3	Neutral
S_4	4	Necessary/ important
S_5	5	Absolutely necessary/ absolutely important

Validity of survey result is test using product moment correlation to calculate the value of r_{count}. This value is compared with the value of r_{table}. If the value of $r_{counts} \geq r_{table}$, then the question item is declared valid. For the number of samples = 75 r_{table} value is 0.2272. Computation of validity test is helped by SPSS 20 software. A validity test result can be seen in Table 4. The results showed that only the item question P13 not valid.

Table 4 Validity test results for each of mobile phone design requirements

Technical Artefacts				
No.	**Design requirements**	r_{count}	r_{table}	**Decision**
P1	Telecommunication network support technology	0.353	0.2272	Valid
P2	Supporting device	0.272	0.2272	Valid
P3	Mobile phone display	0.585	0.2272	Valid
P4	Camera feature	0.448	0.2272	Valid
P5	Internet connectivity	0.578	0.2272	Valid
P6	Battery durability	0.256	0.2272	Valid
P7	Mobile phone robustness	0.655	0.2272	Valid
P8	Connectivity with other media	0.695	0.2272	Valid
P9	Mobile phone safety	0.616	0.2272	Valid
P10	Type of keypad	0.485	0.2272	Valid
P11	Processing unit specification	0.655	0.2272	Valid
P12	Sound quality	0.577	0.2272	Valid
P13	Single or multi-card hybrid phones	0.084	0.2272	Not Valid
P14	Ease of assembly/ disassembly	0.360	0.2272	Valid
P15	Type of battery	0.523	0.2272	Valid
P16	Ease of use	0.713	0.2272	Valid
P17	Mobile phone price	0.572	0.2272	Valid
P18	Ease of handling	0.474	0.2272	Valid
Service				
No.	**Design requirements**	r_{count}	r_{table}	**Decision**
S1	Ease of repair	0.713	0.2272	Valid
S2	Duration of product delivery	0.764	0.2272	Valid
S3	Reliability of service result	0.789	0.2272	Valid
S4	Early warning system	0.705	0.2272	Valid
S5	Product upgrade	0.603	0.2272	Valid
S6	Diagnosis and repair	0.776	0.2272	Valid
S7	Product warranty	0.662	0.2272	Valid
S8	Availability of service centre	0.571	0.2272	Valid

Reliability test is conducted only to valid question items. Reliability is determined by taking into account the value of Cronbach's Alpha obtained. The result acceptable if value of Alpha > 0.70 (Tavakol and Dennick, 2011). That will means all question items are reliable and internally consistent. Computation of reliability test is helped by SPSS 20 software. Reliability test results can be seen in Table 5.

Table 5 Reliability test results

Design requirements	Cronbach's Alpha	Decision
Technical artefacts	0.883	Reliable
Service	0.904	Reliable

The reliability test results show, that the Alpha value of both design requirements > 0.70. This suggests that all question items are reliable and consistent internally.

Design requirements rating is determined by using the Summated Ratings method developed by Likert (1932). The results of Summated Ratings are then transformed into T-scores by using the equation (Anwar, 2013):

$$T = 50 + 10\left(\frac{X-\bar{X}}{s}\right) \qquad \text{... (1)}$$

where:

X = the total value of the scale that would be converted into T-score

$\bar{X}$ = the average of the group scale total value

S = the standard deviation of the group scale total value

Design requirements rating and T-score can be seen in Table 6.

Table 6 Mobile phone design requirements rating and T-score

No.	Design Requirements	Total	$\overline{X}$	S	T-score
Technical Artefacts					
P1	Telecommunication network support technology	328			57.18
P2	Supporting device	308			48.24
P3	Mobile phone display	313			50.47
P4	Camera feature	307			47.79
P5	Internet connectivity	310			49.13
P6	Battery durability	354			68.80
P7	Mobile phone robustness	303			46.00
P8	Connectivity with other media	315			51.37
P9	Mobile phone safety	331	311.94	22.37	58.52
P10	Type of keypad	296			42.87
P11	Processing unit specification	324			55.39
P12	Sound quality	335			60.31
P14	Ease of assembly/ disassembly	262			27.68
P15	Type of battery	279			35.27
P16	Ease of use	290			40.19
P17	Mobile phone price	334			59.86
P18	Ease of handling	314			50.92
Service					
No.	**Design requirements**	**Total**	$\overline{X}$	**S**	**T-score**
S1	Ease of repair	321			55.39
S2	Duration of product delivery	312			47.13
S3	Reliability of service result	325			59.06
S4	Early warning system	301	315.13	10.89	37.04
S5	Product upgrade	304			39.79
S6	Diagnosis and repair	307			42.54
S7	Product warranty	332			65.49
S8	Availability of service centre	319			53.56

The third stage is to integrate product and service design requirements. This can be achieve by explore the correlation between product and service design requirements. To explore the correlation, a product and service relationship matrix is constructed based on product and service requirements. Product and service relationship matrix can be seen in Figure 2.

Figure 2 Product and service relationship matrix

		Service Design Requirements								
		Ease of repair	Duration of product delivery	**Reliability of service result**	Early warning system	**Product upgrade**	Diagnosis and repair	**Product warranty**	Availability of service centre	
		55.39	47.13	59.06	37.04	39.79	42.54	65.49	53.56	**Total**
Telecommunication network support technology	57.18	0	0	0	1	1	0	0	0	**114**
Supporting device	48.24	0	0	0	0	0	0	0	1	48
Mobile phone display	50.47	0	0	0	0	0	0	0	0	0
Camera feature	47.79	0	0	0	0	0	0	0	0	0
Internet connectivity	49.13	0	0	0	1	1	0	0	0	98
Battery durability	68.80	0	0	0	0	0	0	0	0	0
Mobile phone robustness	46.00	0	0	1	0	0	0	1	0	92
Connectivity with other media	51.37	0	0	0	0	1	0	0	0	51
Mobile phone safety	58.52	0	0	0	0	0	0	0	0	0
Type of keypad	42.87	1	0	0	0	0	1	0	0	86
Processing unit specification	55.39	0	0	0	1	1	0	0	0	**111**
Sound quality	60.31	0	0	0	0	0	0	0	0	0
Ease of assembly/ disassembly	27.68	1	0	1	0	0	1	1	0	**111**
Type of battery	35.27	0	0	0	0	0	0	1	1	71
Ease of use	40.19	0	0	0	0	1	0	0	0	40
Mobile phone price	59.86	0	0	0	0	0	0	1	0	60
Ease of handling	50.92	0	1	0	0	0	0	0	0	51
	Total	111	47	**118**	111	**199**	85	**262**	107	

Where:
1 = Relationship between product and service design requirement exist
0 = No relationship between product and service design requirement

A total score of each product and service design requirement is calculated by multiplying a design requirement rating and the existence of the relationship between product and service design requirements. For example, a product design requirement “supporting device” can be scored as follow:

$$\begin{aligned}\text{“supporting device” score} &= (48.24 \text{ x } 0) + (48.24 \text{ x } 0) + (48.24 \text{ x } 0) \\ &\quad + (48.24 \text{ x } 0) + (48.24 \text{ x } 0) + (48.24 \text{ x } 0) \\ &\quad + (48.24 \text{ x } 0) + (48.24 \text{ x } 1) \\ &= 48.24 \\ &\approx 48\end{aligned}$$

Three product design requirements with total highest value will be chosen as critical product design requirements. A similar ways is also applied for service design requirements. Product and service design requirement with yellow colour in Figure 2 is critical design requirements. Critical design requirements become basis for PSS design concept development.

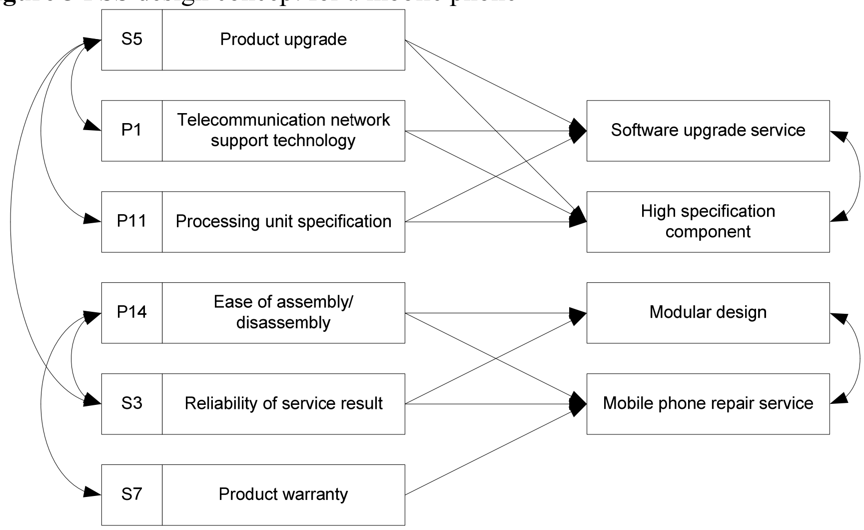
According to Sundin et al (2007), integrated product and service engineering achieve by developing functional design. Functional design then breaks down into product functions and service functions. Based on this approach, a set of critical design requirements which reflect the PSS concept then is synthesized into a set of product and service design concepts. Finally, PSS design concepts are elaborated from both of product and service design concepts.

Table 7 Developed product-service design concept

Critical Design Requirements	**Product Design Concept**	**Service Design Concept**
Telecommunication network support technology	Mobile phone with high specification component	Software upgrade service
Processing unit specification	Mobile phone with high specification component	Software upgrade service
Ease of assembly/ disassembly	Modular design	Mobile phone repair service
Product warranty	Mobile phone with high specification component	Mobile phone repair service
Product upgrade	Mobile phone with high specification component	Software upgrade service
Reliability of service result	Modular design	Mobile phone repair service
PSS Design Concept	Modular mobile phone with high specification component	Software upgrade and mobile phone repair service provision

Figure 3 show an approach to elaborate PSS design concept from a set of critical design requirement and product and service design concept.

Figure 3 PSS design concept for a mobile phone



PSS design concept suggested by product and service integration is modular mobile phone with high specification component. This product design concept supported by mobile phone repair and software upgrade service.

5. Conclusion

This research has discovered a way to develop PSS design concept based on integrated product and service requirements. There are three stages to develop PSS design concept, namely: identification of design requirements, determination of design requirements rating and integration of product-service into the PSS design concepts for a product. A mobile phone design case is used as an illustration to test the developed model. Results suggest developing modular mobile phone with high specification component supported by mobile phone repair and software upgrade service. This research only attempt to develop design concept for PSS without developing specification for design development. Future research can be focused on development model for transforming a PSS design concept into a PSS design specification.

6. Acknowledgements

The author gratefully acknowledge the assistance rendered by the Faculty of Engineering, Andalas University for partially funding this research in DIPA FT Unand 2013 (Contract No.019/PL/SPK/PNP/FT Unand/2013).

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LAMPIRAN B

PROSES PEER REVIEW
DALAM BENTUK *SUMMARY OF MODIFICATION*

Untuk merespons terhadap penilaian dari 2 reviewer

Judul artikel	: Product-Service System Design Concept Development Based on Product and Service Integration
Jurnal	: Journal Design of Research (JDR)/ Penerbit Inderscience
SJR	: 0,3 (Quartil Q2 sejak 2013 bidang Engineering hinga sekarang) http://www.scimagojr.com/journalsearch.php?q=5900152897&tip=sid&clean=0

Submitted	: 22 November 2013
Review report	: 10 Januari 2014
Revise version	: 24 Maret 2014
Post Review	: 25 Mai 2014
Accepted	: 27 Mei 2014
Published	: Februari 2015 (Vol. 13 No.1 Tahun 2015)

Response to Reviewers

Reviewer 1

1. It's very difficult to evaluate an article with references that are not in English… as those of Yuliandra et al.

   We are agree to delete the articles with references that are not in English e.g. Yuliandra B. et al

Reviewer 2

1. On section 2.1 the authors have shown the literature review. I saw only 12 papers in Table 01. Indeed, I am sure there are much more papers about PSS design methodology. I would suggest you to expand the Table 01. Furthermore, there is no description about the relevant literature (their benefit, contribution and weakness) to the research theme. It is essential to understand how your proposed PSS design methodology can contribute to extend the current state-of-the-art.

   Table 01 has been expanded with 16 papers related to PSS design methodology. Table 01 also contains description (their benefit, contribution and specific weakness) about the relevant literature to the research theme.

Table 1. PSS design methodologies in literature

Reference	Contribution	Strengths	Weaknesses
Morelli (2002) Morelli (2006)	A set of methods to define a map of the actors involved in PSS, to define the requirements and structure a PSS and to represent and blueprint a PSS.	Methodical and operational tools to develop an innovative and multidisciplinary approach of PSS design.	Does not explain each of the stages in the design process.
Maussang *et al* (2006) Maussang *et al* (2007) Maussang *et al* (2009)	An integrated product and service design methodology by using functional analysis and agent based model.	Enables designers to take into account the values and detailed costs provided by PSS while considering the functions that will fulfil the expected requirements.	Capable of generating several PSS scenarios, but the method has not explained the general procedures for the selection of the optimal scenario.
Hara *et al* (2007) Hara *et al* (2009)	A CAD system called "service explorer"that can be used to design services.	Enables collaboration amongst managers, marketers, and engineers to improve existing services or design a new service.	Does not explain the feasibility assessment of the combination of products and services offered.
Thomas *et al* (2008)	A PSS design methodology for determining the characteristics of the components of products and services based on a set of criteria developed from the consumer needs.	Allows consumer needs to be linked to product and service components.	Applied only for a specific case study, insufficient general conclusion.
Ericson *et al* (2009)	TRIZ-based tools for PSS design methodology.	Reduces innovation risks through the use of TRIZ-based modules.	Does not have a mechanism for defining the problems in the early stages of design.

Kimita *et al* (2010)	Axiomatic design and service engineering concept for PSS design methodology.	Allows PSS designers to detect and avoid conflicts amongst PSS elements.	Does not consider the constraints in the transition phase between design domains.
Chen and Li (2010)	Designers support to design PSS based on an eco-innovative design method and TRIZ method.	Able to bring a variety of eco-innovative possibilities by using TRIZ inventive principles without requiring contradiction analysis rules.	The solutions offered are considered only for reducing environmental impacts on eco-products or processes.
Geng *et al* (2010) Geng *et al* (2011)	A methodology that translates customer requirements into product-and service-related engineering characteristics in order to determine critical PSS design parameter.	Capable of meeting consumer needs more thoroughly and increases accuracy in the selection of technical characteristics.	The decision making process becomes complicated along with the increased number of technical characteristics.
Kim *et al* (2010)	A systematic methodology to generate the concepts for PSS.	The designer can generate PSS concepts easily and naturally while addressing a variety of customer needs in many different contexts.	The methodology treats a real problem as a general problem and then provides a general solution (but not necessarily a real solution).
Lee and Kim (2010)	A methodology for an effective PSS design concept using both functional modelling and service activities.	Enables a systematic mapping among various functions, service providers/receivers, service activities and product/service elements.	The methodology can produce several PSS design concepts but does not explain how to select the optimal PSS design concept.
Shikata *et al* (2013)	A methodology to examine PSS characteristics that supports competitive advantages.	Improves PSS performance through product architecture analysis.	Only examines two specific case studies, insufficient general conclusion.

2. On section 3 (stage 2) the authors argue that "… the summated rating method was used by Thomas et al (2008), Summated Rating method developed by Likert (1932) is used to determine design requirements rating…". My question is why this method was used? Are there some advantages from other methods?

   Summated Rating method (also called Likert scale) is used to obtain rating from the respondents on a symmetric important-not important scale for a series of design requirements. Compared to similar method like Equal-Appearing Interval (also called Thurstone scale), the summating rating method are simpler and easier to apply.

3. On section 4.1 the authors argue that "… In general, mobile phones and network services are sold separately except for some cases… Therefore, the illustrations in this research will focus only to mobile phones design and do not address the relationship between mobile phone manufacturers and network operators…", however we can see very often the commoditization of mobile phones. Nowadays, the consumers often got confused over how to distinguish and select an appropriate mobile. This is why some mobile phones are now given to consumer through contract which payment is made only for the service that they usually provide. I would like to understand a bit more about this issue.

The mobile phones industry in Indonesia involves two main parties, the mobile phones manufacturers and network operators. In general, mobile phones as a product in Indonesia are sold separately with the network operator. A consumer who buys a mobile phone afterward can freely choose the network provider they want to use. This condition might be slightly different with the other countries around the world, which the mobile phones are given to consumer through contract and the payment is made only for the service from the network provider. Therefore, the illustrations in this research will focus only to mobile phones design and do not address the relationship between mobile phone manufacturers and network operators or the network operator as a service. Product-oriented service design will be focused on producing a better product and product support service by mobile phones manufacturers.

4. On section 4.2 (fourth paragraph) "... product moment correlation..." Why?

   Product moment correlation is used to obtain construct validity from each of design requirement (P1 up to P18 for technical artefacts and S1 up to S8 for service). the product moment correlation coefficient (r) can be counted as follow (Bishop, 2008):

$$r = \frac{N(\sum XY) - (\sum X \sum Y)}{\sqrt{[N\sum X^2 - (\sum X)^2][N\sum Y^2 - (\sum Y)^2]}} \quad (1)$$

   where:

   N= number of samples
   X = score of each design requirement
   Y= total score from all design requirements

5. On section 4.2 (fourth paragraph) "... For the number of samples of 75, r_{table} value is 0.2272..." Why?

   The value of r_{table} for a number of samples of 75 is obtained by using Pearson Product Moment coefficient table(r_{table}) with level of significance 0.05 and 2 tailed. From the table (Bishop, 2008), the r_{table} value is 0.2272.

6. On section 4.2 (fifth paragraph) "... Reliability is determined by taking into account the value of Cronbach's Alpha..." Why?

   The value of Cronbach's Alpha is a coefficient of internal consistency, which should be determined to estimate the reliability of a test. The value of Cronbach's Alpha is obtained by using Equation (Bishop, 2008):

$$\alpha = \left(\frac{K}{K-1}\right)\left(\frac{{s_x}^2 - \sum {s_i}^2}{{s_x}^2}\right) \quad (2)$$

   where:

   K= number of design requirement
   ${s_x}^2$ = the variance of the observed total design requirement scores
   ${s_i}^2$ = the variance of design factor i for the current sample

7. The paper needs thorough editing by a native English speaker.

   The paper has been thorough edited by a native English speaker

LAMPIRAN C

PAPER DENGAN VERSI AKHIR
(AUTHOR'S FINAL VERSION)

Judul artikel	: Product-Service System Design Concept Development Based on Product and Service Integration
Jurnal	: Journal Design of Research (JDR)/ Penerbit Inderscience
Hal	: 18 halaman
SJR	: 0,3 (Quartil Q2 sejak 2013 bidang Engineering hinga sekarang) http://www.scimagojr.com/journalsearch.php?q=5900152897&tip=sid&clean=0

Submitted	: 22 November 2013
Review report	: 10 Januari 2014
Revise version	: 24 Maret 2014
Post Review	: 25 Mai 2014
Accepted	: 27 Mei 2014
Published	: Februari 2015 (Vol. 13 No.1 Tahun 2015)

Product-service system design concept development based on product and service integration

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Abstract: Today's business environment pressurises many high-technology companies to continuously improve the value of their products and services to remain competitive. Product-Service Systems (PSS) is an emerging paradigm that enables a tighter integration between product and service offering. The research described in this paper aims to propose a new PSS design methodology based on the integrated product and service design requirements. The process consists of three stages: the identification of design requirements, the determination of design requirements rating and the integration of product and service design requirement in order to develop a PSS design concept. A case study of mobile phones design has been chosen to validate the proposed PSS design methodology.

Keywords: product-service system; added values; design concept; design requirements; consumer needs; PSS design methodology; integration; mobile phone; product concept; service concept

Reference to this paper should be made as follows: Sutanto, A., Yuliandra, B., Tjahjono, B., Hadiguna, R.A. (201X) 'Product-service system design concept development based on product and service integration', *J. Design Research*, Vol. XX, No. X, pp.XX–XX.

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1 Introduction

Consumer demands for products are becoming increasingly complex and customized (Morelli, 2002). Better consumer awareness of the quality and features of the product, tighter competition between the developed and developing countries and markets trend towards globalization are some examples of the changes that exist in the global business environment (Lay *et al*, 2010). Product differentiation can be considered as a solution to this problem. However, advances in information and communication technology enable companies to compete globally, making it difficult for them to compete on the basis of the product differentiation alone (Tan *et al*, 2007).

Feinberg (2001) states, if the products in the market are not significantly differentiated then customer satisfaction will be a determining factor in the business competition. For that reason, in order to survive in the global competition, companies should increase their competitiveness by improving customer satisfaction. One possible way is to offer added value to the product, which can be done by shifting their paradigm from the product-oriented into the service-oriented economy (Geng *et al*, 2010). Shikata *et al* (2013) argued that it is difficult for manufacturing companies nowadays to succeed by selling only product. The concept of Product-Service Systems (PSS) integrates products and services which can lead to a better value proposition, revenue generation opportunities and sustainable customer value (Roy and Cheruvu, 2009). Shifting from the production-based model to the PSS-based model also means that the manufacturers are required to diversify services around the products (Phumbua and Tjahjono, 2012).

Although PSS offers various benefits through increased added value, the analysis conducted by the Sustainable Product Development Network (SusProNet) showed that the PSS application is not always a win-win solution and sustainability is still questionable; in some cases it failed or simply gave a slight profit margin (Tukker, 2004). To avoid failure in the PSS implementation, the design process clearly needs to be improved. In this way, the implementation of PSS concept will be enhanced.

The research described in this paper aims to provide a new PSS design methodology based on the integrated product and service design requirements. Customer preferences will become the basis for the requirements. The integration process will focus on the product-oriented service. It is expected that the integration can facilitate the companies to shift from product-oriented enterprises to service-based enterprises and improve their competitiveness through the synergy between the product and services offered.

2 State of the Art

2.1 Product-Service Systems

Product-Service Systems (PSS) can be defined as the integration between products and services to generate higher added value and fulfil the specific needs of consumers (Goedkoop et al, 1999; Mont, 2000; Erkoyuncu et al, 2009; Chirumalla et al, 2011; Wallin and Kihlander, 2012). In the context of PSS, a product is a tangible commodity manufactured to be sold, while a service is an activity with economic value often done on a commercial basis. A combination of products and services can expand the functionality offered to consumers, both in terms of improving the quality of products and services as well as reducing the total cost (Goedkoop et al, 1999).

Increased added value can be obtained by expanding the product utility and services during the period of use (Tan et al, 2007). Business strategies have often been purposely developed with a holistic approach to link economic, environmental and social aspects (Mateu et al, 2012). PSS is therefore closely related with sustainability and the relationship between products and services in the context of sustainability dimensions can be described as the “triple bottom line (3BL)” as follows:

- *The economic dimension* means the integration of products and services will offer new functionality, open up opportunities for products and service customization as well as improve product quality and customer satisfaction (Goedkoop et al, 1999). Furthermore, it will expand the market for producers, increase the company's reputation from the consumer point of view (Wimmer and Kang, 2006) and can reduce the cost of investment and production (Goedkoop et al, 1999; Wimmer and Kang, 2006).

- *The environment dimension* emphasises the integration of products and services that will reduce material waste by shifting the company's business from selling only products to providing functionality (Mont, 2002; Maussang et al, 2006). In addition, the combination of products and services that complement each other in providing the needs of the consumers can reduce energy consumption and use of aggregate materials.

- *The social dimension* shows the integration of service activities in manufacturing companies that will grow the employment. This integration will also affect the consumption patterns in the society so it can reduce the impact of the rebound effect. However, the relationship between the PSS concept with the social aspect is somewhat reciprocal. This is due to the effective implementation of PSS that also requires corresponding social structures (such as social infrastructure, community structure and organizational layout) (Mont, 2000).

2.2 Design Approaches in Product-Service Systems

Design aspect has a critical role in the efficiency, visibility and usability of PSS (Morelli, 2002). McAloone and Andreasen (2004) found that design in PSS ideally combines various disciplines by considering the product life cycle and consumer acceptance. The same opinion is expressed by Mont and Plepys (2003). They claimed that the PSS design should be able to connect the consumer perceptions and behaviour as well as the concept of sustainability development. Moreover, the collaboration between product (tangible) and services (intangible) in PSS design needs to be considered in order to increase the value. Therefore, the design process of products and services in PSS should be conducted jointly so as to maximize the potential profit of the resulting design. Design requirement is determined before the design process done and it is based on the perspective of products and services. Both perspective of requirements are then processed together to generate the optimal PSS design.

Vasantha et al (2012) revealed that the design process to integrate products and services into primary goal is widely discussed in PSS literature. Some PSS design methodologies that appeared in the literature are summarised in Table 1.

Table 1. PSS design methodologies in literature

Reference	Contribution	Strengths	Weaknesses
Morelli (2002) Morelli (2006)	A set of methods to define a map of the actors involved in PSS, to define the requirements and structure a PSS and to represent and blueprint a PSS.	Methodical and operational tools to develop an innovative and multidisciplinary approach of PSS design.	Does not explain each of the stages in the design process.
Maussang *et al* (2006) Maussang *et al* (2007) Maussang *et al* (2009)	An integrated product and service design methodology by using functional analysis and agent based model.	Enables designers to take into account the values and detailed costs provided by PSS while considering the functions that will fulfil the expected requirements.	Capable of generating several PSS scenarios, but the method has not explained the general procedures for the selection of the optimal scenario.
Hara *et al* (2007) Hara *et al* (2009)	A CAD system called "service explorer"that can be used to design services.	Enables collaboration amongst managers, marketers, and engineers to improve existing services or design a new service.	Does not explain the feasibility assessment of the combination of products and services offered.

Thomas *et al* (2008)	A PSS design methodology for determining the characteristics of the components of products and services based on a set of criteria developed from the consumer needs.	Allows consumer needs to be linked to product and service components.	Applied only for a specific case study, insufficient general conclusion.
Ericson *et al* (2009)	TRIZ-based tools for PSS design methodology.	Reduces innovation risks through the use of TRIZ-based modules.	Does not have a mechanism for defining the problems in the early stages of design.
Kimita *et al* (2010)	Axiomatic design and service engineering concept for PSS design methodology.	Allows PSS designers to detect and avoid conflicts amongst PSS elements.	Does not consider the constraints in the transition phase between design domains.
Chen and Li (2010)	Designers support to design PSS based on an eco-innovative design method and TRIZ method.	Able to bring a variety of eco-innovative possibilities by using TRIZ inventive principles without requiring contradiction analysis rules.	The solutions offered are considered only for reducing environmental impacts on eco-products or processes.
Geng *et al* (2010) Geng *et al* (2011)	A methodology that translates customer requirements into product-and service-related engineering characteristics in order to determine critical PSS design parameter.	Capable of meeting consumer needs more thoroughly and increases accuracy in the selection of technical characteristics.	The decision making process becomes complicated along with the increased number of technical characteristics.
Kim *et al* (2010)	A systematic methodology to generate the concepts for PSS.	The designer can generate PSS concepts easily and naturally while addressing a variety of customer needs in many different contexts.	The methodology treats a real problem as a general problem and then provides a general solution (but not necessarily a real solution).
Lee and Kim (2010)	A methodology for an effective PSS design concept using both functional modelling and service activities.	Enables a systematic mapping among various functions, service providers/receivers, service activities and product/service elements.	The methodology can produce several PSS design concepts but does not explain how to select the optimal PSS design concept.
Shikata *et al* (2013)	A methodology to examine PSS characteristics that supports competitive advantages.	Improves PSS performance through product architecture analysis.	Only examines two specific case studies, insufficient general conclusion.

From the review, it has become apparent that the main shortcoming of the abovementioned methodologies lays in the fact that they are not well grounded with respect to determining the design requirements. Due to the fact that the primary goal of the design is to fulfil the needs of the consumers, this is a considerable weakness in the way that the PSS design should be developed based on the needs of consumers. Therefore, there is a clear need for a framework that can be used to determine the requirement lists for a development process.

Muller et al (2010) developed a checklist of criteria to determine the needs of consumers in PSS design. The criteria can serve as a basis for developing a PSS design methodology. Using these criteria, the PSS design process which incorporating more systematic measures and structured should theoretically better reflect the consumer needs.

3 PSS Design Methodology

In this research, PSS categories are the main consideration in designing the PSS model. This is because the different groups of PSS categories will have different characteristics and thus they have different design needs. PSS design methodology in this research is, to a large extent, based on the Product-oriented PSS classification developed by Tukker (2004). The integration process is focused on the product-oriented services. This category can be considered as an early stage for a company to adopt PSS which traditionally adopts the product-oriented paradigm to service-based economy. The model will facilitate the adoption of the PSS concept for established companies which still apply the traditional approach.

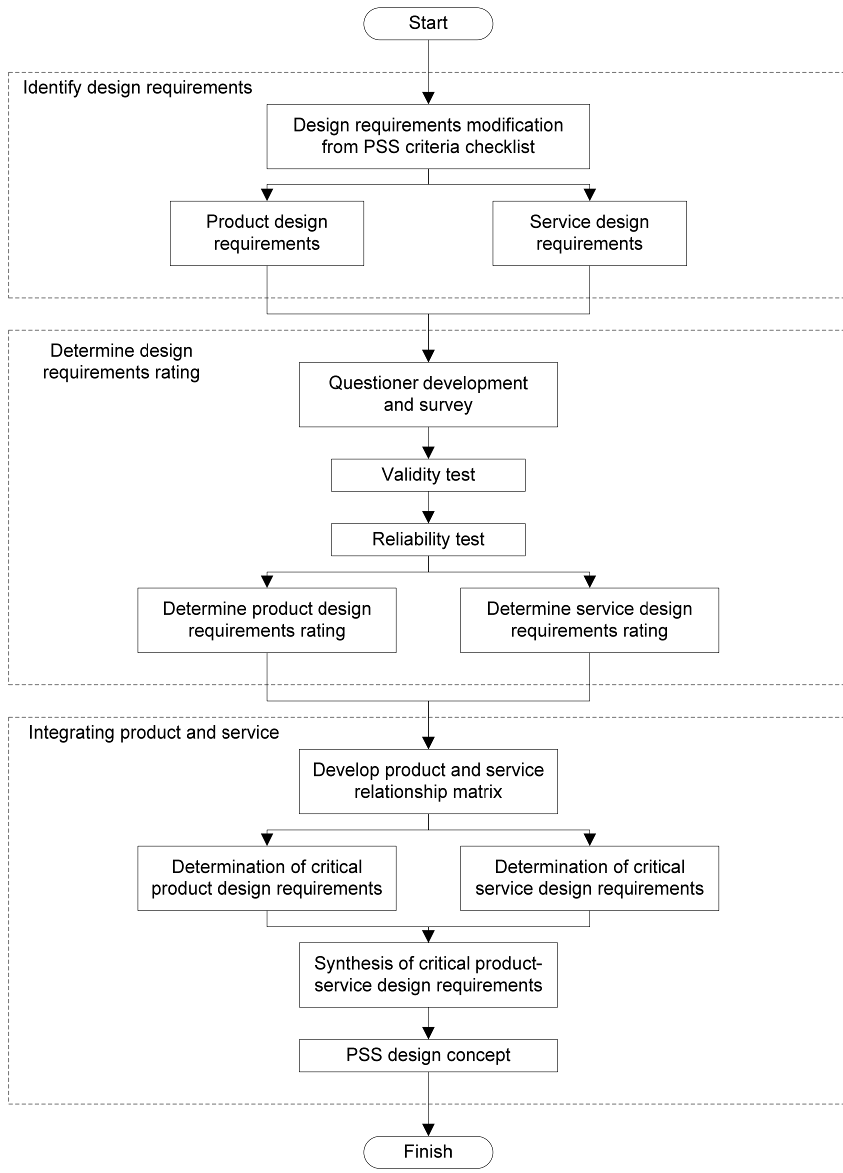
A methodology for product and service integration suggested by this research (Figure 1) consists of three distinct stages as follows:

- **Stage 1** is to identify design requirements. This stage aims to determine the PSS core requirements for designing the products and services. This criterion is general in nature and can be further divided into product and service criteria. The PSS criteria checklist developed by Muller et al (2010), especially technical artefacts and service criteria, are used as a basis for this stage.

- **Stage 2** is to determine design requirements rating. A survey is conducted to rate various design requirements for a product that reflects the customers' desires. As noted by Thomas et al (2008), characteristics of product and service components can be systematically derived on the basis of customer requirements. For that reason the Summated Rating method (also known as Likert scale) developed by Likert (1932) is used to obtain ratings from the respondents on a symmetric important-not important scale for a series of design requirements. Compared to other methods such as the Equal-Appearing Interval (also known as Thurstone scale), the Summated Rating method is relatively simpler and easier to apply.

- **Stage 3** is to integrate product and service design requirements. This stage aims to generate the PSS design concept from product and service requirements in order to fulfil customer's satisfaction. Product and service relationship matrix can be used for this purpose.

Figure 1 PSS design methodology based on integrated requirements



4 Case Study

A case study of mobile phones design has been chosen for testing the developed methodology. This section describes the mobile phones' design process, the product-service integrated design for mobile phones and the result analysis.

4.1 Mobile Phone Design

The design of mobile phones has numerous challenges that have to be considered to ensure the marketing success. These challenges may come from external as well as internal perspectives. The challenge from external marketing perspective has a slightly different technological mastery level from that of the competing manufacturers. This causes at least two problems namely the *lack of products variation* and the *shorter product life cycles*. From the perspective of the mobile phone design process other problems also emerged. The mobile phone design has evolved into a series of communication, knowledge and new innovative entertainment features (Ling et al, 2007 and Ziefle et al, 2006). This makes the design process more complicated than ever before and reduces the usability of mobile phones (Ling et al, 2007).

The mobile phones industry in Indonesia involves two main parties, the mobile phones manufacturers and network operators. In general, mobile phones in Indonesia are sold separately from the network operator. A consumer who buys a mobile phone can afterwards freely choose the network provider he/she wishes to use. This is somehow different from other countries around the world, which the mobile phones are sold to the consumers through contract and the payment is made essentially for the service offered by the network provider. The illustrations in this research will therefore focus only on mobile phones design and do not deliberately address the relationships between mobile phone manufacturers and network operators or the network operator as a service. Product-oriented service design will focus on producing a better product and product support service by mobile phones manufacturers. To test the applicability of the models that have been developed, an illustrative case study of a product-oriented service design for consumers in West Sumatra, Indonesia has been chosen.

4.2 Product-Service Integrated Design for Mobile Phone Product

As mentioned in Section 3, the development activity begins with the identification of the design requirements. This stage is done by using PSS checklist criteria developed by Muller et al (2010), especially the technical artefact and service criteria. The technical artefact criteria are related to the physical form of a mobile phone which will be designed. Service criteria are related with the characteristics of the service support offered by the manufacturers. Checklist criteria from Muller et al (2010) have been modified to suit the design requirements for mobile phones (Table 2).

Table 2 Product and service design requirements for mobile phone

Muller et al, 2010	Modified requirements for mobile phone	Code
Technical artefacts		
Main function	Telecommunication network support technology	P1
Related products/ artefacts	Supporting device	P2
Interfaces	Mobile phone display	P3

Related activities	Camera feature	P4
Related service offers	Internet connectivity	P5
Availability	Battery durability	P6
Robustness	Mobile phone robustness	P7
Flexibility	Connectivity with other media	P8
Safety	Mobile phone safety	P9
Input, throughput, output	Type of keypad	P10
	Processing unit specification	P11
	Sound quality	P12
Required quantity	Single or multi-card hybrid phones	P13
Design for X requirements	Ease of assembly/ disassembly	P14
Ownership and "user ship"	Type of battery	P15
Qualification level of user	Ease of use	P16
Cost	Mobile phone price	P17
Location of product operation	Ease of handling	P18
Services		
Required resources	Ease of repair	S1
Related activities	Duration of product delivery	S2
Estimated result	Reliability of service result	S3
Required information	Early warning system	S4
Facultative services	Product upgrade	S5
Additional services	Diagnosis and repair	S6
Supplemental services	Product warranty	S7
Location of service applications	Availability of service centre	S8

The second stage is to determine the critical design requirement using the Summated Rating Method developed by Likert (1932). This method employs respondents' assessments. In order to determine the importance for each requirement, the respondents are selected from the societies who are deemed to be "savvy" and possess reasonable know-how about the object under study (in this case a mobile phone). Assessment is done through surveys, and respondents were selected using the following two criteria:

1. Respondent's level of education is at least Bachelor.
2. Respondents have used mobile phones for at least five years.

Seventy-five respondents rated each of design requirements. Each design requirement was transformed into a question of the requirement function in order not to confuse the respondent. For example:

Design requirement	:	Telecommunication network support technology
Questionnaire item	:	"How important is the speed of internet access from your mobile phone?"
Description	:	Type of telecommunication network support technology (2G, 3G and 4G) has a significant impact to internet speed.

Rating scales used are listed in Table 3.

Table 3 Rating scales used

Order	Scale	Description
S_1	1	Not important at all
S_2	2	Less important
S_3	3	Neutral
S_4	4	Important
S_5	5	Absolutely important

Product Moment Correlation is used to obtain the construct survey validity from each of the design requirement (coded as P1 to P18 for technical artefacts and S1 to S8 for services). The Product Moment Correlation coefficient (r) can be calculated as follows (Bishop, 2008):

$$r = \frac{N(\sum XY) - (\sum X \sum Y)}{\sqrt{[N \sum X^2 - (\sum X)^2][N \sum Y^2 - (\sum Y)^2]}} \tag{1}$$

where:

N = number of samples
X = score of each design requirement
Y = total score from all design requirements

By using Equation (1), the value of r_{count} for each of mobile phone design requirements can be calculated. This value was then compared to the value of r_{table}. If $r_{count} \geq r_{table}$, then the questionnaire item was deemed valid. The value of r_{table} for the number of sample of 75 can be obtained by using the Pearson Product Moment coefficient table (r_{table}) with the significance of 0.05 and 2 tailed. From the table (Bishop, 2008), the r_{table} value is 0.2272. The calculation of validity test is carried out using SPSS 20 software. The validity test result can be seen in Table 4. The result showed that only item P13 was deemed not valid.

Table 4 Validity test results for each of mobile phone design requirements

Technical artefacts				
No.	**Design requirements**	r_{count}	r_{table}	**Decision**
P1	Telecommunication network support technology	0.353	0.2272	Valid
P2	Supporting device	0.272	0.2272	Valid
P3	Mobile phone display	0.585	0.2272	Valid
P4	Camera feature	0.448	0.2272	Valid
P5	Internet connectivity	0.578	0.2272	Valid
P6	Battery durability	0.256	0.2272	Valid
P7	Mobile phone robustness	0.655	0.2272	Valid
P8	Connectivity with other media	0.695	0.2272	Valid
P9	Mobile phone safety	0.616	0.2272	Valid
P10	Type of keypad	0.485	0.2272	Valid
P11	Processing unit specification	0.655	0.2272	Valid
P12	Sound quality	0.577	0.2272	Valid
P13	Single or multi-card hybrid phones	0.084	0.2272	Not Valid

P14	Ease of assembly/ disassembly	0.360	0.2272	Valid
P15	Type of battery	0.523	0.2272	Valid
P16	Ease of use	0.713	0.2272	Valid
P17	Mobile phone price	0.572	0.2272	Valid
P18	Ease of handling	0.474	0.2272	Valid
Services				
No.	**Design requirements**	r_{count}	r_{table}	**Decision**
S1	Ease of repair	0.713	0.2272	Valid
S2	Duration of product delivery	0.764	0.2272	Valid
S3	Reliability of service result	0.789	0.2272	Valid
S4	Early warning system	0.705	0.2272	Valid
S5	Product upgrade	0.603	0.2272	Valid
S6	Diagnosis and repair	0.776	0.2272	Valid
S7	Product warranty	0.662	0.2272	Valid
S8	Availability of service centre	0.571	0.2272	Valid

Reliability test was conducted only to validate the questionnaire items. The value of Cronbach's Alpha, a coefficient to measure the internal consistency, is determined to estimate the reliability of a test. The value of Cronbach’s Alpha is obtained using (Bishop, 2008):

$$\alpha = \left(\frac{K}{K-1}\right)\left(\frac{s_x^2 - \sum s_i^2}{s_x^2}\right) \qquad (2)$$

where:

K = number of design requirement

s_x^2 = the variance of the observed total design requirement scores

s_i^2 = the variance of design factor i for the current sample

The result is acceptable if the value of $\alpha > 0.70$ (Tavakol and Dennick, 2011). Computation of the reliability test was also done using SPSS 20 software. The reliability test results can be seen in Table 5. The reliability results showed that the Alpha value of both design requirements > 0.70. This suggests that all questionnaire items are reliable and internally consistent

Table 5 Reliability test results

Design requirements	Cronbach’s Alpha	Decision
Technical artefacts	0.883	Reliable
Service	0.904	Reliable

The design requirement rating was determined by using the Summated Ratings method developed by Likert (1932). The results of Summated Ratings are then transformed into T-scores by using the equation (Kreyszig, 2011):

$$T = 50 + 10\left(\frac{X-\bar{X}}{s}\right) \qquad (3)$$

where:

X = the total value of the scale that would be converted into T-score

$\bar{X}$ = the average of the group scale total value

S = the standard deviation of the group scale total value

Design requirements rating and T-score can be seen in Table 6.

Table 6 Mobile phone design requirements rating and T-score

No.	Design requirements	Total	$\bar{X}$	S	T-score
Technical Artefacts					
P1	Telecommunication network support technology	328			57.18
P2	Supporting device	308			48.24
P3	Mobile phone display	313			50.47
P4	Camera feature	307			47.79
P5	Internet connectivity	310			49.13
P6	Battery durability	354			68.80
P7	Mobile phone robustness	303			46.00
P8	Connectivity with other media	315			51.37
P9	Mobile phone safety	331	311.94	22.37	58.52
P10	Type of keypad	296			42.87
P11	Processing unit specification	324			55.39
P12	Sound quality	335			60.31
P14	Ease of assembly/ disassembly	262			27.68
P15	Type of battery	279			35.27
P16	Ease of use	290			40.19
P17	Mobile phone price	334			59.86
P18	Ease of handling	314			50.92
Services					
No.	**Design requirements**	**Total**	$\bar{X}$	**S**	**T-score**
S1	Ease of repair	321			55.39
S2	Duration of product delivery	312			47.13
S3	Reliability of service result	325			59.06
S4	Early warning system	301	315.13	10.89	37.04
S5	Product upgrade	304			39.79
S6	Diagnosis and repair	307			42.54
S7	Product warranty	332			65.49
S8	Availability of service centre	319			53.56

The third stage is to integrate the product and service design requirements. This can be achieved by investigating the correlation between the product and service design requirements. A product and service relationship matrix (Figure 2) was constructed based on product and service requirements and their T-scores obtained in the second stage.

Figure 2 Product and service relationship matrix

Product Design Requirements		Ease of repair	Duration of product delivery	**Reliability of service result**	Early warning system	**Product upgrade**	Diagnosis and repair	**Product warranty**	Availability of service center	
		55,39	47,13	59,06	37,04	39,79	42,54	65,49	53,56	**Total**
Telecommunication network support technology	57,18	0	0	0	1	1	0	0	0	**114**
Supporting device	48,24	0	0	0	0	0	0	0	1	48
Mobile phone display	50,47	0	0	0	0	0	0	0	0	0
Camera feature	47,79	0	0	0	0	0	0	0	0	0
Internet connectivity	49,13	0	0	0	1	1	0	0	0	98
Battery durability	68,80	0	0	0	0	0	0	0	0	0
Mobile phone robustness	46,00	0	0	1	0	0	0	1	0	92
Connectivity with other media	51,37	0	0	0	0	1	0	0	0	51
Mobile phone safety	58,52	0	0	0	0	0	0	0	0	0
Type of keypad	42,87	1	0	0	0	0	1	0	0	86
Processing unit specification	55,39	0	0	0	1	1	0	0	0	**111**
Sound quality	60,31	0	0	0	0	0	0	0	0	0
Ease of assembly/ disassembly	27,68	1	0	1	0	0	1	1	0	**111**
Type of battery	35,27	0	0	0	0	0	0	1	1	71
Ease of use	40,19	0	0	0	0	1	0	0	0	40
Mobile phone price	59,86	0	0	0	0	0	0	1	0	60
Ease of handling	50,92	0	1	0	0	0	0	0	0	51
	Total	111	47	**118**	111	**199**	85	**262**	107	

(Column group heading: **Service Design Requirements**)

Where:
1 = Relationship between product and service design requirement exist
0 = No relationship between product and service design requirement

The total score of each product and service design requirement was calculated by multiplying the design requirement score and the existence of the relationship between product and service design requirements (the value is 1, if the relationship exists and 0, if no relationship). For example, the score of “supporting device” can be calculated as:

$$\begin{aligned}\text{“supporting device” score} &= (48.24 \text{ x } 0) + (48.24 \text{ x } 0) + (48.24 \text{ x } 0) \\ &\quad + (48.24 \text{ x } 0) + (48.24 \text{ x } 0) + (48.24 \text{ x } 0) \\ &\quad + (48.24 \text{ x } 0) + (48.24 \text{ x } 1) \\ &= 48.24 \\ &\approx 48\end{aligned}$$

Three product design requirements with the total highest values will be nominated as the critical product design requirements. The similar method was also applied for the service design requirements. Product and service design requirement in “yellow” (namely “Telecommunication network support technology”, “Processing unit specification”, “Ease of assembly/disassembly” for product design requirement and “Reliability of service result”, “Product upgrade”, “Product warranty” for service design requirement) are the critical design requirements. These will then become the basis for PSS design concept development.

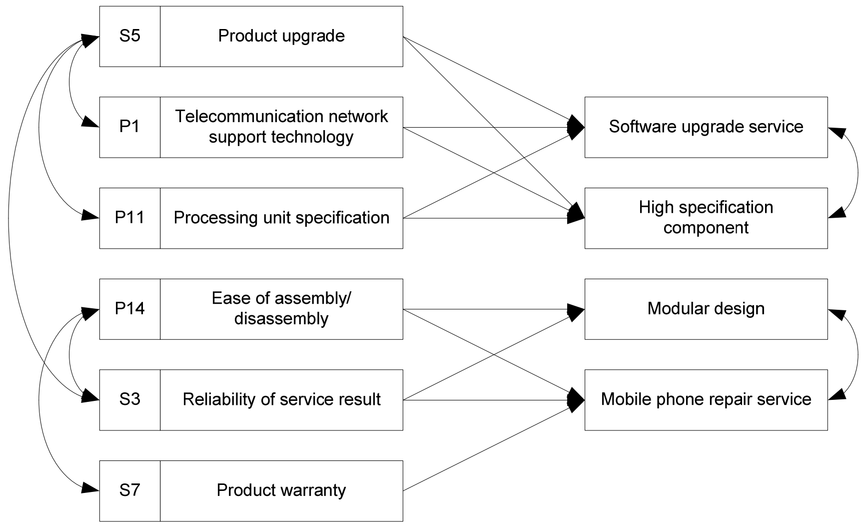
Table 7 Developed product-service design concept

Critical Design Requirements	Product Design Concept	Service Design Concept
Telecommunication network support technology	Mobile phone with high specification component	Software upgrade service
Processing unit specification	Mobile phone with high specification component	Software upgrade service
Ease of assembly/ disassembly	Modular design	Mobile phone repair service
Product warranty	Mobile phone with high specification component	Mobile phone repair service
Product upgrade	Mobile phone with high specification component	Software upgrade service
Reliability of service result	Modular design	Mobile phone repair service
PSS Design Concept	Modular mobile phone with high specification component	Software upgrade and mobile phone repair service provision

According to Sundin et al (2007), the integrated product and service engineering can be achieved by developing the functional design which then breaks down into product functions and service functions. Based on this approach, a set of critical design requirements which reflect the PSS concept was then synthesized into a set of product and service design concepts (Table 7). Finally, PSS design concepts were elaborated from both product and service design concepts.

Figure 3 shows the approach to elaborate the PSS design concept from a set of critical design requirements and the product and service design concept. The PSS design concept suggested by product and service integration is a modular mobile phone featuring high specification components. This product design concept is supported by mobile phones repair and software upgrade services.

Figure 3 PSS design concept for a mobile phone



5 Conclusions

This research proposes a new way of developing the PSS design concept based on the integrated product and service requirements. There are three stages involved namely: identification of design requirements, determination of design requirements rating and integration of product-service into the PSS design concepts for a product. A mobile phones design case has been used to test the proposed model. Results suggest the development of modular mobile phones featuring high specification components supported by mobile phones repair and software upgrade services. This research solely attempted to develop the design concept for PSS without necessarily developing a detailed specification for the design. Future research needs to be focused on the development model for transforming a PSS design concept into a PSS design specification.

Acknowledgements

The author gratefully acknowledges the assistance rendered by the Faculty of Engineering, Andalas University for partially funding this research in DIPA FT Unand 2013 (Contract No.019/PL/SPK/PNP/FT Unand/2013). The authors would also like to thank Hairul Abral (Dean of Engineering Faculty, Andalas University) for his supports and motivations.

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