# Supporting time planning by enhancing an Open Source Software in Alignment with CMMI-DEV and PMBOK

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Abstract. Software projects often fail, because they are not adequately managed. The establishment of effective and efficient project management practices still remains a key challenge to software organizations. Striving to address these needs, "best practice" models, such as, the Capability Maturity Model Integration (CMMI) or the Project Management Body of Knowledge (PMBOK), are being developed to assist organizations in improving project management. In order to provide a low-cost tool support for project management, specifically, for small and medium enterprises (SMEs), we developed enhancements on open-source tool, dotProject, to be aligned with PMBOK and CMMI-DEV for time planning process/practices.

#### 1. Introduction

Many software development projects still have problems to be delivered on time, budget and with the complete scope defined [CHAOS 2009]. One of the reasons for these problems is a lack of project management, which indicates that establishing effective and efficient a project management practices is still a challenge for many organizations [Wangenheim et al. 2010].

As an attempt to improve this situation, "best practices" models have been developed to guide organizations interested in improving the project management process. This includes the Capability Maturity Model Integration for Development (CMMI-DEV) that guides the improvement and appraisal of a software organization's processes [SEI 2010]. This model, although comprehensive, covers also "best practice" for project management. Another more specific "best practice" model for project management is the *Guide to the Project Management Body of Knowledge* (PMBOK) [PMI 2008], which describes the life cycle of managing a project and respective knowledge areas. Such maturity models, e.g., the CMMI, also indicate the importance of improving the project management process, as it is typically one of the first processes indicated to be improved associated to maturity level 2. And, although, these models do not require the adoption of software tools to support project management, such tools can help to support and partially automate steps, increasing efficiency and improving the maturity of the process [McConnell 1997] [Young, Fang, and Hu 2006].

Today, there exist a wide range of project management tools, including commercial as well as open source and free tools [Young, Fang, and Hu 2006]. Especially in the

context of small and medium software organizations, free/open source tools represent an interesting alternative.

Thus, the purpose of this paper is to present the enhancements realized on dotProject, an open source tool for project management, to supports the time planning aligned with PMBOK process and CMMI-DEV specific practices, covering processes as activities definitions, activities sequencing, effort estimations, resources estimation, duration estimation, and also schedule development.

## 2. Background

This session presents the key concepts used along this paper, such as project management, PMBOK and CMMI. All these concepts are used to analyze the current standard dotProject and also to explain the enhancements developed aligned with "best practices" models.

#### 2.1. Project Management

Project management is the application of knowledge, skills, tools and techniques to project activities to meet their requirements [PMI 2008]. A worldwide reference for project management is the PMBOK that defines a lifecycle and knowledge areas for successful project management [PMI 2008]. A project is seen as a temporary effort employed to create a single result. To achieve the goals defined in the project, knowledge, techniques and tools are applied that constitute project management. The project management life cycle is composed of five process groups [PMI 2008] (Figure 1):

- •Initiation: performed to initiate a new project or phase and obtain the authorization for its realization.
- •Planning: performed to establish the project goals and scope and to define the actions necessary to ensure that the project meets its objectives.
- •Execution: processes related to the execution of the project during which the work is carried out to complete the activities defined in the project plan.
- •Monitoring and control: performed to monitor, review and adjust the project performance and progress, realizing corrective actions.
- •Closing: performed to finalize all project activities in a formal way.



Figure 1. Project management life cycle [PMI 2008]

Orthogonal to this, project management processes are divided into 9 knowledge areas [PMI 2008]: Integration, Scope, Time, Cost, Quality, Human Resource, Communication, Risk, and Procurement. In combination, PMBOK defines project management as a set of 42 processes that are distributed among the knowledge areas within each life cycle process group as demonstrated in Table 1. The highlight processes are the ones related to time planning, used for tool enhancement.

Knowledge area	Process groups							
	Initiating	Planning	Executing	Monitoring & Controlling	Closing			
Integration	Develop Project Charter	Develop Project Management plan	Direct and Manage Project Execution	Monitor and Control project work, Perform integrated change control	Close project or phase			
Scope		Collect requirements, Define Scope, Create work breakdown structure (WBS)		Verify Scope, Control Scope				
Time		Define Activities, Sequence Activities, Estimate Activities Resources, Estimate Activity Durations, Develop Schedule		Control Schedule				
Cost		Estimate Costs, Estimate Budgets		Control Costs				
Quality		Plan Quality	Perform Quality Assurance	Perform Quality Control				
Human Resource		Develop Human Resource Plan	Acquire Product Team, Develop Product team, Manage Product Team					
Communication	Identify Stakeholders	Plan Communications	Distribute Information, Manage Stakeholders Expectations	Report Performance				
Risk		Plan Risk Management, Identify Risks, Perform Qualitative Risks Analysis, Perform Quantitative Risks Analysis, Plan Risks Responses		Monitor and Control Risks				
Procurement		Plan Procurements	Conduct Procurements	Administer Procurements	Close Procurements			

### Table 1. PMBOK Processes [PMI 2008]

According with PMBOK time planning contains processes to:

- •Define Activities: process to define the actions to be executed in order to produce project deliverables.
- •Sequence activities: process to define the logical dependencies between project activities, and also to define its execution order.

- •Estimate activities resources: plan human and non human resources needed to execute project activities.
- •Estimated activities duration: estimated the total time period needed to conclude the project activities. To do that is needed to know activities scope, resources availability and others restrictions.
- •Develop schedule this process involves that each project activity has its start and end dates, effort, duration, and resources estimated, as well the activity dependencies. Often it is represented as a Gantt Chat.

### 2.2. CMMI

The Capability Maturity Model (CMMI) is a framework for process improvement for the development of software products and services. It describes best practices associated to maintenance and development activities covering the life cycle of products from conception to delivery and maintenance [SEI 2010]. Currently, there exist 3 different constellations: CMMI for Development (CMMI-DEV), CMMI for Acquisition (CMMI-ACQ) and CMMI for Services (CMMI-SVC). Here, due to our scope on software development, we focus on the CMMI-DEV constellation [SEI 2010]. Its purpose is to help organizations improve their development and maintenance processes for both products and services. Within the CMMI Product Suite, a project is defined as a managed set of interrelated resources which delivers one or more products to a customer or end user. A project has a definite beginning and typically operates according to a plan. Such a plan is documented and specifies what is to be delivered or implemented, the sources and funds to be used, the work to be done, and a schedule for doing the work.

CMMI constellations are basically composed through two dimensions: process areas and capability/maturity levels. CMMI-DEV v1.3 defines 22 process areas grouped in four process categories as presented in Table 2. Table 2 also indicates for each maturity level the associated process areas.

	Process category									
Maturit y Level	Project Management	Process Managemen t	Engineering	Support						
5		Organizational Performance Management		Causal Analysis and Resolution						
4	Quantitative Project Management	Organizational Process Performance								
3	Integrated Project Management, Risk Management	Organizational Process Definition, Organizational Process Focus, Organizational Training	Requirements Development, Technical Solution, Product Integration, Verification, Validation	Decision Analysis and Resolution						
2	Project Planning, Project Monitoring & Control, Supplier Agreement Management		Requirements Management	Configuration Management, Process and Product Quality Assurance, Measurement and						

Table 2. Process Areas by Process Categories and Maturity Levels [SEI 2010]

		Analysis

In this research, we focus mainly on project planning (PP) process area associated to maturity level 2, due to our specific focus on time planning practices that are supported by these processes. For CMMI-DEV the time planning specific practices under PP process area are:

- •PP/SP 1.1 Estimate the Scope of the Project: practice related to project activates definition, derived from project Work Breakdown Structure (WBS).
- •PP/SP 1.2 Establish Estimates of Work Product and Task Attributes: Realization of estimations for work products size. and task attributes, as estimated duration, start and end dates.
- •PP/SP 2.1 Establish the Budget and Schedule: The budget is out of scope for time planning, but the schedule is included, involving activities duration estimation, and activities sequencing.
- •PP/SP 2.4 Plan for Project Resources: Estimate for each project activity the human and non human resources and its quantities for its realization.
- •PP/SP 1.4 Determine Estimates of Effort and Cost: The cost estimation is out of scope for time planning, but the effort estimation is included and means the number of work periods which is needed to realize an activity.

## 3. DotProject

DotProject (www.dotproject.net) is a web-based tool for project management. It supports user management, projects listing, hierarchical task definition and schedule visualization (Gantt), client management, besides offering features such as contact list, file repository and calendar (Figure 2). The software supports MYSQL or ADOdb databases, and has been developed using PHP as programming language. The tool is designed in modules. Its basic features are supported by core modules and new features can be built and installed as *add-on modules* using the tool's development framework. Released in 2000, its current version is 2.1.5. It is an open-source system, publish under General Public License (GPL) v3, what means this software could be customized and redistributed once the GPL is maintained.

View Pr	oject	Search:	new tas	k new event	new file				
PROJECT A									
Details		Summary							
Company:	GQS	Status:	Not Defined	Š.					
Internal Company:		Priority:	high						
Short Name:	-	Type:	Unknown						
Start Date:	15/09/2011	Progress:	0,0%						
Target End Date:	-	Worked Hours:							
Actual End Date:	26/10/2011	Scheduled Hours:	3						
Target Budget:	\$0.00	Project Hours:	7,55	7,55					
Project Owner:	Person, Adm								
Tasks Tasks (Ina Expand All : Collaps	ctive) Forum e All	s Gantt Chart Tasl	k Logs Eve	ents Files					
Pin New Log Work F	Task Name	Start Date	Duration	Finish Date					
🖋 🔍 Log 0%	Activity A	03/10/2011 08:30 am	1 hours	04/10/2011 05:00 pr	n				
🖉 🌒 Log 0%	Activity B	17/10/2011 08:45 am	1 hours	25/10/2011 05:00 pr	n				
/ 🕘 Log 0%	Activity C	17/10/2011 08:45 am	1 hours	26/10/2011 05:00 pr	n				

Figure 2. dotProject

This is one of most popular open-source tools for project management, having a download rate of 2252 per week according with. It is an stable project been maintained by a group of 8 members.

#### 3.1 Evaluation Criteria

The evaluation criteria adopted to evaluate dotProject are based on PMBOK processes and CMMI-DEV practices using an earlier research of the authors on unifying and harmonizing CMMI-DEV v1.2 (PP, PMC, SAM) and PMBOK processes [Wangenheim et al. 2010]. Revising and updating the unification of best practices (considering the current version of CMMI-DEV v1.3), a set of Unified Best Practices (UBP) [Wangenheim et al. 2010] has been revised and used as a basis for the tool evaluation. In this direction the UBPs are used to represent PMBOK and CMMI process/practices in a harmonized way.

To assess the degree of support provided by dotProject in relation to the UBP criteria a 4-point ordinal rating scale is defined as presented in Table 3.

Table 3. Rating scale [Wangenheim, Hauck, Wangenheim 2009]

Rating	Description
-	Does not provide any support.
*	Offers basic support, covering less than half of the UBP.
**	Covers more than half of the UBP.
***	Offers a complete set of elaborate functionalities for this UBP.

### 3.2 Evaluation

The tool was evaluated for each of UBPs related to time planning, that are presented on Table 4. Other UBPs are not related with time planning, but with others project management process, due that they are out of scope for this paper. For tool evaluation, only core functionalities are used, not considering *plug-ins* that might provide additional functionality.

To Define Activities (UBP P1) the tool supports activates creation (activities are named as tasks in the tool). The activities can be created into a project, but since isn't supported work packages definition, consequentially isn't possible to know from which work package an activity belongs.

For Establish Estimates of Work Product and Task Attributes (UBP P2), dotProject don't support work packages definition so also isn't supported estimations of its size. What dotProject supports is to use an activity as parent of another, what can be used to simulate a work package, but it isn't explicated defined.

To Sequence Activities (UBP P3) is supported the definition of activities preconditions, it means the activities that have to be concluded for the specific activity become allowed to start. But to define activities sequencing isn't supported the use of Precedence Diagram Method (PDM), which is recommended by PMBOK. To Plan Activities Resources (UBP P4) dotProject supports users' allocation in project activities. But don't support the non human resources allocation, and also don't supports estimation of resources as roles, what also is recommended by PMBOK.

Estimate Activity Durations (UBP P5) is supported by dotProject, setting the start and end dates of each activity. But isn't supported to document how this estimation was realized. Also the duration isn't calculated automatically.

Estimate Effort (UBP P6) isn't explicitly supported by dotProject. In an activity form there is a field named duration, which the value could be inputted by user. The usage of this field give the choice for user input the effort instead of duration, but it isn't clear. Also isn't supported to document how the effort was estimated.

The Develop Schedule (UBP P7) is well supported by dotProject. Is generated the Gantt chart, showing for the activities the start and end dates, its duration, the allocated resources, and also the activities dependencies.

On Table 4 is presented the rating for each evaluated UBP over the support level provided by dotProject 2.1.5.

UBP		dotProject version 2.1.5
P1	Define Activities	**
P2	Establish Estimates of Work Product and Task Attributes	*
P3	Sequence Activities	**
P4	Plan for Project Resources	**
P5	Estimate Activity Durations	**
P6	Estimate Effort	*
P7	Develop Schedule	***

 Table 4. Summary of evaluation of the support provided by dotProject for time planning

## 4. Enhancements on dotProject

This section presents all improvements implemented in an add-on module for dotProject, in order to align it with PMBOK and CMMI process/practices for time planning.

#### 4.1. Defining Work Breakdown Structure

In project module, was developed a new section that supports the project WBS to be created (Figure 3). WBS is used to define project scope and to organize/create project activities in order to reach project goals.

iv	e) Forums	Gantt Chart	Task Logs Events	Files WBS Derivation PDM Estimations							
	Add										
WBS											
	ID	Order	Identation	WBS Item							
	1	1 L	← →	Time planning enhancement for dotProject	X						
	1.1	↑ ↓	← →	Time planning best practices	X						
	1.1.1 *	↑ ↓	← →	CMMI practices for time plannig	X						
	1.1.2 *	↑ ↓	$\leftarrow$ $\rightarrow$	PMBOK process for time planning	X						

Figure 3. Defining WBS

## 4.2. Deriving activities from work packages

A technique to define project activities is deriving it from work packages. Now that WBS are define is possible to apply this method. In project module was developed a section where is possible to define projects activities organized by work package (Figure 4). The project WBS is presented, and under each work package there is the functionality to define project activities.

su.	. nac
s	Tasks (Inactive) Forums Gantt Chart Task Logs Events Files WBS Derivation PDM Estimations
	Activities Definition
	WBS Description Move
1	L - Time planning enhancement for dotProject
1	I.1 - Time planning best practices
1	I.1.1 - CMMI practices for time plannig
	+
	Download CMML-DEV v1 3 guide
L	
L	Evaluate all time planning practicies and document results.
1	L.1.2 - PMBOK process for time planning
[	+
	Download PMBOK 4ed
	Evaluate all time planning practicies and document results.

Figure 4. Defining project activities by work package

Is important to highlight that all activities created from screen presented at Figure 4, are created as normal dotProject tasks, what mean they are available to be edited and managed as a normal tasks. Also the inverse is true, when a task is defined from standard dotProject way, it is available to be organized in this screen.

## 4.3. Sequence activities

Was implemented on projects module the feature to define the dependences between activities using the Precedence Diagram Method (PDM), which shows project activities linked as a network.



Figure 5. Sequence activities

In the screen presented at Figure 5 is possible to sequence activities in a graphical way, using PDM recommended by PMBOK.

Also is important to highlight that the activities dependencies are created using standard dotProject way. It means that the screen presented at Figure 5 has the goal to facilitate the tasks dependencies definition, once that the standard dotProject way to define tasks dependencies can be used simultaneously.

## 4.4. Creating a minute for estimations meetings

For each project activity is important to estimate its effort, duration and resources. Also is important to estimate work package size. To document these estimations was created a new section (Figure 6) under projects module.



Figure 6. Project estimations

When "Create Minute" button is clicked, is opened its form (Figure 7), where is possible to register what are been estimated (effort, duration, resources, or size), when and who participate, and also a text editor to document what was discussed.



Figure 7. Estimation minute form

## 4.5. Registering estimations for size, effort, duration and resources.

After register what was discussed in estimations meeting, is possible to input for each project activity its effort, duration and resources. For each work package is possible to register its size (Figure 8).

Т	asks (Inactive) Forums Gantt Chart Task Logs Events Files WBS Derivation PDM Estimations					
	Create Minute					
	Minutes					
	ID Date Description Edit					
	4 05/03/2012 was estimated for coding activities that Exclude					
	Estimations					
	WBS ID Activity Effort Duration (days) Resources (roles) Size					
	1 - Time planning enhancement for dotProject					
	1.1 - Time planning best practices					
	1.1.1 - CMMI practices for time planning 7 UCP 💌					
	114 Download CMMI- 1 Hours 1 + DEV v1.3 System analyst 1 X					
	115 Evaluate all time 3 Hours 1 + planning practicies and document results.					

Figure 8. Activities estimations details

The resources roles are provided by organizational diagram, which also is a feature developed with the presented enhancements.

## 4.6. Schedule development

To help on schedule development was defined a functionality that executes the Critical Path Method (CPM) (Figure 9). It can be executed just after all activities already were sequenced and their efforts were estimated. This method calculates activities start and end dates based on project start date, activities sequence, and estimated effort.

1	Schedule development
	This action calculates activities starts and end dates based on project start date, estimated efforts and logic dependencies between activities.

#### Figure 9. Critical path method

As result the Gantt Chart (Figure 10) already gets a well defined format, been needed just to perform some adjusts by project manager in case on resources restrictions.

bed : flat										
sks Tasks (Inactive)	Forums	Gantt Chart	ask Logs	Events	Files	WBS	Derivation	PDM		
From: 25/01/2012 4 To: 01/02/2012 4 F Show captions Show work instead of duration Sort by Ta										
show this month : show full project										

Time planning on dotProject										2	012		
······ • • • • • • • • • • • • • • • •					Jan								
	Dur	Ctart	Cipitala	23/1							30/1		
Task name	Dur.	Start	Finish	H	Т	H	т	F	s	S	H	T	
Download CMMI-DEV v1.3	lh	27/01/2012	27/01/2012					L					
Download PMBOK 4ed	lh	27/01/2012	27/01/2012					L					
Evaluate all time planning practi.	3 h	27/01/2012	27/01/2012					L					
Evaluate all time planning proces.	3 h	27/01/2012	27/01/2012										
Map CMMI and PMBOK process/practi.	8 h	27/01/2012	27/01/2012										
Define generic time planning proc.	16 h	27/01/2012	31/01/2012					-					

Figure 10. Gantt chart

## **5.** Discussion and results

Evaluating dotProject with new enhancements provided by time planning add-on module, we can check now how much the improvements support the UBPs in comparison with standard dotProject.

Table 5. Evaluation of enhancements on dotProject

UBP		dotProject version 2.1.5	dotProject with add-on	What was improved?
P1	Define Activities	**	***	Now is supported the WBS definition, and the creation of project activities for each work package, been possible to know from which work package an activity was derived.
P2	Establish Estimates of Work Product and Task Attributes	*	***	Now is supported to register the estimations for each work package size.
P3	Sequence Activities	**	***	The activities can be sequenced using the PDM, supporting that activities can be sequenced using a graphical network.
P4	Plan for Project Resources	**	***	Now is supported to define organizational diagram, describing all employees' roles available on organization. Based on that now is supported to estimated for each activity the needed roles to execute it. For estimation of non human resources we are using an external add-on module (https://sourceforge.net/projects/dotmods/fil es/Resource%20Management/)
P5	Estimate Activity	**	***	Now is supported after the realization of an

	Durations		,	estimation meeting to register explicitly the activity duration (Figure 8).
P6	Estimate Effort	*	***	Now is supported after the realization of an estimation meeting to register explicitly the estimated effort (Figure 8). It can be estimated in minutes hours, or days.
P7	Develop Schedule	***	***	Is now supported the critical path method, which builds the project schedule automatically based on activities sequencing and estimated efforts.

The add-on module for time planning presented at this paper is an official add-on module dotProject been available dotmods for on (https://sourceforge.net/projects/dotmods/) under "Alignment with PMBOK and CMMI-DEV" folder. This add-on module is also under GPL, what means it could be customized and redistributed.

#### 6. Conclusions

The enhancements of open source tools for project management aligned to "best practices" models are considered of great importance for these tools start supporting the recommendations realized by the models. It could help organizations that use these tools to increase the quality of their time planning, and consequently the quality of products delivered. The importance of this work is that the enhancements were done based in "best practices" models, accepted and validated worldwide. Thus, the development of the tool aim to align with the models and not simply created by some particular necessity.

Other researches already are under development, as the alignment of dotProject with PMBOK and CMMI for others project management processes, as monitoring and controlling, human resources management, project ending, project initiating, and project communication.

Also others researches that realizes in the same direction are the definition of generic models for realization of specific project management processes alignment with PMBOK and CMMI. The generic models could be adopted by any organization that wants to improve its own process. Been not needed to use a specific tool, as dotProject, the organization could decide to improve its own tool to realize the same model.

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