A Model-Based Approach to Unifying Disparate Project Management Tools for Project Classification and Customized Management

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ABSTRACT

Modern project managers are aware that different types of projects need different styles of project management. A construction project is very different from a high-tech research program in several ways, including how each is managed. The NTCP "Diamond" framework suggests classifying complex projects according to four dimensions such that the values attributed to each of these dimensions indicate a recommended style of management for increasing the likelihood of the project's success. It may be difficult to attribute values to these four dimensions in a large and complex project, which calls for systematic analysis of the project as part of its planning phase. The object–process methodology (OPM) caters to such systematic step-by-step analysis by decomposing a project into its fundamental building blocks – objects, possibly with states, and processes that transform the objects. This paper suggests that the confluence of OPM and NTCP can improve the project planning phase and improve the project's overall chances of success.

1. Introduction

Despite modern technological advances, many projects today are destined to fail. Approximately 100 years after Henry Gantt introduced the project management chart that bears his name, and more than 50 years since the introduction of the CPM and PERT techniques, projects still miss their target scope, schedule, budget, and value to the customer. Projects are central to organizational success: "Projects are the means by which all organizations accomplish business change, as well as the means by which some organizations deliver profit to their shareholders" (Cooke-Davies, 2007). In this light, the list of project failures is daunting. Recent studies conducted in the EU (Whitfield, 2007) and at Oxford University (Flyvbjerg, 2011) attest to the degree to which projects continue to fail, as well as to the fact that IT project are 20 times more prone to run out of control than other business projects, such as building, construction, and infrastructure. While IT projects are notorious for their budget and schedule overruns, evidence from other types of projects suggests that all types of projects are subject to such excesses, and deliver only partial scope.

In view of this state of affairs, what can be done to reduce project failures and increase the probability that a project will reach its goals? This paper suggests developing a project management framework that amalgamates two different methodologies into one systematic approach that focuses on the early stages of project planning. The first is the *object process methodology (OPM)* (Dori, 2002) and the second is the *NTCP* framework (Shenhar and Dvir, 2007)

2. What is project success?

“Project success” is an elusive concept. Examples of projects that were considered failures during their execution phase include Denver International Airport, the Sydney Opera House, and the production of the movie *Titanic*. Upon becoming operational, however, each of these projects was deemed to be very successful. In contrast, other projects that were managed flawlessly and met schedule, budget, and quality targets, such as the Irridium satellite phone service provider or the Los Angeles subway system, were regarded as complete failures after “going live.”

Project success has traditionally been measured against the “triple constraint” or the “iron triangle” of performance, schedule, and budget; however, this definition has proven to be partial and sometimes misleading. A project manager trying to meet the performance on time and within budget might risk producing a totally useless product that would be rejected by potential customers.

In view of the inadequacy of the iron triangle criteria, a better and more comprehensive definition of project success had to be established that considered the project’s success as it is perceived by different stakeholders, and during different phases of the project’s life cycle.

One of the recent major efforts to define project success was launched by Shenhar, Levy, and Dvir (1997). They administered questionnaires to 127 project managers representing industrial projects executed in Israel during a period of 10 years prior to the research. They identified four distinct success factors: project efficiency, customer satisfaction, business success, and future potential. Figure presents the four factors on a timeline scale.

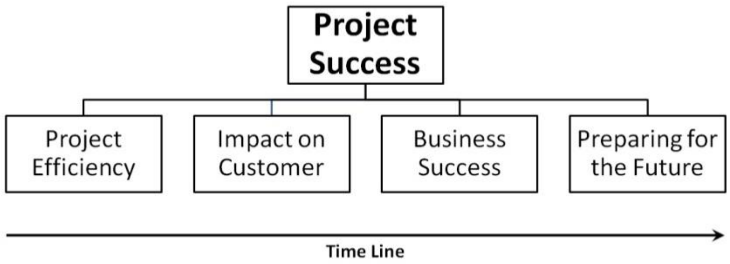

Figure 1: Shenhar, Dvir, and Levy's four dimensions of project success.

- **Project efficiency** defines whether the project was finished on time and within the specified budget.
- **Impact on the customer** relates to the customer and the end user of the product resulting from execution of the project. As Shenhar et al. noted, "Meeting performance measures, functional requirements, and technical specifications are all part of this second dimension, and not, as previously assumed, part of meeting the project plan."" From the contractor's viewpoint, Shenhar et al. consider the level of customer satisfaction and the extent to which the customer uses the product and is willing to come back for a follow-up project or to buy the next generation of this product as parts of this dimension.
- **Business and direct success** addresses the direct impact the project had on the organization (increased business, profit, efficiency, etc.).
- **Preparing for the future** relates to the project's contribution to the organization's readiness for future opportunities and challenges.

The relative importance of the four factors is time-dependent, as shown in Figure 2:

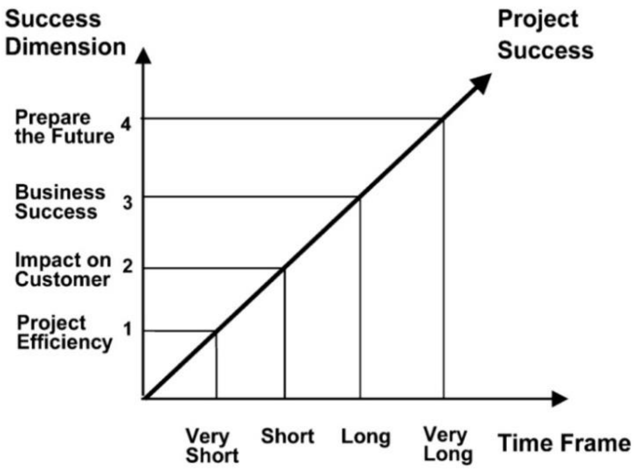

Figure 2: The relative importance of the four factors is time-dependent (Shenhar et al. 1997).

3. Success and failure factors – why do projects succeed or fail?

Defining what makes a project successful inevitably raises the question of what it takes to make a project successful. In other words, what are the “dos” and “don’ts” a manager must apply to the process of project management in order to achieve a successful outcome?

In the 1950s, during the early days of project management, scheduling was the prime success factor. As important as scheduling is, it is clearly not the only factor to influence the rate of the project success. These are known as critical success factors (CSFs).

A vital, yet controversial set of studies related to project success and failure has been produced by the Standish group since 1995. The Standish group undertook to identify the following:

- The scope of software project failures
- The major factors that cause software projects to fail
- The key ingredients that can reduce project failures

The Standish group sent 360 surveys to IT managers representing over 8000 project applications. For the purpose of the analysis, the projects were categorized into three groups:

- **Successful projects –** The project was completed on-time and on-budget, with the development cycle originally specified with all features and functions as initially specified.
- **Challenged projects** – The project was completed and operational but over budget, over the time estimate, and offers fewer features and functions than originally specified.
- **Impaired projects** – The project was cancelled at some point during the development cycle.

Table presents the critical success and failure factors for successful, challenged, and impaired projects.

Table 1: Critical success and failure factors in Standish CHAOS report, 1995.

Successful Projects		Challenged Projects		Failed Projects	
Project Success Factors	**% of Responses**	**Project Success Factors**	**% of Responses**	**Project Success Factors**	**% of Responses**
User involvement	15.9%	Lack of user input	12.8%	Incomplete requirements	13.1%
Executive management support	13.9%	Incomplete requirements & specifications	12.3%	Lack of user involvement	12.4%
Clear statement of requirements	13.0%	Changing requirements & specifications	11.8%	Lack of resources	10.6%
Proper planning	9.6%	Lack of executive support	7.5%	Unrealistic expectations	9.9%
Realistic expectations	8.2%	Technology	7.0%	Lack of executive	9.3%

Successful Projects		Challenged Projects		Failed Projects	
		incompetence		support	
Smaller project milestones	7.7%	Lack of resources	6.4%	Changing requirements & specifications	8.7%
Competent staff	7.2%	Unrealistic expectations	5.9%	Lack of planning	8.1%
Ownership	5.3%	Unclear objectives	5.3%	No longer needed	7.5%
Clear vision & objectives	2.9%	Unrealistic time frames	4.3%	Lack of IT management	6.2%
Hard-working, focused staff	2.4%	New technology	3.7%	Technology illiteracy	4.3%
Other	13.9%	Other	23.0%	Other	9.9%

4. One size does not fit all

One of the major problems arising from the attempts to relate critical success factors to projects is the underlying notion that “a project is a project is a project” and that “one size fits all.” As any manager with real-world experience will quickly point out, it is highly problematic to attempt to define universal factors that are critical to success, and it is equally misleading to expect project managers to successfully follow such guidelines.

The realization that different projects need different types of project management in order to succeed has started to sink in. During the last decade, Shenhar and Dvir’s (2007)novelty, echnology, complexity, and pace (NTCP) “diamond” framework emerged as one of the most eloquent theories for project classification. Its categorization of projects is established on initial characteristics of project, based on the four independent dimensions comprised in the NTCP acronym.

The four diamond dimensions are defined as follows:

- **Novelty** – How new the product is to the customers and to the market.
- **Technology** – The extent of use of new or even non-existing technology at the time of project initiation.
- **Complexity** – Where the project’s product is located on the scale from a simple component to an array.
- **Pace** – How urgent the project is at the time of initiation; the criticality of the project’s completion time.

Different types of projects must be planned and managed differently in order to succeed, so attempting to apply the “one size fits all” approach may lead to project failures. Project types are determined by the level of each of the four dimensions, and the combination of the four levels presents a specific profile – a type of project with specific planning and execution needs.

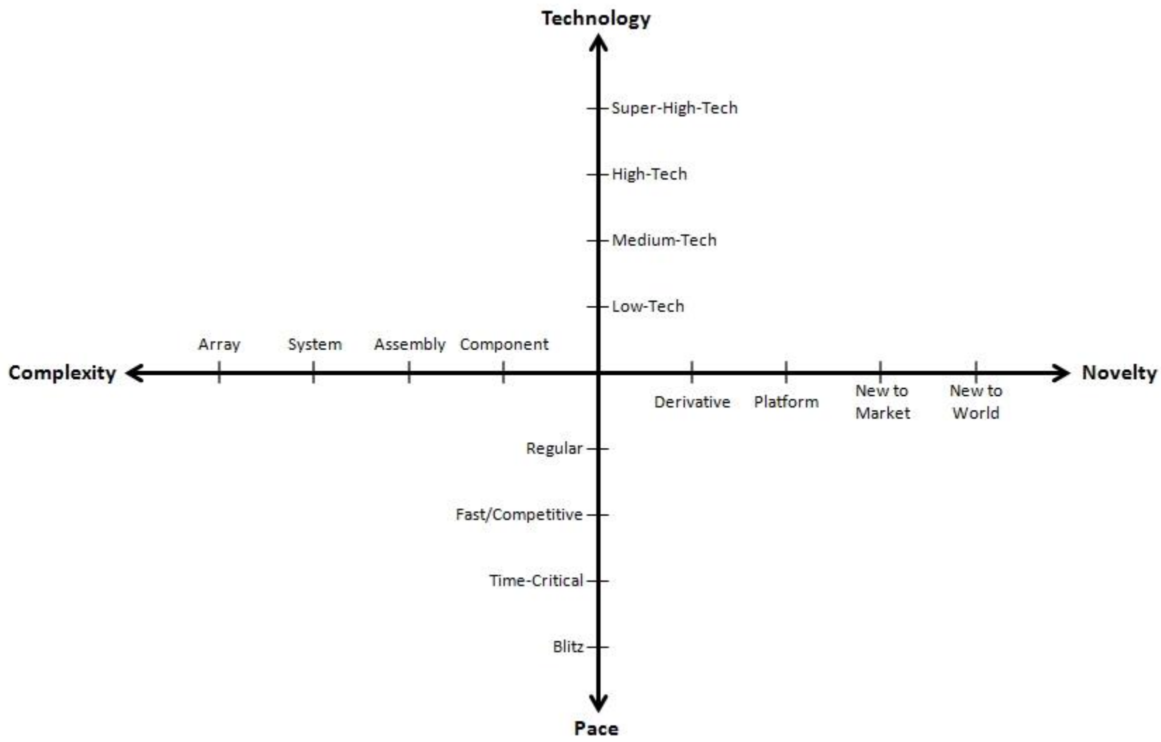

Figure 3: The four dimensions of the NTCP "Diamond" project classification.

Shenhar and Dvir (2007) proposed specific types of project management depending on the project classification as presented by the diamond. The different managerial approaches to different types of projects are a focal issue in their framework. Applying the right managerial type to a project based on its NTCP classification is expected to increase the success rate of the project and decrease the likelihood that an efficient, well-managed project will yield an unusable product. Figure illustrates the fundamental assertions of the NTCP framework.

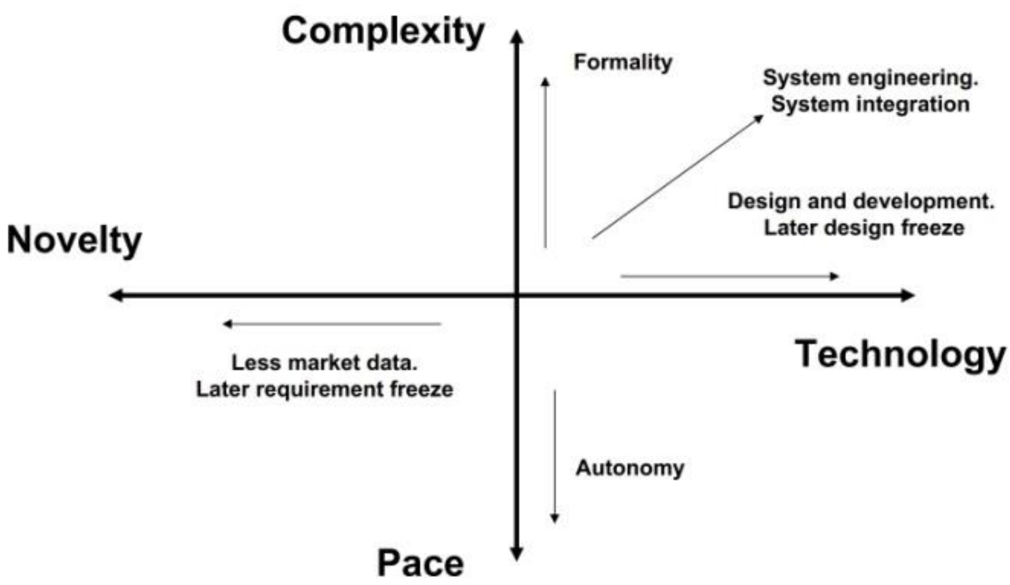

Figure 4: The influence of the NTCP dimensions on the planning and management of a project.

5. The NTCP challenge – how to correctly classify projects

As Shenhar and Dvir (2007) showed, the success of project management is highly dependent on its correct classification during the conceptual, strategic phase. The challenge is how to correctly classify the project according to the four dimensions. While the pace dimension is relatively straightforward, the other three dimensions, particularly technology and complexity, are vaguer. The NTCP framework does not specify clear-cut criteria or algorithms that might assist in performing this classification.

It seems that the correct classification of a project is highly dependent on the evaluator's experience and intuition. If the project manager is experienced, or has access to an experienced consultant, and has the right type of intuition – a highly developed "gut feeling" – then the right classification may emerge. But if the manager does not have experience or access to it, or has a misleading intuition, does this imply that the NTCP framework is challenged or, worse, might lead the project manager astray? How can the NTCP methodology be implemented in order to identify and mitigate this "risk driver," this component of a larger project that is a major contributor to the project's overall risk (Shtub et al., 2005)?

Such questions demand a complementary methodology that can help fill in the gaps left by the NTCP method with respect to: (1) evaluation and determination of the values of the four project's dimensions, and (2) evaluation of the criticality of different components within each dimension, enabling a more precise evaluation of the whole dimension.

One methodology that seems highly suitable for this task is the object process methodology (OPM) developed by Dori (2002).

6. What is OPM?

OPM is a holistic, integrated approach to the design and development of systems, especially complex dynamic systems (like projects). OPM comprises entities and links. The three entity types are objects, processes (jointly referred to as "things"), and states. Objects are things that exist and can be stateful (that is, have states). Processes transform objects: they generate and consume objects or affect stateful objects by changing their states. Objects and processes are of equal importance as they complement each other in the single-model specification of the system. Links, which are the OPM elements that connect entities, are either structural or procedural.

OPM objects relate statically to each other via structural relations, which are expressed graphically as structural links. Structural relations specify relations between any two objects. The four fundamental structural relations are aggregation–participation, generalization–specialization, exhibition–characterization, and classification–instantiation. Objects can also be structurally related to each other by unidirectional or bidirectional user-defined tagged relations. Due to the object–process symmetry, they can also specify relations between any two processes.

Conversely, procedural links connect a process with an object or an object's state to specify the dynamics of the system. Procedural links include (1) transforming links, which are effect link, consumption link, result link, and the pair of input-output links; (2) enabling links, namely agent and instrument links, and (3) control links, which comprise event, condition, invocation, and time exception links.

An OPM model consists of a set of hierarchically organized object–process diagrams (OPDs) that alleviate systems' complexity. A new OPD is obtained by refining – in-zooming or unfolding of a thing (object or process) – in its ancestor OPD. One or more new things (objects and/or processes) can be specified within a thing in an OPD that was refined from a higher-level OPD. Copies of an existing thing can be placed in any diagram, where some or all of the details, such as object states or links to other things, which are unimportant in the context of the diagram, can be hidden. It is sufficient for some detail to appear once in an OPD in order for it to be true for the system in general, even if it is not shown in any other OPD.

7. Why OPM?

OPM is a complementary methodology to NTCP because it exhibits the following features:

1. OPM is a visual methodology that incorporates the static–structural and dynamic–procedural aspects of a system into a unifying model, which is presented in its entirety using a single diagram type. This is achieved by treating both objects and processes as equally important things (entities). Using a single model at varying levels of detail is likely to avoid clutter and incompatibilities, even in highly complex systems.

2. OPM is designed to express triggering events, guarding conditions, timing constraints, timing exceptions, and flow-of-control constructs. These features are the basic elements required for exceptional behavior design.

3. OPM has proven to be an efficient methodology for modeling complex dynamic behaviors in general and temporal exceptions in particular.

4. Through its recursive seamless complexity management (scaling, or abstraction/refinement) mechanisms, OPM is highly appropriate for managing systems' complexities. There are three complexity management mechanisms in OPM: (1) unfolding/folding, which is used for refining/abstracting the structural hierarchy of a thing; (2) in-zooming/out-zooming, which exposes/hides the inner details of things within its frame; and (3) expressing/suppressing, which exposes/hides the states of an object. These complexity management mechanisms enable OPM to represent complex systems gradually.

5. OPM consists of two semantically equivalent modalities of the same model: graphical and textual. A set of interrelated object–process diagrams (OPDs) constitute the graphical model, and a set of automatically-generated sentences in a subset of English constitute the object–process language (OPL). In the graphical-visual model, each OPD consists of OPM elements depicted as graphic symbols, while the OPD syntax specifies the consistent and correct ways by which those elements can be assembled. Since the corresponding textual model is generated in a subset of English, it is immediately understood by domain experts, who do not need to learn any special language or decipher cryptic code.

6. Sharon and Dori (2009) demonstrated the superiority of OPM as a project–product modeling language over its close competitors, UML, xUML, and SysML.

In OPM terms, each of the project dimensions is an attribute of the project, and each dimension value is an OPM attribute value (in OPM, a state of an attribute is its value).

8. Project planning, scoping, and time managing – PMBOK

The process of project planning, particularly of project time management planning, as prescribed by PMBOK (PMI, 2008), is most effectively structured as shown in Figure 5.

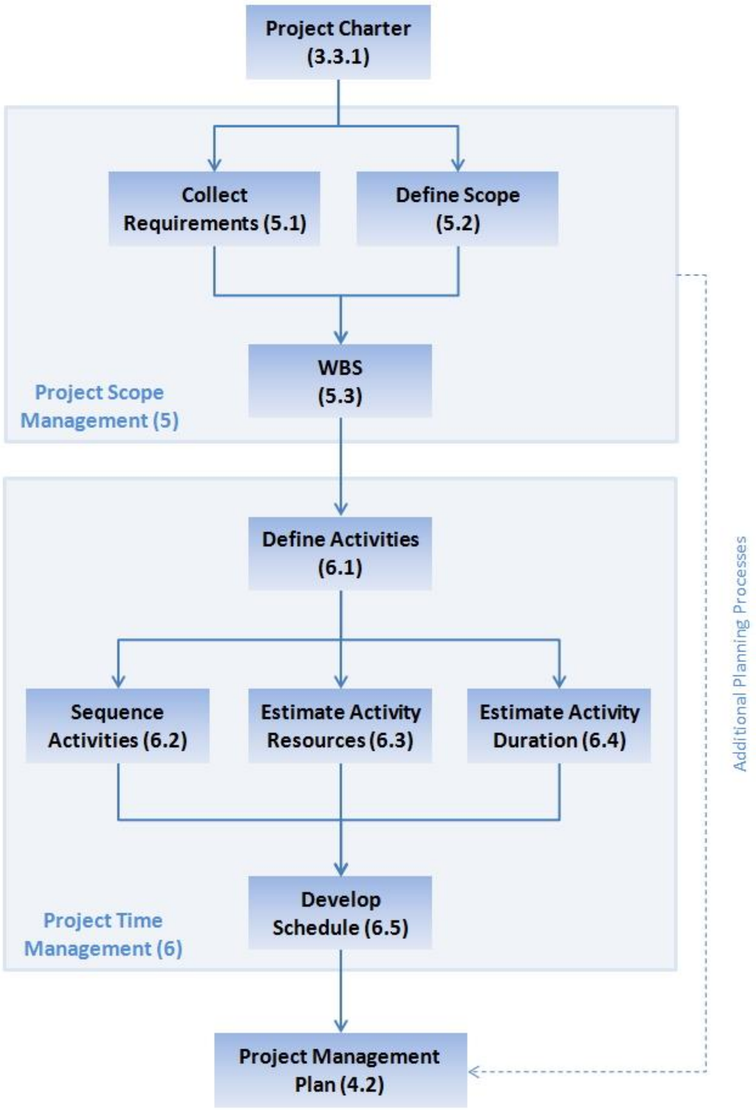

Figure 5: The project time and scope management processes.

The major shortcoming of the PMBOK time and scope management, as presented in Figure 5, is that it leaves no room for diversity between projects. Project classification does not exist, and it seems that the PMBOK promulgates the old “one size fits all” idea.

9. How can OPM and NTCP assist?

Our proposed solution integrates OPM planning and NTCP analysis, as illustrated in Figure.

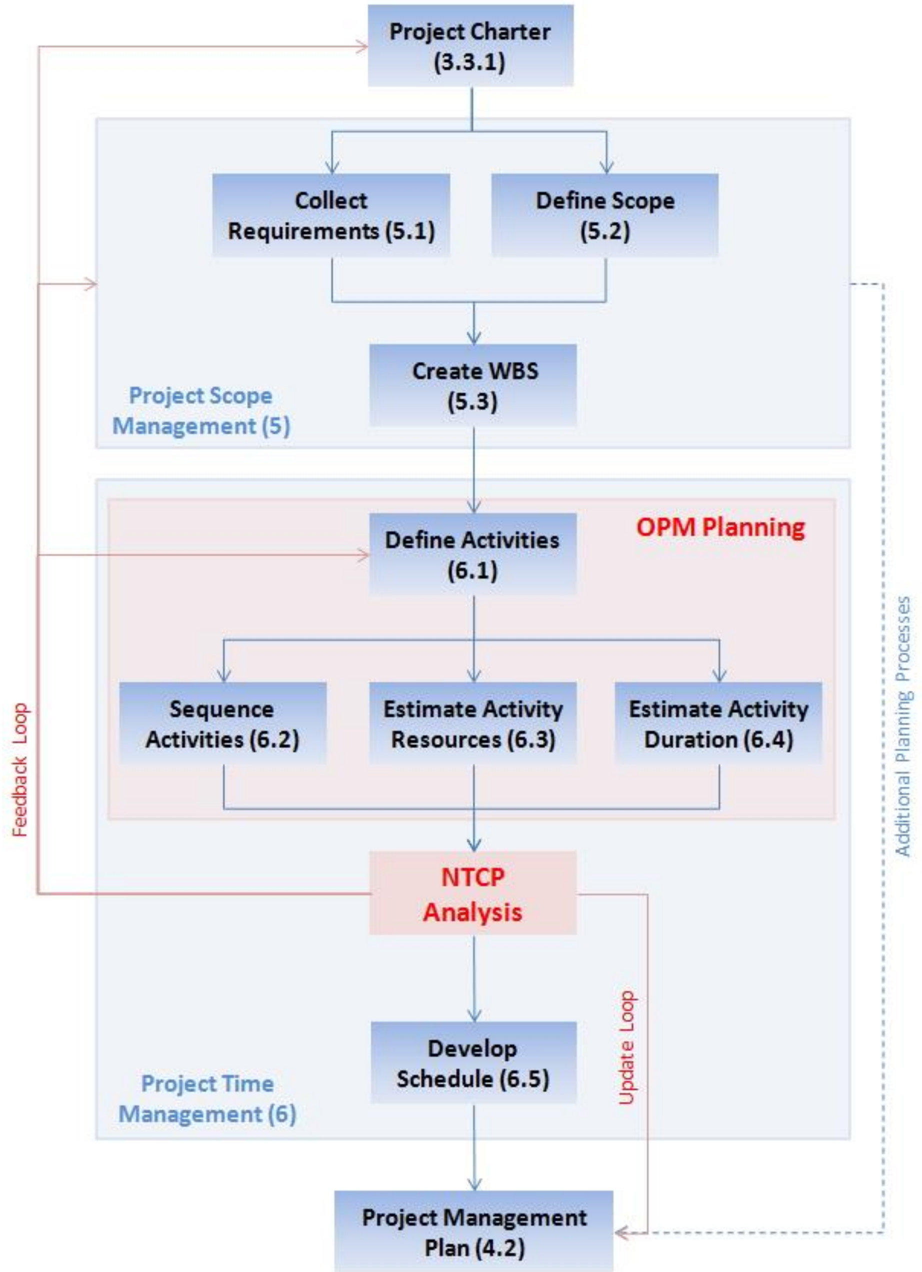

Figure 6: The proposed process for the project time management process.

We address the above-mentioned challenges by incorporating them into the PMBOK's *project time management* process. We embed the NTCP analysis between the activity, sequence, resource, and duration analysis processes, on one hand, and the *project management plan* on the other hand. In order to work with a single coherent framework rather than separate PM tools, OPM serves as a unifying modeling framework. Based on the OPM project model, a procedure is proposed for scanning the model to define the NTCP dimension values of various project activities and related system parts, as well as the NTCP values of the overall project. The sequence of project planning and analysis processes comprising this procedure are as follows:

1. Define project scope and the work breakdown structure of the project (this is the currently accepted process).
2. Based on the WBS, apply OPM model-based planning to obtain the following outcomes:
    - A full activity illustration of the project (a PMBOK requirement)
    - A sequence of all the project's activities (a PMBOK requirement)
    - All the resources associated with the activities (a PMBOK requirement)
    - The time duration for each activity (a PMBOK requirement)
    - An OPM model comprised of a unified interconnected set of diagrams that express the project deliverables, activities, activity durations, activities sequence (logic), and resources associated with each activity
    - An option to run a full simulation of the project plan in order to identify pitfalls and logical errors and correct them during the design stage.
3. During the OPM planning, define NTCP values to leaf-level OPM processes; that is, activities at the lowest OPD level.
4. Apply a bottom-up algorithm to the OPM model, which assigns NTCP attribute values in a bottom-up fashion, from the leaf-level processes of the OPD tree upward to the highest, overall project process (the only systemic process in the OPM system diagram, the top-level diagram in the OPD tree).
5. Apply an algorithm to the OPM model that will determine the relative importance (centrality) of each activity to the success of the project.
6. Determine the criticality of each activity, depending on its centrality and its NTCP values.
7. Identify potential pitfalls in the project (for example, highly critical activity with high values in one or more NTCP dimensions).
8. Assess the NTCP values of the entire project based on step 6.
9. Provide feedback to the *project charter, project scope management,* and *define activities*, and repeat steps 1–7 if necessary.
10. Update the project management plan.

10. Summary and future work

We have presented an approach for combining NTCP – a method for project management based on its multidimensional classification – and OPM – a language and methodology for modeling complex system to improve the project classification process based on the project conceptual OPM model. This approach removes the requirement for special experience of the project manager and chief systems architect in managing complex projects, which is currently required for correct project classification, and which is a prerequisite for adapting the right management style based on the project NTCP dimensions. We are continuing this research by specifying guidelines for modeling projects with OPM and based on this model determine the four NTCP dimension values.

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