Tailoring PMI and OGC Portfolio Frameworks

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Abstract. The strategy definition in organizations and its implementation by projects has been difficult to achieve. Project portfolio management processes provide the linkage between the organization's strategic objectives and their programs and projects. It is worthless to have the latest technology and resources to develop projects, if there are no organized processes and focus on strategic interests. The organizations need to develop processes, tools, and techniques that support their business, to act at the required level, but keeping in mind that these processes and tools need to evolve over time. Therefore, for a better understanding of the processes and use of artefacts from 'project portfolio management', this paper aims to develop an information technology 'project portfolio management' framework based on 'project portfolio management' processes from PMI and artefacts from OGC (Axelos, until 2013). For a better understanding of the process, inputs and outputs artefacts, the framework is modelled using the BPMN-Business Process Modelling and is done a traceability map, of an example artefact, using UML State Machine Model.

Keywords: Project portfolio management · PMI · OGC · BPMN · Axelos

1 Introduction

The term "Portfolio" began to be used by organizations in the area of finance, defining a selection of investments made by an individual or organization, with the objective of reducing investment risk [1]. An organization's investment project portfolio represents its current strategy in that it represents its structure, processes and products [2]. Due to globalization, organizations tend to consider innovation and product development projects as crucial to the longevity of their organizations [3, 4].

Organizations need to develop processes, tools, and techniques that support their business, to act at the required level, but keeping in mind that these processes and tools need to evolve over time [5]. There are different techniques and tools that can be used in estimating, evaluating, and selecting projects for a portfolio. However, many of these techniques and tools are not widely applied, because of its complexity, requiring many input data, or simply because of their high degree of difficulty in understanding and use by decision makers [6].

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Senior management in Information Technology (IT) organizations, despite their evolution, have tended to ignore the perspective of the portfolio, focusing only on the individual management of projects [7].

For 'project portfolio management' (PfM) guidance some frameworks focused on prioritization, selection or monitoring of projects have been developed [6, 8–11].

The PfM Standard from PMI (designate in this paper as, PMI PfM framework) presents the collected knowledge of PfM through a set of processes [12], and PfM Standard from OGC (designate in this paper as, OGC PfM framework) presents the collected knowledge of PfM through as a set of practices [13]. These processes and practices have emerged as an approach to support decision making in organizations.

In the context of this paper, an IT PfM framework is proposed for PfM based on these two most recognized standards for 'project portfolio management': "The Standard for Portfolio Management" from the Project Management Institute (PMI), version 2013 [12] and "Management of Portfolios (MoP)" from Axelos, the Office of Government Commerce (OGC) until 2013, version 2011 [13]. Recently, the PMI released a new version (fourth edition) of "Standard for Portfolio Management" [12], however the researchers already had conclude most of their research and therefore the third version of PMI PfM framework was maintained.

The PMI PfM framework is considered to be the most complete framework currently available for PfM [14, 15], while the OGC PfM framework is particularly relevant for IT PfM [16]. PMI has a better defined structure of PfM processes [17], and the OGC standard for PfM has a greater detail on how to implement PfM practices from the artefacts [18], therefore the IT PfM framework proposed is based on PMI processes and OGC artefacts. For a better understanding of process, and inputs and outputs artefacts, the IT PfM framework is modelled using the *Business Process Modeling Notation* (BPMN) [19].

This paper is organized as follows. Section 2 presents the specification of the dependency analysis between OGC artefacts and PMI processes using BPMN model. Section 3 shows, as an example, the traceability map of, the most used and most updated artefact by all PMI PfM processes, the OGC. A [27.1] Portfolio Delivery Plan – Schedule, using the Unified Modeling Machine (UML) State Machine Model. Finally, conclusions and some highlights for further research are presented.

2 Dependency Between PMI PfM Processes and OGC PfM Artefacts

For the development of a more detailed IT PfM framework was done a merge between the PMI and OGC PfM frameworks, more specifically between the processes defined by PMI and the defined artefacts from OGC, with the objective of helping professionals to execute the PfM processes more efficiently through a complete set of artefacts.

This research's work, based on the researchers' extensive professional experience in PfM and in an in-depth analysis and discussion of the concepts and definitions of each artefact from PMI and OGC PfM frameworks, establishes a mapping between the artefacts from OGC PfM framework and PMI PfM framework.

Therefore, the tailored IT PfM framework proposed adopts the processes from the PMI PfM framework and, through the mapping of artefacts from the PMI PfM framework to OGC PfM framework, a complete artefact's structure from OGC PfM framework is used [20].

Table 1 presets the mapping between all the PMI portfolio processes and OGC PfM artefacts. As an example, the researchers analyze the PMI process {PP1} DPSP 'Develop Portfolio Strategic Plan' [17], through their interaction with artefacts from the OGC PfM framework [20].

2.1 Elementary Dependency Analysis

In Table 1, {PP1} DPSP 'Develop Portfolio Strategic Plan' process from PMI PfM framework receives information through the OGC PfM artefacts ("IN", "I/O" and "OUT"): A[1] 'Strategic Objectives', A[2] 'Organizational Environmental Analysis', A [3] 'Individual Stakeholder Engagement and Communication Plans', A[4] 'Organizational Management Strategy and Risk', A[5] 'Governance Structures', A [6] 'Portfolio Risk Management Strategy', A[7] 'Financial Metrics and Investment Criteria', A[12] 'Portfolio's Categorization', A[13] 'Portfolio's Governance', A[14] 'Portfolio Strategy', A[21] 'Portfolio Stakeholder Engagement and Communication Plan', A[22] 'Portfolio Resource Schedule', A[23] 'Resource Forecast', A[25] 'Standards and Templates to guide programme and project Planners', A[26] 'Lessons Learned', A[27.2] 'PDP. Resources' (PDP represents 'Portfolio Delivery Plan', sub-group, Resources), A[27.3] 'PDP.Cost' (PDP represents 'Portfolio Delivery Plan', sub-group, Cost) and A[27.4] 'PDP.Risk' (PDP represents 'Portfolio Delivery Plan', sub-group, Risk) [20].

The relationships between processes and artefacts are represented in the matrix of Table 1, where an "IN" means input artefact, "OUT" for output artefact, and "I/O" for input and output artefact.

After {PP1} DPSP 'Develop Portfolio Strategic Plan' process is executed, it sends or generates information to the following OGC PfM artefacts: A[27.1] 'PDP. Schedule', A[8] 'Portfolio' and A[14] 'Portfolio Strategy'. All PMI PfM processes in the depicted mapping, in Table 1, are positioned in the respective knowledge area from PMI PfM framework (as an example, the {PP1} DPSP 'Develop Portfolio Strategic Plan', is located in the lane of the '*Portfolio Strategic Management*' knowledge area). All the PMI PfM processes are organized by five knowledge areas [17].

The tailored IT PfM framework proposed is developed under the knowledge areas from PMI PfM framework, with two objectives: (1) to clarify the sequence of processes to be executed for each area of knowledge; and, (2) to perceive if professionals can perform only a set of processes without any dependence on other processes, for example, the professional can only perform the processes of the area of knowledge, '*Portfolio Risk Management'*.

A knowledge area includes PMI PfM processes (see Table 2), which are linked to the respective inputs and outputs (artefacts and processes).

The tailored IT PfM framework, with processes from PMI PfM framework and OGC PfM artefacts, and a possible order of execution of the processes by area of knowledge is presented, in detail by using the Business Process Model and Notation (BPMN), as an example see Fig. 1.

Table 1. The mapping between all the PMI portfolio processes and OGC PfM artefacts

Portfolio Process (PMI) / Artefacts (OGC)			PMI-Defining Process Group								PMI-Aligning Process Group						PMI-Authorizing and Controlling Process Group				
			PSM (PP 1) DPBP S,M,C,I	PSM (PP 2) DPC S,M,C,I	PSM (PP 3) DPR S,M,C,I	PGM (PP 4) DPMP S,M,C,I	PGM (PP 5) DP S,M,C,I	PPM (PP 6) DPPMP S,M,C,I	PCM (PP 7) DPCMP M,C,I	PRM (PP 8) DPRMP S,M,C,I	PSM (PP 9) BSC M,C,I	PGM (PP 10) OP S,M,C,I	PPM (PP 11) BSD S,M,C,I	PPM (PP 12) MPV S,M,C,I	PCM (PP 13) WPI M,C,I	PRM (PP 14) MPR M,C,I	PGM (PP 15) AP S,M,C,I	PGM (PP 16) PPO S,M,C,I	Number of Artefacts	INPUT Number of Artefacts	OUTPUT Number of Artefacts
OGC ARTEFACTS	OGC.A[1] Strategic Objectives	OGC.A[1.1] Market Sizing	IN													IN			2	2	0
		OGC.A[1.2] Innovation	IN													IN			2	2	0
		OGC.A[1.3] Human Resources	IN													IN			2	2	0
		OGC.A[1.4] Financial Resources	IN													IN			2	2	0
		OGC.A[1.5] Physical Resources	IN													IN			2	2	0
		OGC.A[1.6] Productivity	IN													IN			2	2	0
		OGC.A[1.7] Social Responsibility	IN													IN			2	2	0
		OGC.A[1.8] Profit Requirements	IN													IN			2	2	0
	OGC.A[2] Organizational Environmental Analysis	OGC.A[2.1] SWOT analysis	IN	IN		IN		IN		IN						IN			6	6	0
		OGC.A[2.2] PESTLE analysis	IN	IN		IN		IN		IN						IN			6	6	0
		OGC.A[2.3] Porter's five forces analysis	IN	IN		IN		IN		IN						IN			6	6	0
	OGC.A[3] Individual Stakeholder Engagement and Communication Plans		IN			IN		IN	IN	I/O						OUT			7	5	2
	OGC.A[4] Organizational Management Strategy and Risk		IN			IN		IN	IN	I/O						OUT			7	5	2
	OGC.A[5] Governance Structures		IN			IN		IN	IN	I/O						OUT			7	5	2
	OGC.A[6] Portfolio Risk Management Strategy		IN	I/O		I/O	IN	I/O	I/O	I/O	I/O	I/O		OUT	I/O	I/O	OUT	I/O	24	12	12
	OGC.A[7] Financial Metrics and Investment Criteria		IN	I/O		I/O	IN	I/O	I/O	I/O	I/O	I/O		OUT	I/O	I/O	I/O	I/O	25	13	12
	OGC.A[8] Portfolio		OUT		IN		I/O		IN			I/O	I/O	OUT	IN	IN	I/O	I/O	16	9	7
	OGC.A[9] Portfolio Maps				I/O	IN	I/O		IN		I/O	I/O		IN				IN	12	8	4
	OGC.A[10] Portfolio reports								IN			I/O	I/O	I/O	I/O	I/O	I/O	I/O	15	8	7
	OGC.A[11] Portfolio Scope			OUT	OUT	IN	IN				OUT	IN						IN	7	4	3
	OGC.A[12] Portfolio's Categorization		IN	I/O		I/O	IN	I/O	I/O	I/O	I/O	I/O		OUT	I/O	I/O	OUT	I/O	24	12	12
	OGC.A[13] Portfolio's Governance		IN	I/O		I/O	IN	I/O	I/O	I/O	I/O	I/O	OUT	OUT	I/O	I/O	OUT	I/O	25	12	13
	OGC.A[14] Portfolio Strategy		I/O	I/O	IN	I/O	IN	I/O	I/O	I/O	I/O	I/O		I/O	I/O	I/O	OUT	I/O	27	14	13
	OGC.A[15] Benefits Forecast											IN			IN	IN			3	3	0
	OGC.A[16] Portfolio-level Benefits Realization Plan											IN			IN	IN			3	3	0
	OGC.A[17] Portfolio's Business Case																		0	0	0
	OGC.A[18] Financial Plan											IN			IN	IN	I/O	I/O	7	5	2
	OGC.A[19] Portfolio's Performance								IN			IN	OUT	I/O	IN			I/O	8	5	3
	OGC.A[20] Portfolio-level Performance Metrics								IN			IN	OUT	I/O	IN			I/O	8	5	3
	OGC.A[21] Portfolio Stakeholder Engagement and Communication Plan		IN	I/O		I/O	IN	I/O	I/O	I/O	I/O	I/O		OUT	I/O	I/O	OUT	I/O	24	12	12
	OGC.A[22] Portfolio Resource Schedule		IN	I/O		I/O	IN	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O	28	15	13
	OGC.A[23] Resource Forecast		IN	I/O		I/O	IN	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O	28	15	13
	OGC.A[24] Portfolio Skills Register																		0	0	0
	OGC.A[25] Standards and Templates to guide programme and project Planners		IN	I/O		I/O	IN	I/O	I/O	I/O	I/O	I/O		OUT	I/O	I/O	OUT	I/O	24	12	12
	OGC.A[26] Lessons Learned		IN	I/O		I/O	IN	I/O	I/O	I/O	I/O	I/O		OUT	I/O	I/O	OUT	I/O	24	12	12
	OGC.A[27] Portfolio Delivery Plan	OGC.A[27.1] Schedule	OUT	I/O	IN	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O	I/O	30	15	15
		OGC.A[27.2] Resources	IN	I/O		I/O	IN	I/O	I/O	I/O	I/O	I/O		OUT	I/O	I/O	OUT	I/O	24	12	12
		OGC.A[27.3] Cost	IN	I/O		I/O	IN	I/O	I/O	I/O	I/O	I/O		OUT	I/O	I/O	I/O	I/O	25	13	12
		OGC.A[27.4] Risk	IN	I/O		I/O	IN	I/O	I/O	I/O	I/O	I/O		OUT	I/O	I/O	OUT	I/O	24	12	12
	OGC.A[28] Portfolio-level financial plan											IN			IN	IN	I/O	I/O	7	5	2
Number of Artefacts			29	18	5	22	17	20	22	20	16	24	8	19	22	34	18	22			
INPUT Number of Artefacts			27	17	4	22	17	20	22	20	15	24	5	8	22	31	9	22			
OUTPUT Number of Artefacts			3	15	2	14	3	14	14	17	16	17	8	18	15	16	16	20			

Table 2. Alignment between knowledge areas and portfolio processes of PMI PfM framework

Portfolio Management Knowledge Areas (PMKA)	Portfolio Processes (PP)	Acronym
Portfolio Strategic Management (PSM)	Develop Portfolio Strategic Plan	{PP 1} DPSP
Portfolio Strategic Management (PSM)	Develop Portfolio Charter	{PP 2} DPC
Portfolio Strategic Management (PSM)	Define Portfolio Roadmap	{PP 3} DPR
Portfolio Governance Management (PGM)	Develop Portfolio Management Plan	{PP 4} DPMP
Portfolio Governance Management (PGM)	Define Portfolio	{PP 5} DP
Portfolio Performance Management (PPM)	Develop Portfolio Performance Management Plan	{PP 6} DPPMP
Portfolio Communication Management (PCM)	Develop Portfolio Communication Management Plan	{PP 7} DPCMP
Portfolio Risk Management (PRM)	Develop Portfolio Risk Management Plan	{PP 8} DPRMP
Portfolio Strategic Management (PSM)	Manage Strategic Change	{PP 9} MSC
Portfolio Governance Management (PGM)	Optimize Portfolio	{PP 10} OP
Portfolio Performance Management (PPM)	Manage Supply and Demand	{PP 11} MSD
Portfolio Performance Management (PPM)	Manage Portfolio Value	{PP 12} MPV
Portfolio Communication Management (PCM)	Manage Portfolio Information	{PP 13} MPI
Portfolio Risk Management (PRM)	Manage Portfolio Risks	{PP 14} MPR
Portfolio Governance Management (PGM)	Authorize Portfolio	{PP 15} AP
Portfolio Governance Management (PGM)	Provide Portfolio Oversight	{PP 16} PPO

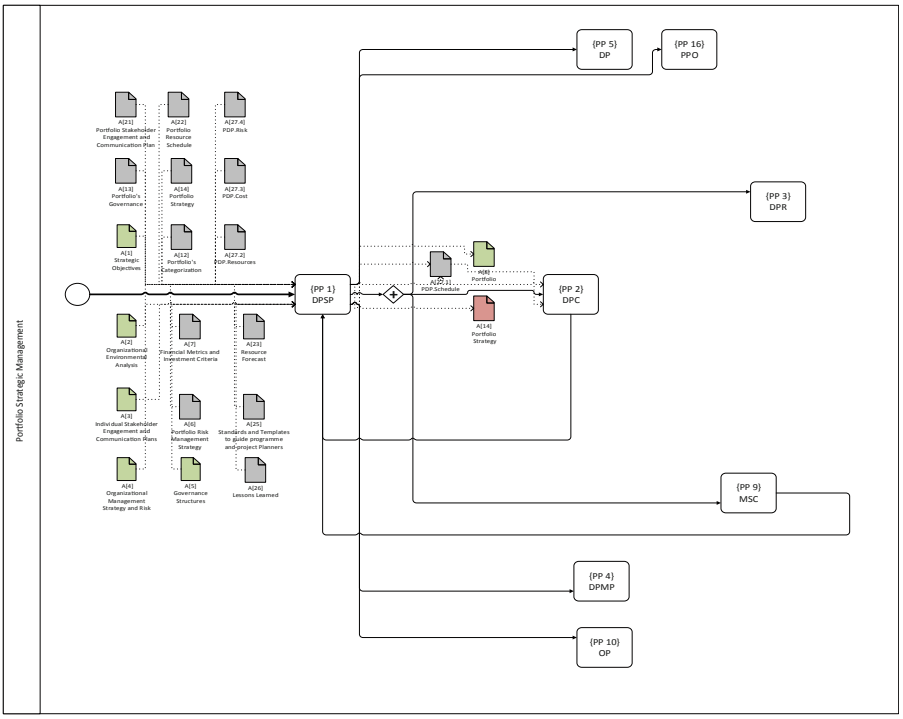


Fig. 1. {PP1} DPSP 'Develop Portfolio Strategic Plan'- centric dependency analysis (Color figure online)

According to the Object Management Group (OMG) [19], the BPMN notation is a process-modelling standard, which purpose is to facilitate the understanding of process diagrams by all stakeholders involved. This notation is used to draw the flowchart drawings that represent the activities or tasks belonging to a business process.

BPMN is a graphical notation explicitly created to represent business processes, identifying activities, dependency control, the tasks, and sub processes [21]. Therefore, the BPMN notation is used for the representation of the Tailoring PMI PfM framework and the OGC PfM framework and their interaction with OGC PfM artefacts.

In Fig. 1, green artefacts represent artefacts not yet used by the PMI PfM processes; grey artefacts represent artefacts created by PMI PfM processes; and red artefacts represent artefacts already created and generated by PMI PfM processes.

2.2 Knowledge Area Centric Dependency Analysis

The objective of using centric dependency analysis in this research work is to show the dependencies between portfolio processes from the PMI PfM framework and artefacts from the OGC PfM framework related to a specific knowledge area from PMI PfM framework. Therefore, five models have been created. They are called KA-n Centric Dependency Analysis Model (where n corresponds to the knowledge area under study, 1 – *Portfolio Strategic Management*, 2 – *Portfolio Governance Management*, 3 – *Portfolio Performance Management*, 4 – *Portfolio Communication Management* and 5 – *Portfolio Risk Management*). Figure 2 (as example, the figure is bigger) to Fig. 6 present, respectively, the KA-1, KA-2, KA-3, KA-4 and KA-5 Centric Dependency Analysis Model. As an example, the construction of the KA-1 Centric Dependency Analysis Model uses the information of all columns with prefix PSM (*Portfolio Strategic Management*) – Knowledge Area, of the global matrix (see Table 1).

For a better understanding of the creation of the KA-1 model, the PMI PfM processes; {PP1} DPSP 'Develop Portfolio Strategic Plan', {PP2} DPC 'Develop Portfolio Charter', {PP3} DPR 'Define Portfolio Roadmap', and {PP9} MSC 'Manage Strategic Change' are analysed as examples.

To represent in the model the dependencies faced by the {PP1} DPSP 'Develop Portfolio Strategic Plan' process with the artefacts, the researchers must parse the matrix column that corresponds to {PP1} DPSP 'Develop Portfolio Strategic Plan', as shown in Fig. 1.

{PP1} DPSP 'Develop Portfolio Strategic Plan' process, as the first PMI PfM process to be handled, needs several inputs from OGC PfM artefacts, such as: A[1] 'Strategic Objectives', A[2] 'Organizational Environmental Analysis', A[3] 'Individual Stakeholder Engagement and Communication Plans', A[4] 'Organizational Management Strategy and Risk' and A[5] 'Governance Structures'. All of them are organizational artefacts, which any organization might have for an efficient PfM.

Green tone artefacts are required to execute a given PMI PfM process, for example, {PP1} DPSP 'Develop Portfolio Strategic Plan' process, but after executing the same process, {PP1} DPSP process, does not occur the update of this same artefact in the process group of area of knowledge covered, for example, A[2] 'Organizational Environmental Analysis'.

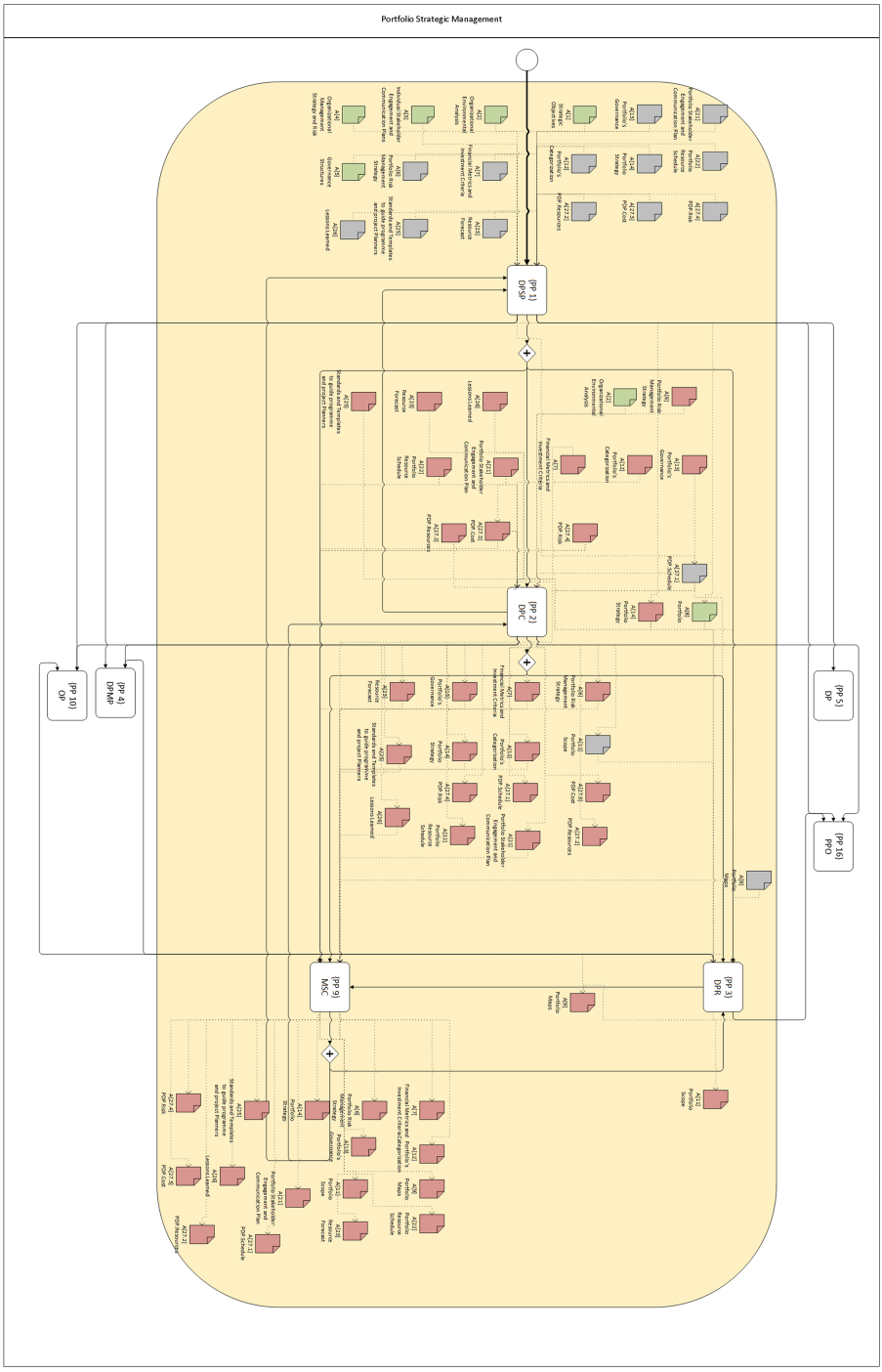


Fig. 2. KA-1 centric dependency analysis model (Color figure online)

Artefacts with grey tone are input or output of a process, but, after the execution of this process, artefact update occurs (red tone).

While A[6] 'Portfolio Risk Management Strategy', A[7] 'Financial Metrics and Investment Criteria', A[12] 'Portfolio's Categorization', A[13] 'Portfolio's Governance', A[14] 'Portfolio Strategy', A[21] 'Portfolio Stakeholder Engagement and Communication Plan', A[22] 'Portfolio Resource Schedule', A[23] 'Resource Forecast', A[25] 'Standards and Templates to guide program and project Planners', A[26] 'Lessons Learned', A[27.2] 'PDP.Resources', A[27.3] 'PDP.Cost', and A[27.4] 'PDP.Risk' are OGC PfM artefacts necessary for implementing {PP1} DPSP 'Develop Portfolio Strategic Plan' process. These artefacts are, also, portfolio artefacts, which are created in the following PMI PfM processes, and represent input artefacts at the second, third, and other iterations of the {PP1} DPSP 'Develop Portfolio Strategic Plan' process. Therefore, these artefacts are represented for the first time in a grey tone, and after being updated, these artefacts turn into a red tone.

When the artefacts have a grey tone, it allows the researchers to conclude that the artefacts are created in other PMI PfM processes during the first iteration of the processes, and are updated during the processes iteration cycles (i.e., performed, more than once, over the PfM).

The area defined at Fig. 2 in yellow shadow tone represents the KA-1 Centric Dependency Analysis Model, i.e., processes executed in the '*Portfolio Strategic Management*' knowledge area; the processes and iterations outside the yellow tone represent iterations with other processes and artefacts in other knowledge management area.

Through the BPMN representations, the artefacts update sequence and the cyclic existence of the PMI PfM framework processes, a sequential order of execution of the processes is proposed. The researchers propose an order for the execution of some processes within a KA. In KA-1 is suggested the following order of the processes' execution: (1º) {PP 1} DPSP, (2º) {PP 2} DPC, (3º) {PP 3} DPR and (4º) {PP 9} MSC. {PP 3} DPR and {PP 9} MSC processes have a dependency between them.

Therefore, PMI PfM processes can be executed in this way or vice versa. In PMI PfM framework, {PP2} DPC, {PP3} DPR and {PP9} MSC processes are executed in parallel after the {PP1} DPSP.

By the iterations between the KA-1 processes, the processes are revisited several times during the PfM lifecycle, as demonstrated in Fig. 2.

Figure 3 shows the KA-2 Centric Dependency Analysis Model with the *Portfolio Governance Managemen*t knowledge area, with the processes {PP 4} DPMP, {PP 5} DP, {PP 10} OP, {PP 15} AP and {PP 16} PPO.

{PP 4} DPMP 'Develop Portfolio Management Plan' process requires several artefacts to be executed, for an organizational artefact, A[2] 'Organizational Environmental Analysis', which is no longer used by any other process of this KA.

The researchers propose an order for the execution of the processes from '*Portfolio Governance Management*' knowledge area: (1º) {PP 4} DPMP, (2º) {PP 5} DP, (3º) {PP 10} OP, (4º) {PP 15} AP, and (5º) {PP 16} PPO. {PP 15} AP and {PP 16} PPO processes, as artefacts have dependency between them; can be executed in this way or vice versa.

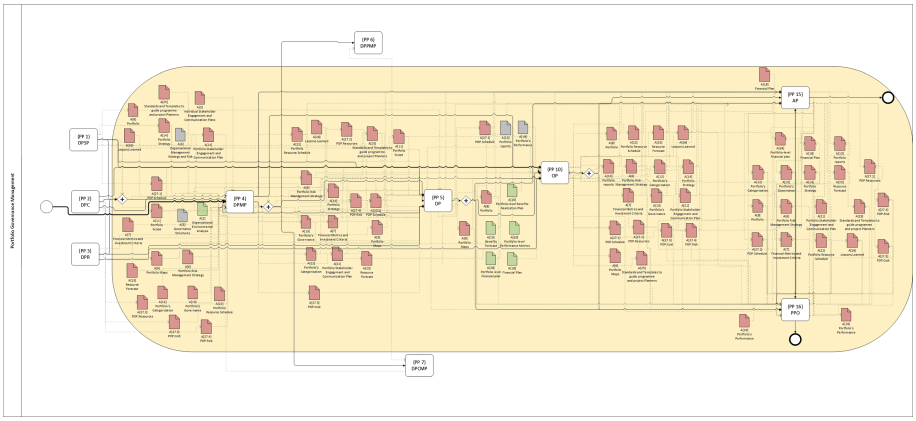


Fig. 3. KA-2 centric dependency analysis model

Figure 4 presents the processes flow of the '*Portfolio Performance Management*' knowledge area, KA-3 Centric Dependency Analysis Model.

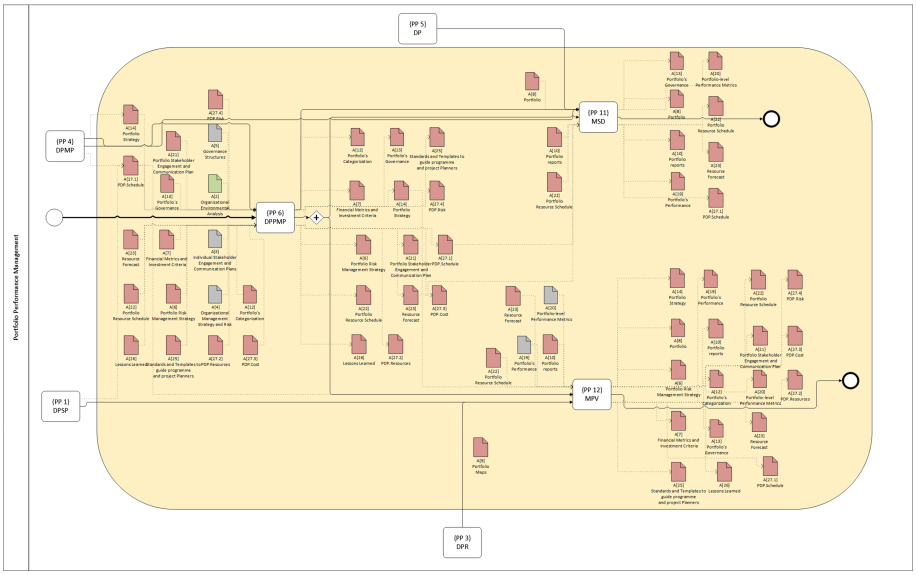


Fig. 4. KA-3 centric dependency analysis model

Three processes are characterized in the KA-3 Centric Dependency Analysis Model: {PP 6} DPPMP, {PP 11} MSD and {PP 12} MPV, which are related through their artefacts. Most of the input and output artefacts represented in Fig. 4 are created in processes of previous areas of knowledge (red tones), the reason why the researchers are able to conclude that this area of knowledge is only used after other areas of

knowledge, which makes sense, because it is about '*Portfolio Performance Management*'. In KA-3 Centric Dependency Analysis Model, for example, A[19] 'Portfolio's Performance' and A [20] 'Portfolio-level Performance Metrics' artefacts (grey tone) are updated (red tone), when executing {PP 12} MPV process.

The order proposed for execution of the KA-3 Centric Dependency Analysis Model processes is as follows: (1º) {PP 6} DPPMP, and then (2º) {PP 11} MSD or (3º) {PP 12} MPV. There is no cyclical interaction between {PP 11} MSD and {PP 12} MPV.

KA-4 Centric Dependency Analysis Model represents the '*Portfolio Communication Management'* knowledge area processes, {PP 7}DPCMP and {PP 13} MPI (see Fig. 5).

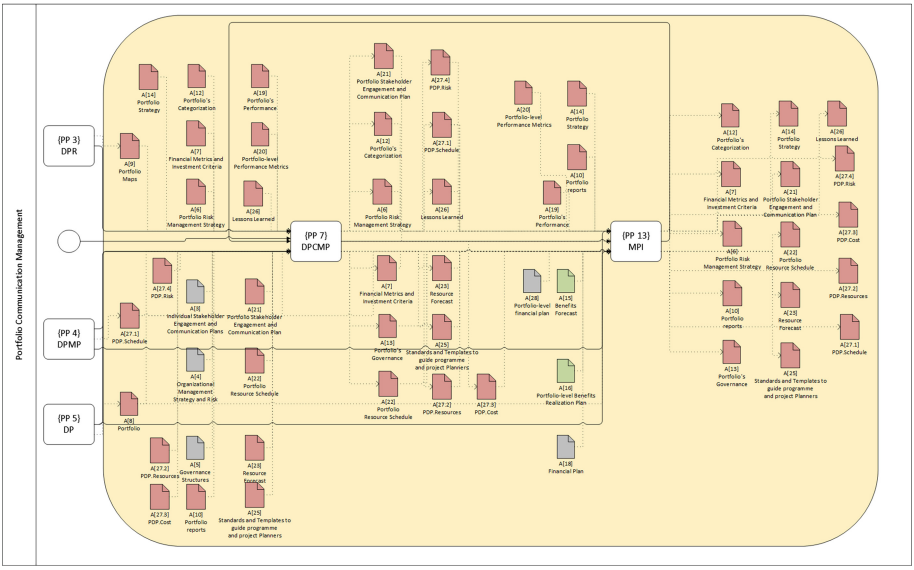


Fig. 5. KA-4 centric dependency analysis model

For the KA-4 Centric Dependency Analysis Model, the processes' order of execution proposed is as follows: (1º) {PP 7} DPCMP, and (2º) {PP 13} MPI, where outputs artefacts in the {PP 13} MPI process may be inputs in {PP 7} DPCMP process during the following iterations. This KA-4 Centric Dependency Analysis Model is characterized only by two processes, but with cyclic iterations, where artefacts are updated according to a new iteration.

Figure 6 presents the KA-5 Centric Dependency Analysis Model, with the two processes of the '*Portfolio Risk Management*' knowledge area, {PP 8} DPRMP and {PP 14} MPR.

KA-5 Centric Dependency Analysis Model is characterized by the input artefacts of the 'portfolio' and 'organizational' among them, A[1] 'Strategic Objectives' and A[2] 'Organizational Environmental Analysis'.

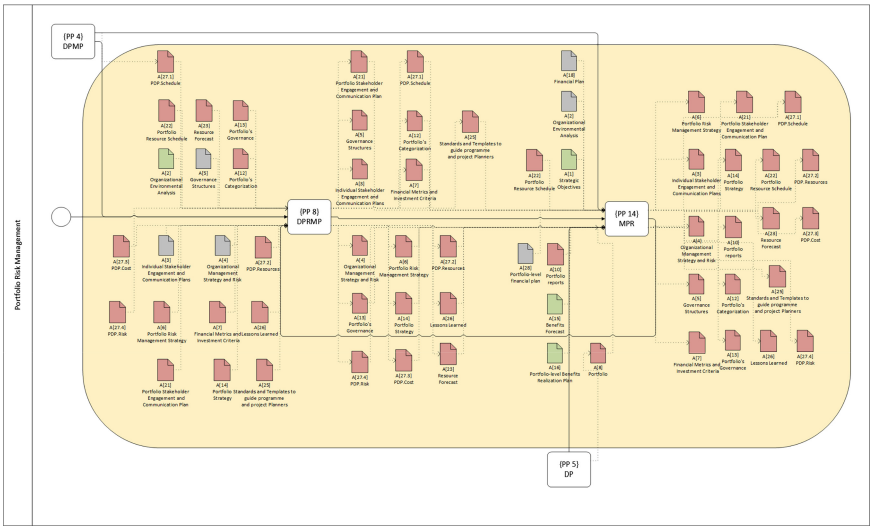


Fig. 6. KA-5 centric dependency analysis model

The order of execution of the KA-5 processes proposed is as follows: (1º) {PP 8} DPRMP, and (2º) {PP 14} MPR, being the iterations cycled between the two processes.

The group of Centric Dependency Analysis Models: KA-1, KA-2, KA-3, KA-4 and KA-5 represents the tailored IT PfM framework, based on the PfM frameworks from PMI and OGC. The use, creation and update of a set of forty OGC PfM artefacts and proposal of an order of execution of the PMI PfM processes allows PfM professionals to perform their jobs systematically.

3 Traceability Map of an Example Artefact Using UML State Machine Model

By the mapping in Table 1, it is noted that the most used and most updated artefact by all PMI PfM processes is A[27.1] 'Portfolio Delivery Plan – Schedule'. Therefore, in order to demonstrate, as an example, the creation and the various updates of this particular artefact A[27.1], throughout the processes and respective knowledge areas, the researchers use the UML State Machine Model (see Fig. 7).

The UML State Machine Model [22] comes from the statecharts [23]. This type of model is used to model the different states of an object during the execution of a process. A state can receive information indicating activities in the input, permanence, and exit of the state (exit/output). The concepts as superstate (or compound states) and substates, present in statecharts, are used in UML state machines model [24].

In Fig. 7, superstate is, for example, '*Portfolio Strategic Management*', with several states 'PSM_1', 'PSM_2', etc. Each state, e.g., PSM_1, represents the transition of the A[27.1] 'Portfolio Delivery Plan – Schedule' artefact for a given process.

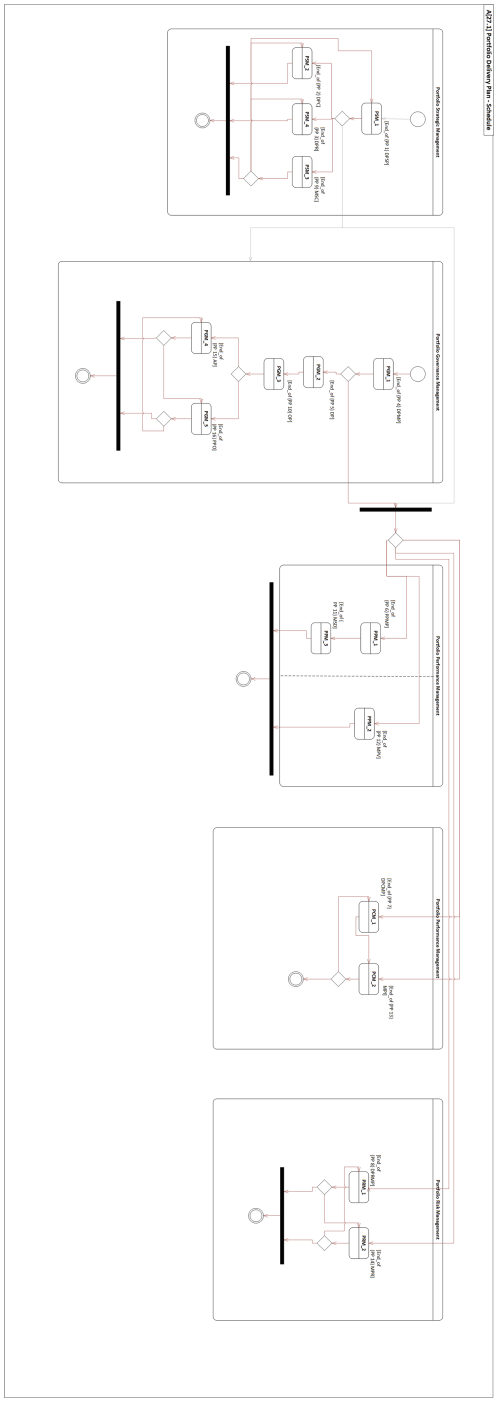


Fig. 7. A[27.1] 'Portfolio Delivery Plan Schedule' artefact using UML State Machine Model

For example, the artefact A[27.1] is input in the process {PP2} DPC, but it is also output in this same process. Therefore, when the process {PP2} DPC is executed, the artefact A[27.1] is modified and a new output of A[27.1] is created.

Portfolio Strategic Management (PSM), *Portfolio Governance Management* (PGM), *Portfolio Performance Management* (PPM), *Portfolio Communication Management* (PCM) and *Portfolio Risk Management* (PRM) knowledge areas are considered the compound states or superstates (see Fig. 7).

Within the '*Portfolio Strategic Management*' compound state or superstate, after passing PSM_1 state, the A[27.1] 'Portfolio Delivery Plan – Schedule' artefact may be executed in the other PSM processes, as can be also used as input artefact in PGM and PPM compound states (represented by a grey line). This artefact may also be input (initialized) in the PGM compound state. After passing the PGM_1 state, A[27.1] 'Portfolio Delivery Plan – Schedule' artefact can input the subsequent processes into the PGM or can input the PPM, PCM or PRM composite states. A [27.1] 'Portfolio Delivery Plan – Schedule' artefact, when showing up in the PPM, PCM or PRM compound states, comes from the PSM or PGM compound states.

In summary, Fig. 7 shows that, A[27.1] 'Portfolio Delivery Plan – Schedule', OGC PfM artefact interacts with sixteen PMI PfM processes, and therefore it is an essential artefact for PfM.

4 Conclusions and Future Work

This paper contributes to individuals and organizations interested in increasing their performance in PfM, by presenting the mapping between OGC PfM artefacts and PMI PfM artefacts and the mapping between PMI PfM processes and OGC PfM artefacts, from the two worldwide recognized PfM frameworks: OGC (now Axelos) and PMI.

Nevertheless, OGC PfM framework has a broader collection of artefacts regarding how PfM processes should be performed. Therefore, this research's work, based on the researchers' extensive professional experience in PfM and in an in-depth analysis and discussion of the concepts and definitions of each artefact from PMI and OGC PfM frameworks, establishes a mapping between the artefacts from OGC PfM framework and PMI PfM framework. The paper increases the understanding of how to execute PfM processes from artefacts, bringing mainly a contribution for practice.

A tailored IT PfM framework, based on processes from the PMI PfM framework and artefacts from the OGC PfM framework is proposed, through a previous mapping between artefacts from the PMI PfM framework and artefacts from the OGC PfM framework.

The tailored IT PfM framework proposed aims to help PfM professionals in understanding "how to" use the PfM processes from PMI PfM framework, and the order of execution of the processes, using a wide range of existing artefacts from OGC PfM framework.

The researchers present the tailored IT PfM framework used BPMN representation. However, due to the complexity and richness of the artefacts, additionally, the researchers, present a representation in UML State Machine of the most used and updated artefact in IT PfM framework, A[27.1] 'Portfolio Delivery Plan – Schedule'

artefact. This representation allows showing all the details of the transitions, through the different areas of knowledge and processes.

Therefore, the next step will be to conduct a case study to validate the IT PfM framework at a particular organizational context - information technology projects in a research and development organization. The case study will allow: (1) to validate the processes flow (i.e. processes execution order) and (2) to identify what artefacts will be necessary to discard or to create taking into account the organizational context, refining the IT PfM framework.

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References

1. Markowitz, H.: Portfolio selection. J. Finance **7**(1), 77–91 (1952)
2. Kopmann, J., Kock, A., Killen, C.P., Gemünden, H.G.: The role of project portfolio management in fostering both deliberate and emergent strategy. Int. J. Proj. Manag. **35**(4), 557–570 (2017)
3. Kester, L., Griffin, A., Hultink, E.J., Lauche, K.: Exploring portfolio decision-making processes. J. Prod. Innov. Manag. **28**(5), 641–661 (2011)
4. McNally, R.C., Durmuşoğlu, S.S., Calantone, R.J.: New product portfolio management decisions: antecedents and consequences. J. Prod. Innov. Manag. **30**(2), 245–261 (2013)
5. McCarthy, I.P., Tsinopoulos, C., Allen, P., Rose-Anderssen, C.: New product development as a complex adaptive system of decisions. J. Prod. Innov. Manag. **23**(5), 437–456 (2006)
6. Archer, N., Ghasemzadeh, F.: An integrated framework for project portfolio selection. Int. J. Proj. Manag. **17**(4), 207–216 (1999)
7. Rautiainen, K., Schantz, J., Vahaniitty, J.: Supporting scaling agile with portfolio management: case Paf. com. In: 2011 44th Hawaii International Conference on System Sciences (HICSS), pp. 1–10 (2011)
8. Bitman, W.R., Sharif, N.: A conceptual framework for ranking R&D projects. IEEE Trans. Eng. Manag. **55**(2), 267–278 (2008)
9. Blau, G.E., Pekny, J.F., Varma, V.A., Bunch, P.R.: Managing a portfolio of interdependent new product candidates in the pharmaceutical industry. J. Prod. Innov. Manag. **21**(4), 227–245 (2004)
10. Cooper, R., Edgett, S., Kleinschmidt, E.: Portfolio management in new product development: lessons from the leaders-II. Res. Technol. Manag. **40**(6), 43–52 (1997)
11. Mikkola, J.H.: Portfolio management of R&D projects: implications for innovation management. Technovation **21**(7), 423–435 (2001)
12. Project Management Institute: The Standard for Portfolio Management. Project Management Institute, Newtown Square (2013)
13. Axelos, MoP™ Management of Portfolios, London (2011)
14. McDonald, C., Sarbazhosseini, H.: A state transition approach to conceptualising research: the project portfolio management domain. In: 24th Australasian Conference on Information Systems (ACIS), pp. 1–10 (2013)
15. Young, M., Conboy, K.: Contemporary project portfolio management: reflections on the development of an Australian competency standard for project portfolio management. Int. J. Proj. Manag. **31**(8), 1089–1100 (2013)

16. Williams, B., Young, M., Young, R., Zapata, J.: Project, programme and portfolio maturity: a case study of Australian Federal Government. Int. J. Manag. Proj. Bus. **7**(2), 215–230 (2014)
17. Lima, A., Monteiro, P., Fernandes, G., Machado, Ricardo J.: Dependency analysis between PMI portfolio management processes. In: Gervasi, O., et al. (eds.) ICCSA 2016. LNCS, vol. 9790, pp. 288–300. Springer, Cham (2016). https://doi.org/10.1007/978-3-319-42092-9_22
18. Lima, A., Machado, R.J., Fernandes, G.: Input and output artefacts in portfolio practices from the OGC standard for Management of Portfolios. In: 2017 17th International Conference on Computational Science and Its Applications (ICCSA), pp. 1–8 (2017)
19. OMG, Business Process Model And Notation™ (BPMN™), OMG (2013). http://www.omg.org/spec/BPMN/2.0.2/PDF/. Accessed 25 Aug 2017
20. Lima, A., Fernandes, G., Machado, R.J.: Mapping between PMI and OGC artefacts for project portfolio management. In: International Conference on Intelligent Systems 2018'IS (2018)
21. Lübke, D., Schneider, K.: Visualizing use case sets as BPMN processes. In: Requirements Engineering Visualization, 2008. REV 2008, pp. 21–25 (2008)
22. OMG, OMG unified modeling language, superstructure version, 2015 (2015). http://www.omg.org/spec/UML/2.5/PDF/. Accessed 28 Aug 2017
23. Harel, D.: Statecharts: a visual formalism for complex systems. Sci. Comput. Program. **8**(3), 231–274 (1987)
24. Gross, H.: Component-Based Software Testing with UML. Springer, Heidelberg (1998)