Process Centric Business Case Analysis for Easing Software Project Management Challenges

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***Abstract*—Software Project management involves coordinating various aspects of a project in order to bring forth a positive result. There have been increasing challenges faced by Project Managers. The major challenges of project management include unrealistic deadlines, communication deficit, uncertain dependencies, failure to manage risk and invisibility of the intermediate products. Meeting these challenges is very difficult and in many cases they are not met which eventually leads to the project failure. This situation is even worse where project dispersion is high. Different studies reveal that an IT project is more likely to be unsuccessful than successful and 7 out of 10 IT projects fail in some respect. The process centric work breakdown structure (WBS) can play a very vital role in this regard to improve the situations significantly. Instead of work breakdown structures as a tree, the proposed process centric WBS takes whole software production process and splits whole process into smaller process units which take right set of inputs with the right set of standard, put right set of practices in place that eventually produce the work products with required standards and quality. This process centric work breakdown structure helps Project Managers plan, estimate, monitor, and control the project activities in greater accuracy and efficiency. In this article, Business Case Analysis phase of software projects has been taken as an example to demonstrate process centric concept of WBS to deal with project management challenges.**

***Index Terms*— Work Breakdown Structure, Project management challenges, Process centric Work Breakdown Structure, Work products, Project dispersion, and Process dependency.**

I. Introduction

Software project management encompasses the knowledge, techniques, and tools necessary to manage the development of software products. Over the past five to ten years, there have been increasing challenges faced by Project Managers. The major challenges of software project management include estimation, planning and scheduling, progress monitoring, and control [1]-[3]. A number of studies were conducted by the different study groups around the globe which provide the failure statistics of software projects which is really alarming. The Robbins-Gioia Survey (2001) reveals that 51% of ERP implementation was unsuccessful [4]. The Conference Board Survey (2001) finds that 40% of the projects failed to achieve their business case within one year of going live [4]. On the success side, the average is only 16.2% for software projects that are completed on-time and on-budget. The OASIG Study (1995) indicates that 7 out of 10 IT projects "fail" in some respect [4], [5]. One of the major causes of Software project failure is the high degree of estimation error. The estimation error significantly increases for distributed projects[6]. Distributed software development is becoming more and more common as a development strategy. Even in high process maturity environments, dispersion significantly reduces development productivity and has effects on conformance of quality, and these negative effects of dispersion can be significantly mitigated through deployment of structured software engineering processes [6],[7].

A work breakdown structure (WBS) in project management and systems engineering is a tool used to define and group a project's discrete work elements (or tasks) in a way that helps organize and define the total work scope of the project [8]-[10]. The traditional tree form representation of WBS is not giving the complete visibility about the different production steps, their work products, the complete linkages and dependencies, the scope of parallelism in the production steps, and the coordination and communication effort. Therefore, the traditional WBS cannot ease the complexity of project management further. On the contrary, our proposed process centric work breakdown structure can play a significant role to address these limitations. The objectives of this article are:

1. To review and identify the major challenges of software project management.
2. To describe the concept of process centric work breakdown structure and describe its strengths and weaknesses in comparison to Tree form WBS to address prevailing project management challenges.
3. To demonstrate the concept with Business Case Analysis as an example of process centric work breakdown structure.

II. Problem Statement

To achieve the major objectives of this article stated in the previous section, literature has been reviewed to understand major challenges of software project management, software failure statistics and their underlying failure reasons, concept of WBS and its role

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to support major project management challenges such as estimation, monitoring, control, and risk management. To deal with these challenges, we propose process centric WBS. The underlying concept of process centric WBS is to discretize the production process to define work products up to the optimum level. This discretization will better enable the project manager to estimate, monitor, control, and improve project activities to achieve desired goals.

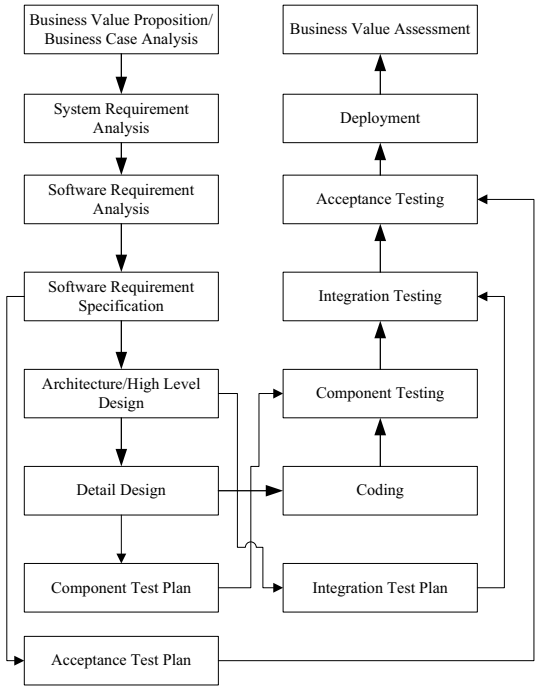

Figure 1. Software production process

A typical software project starts with the setting up of target business value and ends with the business value assessment during the implementation and usages of the product over the years. The Fig. 1 depicts the typical software production process expected to be covered by project management activities. The achievable business value has to be determined at the very beginning of the project. The project has two main roles which are current and future. The current role of project is to complete the project in estimated time and money and the future role of the project is to deliver the customer maximum return on investment (RoI). Although the importance of business value has been reported very well, but the process to carry out business case analysis has hardly been reported. Therefore, this work focuses on spelling out such an important step of software projects into the process centric description of WBS for clarifying our proposed concept.

III. Literature Review

A. Concept of Work Breakdown Structure

The Work Breakdown Structure (WBS) was initially developed by the U.S. defense establishment, and it is described in Military Standard [11] as "a product oriented family tree composed of hardware, software, services, data and facilities. It displays and defines the product(s) to be developed and/or produced and relates the elements of work to be accomplished to each other and to the end product(s)". The CMMI also defines WBS as a product-oriented hierarchical structure [7], [12]. A work breakdown structure, in project management and systems engineering, is a tool used to define and group a project's discrete work elements (or tasks) in a way that helps organize and define the total work scope of the project [3], [5], [6], [8], [9]. A well-organized, detailed WBS can assist key personnel in the effective allocation of resources, project budgeting, procurement management, scheduling, quality assurance, quality control, risk management, product delivery and service oriented management [10]-[13]. But traditional work breakdown structure will not be able to define the total scope of the project accurately and specifically as it does not take production process into consideration. The tree structure work breakdown will simply consider the total work scope in a sequential way. But practically this doesn't happen. How much parallelism can be brought into production process, how many resource can be loaded and when, what could be the waiting time due to dependency should also be considered. The coordination and communication need has to be determined and estimated. Otherwise the main purpose of WBS in estimation, scheduling, and controlling will not be met. These are examples of main limitations of Tree form representation of WBS.

As part of the project management planning process it is important to create a work breakdown structure (WBS). This structure groups and organizes deliverable project elements so that the work can be more easily managed. WBS relates to scope definition that helps characterize the total scope of the project leading to a successful end product. The WBS also helps to verify a common team understanding during project management. The WBS can be presented in the form of a chart but should not merely be a loose-fitting list of work activities for the project. Because projects can be similar in their development, it might be helpful to create a template to use as a point of initiation to keep in mind that the WBS is not a one size fits all document and that each project should be organized based on its own unique requirements for success.

B. Role of WBS in estimation, scheduling, monitoring and controling

The reason for using a WBS in projects is to help with assigning responsibilities, allocating resource, monitoring the progress, and controlling the project. This also allows for better estimation of cost, risk, and time because one can work from the smaller tasks back up to the level of the entire project [13]-[16]. But practically this is also very difficult to be met in traditional work breakdown structure. In traditional work breakdown structure, it is not specified what would be inputs for a particular work package and from where one is getting those, what would be the outputs from that work package and who will be using those. That means dependencies and linkages are

absent in traditional work breakdown structure which will significantly limit the capability of allocating project resource, monitoring the execution and controlling the project. In tree form WBS representation, the communication and coordination aspect is completely missing.

The main purpose of Work Breakdown Structure is that firstly, it helps to define and organize the scope of the total project accurately and specifically. The most common way of doing this is by using a hierarchical tree structure. Each level of this structure breaks the project deliverables or objectives down to more specific and measurable chunks. The second reason for using a Work Breakdown Structure in projects is to help with assigning responsibilities, allocating resource, monitoring the progress, and controlling the project. The WBS makes the deliverables more precise and concrete so that the project team knows exactly what has to be accomplished within each deliverable. This also allows for better estimation of cost, risk, and time because you can work from the smaller tasks back up to the level of the entire project. Finally, it allows one double check all the deliverables' specifics with the stakeholders and make sure there is nothing missing or overlapping [17]-[19].

One of the main reasons for Software Project failure is the high degree of estimation error. Each project has high degree of uncertainty (variability) in software cost estimation [20],[21] which may risk the project very high. Many models such as COCOMO primarily use the number of source lines of code (SLOC) as the basis for effort estimation. An alternative metric for SLOC is function points (FPs), where the FP is the product of the number of function counts and the processing complexity adjustment [22]-[24]. The COCOMO II model, which is the current version of COCOMO, uses 17 effort multipliers and five scale factors to estimate development effort based on project size [21],[23]. But, in most of the cases these turn out insignificant and which eventually leads to high degree of estimation error. The basis for this estimation is the traditional WBS where communication and coordination effort is absent or insignificant and consideration of uncertainty is insufficient.

C. SW-CMMI software production process framework

The "CMMI Framework" is the basic structure that organizes CMMI components, including common elements of the current CMMI models as well as rules and methods for generating models, their appraisal methods (including associated artifacts), and their training materials. The CMMI framework was developed using a consensus-based approach to identifying and describing best practices in a variety of disciplines. Successful process-improvement initiatives must be driven by the business objectives of the organization [16].

The SW-CMMI does not recommend any single production process. The SW-CMMI has defined its process framework in different process areas. These process areas can be grouped into four categories:

- Process Management
- Project Management
- Engineering
- Support

Although the process areas are grouped in this way, but they often interact and have an effect on one another regardless of their defined group. The Software Production process is mainly related to the Project Management Process Areas and Engineering Process Areas. The major Project Management process areas of CMMI include:

- Project Planning
- Project Monitoring and Control
- Risk Management

The basic Project Management process areas address the basic activities related to establishing and maintaining the project plan, establishing and maintaining commitments, monitoring progress against the plan, and taking corrective action. The Engineering process areas have been written to support recursion throughout the product architecture. The Support process areas have different goals and for meeting those goals need to perform different practices and eventually produce different work products. But, these are not aligned to single production process. This is the big limitation of CMMI production process framework.

IV. Concept Of Process Centric WBS Representation

The process centric work breakdown structure is different from the traditional tree structured work breakdown structure. Here, total production process is broken down into smaller process units. Each process unit takes a set of inputs with the right set of standards. A right set of practices has to be put in place that will produce work products with expected standards. One output work product will be the input to one or multiple process units. Before going to be input to the other process units, the compliance of work products with appropriate standards is ensured so that it can't cause any harm such as entry of defects for the next outputs. All the process units are linked together which ultimately complete the production process. The Fig. 2 depicts a typical process unit. To complete a process, a set of practices has to be performed. Quality of the produced work products has to be ensured before using as input to the other process unit through verification and validation.

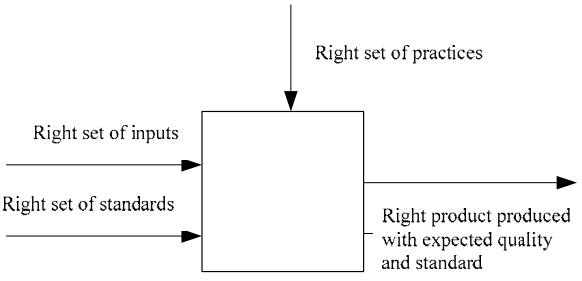

Figure 2. WBS process unit

The high maturity software companies uses the SW-CMMI as the reference of project development and management. But, the SW-CMMI does not recommend

any single production process which can be brokendown into the small process units and the work can be performed. Rather, it defines and recommends a number of process areas. All the different process areas have different goals and meeting those goals need to perform different practices and eventually produce different work products. But, these are not aligned to single production process. So, doing this is very challanging and critical which sometimes leads to the project failure. The process centric representation and practice of software production can significantly improve the situation.

V. Generic WBS Vs Process Centric Production Process

The proposed processs centric software production enforces execution of the software production activities along the way of software project management following production process flow in managed and controlled way. Total production process is broken down in a number of process units and these are logically linked together.

The process centric Work Breakdown Structure groups and organizes deliverable project elements so that the work can be more easily managed leading to a successful end product. But, traditional tree structure WBS cannot ensure that as it does not consider the production process.

The Work Breakdown Structure in projects is to help with assigning responsibilities, resource allocation, monitoring the project, and controlling the project. The WBS makes the deliverables more precise and concrete so that the project team knows exactly what has to be accomplished within each deliverable. This also allows for better estimation of cost, risk, and time. It allows Project Manager double checks all the deliverables' specifics with the stakeholders and make sure there is nothing missing or overlapping. But practically this is also very difficult to be met in traditional work breakdown structure. In traditional work breakdown structure, it is not specified what would be inputs for a particular work package and from where one is getting those, what would be the outputs from that work package and who will be using those. That means dependency and linkage is absent in traditional work breakdown structure which will significantly limits success of project resource allocation, monitoring and controlling the project.

VI. Process Centric Representation Of Business Case Analysis

The business case analysis is the very first step of software production process. But, usually this is ignored and not conducted. The SW-CMMI has also not addressed business case analysis in its recommendation. Therefore, the defects are entered in the very early stage of the project and which risk the project to be successful.

The business case analysis starts from a business idea or a set of business goal taking as input and ends in producing validated system requirements as output. The Fig. 3 depicts the typical process centric work breakdown structure of Business case analysis framework which has been detailed in Fig. 3a through 3f. Here, only the main process units are considered. The review and verification of work products have been omitted to keep it simple. Each process unit or work package needs to perform some specific practices to produce the desired work product. Some standard and templates have to be put in place to produce the right quality of work products. Some measurement framework has also to be put in place so that effectiveness of the process and quality of the product can be assessed, controlled and improved.

For conducting business case analysis six high level practices (a-f) need to be performed as shown in Fig. 3.

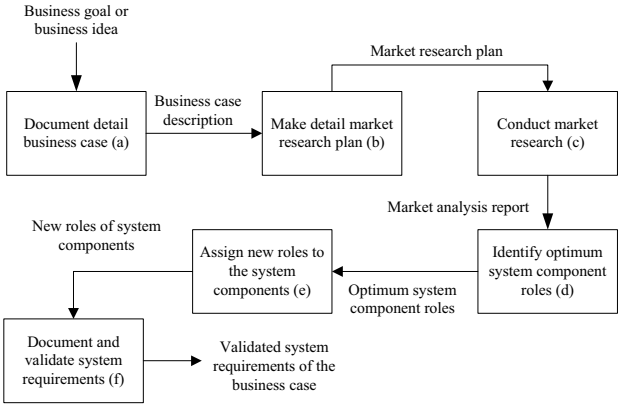

Figure 3. Process Centric Representation of Business case analysis (high-level)

The very first step is to document the conceived business case taking the business goal or business idea as the main input. For doing this, four practices are required as depicted in Fig. 3a. Out of four practices two can be performed parallel which will allow more work distribution and resource loading. This step produces business case description which is input to the first practice of the second step.

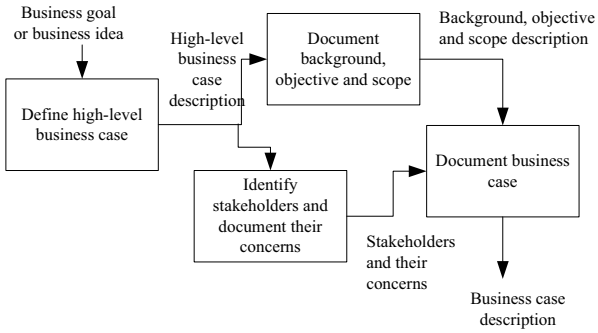

Figure 3a. Step 1 – Documentation steps of detailed business case analysis

The second step of business case analysis is to conceive a suitable market research plan as depicted in Fig. 3b. Here six practices need to be performed to produce an effective and efficient market research plan. The degree of parallelism of this step is very high which becomes sometimes very crucial for the success of the project.

The third step of business case analysis is to conduct the market research based on the market research plan as shown in Fig. 3c. A number of practices need to perform in this step which varies based on the number of

participants. This step eventually produces a detailed market analysis report.

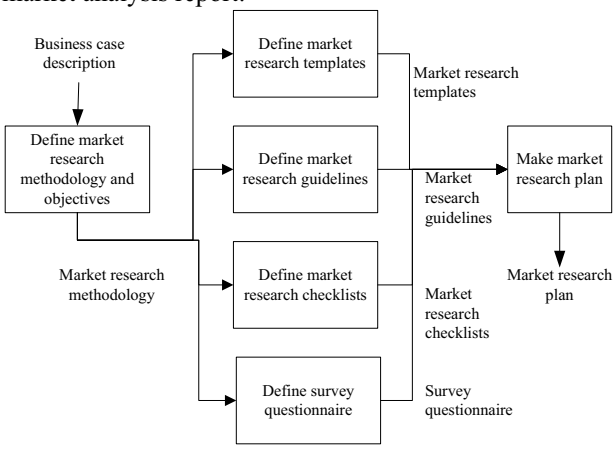

Figure 3b. Step 2 – Major steps of market research plan

The fourth step of business case analysis is to identify optimum roles of system components as depicted in Fig.3d by taking market analysis report as an input. The system component includes process (policy, procedure and standard), people, hardware, software, communication link and database. By changing the roles of these system components different performance can be obtained for a system. So, it is very important to optimize the roles of the system components to get maximum performance or benefits by incurring minimum costs in terms of time, effort and money.

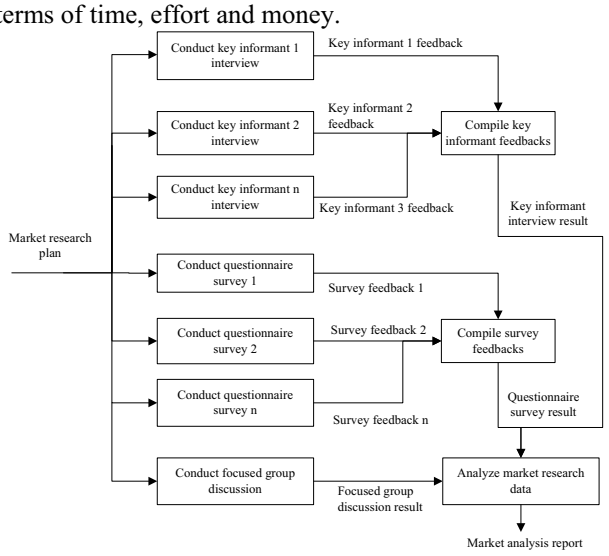

Figure 3c. Step 3 – Process of conducting market research

The fourth step is very important step of the business case analysis. In this step, a number of practices are performed including documenting current functional capabilities, developing process model, identifying current system components' roles and taking process performance measurement. The degree of parallelism of this step varies based on the number of process models, system component roles, performance measurements are considered. This step eventually produces optimum roles of the system components.

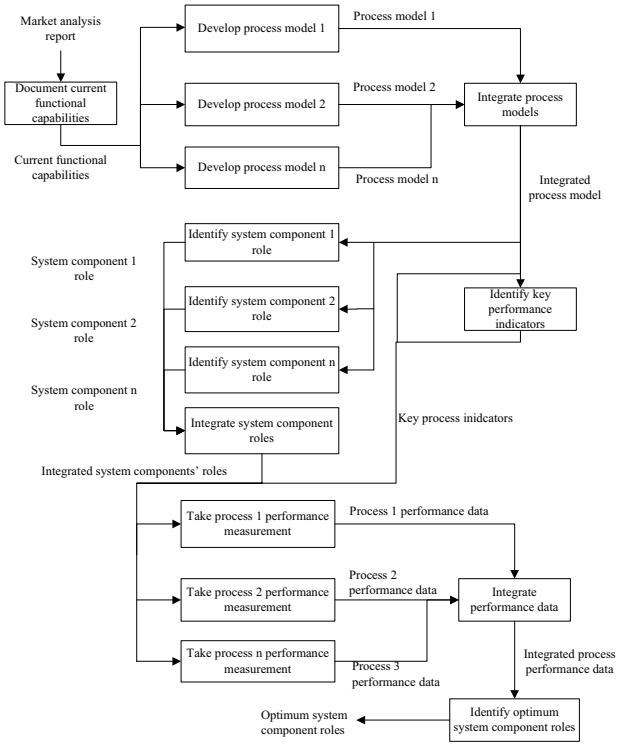

Figure 3d. Step 4 – Steps for identification of optimum system components' roles

In the fifth step of business case analysis, new roles of the system components are defined. In this step, by taking optimum system component roles and market analysis report as input and performing a number of practices, as shown in Fig. 3e, new roles of the system components are defined.

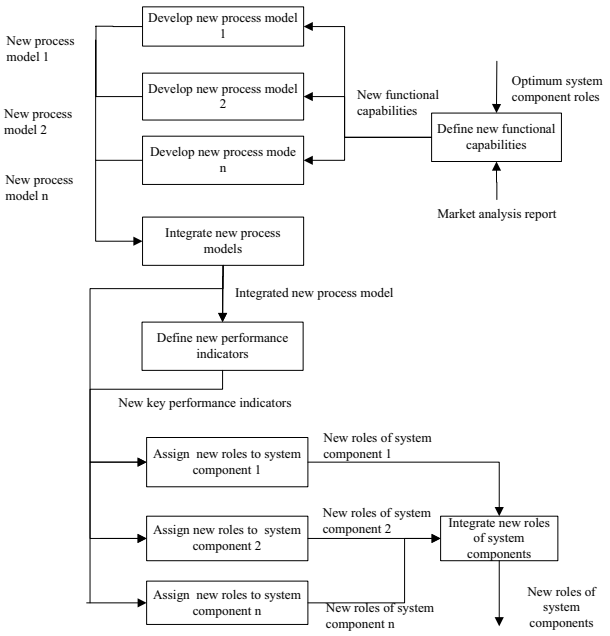

Figure 3e. Step 5 – Steps to assign new roles to system components

In this step a number of process models are developed by taking the input of new functional capabilities. By taking into consideration of the process models and new

performance indicators new roles are assigned to the system components.

The sixth and last step of the business case analysis is to document and validate the system requirements of business case as shown in Fig. 3f. Here new roles of the system components are taken as input to perform some prototypes and validate the requirements with the relevant stakeholders. The outcome of this step as well as of business case analysis process is validated system requirements. This is most likely to be the input for the software requirement engineering.

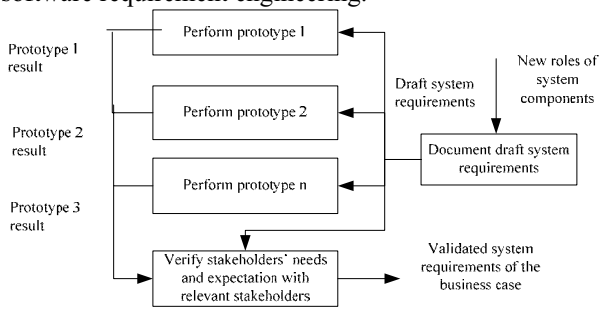

Figure 3f. Step 6 – Process of document and validation of the system requirements

The Fig. 3a-3f represents the complete linkages and dependencies among the different work products and practices of business case analysis. This increases the visibility of business case analysis process significantly.

VII. Practices And Work Products Of Business Case Analysis

For the successful execution of business case analysis a number of practices need to be performed. Each practice requires at least one input and which produces at least one work product. Some practices can be performed in parallel and some are in sequential manner. Increasing the parallelism is one of the main attempts of this representation of business case analysis. Some practices might require to be performed multiple times based on need and logistics availability. The practices and work products have been discussed in Table I and II.

Table I contains the detailed listing of the practices and work products for the steps of business case definition, market research plan and market research execution of business case analysis.

TABLE I.
PRACTICES AND WORK PRODUCTS FOR BUSINESS CASE DEFINITION, MARKET RESEARCH PLAN AND MARKET RESEARCH

SL No.	Practices	Frequency	Inputs (Work Product)	Outputs (Work Product)
1	Define high-level business case	1	Business goal or business idea	High-level business case description
2	Document background, objective and scope	1	High-level business case description	Background, objective and scope description
3	Identify stakeholders and document their concerns	1	High-level business case description	Stakeholders and their concerns
4	Document business case	1	Background, objective and scope Stakeholders and their concerns	Business case description
5	Define market research methodology	1	Business case description	Market research methodology
6	Define market research templates	1	Market research methodology	Market research templates
7	Define market research guidelines	1	Market research methodology	Market research guidelines
8	Define market research checklists	1	Market research methodology	Market research checklists
9	Define survey questionnaire	1	Market research methodology	Survey questionnaire
10	Make market research plan	1	Market research templates Market research guidelines Market research checklists Survey questionnaire	Market research plan
11	Conduct key informant interview	1 .. n	Market research plan	Key informant feedback
12	Compile key informant feedbacks	1	Key informant feedback	Key informant interview result
13	Conduct questionnaire survey	1 .. n	Market research plan	Survey feedback
14	Compile survey feedbacks	1	Survey feedback	Questionnaire survey result
15	Conduct focused group discussion	1	Market research plan	Focused group discussion result
16	Analyze market research data	1	Key informant interview result Questionnaire survey result Focused group discussion result	Market analysis report

Table II contains the detailed listing of the practices and work products optimum system component identification, assigning new roles to the system components, documentation and validation of the system requirements of business case analysis.

TABLE II.
PRACTICES AND WORK PRODUCTS FOR OPTIMUM SYSTEM COMPONENT IDENTIFICATION, ASSIGNING ROLES, DOCUMENTATION AND VALIDATION STEPS

SL No.	Practices	Frequency	Inputs (Work Product)	Outputs (Work Product)
1	Document current functional capabilities	1	Market analysis report	Current functional capabilities
2	Develop process model	1 .. n	Current functional capabilities	Process model
3	Integrate system component roles	1	System component role	Integrated system components' roles
4	Take process performance measurement	1 .. n	Integrated process model	Process performance data
5	Integrate performance data	1	Process performance data	Integrated process performance data
6	Identify optimum system component roles	1	Integrated process performance data	Optimum system component roles
7	Define new functional capabilities	1	Optimum system component roles Market analysis report	New functional capabilities
8	Develop new process models	1 .. n	New functional capabilities	New process model
9	Integrate new process models	1	New process model	Integrated new process model
10	Define new performance indicators	1	Integrated new process model	New key performance indicators
11	Assign new roles to system component	1 .. 6	Integrated new process model New key performance indicators	New roles of system component
12	Integrate new roles of system components	1	New roles of system component	New roles of system components
13	Document draft system requirements	1	New roles of system components	Draft system requirements
14	Perform prototype	1	Draft system requirements	Prototype result
15	Verify stakeholders' needs and expectation with relevant stakeholders	1	Draft system requirements Prototype result	Validated system requirements of the business case

VIII. METRICS OF PRACTICES AND WORK PRODUCTS OF BUSINESS CASE ANALYSIS

A metric is a quantifiable measurement of software product, process, or project that is observed, calculated, or predicted. Software measurement is the quantitative assessment of any aspect of a software engineering process, project, product, or context; it aims to enhance ones understanding and to help control, predict, and improve what one produces and how s/he produces it. The driving force of measurement is dealing with the uncertainty, complexity, productivity, quality, ROI, readability, maintainability, reliability, etc. The metric is related with the purpose of the work products and the process unit that produces that work products. The objective of business case analysis metric is to see the effectiveness of the business case analysis processes and the quality of work products.

The proposed Metrics for Business Case Analysis are shown in Table III-V against process unit or practices and work products. These tables also indicate the benefits as well as costs of practicing those metrics. These indications are all qualitative.

The practicing of metrics involves some costs. Therefore, the usages of metrics will be dependent on the scope of the project upon consideration of the RoI. However, it would be very difficult to adopt the optimum level of metrics. Some methodical approach need to be employed to determine the optimum need of the measurement for the practices and work products. Experience and expertise will be great help here. Matrices include both the process metrics and product metrics. The process metrics are applicable for the practices and the product metrics are applicable for the work products.

The Table III describes the metrics for the practices of defining business case step of business case analysis.

TABLE III.
METRICS FOR BUSINESS CASE DEFINITION PRACTICES AND WORK PRODUCTS

SL No.	Process Unit/Practice	Process Metrics + benefits/cost (H:High, M:Medium, and L:Low)	Work Product	Product Metrics + benefits/cost (H:High, M:Medium, and L:Low)
1	Define high-level business case	Quality (H/M) Manageability (M/M) Productivity (M/L)	High-level business case description	Clarity (H/M) Completeness (H/M) Readability (M/L)
2	Document background, objective and scope	Quality (H/M) Reusability (M/L) Manageability (M/M) Productivity (M/M)	Background, objective and scope description	Clarity (H/L) Completeness (H/M) Consistency (M/L) Readability (M/L)
3	Identify stakeholders and document their concerns	Manageability (H/M) Productivity (M/L)	Stakeholders and their concerns	Completeness (H/L) Readability (M/L)
4	Document business case	Quality (H/M) Manageability (M/L) Flexibility (L/M) Productivity (M/L)	Business case description	Clarity (H/M) Completeness (H/M) Consistency (M/L) Readability (L/L)

The Table IV describes the metrics for the practices of making market research plan, market research execution, optimum system components identification and assigning new roles to system components steps of business case analysis.

TABLE IV.
METRICS FOR MARKET RESEARCH PLAN, MARKET RESEARCH, OPTIMUM SYSTEM ROLES IDENTIFICATION, ASSIGNING NEW ROLES PRACTICES AND WORK PRODUCTS

SL No.	Process Unit/Practice	Process Metrics + benefits/cost (H:High, M:Medium, and L:Low)	Work Product	Product Metrics + benefits/cost (H:High, M:Medium, and L:Low)
1	Define market research methodology and objectives	Reusability (L/M) Manageability (M/M) Productivity (M/L)	Market research methodology	Clarity (M/M) Reusability (L/M) Complexity (M/M)
2	Define market research templates	Quality (H/M) Reusability (H/M) Manageability (M/L)	Market research templates	Reusability (M/H) Complexity (M/L) Consistency (L/M)
3	Define market research guidelines	Quality (H/M) Reusability (H/M) Manageability (M/L) Productivity (M/M)	Market research guidelines	Clarity (M/M) Reusability (L/M) Complexity (L/M) Readability (L/L)
4	Define market research checklists	Quality (H/M) Reusability (M/L) Manageability (M/M)	Market research checklists	Completeness (H/M) Reusability (L/M) Complexity (L/L)
5	Define survey questionnaire	Quality (H/M) Reusability (M/L) Manageability (H/M) Productivity (M/M)	Survey questionnaire	Completeness (M/M) Reusability (L/L) Complexity (M/L) Consistency (M/L) Readability (L/L)
6	Make market research plan	Reusability (M/L) Manageability (M/L) Productivity (M/L)	Market research plan	Completeness (H/M) Complexity (M/L) Readability (M/M)
7	Conduct key informant interview	Quality (H/M) Manageability (M/L) Productivity (M/M)	Key informant feedback	Completeness (L/L) Consistency (M/L) Readability (M/L)
8	Compile key informant feedbacks	Reusability (L/M) Manageability (M/M) Productivity (M/M)	Key informant interview result	Completeness (M/L) Consistency (M/L) Readability (L/L)
9	Conduct questionnaire survey	Manageability (M/M) Productivity (M/M)	Survey feedback	Clarity (M/L) Completeness (M/M) Consistency (L/L)
10	Compile survey feedbacks	Quality (H/M) Manageability (M/L) Productivity (M/L)	Questionnaire survey result	Clarity (M/L) Completeness (H/M) Consistency (L/L)
11	Conduct focused group discussion	Manageability (H/M) Flexibility (M/L) Productivity (H/M)	Focused group discussion result	Clarity (M/M) Completeness (H/M) Consistency (L/L) Readability (L/L)
12	Define new functional capabilities	Quality (H/M) Manageability (M/L) Productivity (M/L)	New functional capabilities	Clarity (M/L) Completeness (M/M) Consistency (M/L)
13	Develop new process model	Quality (H/M) Reusability (M/M) Manageability (M/L) Productivity (M/L)	New process model	Clarity (M/M) Completeness (H/M) Reusability (M/L) Complexity (M/M)
14	Integrate new process models	Manageability (M/H) Flexibility (L/L) Productivity (M/L)	Integrated new process model	Clarity (M/M) Completeness (H/M) Reusability (M/L)
15	Define new performance indicators	Quality (M/L) Reusability (M/L) Flexibility (L/M) Productivity (M/M)	New key performance indicators	Clarity (M/L) Reusability (M/L) Complexity (L/L) Stability (M/M)
16	Assign new roles to system component	Reusability (M/M) Manageability (M/L) Flexibility (L/M) Productivity (M/M)	New roles of system component	Clarity (M/M) Completeness (H/M) Stability (M/M) Consistency (M/L)
17	Integrate new roles of system components	Manageability (M/L) Productivity (M/M)	New roles of system components	Clarity (H/M) Completeness (H/M) Stability (M/M) Consistency (M/L)

The Table V describes the metrics for the practices and work products of documentation and validation of requirements steps of business case analysis.

TABLE V.
METRICS FOR DOCUMENTATION AND VALIDATION OF REQUIREMENT PRACTICES AND WORK PRODUCTS

SL No.	Process Unit/Practice	Process Metrics + benefits/cost (H:High, M:Medium, and L:Low)	Work Product	Product Metrics + benefits/cost (H:High, M:Medium, and L:Low)
1	Define new functional capabilities	Quality (H/M) Manageability (M/L) Productivity (M/L)	New functional capabilities	Clarity (M/L) Completeness (M/M) Consistency (M/L)
2	Develop new process model	Reusability (M/M) Manageability (M/L) Productivity (M/L)	New process model	Completeness (H/M) Reusability (M/L) Complexity (M/M)
3	Integrate new process models	Manageability (M/H) Flexibility (L/L) Productivity (M/L)	Integrated new process model	Clarity (M/M) Completeness (H/M) Reusability (M/L)
4	Define new performance indicators	Quality (M/L) Reusability (M/L) Productivity (M/M)	New key performance indicators	Reusability (M/L) Complexity (L/L) Stability (M/M)
5	Assign new roles to system component	Quality (H/L) Reusability (M/M) Manageability (M/L)	New roles of system component	Clarity (M/M) Completeness (H/M) Stability (M/M)
6	Integrate new roles of system components	Manageability (M/L) Productivity (M/M)	New roles of system components	Clarity (H/M) Completeness (H/M) Stability (M/M) Consistency (M/L)
7	Document draft system requirements	Quality (H/M) Reusability (M/L) Manageability (M/M) Flexibility (M/L) Productivity (M/M)	Draft system requirements	Clarity (H/M) Completeness (H/H) Reusability (L/M) Stability (M/M) Consistency (M/L)
8	Perform prototype	Quality (H/M) Reusability (H/M) Manageability (M/M)	Prototype result	Clarity (M/L) Completeness (M/M)
9	Verify stakeholders' needs and expectation with relevant stakeholders	Quality (H/M) Manageability (M/M) Flexibility (L/M) Productivity (M/L)	Validated system requirements of the business case	Clarity (H/M) Completeness (H/H) Reusability (L/M) Complexity (L/L) Stability (M/M) Consistency (M/L)

For deriving the metrics, it is needed to collect some primary data or take basic measurement. Based on these basic data usable metric is derived. The Table VI shows the data requirement for the major metrics. However, readability, clarity, complexity, effort variance and reusability can be used as a thumb rule.

TABLE VI.
DATA REQUIREMENT FOR METRICS

Metrics Names	Data Requirement	Measures
Clarity	Number of ambiguous or unclear statement. Number of sections/ pages.	No. of unclear statements per sections/pages
Completeness	Number of missing points, Number of sections/pages/documents.	No. of missing points per sections/pages/documents
Reusability	Number of reusable sections/ templates/ models/ concept/ documents. Number of reusable sections/ templates/ models/ concept/ documents.	% of reusable work products
Stability	Number of changed work products. Number of work products.	% of stable work products
Readability	Number of comments. Number of sections/pages.	No. of comments per sections/pages
Consistency	Number of inconsistency found. Number of work products.	No. of inconsistency per work product
Quality	Number of defects found. Number of sections/ pages/ work products.	Defect density
Productivity	Number of pages/documents/work products produced. Unit of Time Required/ Spent.	No. of pages/documents/work products per unit of Time

IX. Stakeholders And Communication Process In Business Case Analysis

Different stakeholders are required to be involved in the different stages of business case analysis process. These stakeholders will include but not limited to

- Customer side senior management staff
- Customers business partners
- System end users
- System engineering team

Different types of communication would be required to perform the total tasks of business case analysis:

- Formal, impersonal
  All the documentation will come under this category. This includes Business case description, Market Research Plan, Functional Capability Document, Process Model, and System Requirement.
- Formal, interpersonal procedures
  Formal meetings with defined agenda with System Engineering team members, with senior client management, progress reviews, process formulation and change etc. will come under this communication plan. Structured questionnaire survey can come under this form of communication as well.
- Informal, interpersonal procedures
  All brainstorming for identifying stakeholders, defining the research methodology, identifying the performance indicators, and identifying system element roles can come under this procedure. Key Informant interview and focused group discussion can come under this category as well.
- Electronic communication
  This can be done with all the team members and client stakeholders. This is very effective and prompt communication method. During business case analysis this can be used in different phases. This can be used for market research purpose as well.
- Interpersonal network
  This can be used to identify the business goal, key performance indicator etc. Key informant interview also can come under this category.

The communication is a very important determinant for the success of business case analysis. Therefore, well thought communication plan needs to done before execution of the business case analysis.

X. Benefits Of Process Centric Representation Of WBS Of Business Case Analysis

As stated earlier, the process centric WBS is different from the traditional tree structure WBS. In process centric work breakdown structure, total production process is broken down into small logical process units which take a set of inputs with the right set of standards and perform the appropriate set of practices to produce required work products in compliance with applicable standards. This is the main strength of process centric WBS. The process centric WBS provides a great tool to the project manager to estimate, monitor, control and improve the project activities from process perspective. Following are examples of benefits which can be achieved from process centric WBS:

1. Full production process splits into small logical process units. This ensures full process view at a glance at the planning stages.
2. Parallel process steps are clearly shown. Therefore, resource planning and resource loading will be efficient, less error prone, and easier.
3. A process unit takes quality inputs in compliance with applicable standards and performs specific practices in specified manner.
4. A process unit's or work package's task is very clear; dependency and stakeholders' engagement are clearly defined. This ensures better estimation and scoping of the project.
5. It ensures efficient management of distributed projects as communication and coordination need and overhead are clearly understood.
6. All process units are dynamically reconfigurable. The project manager would be able to choose the required process units, standards, templates and products to adjust production process based on the diverse project forces.

XI. Summary And Conclusions

The process centric WBS is a great tool for the project manager for increasing visibility. The probability of making the project successful will increase significantly due to higher visibility. The example given to clarify process centric representation of Business Case Analysis not only increases the visibility of this particular step, but also clarifies the implementation of the concept in other phases of software development.

The main challenge of this concept is to optimally discretize the production process. Too much discretization will increase the visibility. However, this will complicate communication and manageability. So, there is a need to make a balance. The measurement and review process cost time and money. Therefore, the measurement and review of process should also be optimum. The main focus should be on value creation from such process centric WBS representation and RoI of such value creation should be maximized by practicing optimum level of process decomposition.

The limitation of this concept is highly dependency on optimization of different aspects like process decomposition, applying standards, taking measurements, and applying review process. Therefore, the success of process centric WBS greatly depends on optimization.

The process representation of Business Case Analysis presented in this paper is at conceptual state and has not been applied in real life project yet. Therefore, the proposed process representation of Business Case Analysis should be validated and optimized by applying

it in several real life projects. Both the process centric WBS and tree structure WBS can be applied in the similar projects and comparative analysis can be done. This will give the more insight of process centric WBS. Moreover, further research is required to develop methodology to make proposed metrics for business case analysis measurable.

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