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Adaptive Information System Life Cycle: Case Study on Petra Christian University Library Adi Wibowo Informatics Department Petra Christian University Siwalankerto 121-131 Surabaya +62312983455 adiw@peter.petra.ac.id ABSTRACT developed applications. To overcome these problems there is a Petra Christian University Library faces several problems in need to determine information system life cycle that fit with PCU developing and maintaining its IS portfolio. These problems library conditions. arised from IS strategy miscalculation and then caused business strategy miscalculations too. To overcome these problems an IS life cycle that fit with PCU library conditions needs to be identified. This research proposes IS life cycle that uses principles such as incremental finding and execution, time boxed development, and knowledge management that also concerned with formation of business and IS strategy. Keywords Information system life cycle, business process management. 1. INTRODUCTION Petra Christian University Library has a software development division. This division analyses, designs, and develops PCU library information system according to the library's needs and strategic plan. Figure 1. Problems at PCU Library IS Development Process As shown in Figure 1 there are several problems faced by PCU Library IS development process such as business strategy miscalculation including IS strategy miscalculation. There was no clear analysis of strategic needs and information system environment. This caused miscalculations of PCU library business strategies [1]. These problems have caused several practical aspect problems at IS development and maintenance process. There were duplication in development efforts although the library had to cope with lack of IS staff, soon-will-be-obsolete technology platform, delays in finishing some of IS projects, and also not optimum quality of the 2. PRINCIPLES OF ADAPTIVE INFORMATION SYSTEM LIFE CYCLE Roger T. Burlton suggests ten principles of business process management [2].

Eighth principles states that every reform initiative should always be performed through a time-boxed and iterative approach. Seventh principle states that the process of change must be done from the outside in, and the sixth principle states that renewal initiatives should inspire thoughts that can be shared among people (shared insights). In the eighth principle, Roger T. Burlton stated that any improvements will results in more errors before the organization can determine what are the right processes or paths. This means that any changes must be implemented first in order to know what the errors would be. Therefore it is necessary to set a short period of execution and then the evaluation is performed. This brief period is referred to as time-boxed execution and evaluation. Period of execution should not be too long that makes the efforts to improve will be too late. Execution and evaluation process will be performed over and over again in a short period of time that make the basis for improvement efforts. The main principle is incremental finding and execution. The knowledge gained from each iteration will be used to improve the next iterations. Seventh principle states that improvement efforts should be based on particular levels. Without separation of improvement analysis in particular levels, the analysts will be stucked in "analysis paralysis". Improvement effort is initiated at the highest level, which then becomes more detailed at the next levels. The process of analysis begins by considering all stakeholders involved and pay attention to the interaction with the organization's stakeholders. Then the level of detail of process (analysis decomposition) is increased up to the level of activity. The sixth principle states that the people within the organization who change. In any improvement step, organization must obtain knowledge, understanding, and innovative solutions required by the improvement process. But without the efforts to disseminate the knowledge, the knowledge will be owned only by certain people. There needs to be an effort to record and disseminate knowledges collected in each iteration of improvement so that each iteration of improvement will be built on the knowledge gathered in previous iterations. Therefore in order to create an adaptive business environment, an organization needs an adaptive information system, and also an adaptive development process. An adaptive development process needs to adhere several criterias: 1. Both processes of forming business strategy, and information systems development process should be divided into several levels of specific detail. 2. Each level will be carried out on separate iterations, and the previous iteration is the process of analysis (or development) of a higher level than the level at the current iteration (process decomposition). 3. Any knowledge from previous iteration is used for the purpose of achieving goals of current iteration (incremental finding and execution). 4. 5. Each iteration is carried out in a short time (time-boxed) and evaluated at the end of each iteration (periodic evaluation). Any knowledge gained in each iteration must be stored in order to be utilized in the next iterations (needs knowledge management system). 3. PROPOSED ADAPTIVE LIFE CYCLE As the base of proposed adaptive IS life cycle (ISLC), this research uses 8 stages of system development life cycle as stated by Turban [3]. Eight stages of SDLC provides complete steps in planning, developing, implementation, auditing, and maintaining information system of the organization. In order to be adaptive the eight stages of SDLC needs to consider changing business environment, so several stages have to be modified to include business process planning as seen in Figure 1. Stage 2 and 3 of the SDLC are processes to establish information system design translated into seven separate stages in the proposed adaptive ISLC. In the adaptive ISLC, stage 2 to stage 8 are not only aiming to design information system, but also to form organization’s business and information system strategy. The information systems strategy implements the business strategy. Phase 4 of the eight stages of SDLC is translated into two separate stages in the adaptive ISLC, i.e. the stage 9 and 10. Stage 9 of the adaptive life cycle aims to establish a migration plan from current state of information systems into IS design that has been made at stage 7 and 8. Stage 8 will not produce actual information systems, so stage 9 is important to determine the sequence of the development of planned IS. A complete stages of adaptive life cycle is shown in Figure 2. 3.1 Stage 1: Project Initiation Project initiation is an effort to start the project. At this stage the head and members of the project are appointed. The scope of the project, as well as constraints of cost, time, and budget are established. At this stage it can also be determined the tools (software and hardware) that can be used by a team in doing their jobs. 3.2 Stage 2: Collecting Business Data and Current Information Systems Adaptive information

system life cycle begins with identifying the organization's business strategy, information systems strategy and then determines data, applications, and technology architectures necessary to implement the business strategy (stage 3-8). Once the entire set of architectures are established, information systems are developed (stages 9-10), implemented (stage 11), and maintained (stage 13). Figure 2. Information System Life Cycle Figure 3. Complete Information System Life Cycle Formulation of business strategy and information systems strategy are directed to achieve two targets suggested by John Ward [4]. Every analysis in this approach should be performed to achieve: 1. Strategic alignment. The alignment between business processes with information systems 2. Competitive advantage is to get an advantage against competitors using information systems. To establish business strategy, necessary information about internal business environment and internal information system environment are needed. Information about internal business environment are: 1. 2. Business strategy (not just business goals but the means to achieve business objectives): mission, vision, objectives, CSF (Critical Success Factor), business plan for every part of the organization. Business processes, and data entities for each processes, Functional Decomposition Diagram, Process Flow Model, Entity Relationship Diagram, Data Flow Diagram, and Activity vs Entity Matrices. The main purpose of this step is to figure out the major functions, and minor functions performed by the organization. Business function is defined as a set of activities conducted in an effort to run a business [5]. 3. Organizational environment, including organizational structure, assets and capabilities, and factors that are less visible (less tangible) such as knowledge, competencies, values, style, culture and relationships. All items can be molded into business principles that underlie all activities and strategies of the organization. 3.3 Stage 3: Identification of Business Model After all information are gathered, the next step is to identify the business model of the organization. This step is to determine clearly what the business logic of the organization without being distracted from the short term strategy, or tactics of the organization. Analysts have identified nine pillars of the business model, including value proposition, target customer, distribution channel, relationship, value configuration, core competency, partner network, cost structure and revenue model. This step is very important because the pillars identified in this step will be used as an element of subsequent analysis steps. 3.4 Stage 4: Understand Business Condition and Environment After the business model is identified, then analysis are performed to determine the condition of the organization, the external environment of business, and the organization position in the external business environment. Several tools can be used to perform the analysis such as Boston Consulting Group Matrix, Value Chain, Porter's Competitive Analysis, SWOT, and other tools. Value Network is also used to describe all outstanding assets, both tangible and intangible assets, either in the form of products or services between internal entities within the organization, or with entities outside the organization. This stage uses Value Network instead of Value Chain [6] because: 1. Linear approach of inbound to outbound logistics is strongly influenced by processes in manufacturing industry. Whereas the conditions of modern business or assets of the flow of information can come from any place, and leads to any place too. Mechanistic and linear approach of the Value Chain is no longer adequate to describe the current production process. 2. Value Chain usually represents tangible values, but in today's world intangible value is also very important for the organization. 3. Value networks can be used on various types of organizations, both profit, and non-profit, manufacturing and service industries. Value Network thus is more suitable for analyzing the flow of assets and information in various types of the organization. 3.5 Stage 5 & 6: Business Opportunities Analysis After the analysis of business environment and internal information systems, stage 5 and 6 are performed to identify the opportunities that can be utilized by the organization. Stage 5 is oriented to business targets, and stage 6 is oriented to the exchanged information both within, and with parties outside the organization. Analysis to find target-oriented business opportunity uses Balanced Scorecard (BSC), and Critical Success Factor (CSF). By using both tools, it must find: 1. Activities to be carried out by organizations that contribute directly to the achievement of business objectives. From these activities should then be determined the information, and applications needed to support these activities. 2. Activities to be undertaken by the organization to monitor and evaluate the activities from number 1. From this activity should also be

found the information, and applications necessary to support, or allow such activity to take place (enabler). The analysis of information-oriented opportunity uses Value Network diagram that was created in the second part of stage 4. By using the diagram from stage 4, two analysis are performed: 1. Value Impact Analysis. This analysis aims to find out problems, and opportunities gained from the information and assets (products, and services) received by organizations from outside entities. This analysis can help to find benefits gained by the organizations by making use of information not previously identified. 2. Value Creation Analysis. This analysis aims to determine the profits to be gained when organizations create value for other entities such as the loyalty of customers or suppliers. 3.6 Stage 7 & 8: Formulation of Business Strategy and IS Strategy These stages use simplified The Open Group Architecture Framework (TOGAF) to form business strategy and information systems strategy. The formation process of business strategy and information systems strategy begins by establishing business scenarios. Business Scenario analysis is an attempt to understand how the processes within the organization are progressed, who are involved, and requirements to be fulfilled in order to run the business scenario. Business scenario may consists of: 1. Purpose of the scenario 2. Environmental and process models: a. Description of process b. Processes are mapped to the division of work c. The flow of information 3. Actors and responsibilities: a. Human actors, roles, and responsibilities b. Computer actors, roles, and responsibilities 4. Requirement of this scenario In the PCU library, several examples of business scenarios are purchasing library materials from publishers, information dissemination process, and daily transactions of library materials. It is not required that the business scenarios reaches a certain level of detail in the initial iteration because it can be made more detail through the decomposition of business on the next iterations. After initial business scenario has describes the entire organization process, although not in complete detail, then the process continues to the stage of formation of Business Architecture. Business Architecture is a model that describes the business structures which oriented in the business process, and information technology. Business architecture consist of: 1. Organizational structure. 2. Business functions in the form of functional decomposition diagram. 3. Architecture Building Block (ABB), which consists of: a. Business Process Model. b. Architectural Model: i. Data block ii. Application block The first step in the formation of business architecture is the identification of the organizational structure, and functional decomposition diagram. By using these two information, first iteration of business process model is created. First iteration of business process model only describes high level process of the organization and then can be used to create high level data block and application block to support the implementation of the business process model. Next iterations will repeat the same steps for lower level of business scenarios. Acrhitecture building block (business process model, data block, and application block) will be revised in accordance with the details obtained from lower level business scenario. If ABB made from previous iteration is created for organizational level, next iterations will establish ABB for division level within the organization. Formulation of business scenario and architecture building block iteration is repeated until architectural models (data, application) are adequate to be developed for the organization. The process of formation of business architecture in a few iterations allow the use of creative or innovative principles that seek to answer the needs that have been identified at stage 5 and 6. At each iteration each person involved in the planning will seek to improve business processes with, or without, the involvement of information technology, and improve the architectural models that support these functions and business processes by leveraging the development of better technology. 3.7 Stage 9: Migration Planning This stage compares current application portfolio (collected at stage 2), and target application portfolio made in stage 8. From target portfolio it should be identified which applications are new applications, which applications should undergo major changes, applications that have minor changes, applications that do not need to be changed, applications which are a combination of some old applications, and applications as a fraction of the old application. The list of applications that are no longer needed from current portfolio also need to be identified. 3.8 Stage 10: Architecture Block Development Process In stage 10 the processes to develop each application block are started. The processes to develop application blocks use iterative development principles that each iteration will develop only small part of application requirements. This iterative development

process allows less revision since previous iteration was performed in short time, and the evaluation process can be done immediately. There are currently two major methods of application development that use iterative and incremental principle: the incremental model as used by the Unified Process (UP), and agile software development as used by Dynamic Software Development Model (DSDM), Scrum, and Extreme Programming (XP). These two models differ in the size of the application development iteration time. Each iteration of the incremental model like UP can take several months, while each iteration of the agile software development takes place in much shorter time, for example, during one week, two weeks, or one month. Because there is the need to be more adaptive, therefore it is decided use agile software development in the process of developing application blocks. The three methods of agile software development are Dynamic System Development Method (DSDM) [7], Scrum [8], and Extreme Programming (XP) [9]. These three methods will be analyzed to determine which method is most suitable to be applied in the library of Petra Christian University, and whether it can be linked to other stages in the overall approach of this information system life cycle. The analysis shows that: 1. All three types of method require a small number of programmers so that interaction and communication can go very intensively in the process of decision making at every stage of development. The number of programmers at Petra Christian University library amounted to no more than 5 people so PCU Library is very suitable for these methods. 2. Further analysis showed that the following conditions are not met, that is all of programmers should have qualification as senior programmers. This qualification is very important in agile software development because every programmer should be trusted to make their own analysis and design after communication with the user. The less skilled programmers will produce a design application that is not easily understood by other programmers, and not scalable. Most of PCU library programmers are students so that the lack of experiences and insights into the development processes can reduce the quality of requirements analysis, and design of the application. DSDM provides the opportunity to reduce the problems that may arise because in DSDM the process of formation of functional requirements are placed at different phases. Scrum and XP performed all analysis and design steps on the same phase (they can even be done over and over again in a day if it is required). Given the separation of functional requirements iteration, and the design and build iteration, a senior programmer can do the prototyping process to record all functional and non functional requirements along with deciding the best methods to achieve these requirements. Junior programmers then can continue to build working prototypes according to the direction of senior programmer from the previous iteration. 3. Creating development documents is often not a major concern in the agile software development. There is no requirement analysis phase, analysis, and formal design, and programmers are advised to directly contact the user, analyze the request from the user, and immediately apply it to lines of code that makes the documents are often abandoned. Although the number of documents created remains much less than the incremental model, DSDM still provide a better approach than the two other agile methods. DSDM has business studies stage, and functional model iteration stage that formally analyze and produce documents as shown in Table 1 [7]. Scrum produced backlog and documents that are essentially derivatives of backlog, and XP generates user stories and the CRCs. These documents do not show all considerations that were taken in the process of analysis and design. To solve this problem every programmer can be asked to record all considerations taken in the analysis and design process and record it in any code written. Programmers can also use automatic documents generator tools that analyze source codes and interrelationships between each component in these lines of code. Table 1. Documents Produced by DSDM Phase Documents Produced by DSDM Business Study 1. 2. 3. 4. 5. Business Area Definition Prioritised Requirements List System Architecture Definition Development Plan Updated Risk Log Functional Model Iteration 1. 2. 3. 4. 5. 6. Functional Model (including Functional Prototypes) Functional Model Review Records Non-Functional Requirements List Timebox Plans Implementation Plan Risk Log 4. 5. All methods of agile software development are using short iterations ranging from one week to one month to produce a working prototype. Interactions with the user in each iteration are very intensive. Interactions are needed to determine functional and non functional requirements, and also to perform analysis, design, and testing. These interactions are so high that the criticism that

arise for agile software development is that users who represent organizations in the team will have difficulty in doing the work for themselves. Non-IT related staffs at Petra Christian University library are relatively small in number so it will be difficult to ask one of the staff to be involved full time in the team. And also organization's representatives should be staffs that has high enough position to have insight and knowledge to make decisions, and also the authority to take decisions themselves without every time having to asking permission from the organization. DSDM gives flexibility that the iteration time length is longer than the two other methods, and the separation between functional model phase and design and build phase allows reduced interaction with the user. All agile software development methods require that there are no interruption in the development iterations. Interruptions will disrupt the whole iterations' schedule, and for DSDM it can even disturb the whole project. Interruptions that may occur in the case of Petra Christian University library are data requests from the other PCU departments, and development of applications that previously have not even become a priority. To overcome this problem the library have to make a commitment that the development of new applications that previously have not been a priority to be carried out after a project is completed. And the library also have to create a tool that can be used by data processing division to provide data requested by other PCU departments without the need to involve the division of Software Development again. By considering these five points of analysis, it was decided that Dynamic Software Development Method (DSDM) is more appropriate for the conditions in Petra Christian University library. DSDM consists of five phases, coupled with a preliminary phase (pre-project), and the closing phase (post-project). The fifth phase is a feasibility study, business study, functional model iterations, design and build iterations, and implementation. Feasibility study and business study phases have already been completed in stage 7 and 8 (formulation of business strategy and information systems strategy). Business area definition and system architecture definition that should be the products of the business study phase of DSDM has been produced in stage 8 as an architectural model. Each building block in the architectural model has described functions and business processes that must be met by the block, the parties involved (the divisions, and their responsibilities), the data architecture required to support the block (including operations on data - CRUD), and other applications that cooperate with the application block. What has not been generated from stage 7 and 8 compared with DSDM phases is a development plan for each building block. Development plan is the result of the planning process that try to identify which prototypes needed to produce a working prototype. As with all methods of agile software development, the development process using prototypes that were developed in short iterations, and always get a review from the user. At the end of the development the working prototype gained acceptance from the user after going through the testing process. By using this method the user is always involved in every aspect of working prototype from requirements analysis, design, and testing. In the early of stage 10 development plan is formulated. The objectives of formulation of development plan are: 1. Determine prototypes development priorities. 2. Identify the categories of prototypes necessary for the building block, and when the apropriate time to build them. 3. Decides the mechanism to determine when the prototype development activities should be stopped. 4. Determine individuals responsible in each development iteration. Once the development plans are established then the iterations are conducted to produce functional prototypes and working prototypes. There are two types of iterations, i.e. functional model iterations, and design-and-build iterations. Functional model iterations are intended to produce documents and functional prototypes that defines the functional requirements, and non- functional requirements. Design -and- build iterations aims to implement functional prototypes to become working prototypes with high development standards specified in the coding principles. In the iterations all of non-functional requirements should also be met such as security issues, and performance. DSDM also support the implementation of development projects management unlike Extreme Programming (XP). Extreme Programming has a development principle "what can be done tomorrow, do not do this now". It underlies every iteration of Extreme Programming so that user stories that have not been planned to be implemented will be stored and should not be considered in current development process, until finally the user story development schedule arrives. This results in no one can say when the entire project

will be completed. On the other hand DSDM must determine when the entire project must be completed through the outline plan, and when each iteration must be resolved through the development plan, and when the activities will be finished in each iteration through the timebox plan. The differences with traditional project management are the traditional project management establishes in exact detail all activities needs to be done, resources that must be provided, and the risks that must be addressed from the beginning of the project, even when the project has not been started yet. DSDM project management support incremental principle. At the beginning of the project sufficient detail are established so that the project can be started. If in the process more complete and detailed information are obtained (for example: protoype, and functional requirement) the project will be adjusted. If in an iteration not all requirements are expected to be completed, then the requirements that are not a must-have requirements (which are: should-have, could-have, and want-to-have-but-will-not- have-this-time) can be moved to the next iteration. At the end of each design-and-build iteration the testing is always performed to check whether working prototypes has met the functional and non functional requirements. By using this approach then at the end of each iteration there are always new parts of product added without having to wait for the end of the project. Thus the user can trust the progress of the project better, and ensure that the end results will be in accordance with expectations. After the development project for the building block (stage 10) is completed the life cycle return to stage 9. At stage 9 it needs to be determined what subsequent building block need to be developed according to development map that has been made previously. If all the building blocks necessary for implementation have been developed, then the life cycle can enter the stage 11 (implementation). 3.9 Stage 11: Implementation Stage 11 converts old system into newly developed system. There are three ways that the organization can use to migrate from old system to new system. In the Parallel conversion old and new systems operate together during testing. When the new system considered to be stable and able to replace the old system, then the old system is stopped. In the Direct Cutover the old system is stopped and new system put into effect right away. This approach is most rapid, but also have the greatest risk. In Pilot Conversion the new system is implemented only in some divisions or branches. This approach is similar to the direct cutover on a particular branches, but for overall system it is like parallel conversion. 3.10 Stage 12: Operation and Post Audit Stage 12 is the stage where the entire information system has been implemented, and begin to be used in daily operations by the organization. At this stage post audit is performed to evaluate the performance of the whole process of IS development process from stage to stage 1-11. 3.11 Stage 13: Maintenance As can be seen in Figure 3 maintenance process uses chain of process that like a life cycle itself. It is advised to use maintenance process only to change bug fixing request, or minor enhancement, and not to change applications by requests that involves major changes in business process. Each maintenance request will be classified to determine if it is a correction request (bug fixing) or enhancement request. Each request then analyzed to determine modification impact, alternative solutions, tests plan, and implementation plan. Maintenance team designs and develops changes needed by the application, tests the changes, and implements it to the organization. Figure 4. Maintenance Process 3.12 Knowledge Management System Incremental finding and execution principle used in this approach needs that every knowledge gathered are stored to be used in the next iterations. To do this the organization needs knowledge expert to guide in knowledge capture process, decides formats suitable to store knowledge, create knowledge representations and knowledge base, tagging, and build knowledge taxonomy. This process will be addressed in future researchs. 4. CONCLUSION This study propose to expand 8 stages of SDLC into information system life cycle suitable to Petra Christian University Library. The information system life cycle uses principles such as incremental finding and execution, time boxed development, and knowledge management to record all knowledge gathered throughout the process. For PCU Library it is advised to use DSDM as a software development method with several modifications. 5. REFERENCES [1] Wibowo, A. 2009. Faktor-faktor yang Mempengaruhi Kemampuan Sistem Informasi Beradaptasi Terhadap Perubahan Strategi Bisnis Organisasi: Perpustakaan Universitas Kristen Petra, Design and Application of Technology. Surabaya [2] Burlton, R. T. 2001, Business Process Management : Profiting from Process, Sams Publishing [3] Turban, E., McLean, E.,

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