Model of a maturity capsule in managing IT projects

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INTRODUCTION

The main purpose of this paper is to present a report of the development of a (MITM) model of information technology management. This model is an answer to the need to support decision-making in the selection of methods and information technologies. This paper presents a multi-sequential model (MSM) of technology selection, and a model for initial processing procedures (IPP) necessary for the MITM model. The presentation of the construction stages of both models is followed by a discussion on their verification processes in an environment of enterprise architecture (EA) development. Aggregated (within the process of IPP) variables are applied, such as the maturity of the client (C) and the provider/supplier (S), as well as the project negentropy (P), being a measure of the project development state. Next, the concept of an integrated maturity capsule (C-S-P) is introduced. The work concludes with the authors' observations, concerning mainly on the purposefulness of using decision-making models in the management of information technology projects, but also on the applicability of the methods of modeling such projects.

PROBLEMS CONNECTED WITH INFORMATION TECHNOLOGY MANAGEMENT

This article deals with the problem of modeling in information technology management, which is an important issue in IT project management (Bass *et al.*, 2003). The authors' previous works in this area present a model approach to the three components of IT project management: the team, the manufacturing and management processes, as well as the application of information technology in the manufacturing and management processes of projects (Chabik and Orłowski, 2010; Orłowski and Szczerbicki, 2002; Kowalczuk and Orłowski, 2007, 2014).

There are three variables, influencing the above-mentioned three components, which can be indicated in projects management. These are: provider maturity, client maturity and project negentropy – a specific variable introduced for the modeling processes. We are attempting to determine the values of these variables and to propose a linguistic approach for assessing the results of the evaluation of organization maturity obtained on the basis of IT standards applied in practice (http, 2009), such as COBIT (version 4.1), ITIL (version 3.0) and TOGAF (version 8.1). The knowledge arising from the COBIT and ITIL standards proved to be important in evaluating the maturity of the client organization and that of the provider (Brandon and Shrum, 2009). In evaluating the specific indicator for measuring the degree of a global maturity of a project, called *negentropy*, it is appropriate to use the TOGAF standard.

Since the client and provider organizations/institutions, as well as the organization of the project mentioned above are submitted to a common analysis in terms of their *maturity*, we will, for simplicity, use the concept of a *maturity capsule* of the client (C) and the provider (S) institutions and the organization of the project (P), in short C-S-P. Such a capsule provides a detailed and integrated specification of the evaluation of the quality (level) of project management (as a whole), and can constitute a basis for developing models of IT project

management. To simplify the construction processes of the MITM model, the linear discrete models are mainly taken into account, and specifically the discrete-time and the dynamic models using state variables, that is, having a system memory (Korbicz *at al.*, 2004; Nguyen and Szczerbicki, 2010).

Non-linearities, which are evident from a practical point of view, are represented chiefly by saturation characteristics and by quantization to certain discrete levels (Kowalczuk, 1998; Steinberg and Randy, 2005). The main mechanism for implementing non-linear processing lies in using the linguistic and fuzzy-rule-based approaches with a fundamental contribution of linguistic evaluations obtained through a researcher-administered survey, i.e. test questions (Tong, 1979; Zadeh, 1978).

For describing the enterprise architecture management and development processes, and the maturity of the client and provider organizations, elementary mathematical tools (matrices and vectors) can be applied, as well as the linguistic approach, which increases the applicability of the developed models (Orłowski and Kowalczuk, 2006; Kowalczuk and Orłowski, 2014). Such treatment not only structures the most relevant concepts for a project team manager, but it also supports the implementation of IT standards and identifies the areas for their application while selecting information technology.

MODEL OF INFORMATION TECHNOLOGY MANAGEMENT – MITM

The proposed method of modeling the project management process, in which the model (build around the capsule) of its maturity is integrated with the technology selection model (*i.e.*: management information technologies, such as the methods and tools of management) complies with the contemporary approach in the IT environment to detach the models of projects from technology (that is assuming that technology plays is a secondary role). Therefore, in the presented study, the multi-level sequential model (MSM) of information

technology selection (for management methods and tools) represents the objective model of project and information technology management, MITM.

The MSM model includes two sub-models concerning: methods selection (MSMm) and tools selection (MSMt). There are abilities to change the tools and their functionalities (to modify the tool's functions) during the project development (as such changes are relatively common). The model does not, however, account for changes in project management methods during the project. Both the models and a feedback mechanism, showing the impact of changes in the project in the scope of the functionalities of the tools, are presented in Figure 1. It demonstrates the multi-level sequential MSM model of selecting methods and tools for IT project management.
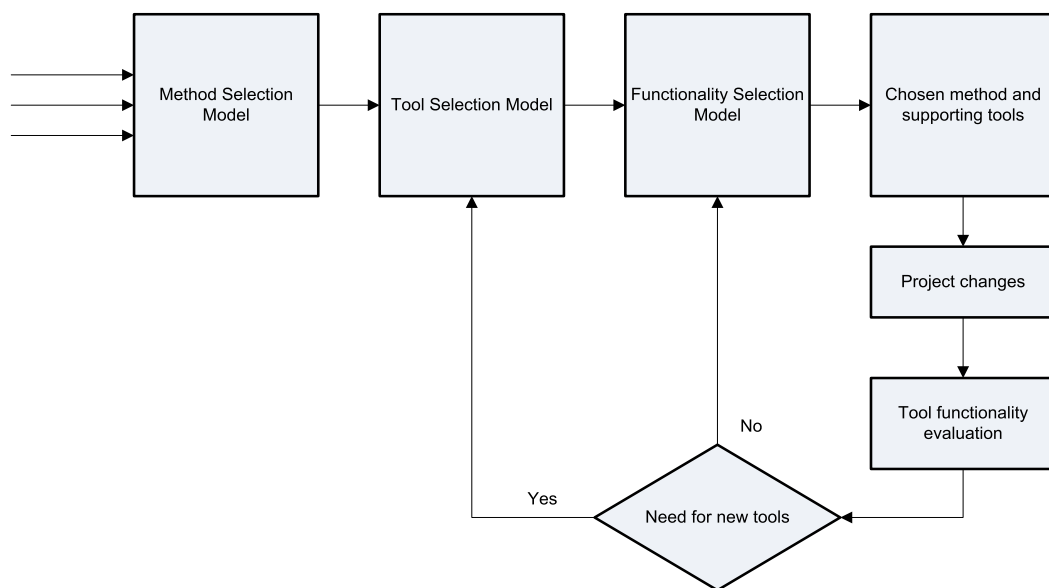

Fig. 1.   Multi-level sequential model MSM of selecting methods and tools for IT project management (Kowalczuk and Orłowski, 2014).

The MSMm model of selecting management-support methods (the left-hand side of Figure 1) is shown in detail in Figure 2, whereas the MSMt model of selecting functionalities and tools to support management (the middle part of Figure 1) – is shown in detail in Figure

3. Both models (MSMm and MSMt) are hierarchical and multi-level. The model of selecting the methods of IT project management, shown in Figure 2, demonstrates four procedure levels of the estimation process (the evaluation procedures) of the maturity of the organizations of the client and provider, as well as the project negentropy, contained in the maturity capsule.
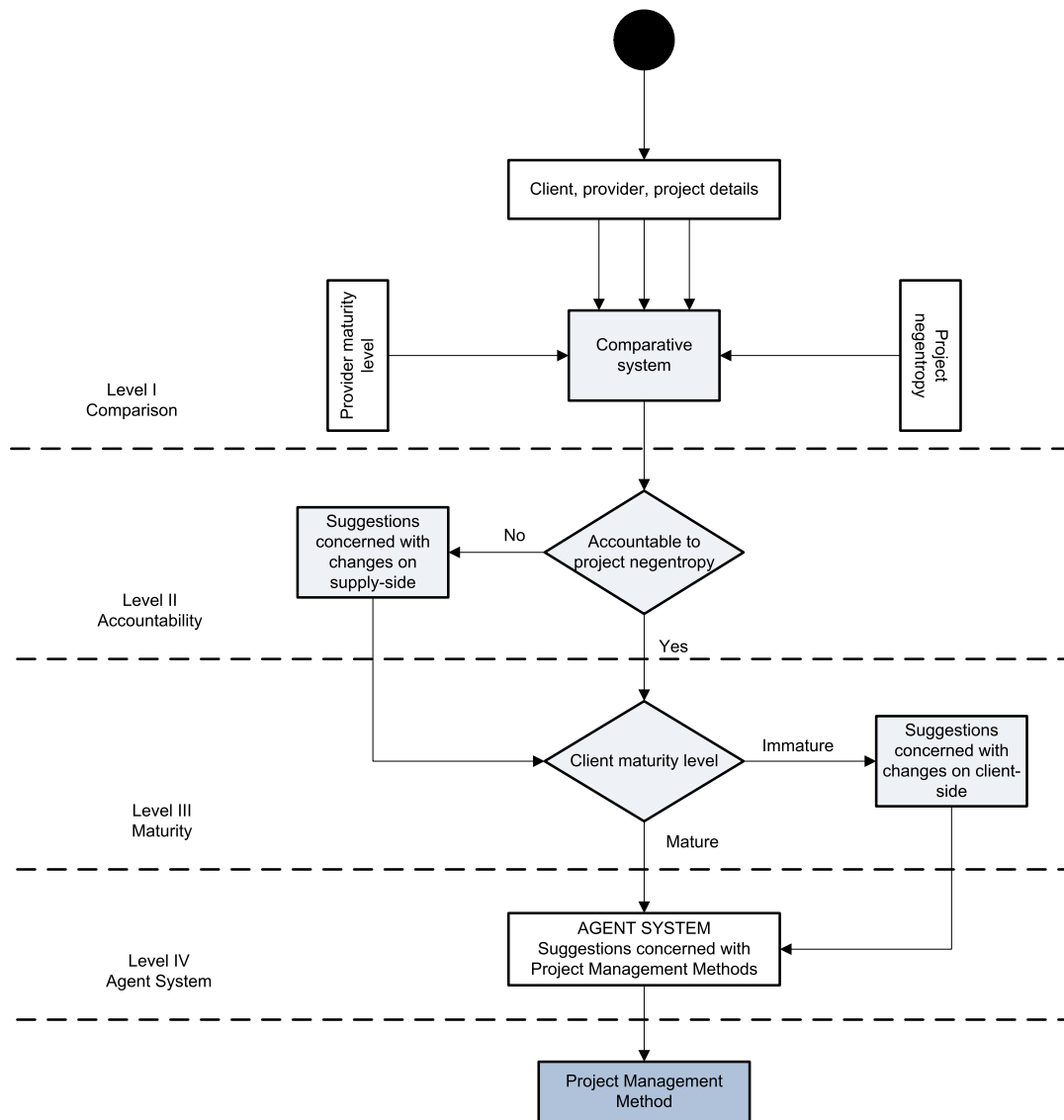
Fig. 2.   Detailed model of selecting the project management method – MSMm (Kowalczuk and Orłowski, 2014).
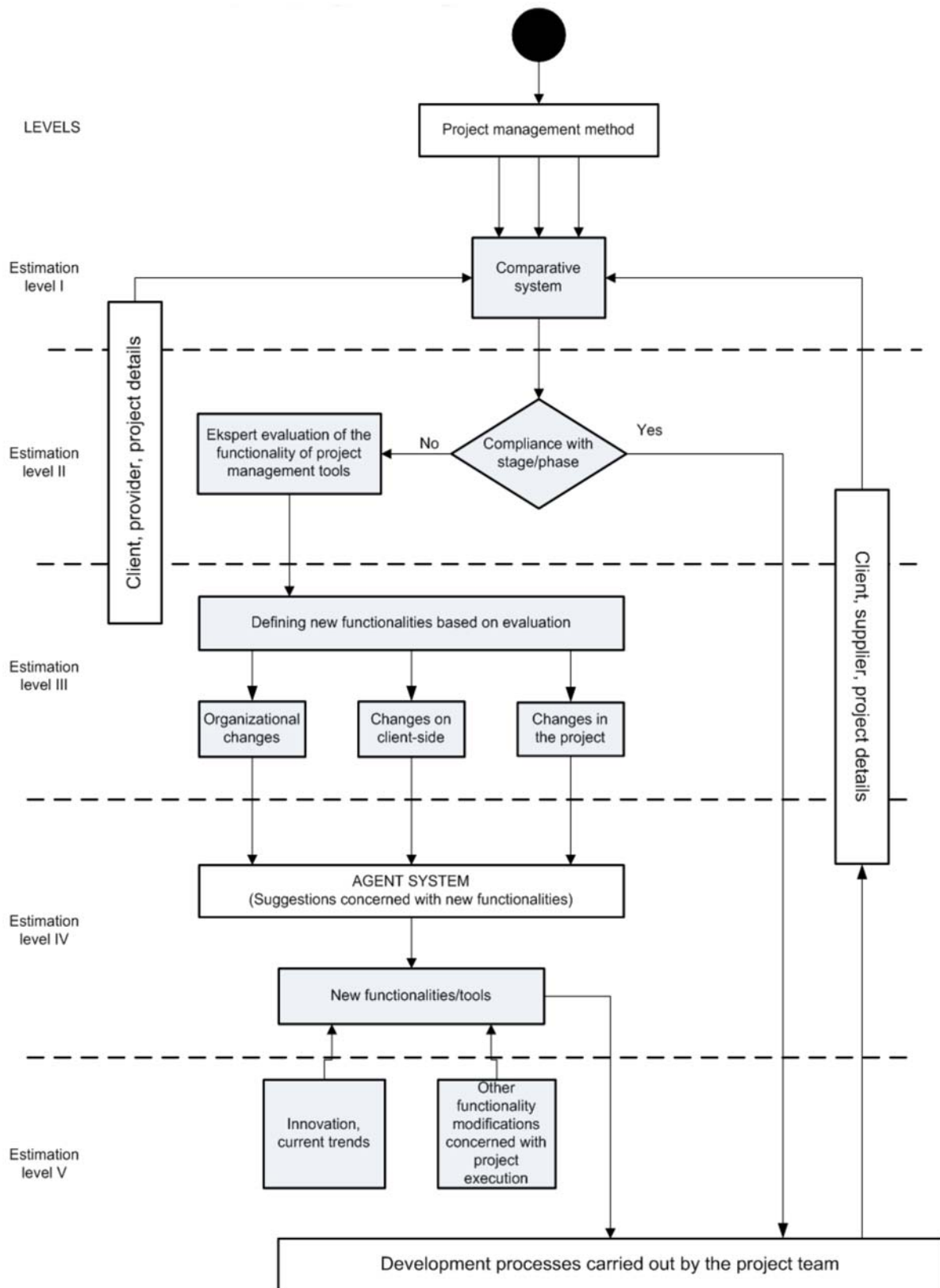
Fig. 3.   Detailed multi-level model of selecting IT project management tools or changes in their functionalities – MSMt (Kowalczuk and Orłowski, 2014).

After introducing the MSMm model, the MSMt model of selecting comprehensive tools or some of their functions (Figure 3) can be presented. It includes five procedural levels. In Figures 2 and 3, the sketch 'client, provider, project details' means a specific evaluation of the maturity of the client and provider organizations, as well as the scalar negentropy of the project.

DYNAMIC IMPLEMENTATION OF THE MATURITY CAPSULE IN THE MITM MODEL

Below we present a general four-phase diagram of the MITM processes for determining the state of the project via the maturity capsule, which contains the fundamental variables of the *ITM* process. The ultimate result of the state of the capsule is to be cast on the changes in IT services, such as the functionality of the technology (methods and IT tools) of project management.

The parallel channels (C-S-P) in Figure 3 are integrated to the form of a static IPP system, which in Figure 4 constitutes the input for the dynamic sub-model (maturity capsule). After the capsule, there is a decision-making sub-model, which is a rule-based-linguistic implementation of the MSM model, which converts its variables into the above-mentioned categories of IT services.

STEP ONE: the initial processing IPP applies to static data.

(**s**) Channel (S) includes, the aggregation procedures of the increased level of maturity of the provider organization with the scalar variable (Δo_t), on the basis of the increased maturity of its key processes: in manufacturing $(\Delta ok1_t)$ and in management $(\Delta ok2_t)$.

(**p**) The increase in the scalar project negentropy is defined similarly as (Δp_t) aggregating variables (Δpn_t) and (Δpd_t), corresponding to the growth of applied project management

technologies and the level of expertise, *i.e.* the knowledge and understanding of the project area. We assume that the increase in the level of the applied technology is due to the change or the introduction of new features in the IT used in the project. We also assume that the increase in the level of domain knowledge determines changes in the level of knowledge, which is required in dealing with the provider in the creation of the *system metaphor* (a common image of the system seen by the provider and the client). This increase can be identified by defining new use cases, with the *system metaphor* in the form of diagrams of these cases. Both the increase in the level of domain knowledge and in IT is observed with the use of the IPP – for the (scalar) evaluation of project negentropy.

(**c**) The increase in client maturity (Δk_t) is associated with an increase in the level of matching (Δpp_t) and suitability (Δpo_t) of the client. The increase in client matching means formating of new personal traits in the software development processes performed together with the provider. On the other hand, the growth in client suitability refers to increasing the level of the client's knowledge of the domain (as a result of working with the provider on the system metaphor). These increments are determined according to the implemental assumptions made in (Kowalczuk and Orłowski, 2014) in order to suitably describe the IPP processes in terms of client organization maturity.

STEP TWO shows the direct effect of static channels, with the use of the management level increase function P_ϕ, on the maturity capsule in the form of a change (Δz_t) in the level of project management. This level is described by the vector $\mathbf{z}_t$, which represents the aggregated, three-element state of the capsule, adequately to its three coordinates. The input growth determines the changes in project management, which are the consequences of the growth in the level of the client and the provider organization maturity and the (secondary) negentropy of the project.

STEP THREE of the processing constitutes the *maturity capsule* (being a dynamic system), which reflects the maturity growth processes of the provider organization (Δo_t), of the client (Δk_t) and the scalar project negentropy (Δp_t), represented by an increment in the variable (Δz_t), and the new state, the level of project management ($\mathbf{z}_t$). This process is realized with the help of a function P_ω, which dynamically refers to the current increment ($\Delta \mathbf{z}_t$) in the previous level of project management ($\mathbf{z}_{t-1}$), which expresses the quality of management in the previous calculation cycle.

The computed new level of project management is, therefore, a consequence of the increased maturity of the provider and client organizations, as well as of the project negentropy within the integrated maturity capsule. The scalar measurement of management quality (z_t), resulting from normalization to the interval <0, 5>, which is standard for such considerations, can be used for a general tool evaluation of the maturity capsule and the level of management. The target result of management is to increase the functionality of the tools used in project management.

STEP FOUR implements a *decision-making system* based on a rule-based description generating output variables, which are determined using the generally described function P_ψ (Kowalczuk and Orłowski, 2004, 2006, 2007). These variables express the level of expected functionalities, specifically in terms of their growth Δy_t. Changes in the functionality of the tools thus relate directly to the maturity capsule (C-S-P) and the generic change in the management of the provider's team, changes in the applied IT and process changes of the client organization.
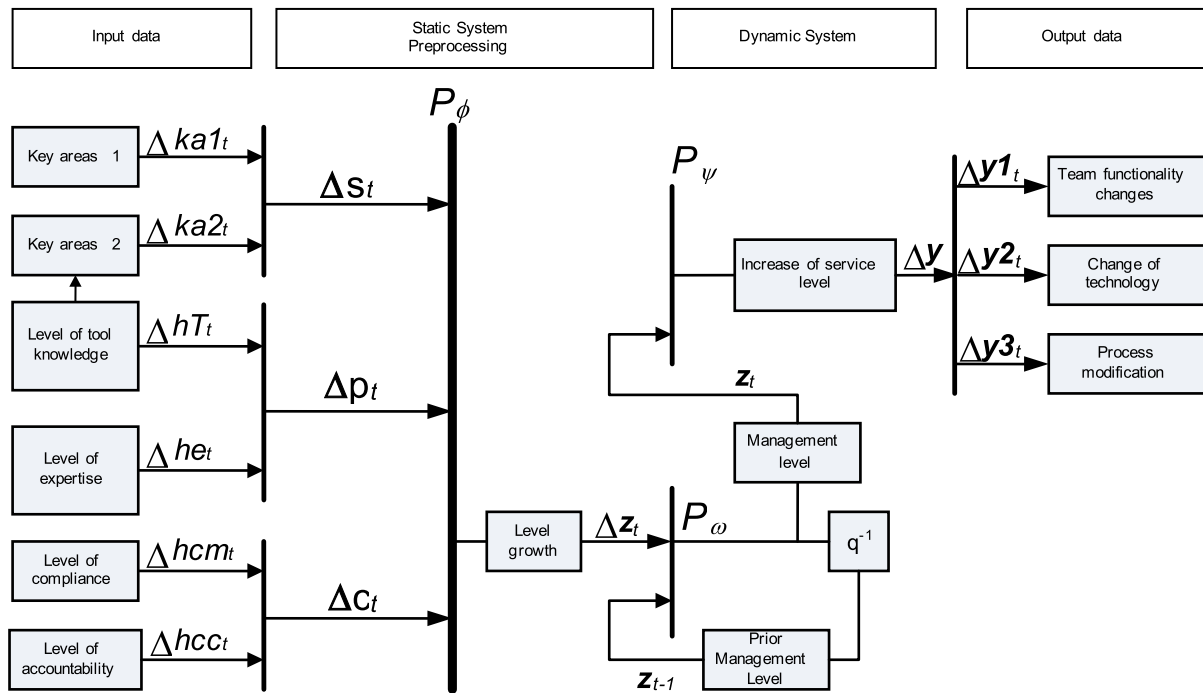
Figure 4.   The integrated dynamic MITM model: IPP + capsule + a decision-making system (Kowalczuk and Orłowski, 2014).

MATRIX-VECTOR IMPLEMENTATION OF THE C-S-P MATURITY CAPSULE IN THE MITM

Let us now present a simplified general model of the initial processing procedures, which is an extension of the model from Figure 4 in the fuzzy rule-based decision-making mechanism. After showing its detailed description that is based on properly defined variables and procedures and their processing (Kowalczuk and Orłowski, 2014; Patterson and Hennessy, 2006), we will present exemplary IT management models adapted for enterprise architecture development – with the use of the vector description of both the IPP and the maturity capsule.

A general IPP (initial processing) procedure is based on previous findings in terms of processing. This model is based on the proposed IPP specification focused in the case of project negentropy on manufacturing and management processes. We suggest the division of project processes resulting from experience gained from implementation of many projects.
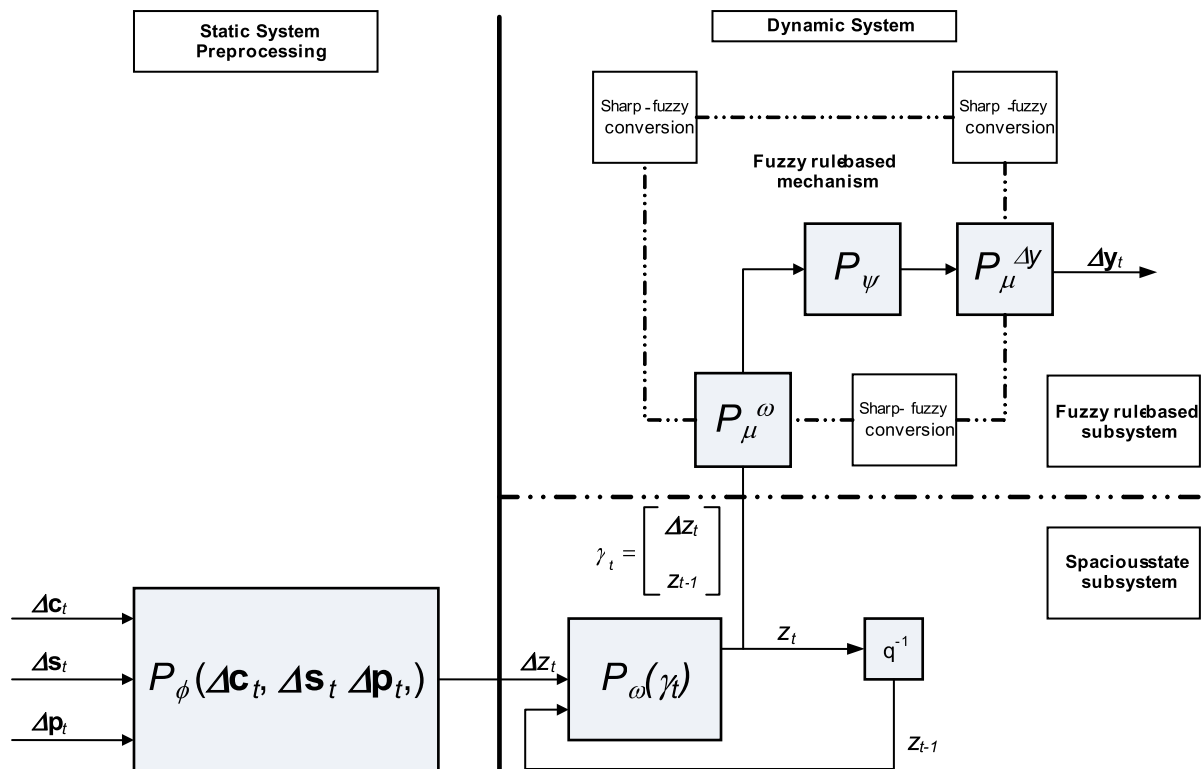
Figure 5. The dynamic MITM model for the selection of IT technologies through a decision-making system (Kowalczuk and Orłowski, 2014).

Underneath we describe how to measure the scalar negentropy of a project and how the processes of management and manufacturing intertwine. Figure 5 shows this division and common processes carried out in both areas, including best practices, processes and technologies.

The general IPP model presented here is the starting point for the presentation of the complete IPP model. This model contains areas of static (incremental), dynamic and decision-making (rule-based) processing.

Within the static part, the initial processing is connected to the previously introduced variables (Δk_t), (Δo_t), (Δp_t). The characteristics of the complete conversion process P_ϕ is shown below on the basis of separate (independent) member functions P_ϕ^k, P_ϕ^o, P_ϕ^p :

$$P_\phi^k : \Delta \mathbf{k}_t \rightarrow \Delta z_t^k \qquad \text{and} \qquad P_\phi^k : \Delta z_t^k = \mathbf{\Pi}_k \cdot \Delta \mathbf{k}_t \qquad (1)$$

$$P_\phi^o : \Delta\mathbf{o}_t \rightarrow \Delta z_t^o \qquad \text{and} \qquad P_\phi^o : \Delta z_t^o = \mathbf{\Pi}_o \cdot \Delta\mathbf{o}_t \qquad\qquad (2)$$

$$P_\phi^p : \Delta\mathbf{p}_t \rightarrow \Delta z_t^P \qquad \text{and} \qquad P_\phi^p : \Delta z_t^P = \mathbf{\Pi}_p \cdot \Delta\mathbf{p}_t \qquad\qquad (3)$$

$\Delta\mathbf{k}_t$ – client maturity growth vector

$\Delta\mathbf{o}_t$ – provider organization maturity growth vector

$\Delta\mathbf{p}_t$ – vector of variable increment 'secondary project negentropy'

Δz_t^k – partial growth in the level of management resulting from client maturity growth

Δz_t^o – partial growth in the level of management caused by provider maturity growth

Δz_t^p – partial growth in the level of management connected with project negentropy growth

t – project realization time $t \in\, <1, t_{kon}>$, where t_{kon} refers to project completion time

$\mathbf{\Pi}_i$ – matrix (line) of partial methodological transformation, for $i \in \{k,o,p\}$, i.e. the impact of maturity growth of the capsule (C-S-P) on the growth in the level of management.

Determining the matrix coefficients of partial methodological transformation allows for the specification of the differentiated impact of the growth of client and provider maturity and the project negentropy growth on the increase in the level of management.

Knowing the partial effect of each variable in (1)-(3), the complete function P_ϕ, can be defined, realizing the transformation process of vector increments in the maturity capsule (Client-Supplier/provider-Project) into an increase in the level of project management:

$$P_\phi : \Delta\mathbf{z}_t = \begin{bmatrix} \mathbf{\Pi}_k \Delta\mathbf{k}_t & \mathbf{\Pi}_o \Delta\mathbf{o}_t & \mathbf{\Pi}_p \Delta\mathbf{p}_t \end{bmatrix}^T \qquad\qquad (4)$$

$\Delta\mathbf{z}_t$ – vector of management level growth (using such elements as Δz_t^k, Δz_t^o and Δz_t^P), while

Δz_t – effective scalar evaluation of management level growth, $\Delta z_t \in\, <0,5>$, and

T – refers to matrix transposition.

For this modeling, we assume that the vector of the maturity growth $\Delta\mathbf{o}_t$ of the provider organization is described with the help of the elements $\Delta ok1_t$ and $\Delta ok2_t$:

$$\Delta\mathbf{o}_t = \begin{bmatrix} \Delta ok1_t \\ \Delta ok2_t \end{bmatrix} \tag{5}$$

$\Delta ok1_t$ – variable of the growth in processes located in the key area 1, $\Delta ok1_t \in <0,5>$

$\Delta ok2_t$ – variable of the growth in processes located in the key area 2, $\Delta ok1_t \in <0,5>$

t – project realization time $t \in <1, t_{kon}>$, with project completion time t_{kon}, while

Δo_t – will represent the scalar evaluation of provider maturity growth, $\Delta o_t \in <0,5>$.

The vector $\Delta\mathbf{k}_t$ of client maturity growth is described in a similar way, with the use of the element Δpp_t (growth in matching) as well as Δpo_t (growth in the level of suitability):

$$\Delta\mathbf{k}_t = \begin{bmatrix} \Delta pp_t \\ \Delta po_t \end{bmatrix} \tag{6}$$

Δpp_t – variable of growth in (the level of) client matching, $\Delta pp_t \in <0,5>$

Δpo_t – variable of growth in client suitability, $\Delta po_t \in <0,5>$, while

Δk_t – will refer to the scalar evaluation of client organization maturity growth, $\Delta k_t \in <0,5>$.

The vector $\Delta\mathbf{p}_t$ of growth in secondary project negentropy can also be described with the use of elements of growth in the level of the applied IT technology (Δpn_t) and the knowledge of the domain (Δpd_t):

$$\Delta\mathbf{p}_t = \begin{bmatrix} \Delta pn_t \\ \Delta pd_t \end{bmatrix} \tag{7}$$

Δpn_t – variable of growth in the level of the applied IT technologies, $\Delta pn_t \in <0,5>$

Δpd_t – variable of growth in the level of domain knowledge, $\Delta pd_t \in <0,5>$, while

Δp_t – will describe the scalar evaluation of growth in secondary project negentropy,

$$\Delta p_t \in <0,5>.$$

Thus, according to P_ϕ defined in equation (4), growths in the client maturity (Δk_t) and provider maturity (Δo_t) as well as in the project negentropy (Δp_t) can be mapped onto the growth in the level of project management ($\Delta \mathbf{z}_t$ i Δz_t):

$$\begin{bmatrix} \Delta k_t \\ \Delta o_t \\ \Delta p_t \end{bmatrix} \rightarrow \Delta \mathbf{z}_t \text{ lub } \begin{bmatrix} \Delta \mathbf{k}_t \\ \Delta \mathbf{o}_t \\ \Delta \mathbf{p}_t \end{bmatrix} \rightarrow \Delta z_t \qquad (8)$$

The above model requires fixing the matrix coefficients, *i.e.* the rows $\mathbf{\Pi}_i$ to be established as partial transformations, for $i \in \{k,o,p\}$. Each of them contains different management coefficients α_j, β_j, γ_j, $j = 1,2$. A new object, the *aggregate methodological transformation matrix* $\mathbf{\Pi} = \begin{bmatrix} \mathbf{\Pi}_k^T & \mathbf{\Pi}_o^T & \mathbf{\Pi}_p^T \end{bmatrix}^T$, encompasses the full impact of the capsule elements (the maturity of the client and provider organizations and the project negentropy) onto the management level evaluation:

$$\mathbf{\Pi} = \begin{bmatrix} \mathbf{\Pi}_k \\ \mathbf{\Pi}_o \\ \mathbf{\Pi}_p \end{bmatrix} = \begin{bmatrix} \alpha_1 & \alpha_2 \\ \beta_1 & \beta_2 \\ \gamma_1 & \gamma_2 \end{bmatrix} \qquad (9)$$

α_i – matrix coefficient of provider organization maturity transformation, $\alpha_i \in \mathcal{R}_{[0,1]}$

β_i – matrix coefficient of client maturity transformation, $\beta_i \in \mathcal{R}_{[0,1]}$

γ_i – matrix coefficient of project negentropy maturity transformation, $\gamma_i \in \mathcal{R}_{[0,1]}$, while

$\mathcal{R}_{[0,1]}$ – a set of real numbers from the closed interval <0, 1>.

Lines $\mathbf{\Pi}_{k/o/p}$ of this matrix reflect the impact of the maturity capsule elements on the level of information technology management (*ITM*). The values of these matrix coefficients need to be fixed (tuned) according to the knowledge of the dynamic (incremental) effect of client,

provider and project negentropy maturity (1) - (3) and (8) - (9) on the level of management ($\Delta \mathbf{z}_t$ and Δz_t).

We shall thus describe the method of evaluating the coefficient γ_1 in reference to the level of project negentropy (management of component architecture development, based on the model).

Component architecture development is based on the organization of the manufacturing cycle, which allows the re-use of the source code. It is assumed that the components should be independent of the implementation platform and should enable cooperation between applications. This allows the creation of multi-level and multi-layer applications. Such components increase the manufacturing team efficiency and the scalability of the manufactured systems. The component approach is especially valid when building a transparent and standardized structure in distributed systems. This facilitates the management of IT systems development.

VERIFICATION OF THE MITM MODEL

The verification processes evaluates the applicability of the multi-level sequential model of information technology selection (MITM) presented above and the model of the initial processing procedures (IPP). The applicability of the IPP models is presented in two stages with varying levels of detail. The first one shows the possible adaptation of the proposed approach for predicting the development of the support organization.

On the second (lowest) level of verification, a classical reference is applied, in which the IPP is used to evaluate the maturity of the organization (Figure 6).
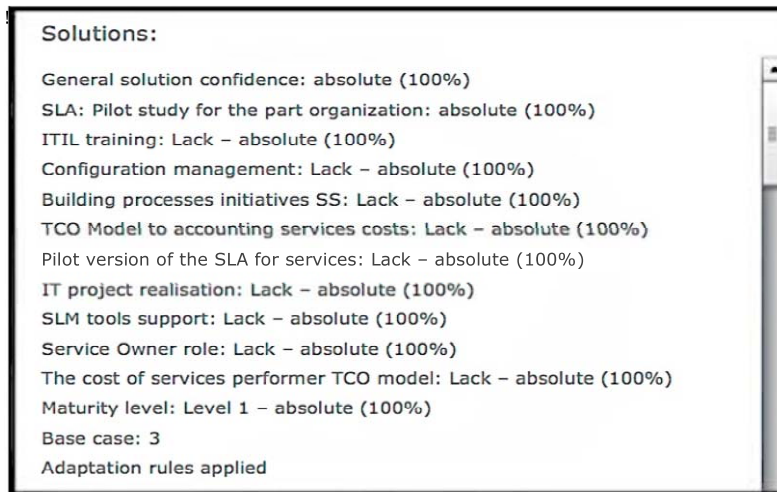
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Solutions:

General solution confidence: absolute (100%)
SLA: Pilot study for the part organization: absolute (100%)
ITIL training: Lack – absolute (100%)
Configuration management: Lack – absolute (100%)
Building processes initiatives SS: Lack – absolute (100%)
TCO Model to accounting services costs: Lack – absolute (100%)
Pilot version of the SLA for services: Lack – absolute (100%)
IT project realisation: Lack – absolute (100%)
SLM tools support: Lack – absolute (100%)
Service Owner role: Lack – absolute (100%)
The cost of services performer TCO model: Lack – absolute (100%)
Maturity level: Level 1 – absolute (100%)
Base case: 3
Adaptation rules applied
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Fig. 6.   Development forecast for an organisation prepared on the basis of the MITM model (Kowalczuk and Orłowski, 2014).

The multi-faceted verification environment served the purpose of justifying the applicability of the ITM model (MITM). The verification of the MITM model of project and information technology management was performed on the IBM RTC platform. The choice of such a tool is the responsibility of the provider organization manager. It is the project manager who selects the management method and the platform. The implementation of the developed model on this platform demonstrates its applicability in the selection of methods and tools to minimize the risk of project failure. It also allows the manager to monitor the development status of the project and to take adequate decisions about any possible changes to maximize the project negentropy.

The verification of the developed solution for supporting Governance processes has shown that cross-sectional treatment of the project in terms of its negentropy organizes the implementation of the Governance processes. The suggested monitoring of the Governance processes via project negentropy confirms the need to analyze the processes of compliance (for specified areas). The two cases of Governance processes considered for this purpose, the enterprise architecture development and the implementation of the system, show that the monitoring of the project in terms of negentropy helps to identify the areas of Governance,

thereby reducing the risk of unsuccessful implementation and increasing the chances of ensuring corporate governance within the entity in which the IT system is implemented.

Controlling the organization development processes is vital for the development of the support organization. The developed model helps the CIO to make decisions in this area. The ITIL standard has so far been the only one used in building the structures of such institutions. The proposed solution, in which the evaluation of the provider organization (its goals and processes) is implemented in linguistic terms, allows for the establishment of a development path and for the recognition of the mechanisms of change. The developed specification of the evaluation of the provider organization maturity resulted in classifying and identifying the potential directions of the development of the status of this institution. In order to authenticate the developed model, six experiments were carried out showing scenarios for organization development. States of the IT support organization were identified, as well as ways to create conditions for presenting the directions for development.

The last stage of verification was based on the environment for the evaluation of client organization maturity, with the use of surveys. As a result, there arose the need for their modification and for the evaluation to be treated in linguistic terms. The typical bivalent scales used in indirect assessment failed. Therefore, a tetravalent scale was used, which better reflects the intermediate states of the organization and which is part of the philosophy of applying IT standards. A client organization implementing a CRM (Customer Relationship Management) system in order to build an enterprise architecture was also analyzed. This case qualifies within projects of high negentropy in which the evaluation of the client is significant.

The COBIT philosophy was applied with modified control questions (for IPP). The analysis carried out streamlined the relationship between the provider and the client and it contributed to finding 'problematic' areas. The verification process revealed the multi-faceted nature of the developed model, both in reference to the organization and the projects. The model supports the environment of IT project management, and it can constitute a basis for

the construction of decision support systems, which means that it can be used in making decisions regarding changes in project negentropy, as well as changes in the organizations of the provider and the client.

SUMMARY

The reader may have some observations or concerns about the method used for modeling IT management processes. The first concerns could relate to the structure and complexity of the model. One might ask the question whether the variables used in the model fully describe the process of IT project management. The answer would be affirmative: especially, considering the fact that the initial processing procedures described in this work proved useful in the specification of the model variables.

The analysis of the process of determining the *client maturity* variable has highlighted the need for the client's acceptance of subsequent products of manufacturing. However, such an approach (acceptance or rejection) is only possible when we are dealing with a mature client. Attempts to contact an immature client can directly contribute to the failure of the project. Therefore, taking client maturity into account is a very important parameter in the construction of the project management environment.

The provider organization's maturity variable performs a similar function. Its application is very important when dealing with clients and in realizing manufacturing processes for a project of whatever negentropy. It also involves a different vision of the project seen by mature managers and with possibilities stemming therefrom. A manager of a mature organization can implement light management methods, while their application by a less mature manager might involve high risk.

Scalar project negentropy is another important variable affecting the IT project management environment. In complex projects, the use of light methods can be problematic,

whereas in the course of the development of projects with smaller negentropy, light methods could prove to be a sensible solution for the project manager.

Taking the three variables into account allows us for a functionally useful and complete description of project management and for the selection of appropriate solutions. It is worth noticing that the method of evaluating the client and the provider environments are common, i.e. both standards (COBIT and ITIL) can be applied to evaluate both the client and the provider.

The selection of variables closes the structural modeling of the project environment. The model must be made precise by estimating the values of these variables. Their rough (and not useful) determination may be based on such models as CMMI (Capability Maturity Model Integration) for evaluating the provider organization maturity, and COCOMO (Cost Model Construction) for project negentropy, as well as on the qualification of the client's psychological profile to evaluate the maturity of the client. This paper shows a more effective solution involving the assessment of these values through appropriate initial processing procedures IPP.

Applying the model together with the IPP simplifies the implementation of such IT standards as ITIL, COBIT and TOGAF for the needs of the client and provider organizations. The proper evaluation of the variables expressed in the maturity capsule (C-S-P) substantially increases the efficiency of the implementation of these standards.

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