ORIGINAL ARTICLE

Evaluating the Reusability of Core Assets for Service Oriented Product Line: Case Study of Patient Navigation Program (PNP)

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ABSTRACT

Introduction: Patient Navigation Program (PNP) act as an intervention tool that resolve and overcome various obstacles that patients face as they navigate through healthcare system. This makes the use of PNP worth to be widen but delivering needs of PNP involves high efforts. Thus, Service Oriented Product Line (SOPL) is introduced as systematic approach in identifying reusable core assets to reduce time and effort in developing new PNP. Consequently, due to reusable nature of core assets, evaluating its reusability is crucial to determine the development performance. Therefore, this paper measures reusability of core assets to ensure that core assets development approach can lead to highly reusable core assets. **Methods:** Reusability Matrix for Functional Commonality (FC) and Modularity (MD) is considered to compose core assets without much complication. Reusable core assets derived from two different development approaches is used as input where matrix of reusability evaluation is applied. The approaches includes an approach from previous existing study and enhanced approach with implementation of Business Process Feature Model (BPFM) and Trade-off Analysis. Evaluation results is compared using reusability matrix to identify which approach contributes to higher core assets reusability. **Results:** From overall results, enhanced approach shows an improved reusability by achieving 92% of FC results compared to existing approach, while results of MD remains the same. Utilizing BPFM and Trade-off Technique is proven to be the contributing factor in higher reusability. **Conclusion:** This study concluded that reusability of core assets can be improved with a comprehensive core assets development approach.

Keywords: Service Oriented Product Line, Core Assets, Reusability, Functional Commonality, Modularity

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INTRODUCTION

Patient Navigation Program (PNP) is considered as a patient-centric health care service delivery strategy which primary aim is to eliminate barriers across health care spectrum, to prompt diagnosis, and guiding patients throughout treatment process (1). Freeman and Rodriguez (1) also describe PNP as a service that focus on facilitating patient's timely movement across an often-complex healthcare continuum. Throughout most developing nations and countries, PNP has been introduced to monitor and prevent cancer. PNP have impact on assisting in managing chronic illness care, including screening rates, screening abnormality, diagnosis to treatment initiation, treatment adherence and completion, and end-of-life care, despite lack of proof of its effectiveness (2).

Looking in the perspective of real world, with a vast amount of data generated, a proper way to evaluate and store medical information in real time is needed but it is undeniably a challenging task to implement (3). In Malaysia, PNP functioned as data management, analysis, barrier prediction, milestone prediction, incidence prediction, efficacy, response, and side effects of treatment analysis and manual reporting (4). However, in Malaysia, use of PNP is only implemented in Hospital Tengku Ampuan Rahimah (HTAR). Figure 1 depicts the current PNP implementation (4). To ensure that patients receive most effective and systematic treatment across Malaysia, implementation of PNP need to be widen across Malaysia but fulfilling needs for customized PNP for specific healthcare providers necessitate efforts in meeting requirements. Therefore, a systematic approach of reuse especially

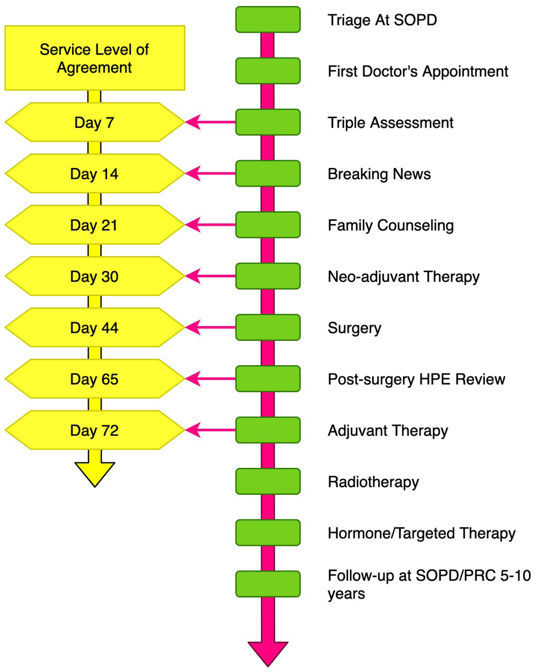

Figure 1 : PNP implementation in HTAR from the study by Suvelayutnan U (44). This figure presents the overview of current PNP implementation for breast cancer in HTAR.

in identifying reusable core assets of PNP services to reduce cost and time must be adopted.

Service Oriented Product Line (SOPL), a combination of Software Product Line (SPL) and Service Oriented Architecture (SOA), has emerge as an approach that promise a flexible development, cost-effective software systems, and high degree of reuse (5). In SPL and SOA, as both paradigms have the same purpose of promoting reuse concept, new systems are not repeatedly developed (6). It incorporate existing components rather than coding a new system from scratch (7). It can be used in various domains where SOA-based application are needed (8). A SOA family is managed using a feature model with conventional SPL paradigm (9). Two lifecycles are taken into account which are Domain Engineering (DE) and Application Engineering (AE). Among phases involved in developing core assets are Domain Scoping, Domain Analysis, and Domain Design (10). In increasing reusability of core assets, Domain Scoping helps in capturing business nature (11,12) and is often represented in a form of Product Map (10, 13). Knowing areas that are essential to provide reuse benefits is crucial for gradual implementation of an organization's product line development (13). However, most study often neglected the process of Domain Scoping thus missing the important benefits of increasing core assets reusability (14).

Our previous study, Basmmi et al. (15), has already tackled the enhancement of Domain Scoping process from work by Ezenwoke et al. (10). Although both approaches involves process of Domain Scoping, Domain Analysis, and Domain Design, Domain Scoping in Basmmi et al. (15) were enhanced to generate a more refined Product Map in order to represent core assets into feature model during Domain Analysis. Use of Business Process Feature Model (BPFM) and Trade-off Analysis technique is being introduced in the enhancement. Results shows that designed feature model in Basmmi et al. (15) seems to be less complex compared to Ezenwoke et al. (10) but it is not enough to justify that it contributes in a better process of highly reusable core assets identification.

Reusability is one of attributes of quality that reflects the significance of software. As reusability of core asset plays an important role in entire success of product line (16), key features of reusability which are Functional Commonality (FC) and Modularity (MD) need to be taken into account to ensure core assets can be composed without much complication. FC and MD are among metrics for reusability evaluation that has recently been developed by Ali (17). Framework by Ali (17) outlines a standard that continues to improve reusability of core assets through use of SPL and SOA. Therefore, this paper focus on evaluation to measure reusability of identified core assets.

FC evaluates functional commonalities between functions among scoping of product line. Reason for specifying these characteristics is that features produced should be common to all applications specified in specification of product line requirements (17). If core web service offers a number of superior features, such as developing and building a software product, it will not be commonly subscribed by user and will not be widely reused unless those features are standard among all applications (18). FC is measured by Functional Coverage and is used to measure reusability of core assets as all services to be reused involves a functional domain requirement. It measures average commonality for each functional feature in core asset web service and can calculate commonality of each feature by measuring degree of family member using each functional feature (18). FC can be calculated using (Equation 1) where n is the total number of functional features. Degree of range for FC is between 0 and 1. 1 implies that all functional features are common among all applications in the scope of product line, while 0 means no common features can be shared.

$$\text{Functional Commonality (FC)} = \frac{\left(\sum_{i=1}^{n} \frac{\text{number of application using ith feature}}{\text{total number of application in product line scope}}\right)}{n}$$

(Equation 1)

Nevertheless, MD is a key factor which affects reusability of core assets and portability of software and has proven to brings significant positive impact on software reuse (19). Core assets is a highly modularized unit of capability that can be composed without much complexity in different business process (20). Based on study by Ali (17), MD evaluates scope of core assets in order to have distinct functionality without dependency on other core assets. Therefore, core assets must be modularized by reducing coupling and increasing cohesion to increase reusability of features. MD calculates degree to which core assets is independent from other core assets (17, 20). MD can be calculated using (Equation 2). Degree of range for MD is also between 0 to 1. 1 implies that all core assets are independent, so core assets is considered self-contained, while 0 implies that core assets are dependent.

$$\textit{Modularity (MD)} = 1 - \frac{\textit{number of assets that are dependent on other core asset in a service}}{\textit{number of total core assets on service core assets}} \quad \text{(Equation 2)}$$

Case study of PNP (4) is used and a set of reusable core assets derived from approaches by Ezenwoke et al. (10) and Basmmi et al. (15) which acts as inputs to measure reusability. Importance of this evaluation is to find and choose a better approach of core assets development that can lead to high reusability of core assets by comparing result of evaluation for both approaches. A higher result of FC and MD will implies that the approach results in reusable core assets with common functionalities that can be provided without relying on other core assets.

MATERIALS AND METHODS

Evaluation takes place by using case study of PNP (4). A set of reusable core assets of PNP is used which was derived from two different core asset development approaches which are approach by Ezenwoke et al. (10) and another enhanced approach from Basmmi et al. (15). Both approach aims to identify reusable core assets which includes process of Domain Scoping, Domain Analysis, and Domain Design. However, one major enhancement that Basmmi et al. (15) is trying to highlight is implementation of Trade-off Analysis technique (21) and Business Process Feature Model (BPFM) (22) during process of Domain Scoping, which is the process of identifying reusable core assets. Prior to that, available core assets of PNP are identified and user requirements and preferences are derived.

BPFM (22) was introduced in study by Basmmi et al. (15) as a notation to cover all business operations, making it the most expressive business process model for system reuse. A weight is assigned to BPFM as a probability of occurrence for each core assets and a potential reusable core assets is derived through Trade-off Analysis in finding best compromise between added value and structural stability of a system. In performing and automating process of Trade-off Analysis, Macro programming codes are developed by using Visual Basic Application (VBA) programming language to shorten time in deriving potential core assets. All information for core assets including its weight and variability is tabulated in a Product Map (15).

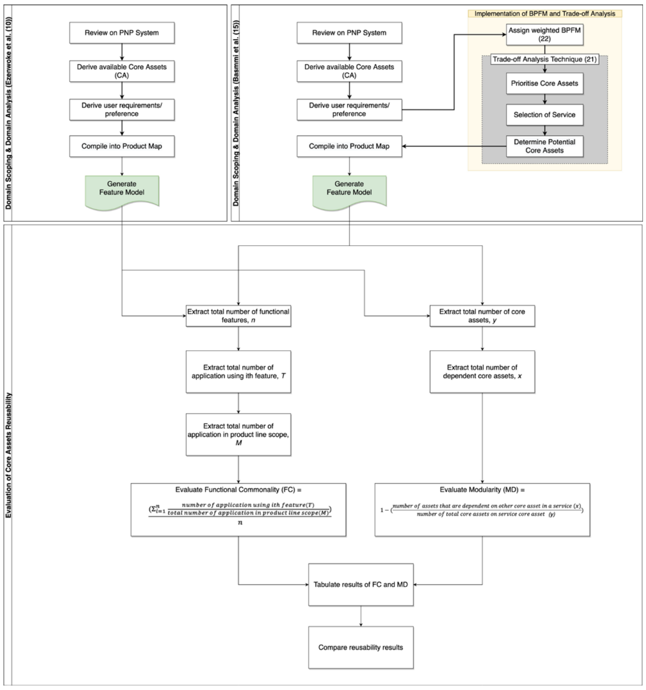

Figure 2 : Methodology of experiment. This figure presents the methodology to perform core assets evaluation discussed in this study which includes the difference between approach by Ezenwoke et al. (10) and enhanced approach from Basmm et al. (15).

Feature model is generated to represent identified reusable core assets. Based on feature models, both figures shows the same number of 25 parent nodes but differs in number of child nodes and sub-tree. Feature model of existing approach (10) includes 67 child nodes with 21 sub-tree, compared to feature model of enhanced approach (15) which only include 58 child nodes with 18 sub-tree. Next, identified core assets will go through evaluation of FC and MD by applying (Equation 1) and (Equation 2) respectively. Each components needed for evaluation is gathered from generated feature model and evaluation results are tabulated. Results of FC and MD for both approaches is compared to prove which approach produce higher reusability of core assets. It is believed that a proper steps during Domain Scoping including implementation of Trade-off Analysis technique and adaptation of BPFM can results in a high reusability of core assets. Figure 2 illustrates complete methodology for this study.

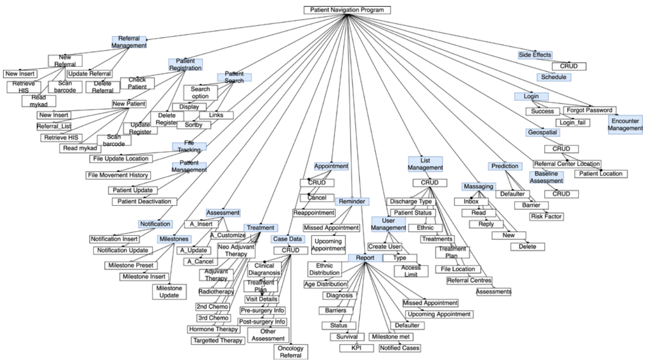

Figure 3 : Feature Model of PNP from approach by Ezenwoke et al. (10). This feature model is the results of reusable core assets derived from approach by Ezenwoke et al. (10). Parent nodes included: Referral Management, Patient Registration, Patient Search, File Tracking, Patient Management, Notification, Milestones, Assessment, Treatment, Case Data, Appointment, Reminder, Report, User Management, List Management, Messaging, Prediction, Baseline Assessment, Geospatial, Login, Encounter Management, Schedule, Side Effects.

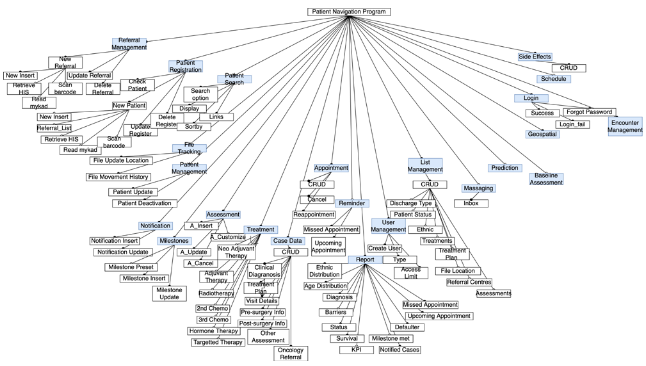

Figure 4 : Feature Model of PNP from enhanced approach in Basmmi et al. (15). This feature model is the results of reusable core assets derived from enhanced approach. Parent nodes included are the same as Figure 3 but differs in number of child nodes and sub-tree.

RESULTS

Figure 3 shows feature model from approach by Ezenwoke et al. (10) while Figure 4 shows feature model resulted from enhanced approach, Basmmi et al. (15). From booth feature models, it thus demonstrate that enhanced approach selects potential reusable core assets based on how often it is being used and how it may affect structural stability of the system if those core assets are being reused (15). Further discussion on this approach and results can be found in previous study (15).

Evaluation of FC

Approach by Ezenwoke et al. (10) resulted in 116 reusable functional features while enhanced approach, Basmmi et al. (15), resulted in 105 reusable functional features. Three different applications that uses product line core assets are set as a fixed value to present the experiment. Table I are constructed to depict components needed to perform FC evaluation and FC results of both approaches.

Table I : Result of FC for both approaches

	Ezenwoke *et al.,* (10)	**Basmmi *et al.,* (15)**
Total summation of *T/M*	98.33	97
Total number of functional features *(n)*	116	105
Result *((T/M)/n)*	0.85	0.92

T/M = number of application using ith feature / total number of application in product line scope (as stated in Equation 1)

Evaluation of MD

For MD, there are 23 core assets that depends on one another and 116 total number of core assets resulted from both approaches. Relationship between core assets are taken from feature model as shown previously. Table II are also constructed to depict components needed to perform MD evaluation and MD results of both approaches.

Results shows that 92% of FC is produced from enhanced approached by Basmmi et al. (15) and 85% of FC is produced for existing approach by Ezenwoke et al. (10). 7% increment of FC results is identified between these two approaches. Contrarily, results of MD for both approaches remains 80% and did not show any improvement. Overall percentage

Table II : Result of MD for both approaches

	Ezenwoke *et al.,* (10)	**Basmmi *et al.,* (15)**
Total number of dependent core assets (*x*)	23	23
Total number of core assets (y)	116	116
Result *(1-(x/y))*	0.8	0.8

Table III : Overall results of reusability evaluation

Reusability Metrics	**Ezenwoke *et al.,* (10)**	**Basmmi *et al.,* (15)**
Functional Commonality (FC)	85%	92%
Modularity (MD)	80%	80%

result that includes the results of FC and MD evaluation is tabulated in Table III and discussion is elaborated in next section.

DISCUSSION

Results of evaluation is compared by perceiving value of FC and MD. In terms of MD, both approaches shows same result for MD which are 80% as shown in Table III. This means that despite implementing BPFM and Trade-off Analysis, both approaches are well modularized and adhere to high cohesion and low coupling. Based on study by Choi and Soo (20), a better modularity is indicated by a value nearer to 1. If MD value is 1, then it implies that the service is self-contained and would, however, be unique since most services will have some degree of involvement in invocation and delegation types with other services.

Contrarily, result of FC for Basmmi et al. (15) is 92% which is 7% higher than result from approach by Ezenwoke et al. (10), 85%. A core assets with higher FC value yields a broader range of applicability (18). This makes the enhanced approach from Basmmi et al. (15) better than approach by Ezenwoke et al. (10) as features supplied by core assets are common to application specified in product line requirement and user preference also plays a major role in increasing reusability of core assets (17, 18).

With overall result, it is clear that with the enhancement made on existing approach by Ezenwoke (10), which are by implementing BPFM and Trade-off Analysis, reusability of core assets can be improved in terms of FC. Even both approach shows same result of MD, approach in Basmmi et al. (15) offers a more reusable core assets with high value of FC. This helps to lower effort and time for system development as it promise easy adaption due to high commonality of core assets.

With a high value of FC and MD, it shows a promising approach to facilitate the development of system. In developing a new PNP to widen the implementation of it in Malaysia, enhanced approach in Basmmi et al. (15) is suitable to be performed. This is because it shows a great result in improving reusability of core assets as well as enabling a systematic reuse and runtime flexibility which leads to cost-effective and time-efficient development as the system did not have to be developed from scratch.

CONCLUSION

In conclusion, core assets derived from approach by Basmmi et al. (15) promise a higher reusability compared to core assets derived from approach by Ezenwoke et al. (10). The core assets of PNP is being evaluated by implementing reusability metrics of FC and MD by Ali (17). A comparison of results from approach by Ezenwoke et al. (10) and enhanced approach by Basmmi et al. (15) is made. The outcome serves as the basis for determining whether the core assets is quality enough to be reused or not. As a result, the development of a new PNP will comprises of more reusable core assets with a short product's time to market in a cost effective way. From the case study, it was found that the enhanced approach in Basmmi et al. (15) can improve the reusability of identified core assets with 7% increase from Ezenwoke et al. (10) but the same MD results for both, thus implies that the reusability can be improved with a comprehensive approach of development. As a future work, a continuation of Domain Design phase will be carried out to design a reference architecture using the identified core assets.

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REFERENCES

1. Freeman HP, Rodriguez RL. History and principles of patient navigation. Cancer. 2011;117(15):3537-3540.
2. Raich PC, Whitley EM, Thorland W, Valverde P, Fairclough D. Patient navigation improves cancer diagnostic resolution: An individually randomized clinical trial in an underserved population. Cancer Epidemiology Biomarkers and Prevention. 2012;21(10):1629–1638.
3. Akhtar U, Khattak AM, Lee S. Challenges in managing real-time data in health information system (HIS). Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics). 2016;9677:305–313.
4. Suvelayutnan U. Reusable Patient Navigation Software Architecture using Software Product Line Approach. Master of Philosophy Dissertation, Universiti Teknology Malaysia. 2018.
5. Kang D, Baik DK. Bridging software product lines and service-oriented architectures for service identification using bpm and fm. In 2010 IEEE/ACIS 9th International Conference on Computer and Information Science. 2010;755-759.
6. Mohabbati B, Asadi M, Gasevic D, Lee J. Software Product Line Engineering to Develop Variant-Rich Web Services. Web Services Foundations. 2014;535-562

7. Castelluccia D, Boffoli N. Service-oriented product lines. ACM SIGSOFT Software Engineering Notes. 2014;39(2):1–6.
8. Achour I, Labed L, Ghezala HB. Proposition of secure service oriented product line. In 2015 6th International Conference on Information Systems and Economic Intelligence (SIIE). 2015;52-59.
9. Gomaa H, Hashimoto K. Dynamic software adaptation for service-oriented product lines. In Proceedings of the 15th International Software Product Line Conference. 2011;2:1-8.
10. Ezenwoke A, Misra S, Adigun MO. An approach for e-commerce on-demand service-oriented product line development. Acta Polytechnica Hungarica. 2013;10(2):69-87.
11. Da Silva IF, Da Mota Silveira Neto PA, O'Leary P, De Almeida ES, Meira SRDL. Software product line scoping and requirements engineering in a small and medium-sized enterprise: An industrial case study. Journal of Systems and Software. 2014;88:189-206.
12. Herrera JC, Losavio F, Ordaz O. Product Line Scoping for Healthcare Information Systems Using the ISO/IEC 26550 Reference Model. Memorias Del Simposio Cientнfico y Tecnolygico en Computaciyn. 2016;33–46.
13. Schmid K. A comprehensive product line scoping approach and its validation. In Proceedings - International Conference on Software Engineering. 2002;593-603.
14. Lee J, Kang S, Lee D. A comparison of software product line scoping approaches. International Journal of Software Engineering and Knowledge Engineering. 2010;0(05):637-663.
15. Basmmi ABMN, Halim SA, Jawawi DNA. Business Process Feature Model in Identifying Potential Core Assets. KSII The 12th International Conference on Internet (ICONI). 2020.
16. Oh SH, Her JS, Kim JH, RhewSY, Kim SD. A Quality System for Evaluating Reusability of Core Assets in Product Line Engineering. Journal of Kiise: Software and Applications. 2006;33(3):277-288..
17. Ali ARS. A Framework for Evaluating Reusability of Core Assets using SPL and SOA. Doctoral dissertation, Sudan University of Science & Technology. 2018.
18. Her JS, Kim JH, Oh SH, Rhew SY, Kim SD. A framework for evaluating reusability of core asset in product line engineering. Information and Software Technology. 2007;49(7):740-760.
19. Buzurovic I, Podder TK, Fu L, Yu Y. Modular software design for brachytherapy image-guided robotic systems. In 2010 IEEE International Conference on BioInformatics and BioEngineering. 2010;203-208.
20. Choi SW, Soo DK. A quality model for evaluating reusability of services in soa. E-Commerce Technology and the Fifth IEEE Conference on Enterprise Computing, E-Commerce and E-Services, 2008 10th IEEE Conference. 2008;293-298.
21. Galster M, Eberlein A. Identifying potential core assets in service-based systems to support the transition to service-oriented product lines. 18th IEEE International Conference and Workshops on Engineering of Computer-Based Systems. 2011;179-186.
22. Khoshnevis S, Shams F. Automating Identification of Services and Their Variability for Product Lines using NSGA-II. Frontiers of Computer Science. 2017;11(3):444-464.
23. Yeoh ZY, Jaganathan M, Rajaram N, Rawat S, Tajudeen NA, Rahim N, Wahab MYA. Feasibility of patient navigation to improve breast cancer care in Malaysia. Journal of global oncology. 2018;4:1-13.