# An Intelligent Approach to Increase Efficiency of IT-Service Management Systems: University Case-Study

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**Abstract.** A comprehensive framework to increase efficiency of IT-services management systems (ITSMS) is proposed, which resolves 3 interconnected tasks in a target organization: 1) providing an effective configuration of ITSM-modules according to their specific features and needs; 2) integration a given ITSMS with existing enterprise architecture; 3) advanced incidents management in ITSMS. The applicability of this approach was tested successfully on the case-study at the National Technical University "Kharkov Polytechnic Institute" (www.kpi.kharkov.ua ).

**Keywords.** IT-service management, effectiveness, multi-criteria ranking, data integration, adaptive ontology, case-based reasoning, e-learning

**Key terms.** Academia, ICTInfrastructure, KnowledgeManagementProcess, Model, SoftwareEngineeringProcess

## 1 Introduction: Problem Actuality and Research Objectives

Nowadays the concept of ITIL (IT Infrastructure Library) [1] and the new kind of computerized management systems, namely: IT Service Management Systems (ITSMS) became a growing and perspective approach to solve very important and complex technical problem and, at the same time, business-focused one: how to organize a well-structured and controllable IT-environment at an appropriate organization?

According to ISO/IEC 20000 [2] an IT Service Management System (ITSMS) provides "*…a framework to enable the effective management and implementation of all IT-services*". Due to high complex and multi-dimensional nature of IT-services in large modern business organizations, which ITSMS are dealing with, recent publications in these domain present some sophisticated approaches to design and to use these facilities. One such important topic in ITIL-ITSM domain is the integration of ITSMS functionality into enterprise architecture (see, e.g. in [3,4]). Another recent trend in ITSMS-development is the usage of ontologies and model-driven architecture

(MDA) [5, 6] for knowledge handling and re-using. Their authors emphasize the actual need to elaborate and to apply several knowledge-oriented approaches to requirements analysis within ITSMS-development, and to quantitative quality assessment of appropriate project solutions.

Taking into account some ITSMS-issues mentioned above, the main objective of the research presented in this paper is to propose the first vision for intelligent complex approach to increase efficiency of typical ITSMS, with a proof of concept basing on the ITSMS university case-study. The rest of this paper is organized in the following way: Section 2 analyses some existing ITSMS, introduces our vision about their typical functionality, and shows the list of prioritized tasks to be resolved to increase an efficiency of an ITSMS. In Section 3 we present the method elaborated for effective ITSM-modules configuring in a target business organization, and Section 4 reports the first version of ITSMS - ontologies to integrate the selected modules into enterprise architecture (EA). In Section 5 the designing perspective for the combination case-based reasoning (CBR) with ontology-based approach to advanced incident management it ITSMS is briefly outlined. In Section 6 we present the university case-study for our method to estimate an effectiveness of different ITSMS configurations and discuss the results achieved. In Section 7 the paper concludes with a short summary and with an outlook on the next steps to be done in the proposed development framework.

## 2 Typical Functionality of ITSMS and the Complex of Intelligent Tasks to Increase its Efficiency

In order to elaborate a way how to provide a complex approach to increase an efficiency of ITSM-system operating, it is necessary to understand its typical functionality and to analyze its specific features.

### 2.1 Overview of existing ITSMS

We have analyzed some already existing ITSMS [7-10], and the results of this study is presented in the Table 1. Basically, all such systems can be divided into 3 groups, namely: (a) advanced business ITSM-products; (b) open source ITSM-solutions; (c) bespoke ITSM-systems.

To the group (a) belong such systems as, e.g., HP OpenView Service Desk [7] and BMC Remedy [8]. The first software product is the absolutely leader in this market segment, because the most part of organizations which prefer ITSM-business solutions from the group (a), are using exactly HP-platform. The number of its running installations is essentially less than HP, at least because of more expensive costs of Remedy ITSM Suite.

**Table 1.** Results of comparison for some ITSMS

| *Criteria / Systems* | *BMC Remedy ITSM Suite 7.5* | *Axios Assyst 7.5* | *HP Service Manager 7.10* | *OMNINET OmniTracker ITSM Center 2.0* |
|---|---|---|---|---|
| Basic functionality | 5 | 5 | 5 | 4 |
| Maintainability | 5 | 4 | 5 | 4 |
| Report generation | 4 | 5 | 5 | 4 |
| Scaleability | 4 | 2 | 3 | 5 |
| Web-interface | 5 | 5 | 5 | 5 |

ITSM-solutions from the group (b) also are used in practice, but they definitely have limited functionality and provide less level of IT-services management. The typical open source ITSMS are, for instance, GLPI [8], OTRS [9], and some others, which are listed at the Web-resource SourceForge [10].

And, objectively, the business organizations, which are not ready to buy advanced software products from group (a), and which are not satisfied with functionality provided by ITSM-systems from group (b), because they have some specific IT-needs and challenges, exactly these companies try to develop their own ITSM-solutions to be considered as members of the group (c). The more detailed comprehensive study of some existing ITSM-systems is presented in [11].

### 2.2 Typical ITSMS-functionality

Based on the given analysis of the real ITSMS (see above), we have elaborated the following vision for their typical functionality (see Fig. 1).

There are 5 main subsystems (or packages) of system functions, namely:

1. *IT Business Alignment*: this subsystem is supposed to implement a IT-strategy in given business organization with respect to its main goals and needs, and to provide a base for costs assessment to whole IT-infrastructure;
2. *Service Operations*: this facility is responsible for customer's requests management (regarding to a current incident and to a related problem), and for providing of ITSM-support functions;
3. *Service Delivery Assurance*: this functional package implements a configuration and change management of all ITSM-software tools thus is extremely important for a stable IT-environment;
4. *Service Design and Management*: this ITSMS-functionality provides detailed information about new perspective IT-services to be designed with respect to their availability and quality for IT-customers;
5. *Service Development and Deployment*: this subsystem allows to create and to test new ITSM-services and appropriate IT-infrastructure solutions, including installa-

tion of new hard-ware components, development of additional software applications, and training programs for ITSM-staff' and for end-users as well.

As we can see on the structure presented in Fig.1, each of these 5 subsystems is built from several functional modules (they are depicted as UML-classes). The most important of them are the following ones:

1. *Module M1* =”*Incident management*”: it includes organizational procedures and appropriate tools to resolve current incidents, which IT-service users are facing with (hard-and software errors, network connection problems, request for consultations, etc.);

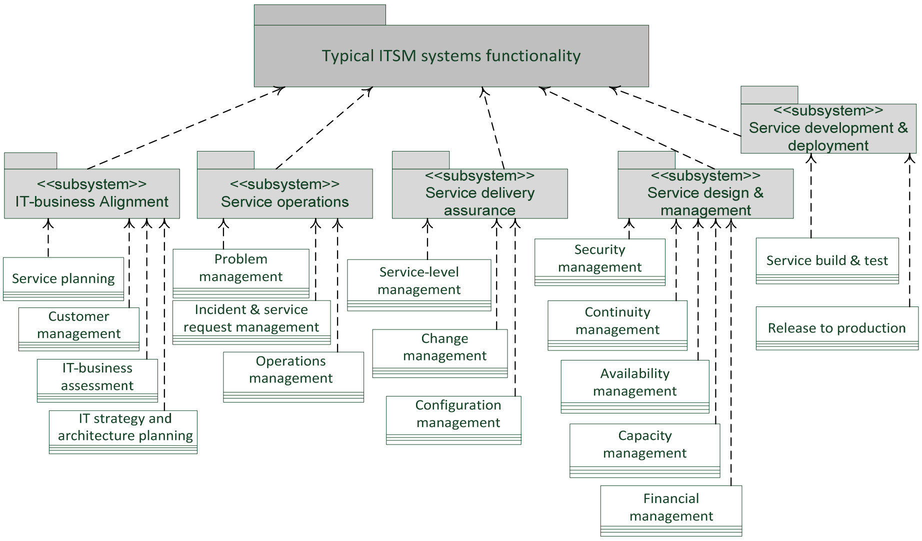


**Fig. 1.** Typical functionality of a ITSMS

- *Module M2* = ”*Problem management*”: this facility provides tools to detect and to eliminate any problem situation which is a reason for different incidents;
- *Module M3* = ”*Configuration management*”: this module supports all operating sub-schemes in the IT-infrastructure of given business organization;
- *Module M4* = ”*Change management*”: it supervises and coordinates all changes which arise in IT-infrastructure; .
- *Module M5* =”*Service level management*”: this unit is responsible for definition and implementation of an appropriate level of IT-services to be provided for customers.

In ITIL-best practice manuals (see e.g. in [12]) the following 3 main schemes are considered to introduce these modules into IT-infrastructure of a target organization: a classic scheme (S1); a contract scheme (S2); an infrastructure-centered scheme (S3).

A *classic scheme* S1 is the most applied solution in the ITSM-domain, and it supposes the following sequence of modules M1-M5:

$$S1 = (M1, M3, M4, M2, M5) \tag{1}$$

This approach quickly allows to resolve the most actual communication problems between IT-service department and customers basing on incident management (module M1), and it provides some tools for all IT-services support (the modules M3 and M4), and after that a platform for future IT-infrastructure development is introduced (modules M2 та M5 respectively). But in this case it has to be taken into account this scheme is a most expensive way for a given business organization, and it requires a lot of resources exactly at an initial phase of whole ITSM-configuring framework.

A *contract scheme* S2 actually aims to formalize a communication process between IT-service department and customers, and it has the following modules-workflow:

$$S2 = (M5, M3, M1, M4, M2) \tag{2}$$

In this case all customer requirements to IT-services have to be collected and specified (in module M5), and appropriate IT-infrastructure sub-schemes can be built (using module M3), in order to define prospective IT-strategy in the target organization, next an operative ITSM-functionality is provided, including incident management (in module M1), change management (in module M4), and problem management (in module M2). Obviously, this scheme definitely has some risk factors regarding its efficiency, if the initial IT-service specifications were done not correctly (in module M5).

And, finally, *an infrastructure-centered scheme* S3 proposes the modules sequence indicated as following:

$$S3 = (M3, M4, M2, M1, M5) \tag{3}$$

that is, firstly, to provide tools for all IT-services support (modules M3 and M4 respectively). Secondly, this approach allows to manage all typical problem situations (in module M2), and already based on this one to detect and to resolve corresponded incidents by IT-service customers (in module M1). Thirdly, it creates an opportunity to define in computer-aided way the necessary composition and the IT-service level management (in module M5).

It is necessary to note that besides some empirical recommendations concerning the possible ITSM-modules configurations defined as (1)-(3), in the appropriate technical documentation there are no more or less proved suggestions about possible quantitative estimations for effectiveness of these alternative approaches.

### 2.3 The complex of intelligent tasks to increase of ITSM-system efficiency

Taking into account the results of performed analysis (see above), and based on some modern trends in the domain of ITSMS-development (see Section 1), the following list of prioritized tasks can be composed in order to increase ITSMS-efficiency, namely

1. to provide *an effective configuring* of ITSM-modules for a target organization, taking into account its specific features and needs;
2. to elaborate *an integration framework* for a given ITSM-system's configuration and for an existing enterprise architecture (EA);
3. to support *an advanced incidents management* in the already installed ITSM-system.

In our opinion, the task (I) can be resolved basing on some expert methods for multi-criteria ranking, with respect to specific IT-infrastructure's features and customer needs in a concerned business organization [13,14]. The task (II) belongs to already well-known integration issues in distributed heterogeneous information systems, and e.g. an ontology-based approach can be used for this purpose (e.g. in [3,6,15]). And, finally, to solve the task (III) an additional decision-making functionality for typical ITSM-services (see Fig.1) has to be elaborated, e.g. basing on the combination of case-based reasoning (CBR) approach with ontologies [16,17]. Below these tasks and their possible solutions are presented and discussed in more detail.

## 3 The Method for Effectiveness Estimation of Alternative ITSM-Module Configurations

To formalize the task (I) from their list considered in the Section 2.3, namely: to *provide an effective configuring* of ITSM-modules for a target business organization, the following factors have to taken into account: such a problem has a high complexity grade and it is semi-formalized; estimation criteria for it are of different nature and they are multi-valued; an information base to solve this task mainly can be collected basing on expert data only; available expert data could be quantitative and qualitative values both.

To solve this task we have chosen one of the multi-criteria ranking methods, which is presented in [14]. Accordingly to this approach the following steps have to be performed:

*Step 1*. A set of possible alternatives,

$$X = \{x_1, x_2, ..., x_n\} = \{x_i, i = \overline{1, n}\} \quad (4)$$

and a set of global importance criteria to characterize these alternatives

$$K = \{K_1, K_2, ..., K_m\} = \{K_j, j = \overline{1, m}\} \quad (5)$$

have to be defined.

*Step 2*. Each global criteria $K_j$ is characterized by a subset of appropriate local criteria

$$K_j = \{k_{j1}, k_{j2}, ..., k_{jQ}\} = \{k_{jq}, q = \overline{1, Q}\} \quad (6)$$

further, a set of membership functions according to all local criteria alternatives

$$\{\varphi_{k_{j1}}(x_i), \varphi_{k_{j2}}(x_i), ..., \varphi_{k_{jQ}}(x_i)\} = \{\varphi_{k_{jq}}(x_i), q = \overline{1,Q}, j = \overline{1,m}\} \tag{7}$$

and the weight coefficients of their relative importance for these local criteria

$$\{w_{j1}, w_{j2}, ..., w_{jQ}\} = \{w_{jq}, q = \overline{1,Q}\} \tag{8}$$

have to be determined, where the following condition has to be fulfilled

$$\sum_{q=1}^{Q} w_{jq} = 1 \tag{9}$$

*Step 3.* To determine membership functions of alternatives $\{x_i, i = \overline{1,n}\}$ to criteria $K_j, \{j = \overline{1,m}\}$ based on an additive convolution of their local criteria

$$\varphi_{k_j}(x_i) = \sum_{q=1}^{Q} w_{jq} \varphi_{k_{jq}}(x_i) \tag{10}$$

**Table 2**. Definition of membership functions for criteria to alternatives (fragment)

| Alternatives | | Criteria $K$ | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | $K_1$ | | | $\dots$ | $K_M$ | | |
| | | $k_{11}$ | $\dots$ | $k_{1Q}$ | $\dots$ | $k_{M1}$ | $\dots$ | $k_{Mm}$ |
| $X$ | $x_1$ | $\varphi k_{11}(x_1)$ | $\dots$ | $\varphi k_{1Q}(x_1)$ | $\dots$ | $\varphi k_{M1}(x_1)$ | $\dots$ | $\varphi_{Mm}(x_1)$ |
| | $\dots$ | $\dots$ | $\dots$ | $\dots$ | $\dots$ | $\dots$ | $\dots$ | $\dots$ |
| | $x_n$ | $\varphi k_{11}(x_n)$ | $\dots$ | $\varphi k_{1Q}(x_n)$ | $\dots$ | $\varphi k_{M1}(x_n)$ | $\dots$ | $\varphi_{Mm}(x_n)$ |
| | | | $\dots$ | | $\dots$ | | $\dots$ | |

*Step 4*. Taking into account the membership functions obtained $\{\varphi_{K_j}(x_i), j = \overline{1,m}\}$ for all alternatives $x_i, \{i = \overline{1,n}\}$ it is possible to determine a joined membership function for a generalized criterion $K$ :

$$\varphi_K(x_i) = \sum_{j=1}^{m} w_j \varphi_{K_j}(x_i) \tag{11}$$

where $w_j, j = \overline{1,m}$ are coefficients of their relative importance $K_j, j = \overline{1,m}$.
*Step 5*. Finally, an alternative with a maximum value of membership function for generalized criterion $K$ can be chosen as a target solution:

$$\varphi(x^*) = \max\{\varphi_K(x_i), i = \overline{1,n}\}) \tag{12}$$

Below in Section 6 we present the case-study, which was performed to prove this method, and we discuss the results achieved.

## 4 Ontological Specifications for ITSMS-EA Integration Framework

As already mentioned above (see Section 2), any ITSMS has to be integrated into an existing EA of a target organization. In our approach this task (II) has to be resolved for an ITSMS-configuration defined with the method presented in Section 3.

This issue is already discussed intensively in a lot of publications, and their authors consider both its conceptual and technological aspects. E.g., an ITSMS-EA integration based on well-known SOA – framework is presented in [3], and as the important conceptual input for this issue the appropriate meta-model (actually, some kind of a domain ontology) for IT services is designed. In [5] an approach to integration of ITSM-services and business processes in given organization is elaborated, using ontological specifications to formalize the good practice guidance for ITSM. An ontology-based framework to integration of software development and ITSMS-functioning is proposed in [15], thus resulting in enhanced semantic-aware support tools for both processes. Even this brief overview allows us to conclude that exactly an ontology-based approach is a most effective way to solve this problem. That is why, in our opinion, to provide ITSM-EA integration effectively, it is necessary to combine the following information resources (IR), namely: a) IR related to ITSMS – functionality, b) IR concerned EA-domain, c) IR characterized a target organization (TO), which is facing an ITSMS-EA integration problem with. Let's define these IR (a)-(c) as: *Onto-ITSMS*, *Onto-EA*, and *Onto-TO* respectively. Thus, the IR needed to provide an ITSMS-EA integration should be specified using an appropriate joined ontology, designated as *Onto_ITSMS-EA.*

$$Onto\_ITSM - EA = < Onto - ITSMS, Onto - EA, Onto - TO > \tag{13}$$

Obviously, some already existing ITIL / ITSM ontological specifications can be used for this purpose, e.g.: *Onto-ITIL* ontology elaborated in [5] basing on *OpenCyc* ontology (www.opencyc.org), *Onto-SPEM* (Software Process Engineering Meta-model) ontology [18], and *Onto-WF* (WorkFlow) ontology [19]. Taking these resources into account, we can represent the ontological specification for *Onto_ITSM* in the following way

$$Onto - ITSMS = < Onto - ITIL, Onto - SPEM, Onto - WF > \tag{14}$$

There are also several ontologies developed to specify EA, and according to one of recent and comprechensive researches in this domain presented in [20], we accept the following 3-level definition for EA-ontology

$$Onto - EA = < Onto - BT, Onto - AC, Onto - RS > \tag{15}$$

where: *Onto_BT* is a sub-ontology of *Business Terms (BT)*, *Onto-SC* is a sub-ontology of *Architecture Components (AC),* and *Onto-RS* as a sub-ontology of *RelationShips (RS)* among items of AC.

And finally, to define an *Onto-TO* ontology for target organization given in expression (13), its specific features and needs related to ITSMS-usage within existing EA have to be taken into account. As a small excerpt of such domain-specific *Onto-TO*, which is elaborated in our University-ITSMS case-study (see Section 6), the following UML-class diagram in Fig. 2 is shown.

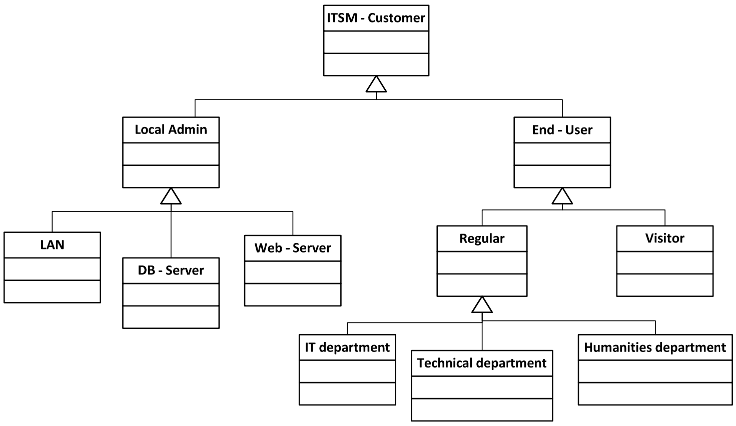


**Fig. 2**. Taxonomy of customers in a University-ITSMS as a part of a *Onto-TO* ontology

The proposed ontology-based approach for ITSMS-EA integration can also be used to elaborate the solution for the task (III) from their list completed in Section 2.3.

# 5 Adaptive Onto-CBR Approach to Advanced Incidents Management in ITSM

In order to solve the task (III), namely: to provide *an advanced incidents management* in ITSMS, accordingly to our inter-disciplinary vision about the ITSMS-development in general, we propose to amalgamate the following design-principles (i)-(iv) listed below

(i) an *incident management* as a weak-formalized and complex task within the ITSMS-support for its customers can effective be resolved using one of the intelligent decision-support methods, e.g., using *CBR-method*;

(ii) to enhance a CBR-functionality, especially with respect to specific needs in a target organization, an appropriate *domain-ontology* should be elaborated and used combining with CBR;

(iii) because of the permanent changes in an IT-infrastructure of a given organization, and of the changes arising in its environment as well, such a domain-ontology has to be constructed as an *adaptive ontology*;

(iv) to provide a possibility for knowledge gathering and their reusing in ITSMS, some *e-Learning models and technologies* can be applied.

There are already the approaches elaborated to combine a CBR-method with ontologies [16, 17], which allow to provide more efficiently a case-representation, to enhance case-similarity assessment, and to perform case-adaptation process for a new solution. From the other hand, an ontology-centered design for ITSM-services, and especially, for *Incident Management (IM)*, is also discussed in some recent publications in this domain. In particular, the proposed in [21] *Onto-IM* ontology is built according to ISO/IEC20000 for ITIL/ITSM [2], it includes such concepts as *Incident Management, Incident Record, Incident Entity,* etc. specified using OWL (Ontology Web Language), and the small example of its notation is shown in Fig.3.

```
(contains some CreateIncidentRecord)
 and (contains some
CreateIncidentRecordCapability)
 and (contains some IncidentRecord)
 and (contains some
IncidentRecordStructurePolicy)
 and (contains some RecordIncident)
 and (contains some ServiceDeskEmployee)
```

**Fig. 3.** The excerpt of Onto-IM ontology elaborated in [21]

These results provide a solution for the tasks (i)-(ii), but in our opinion to cover the task (iii) in efficient way, with respect to permanent changes in IT-infrastructure of a target organization, an appropriate ontology has to be constructed as an *adaptive* facility [22]. In this way the *Onto-TO* ontology given in Section 4 should be given as the following tuple

$$Onto-TO^{(adapt)} = < C, R, P, W^{(C)}, W^{(R)} > \tag{16}$$

where, additionally to the basic components of any ontology, namely: *C* – set of concepts, *R* – a set of relationships among these concepts, and *P* – a set of axioms (semantic rules), the following ones have to be defined: $W^{(C)}$ is a set of weight coefficients for concepts of *C,* and a $W^{(R)}$ is a set of weight coefficients for relationships of *R* respectively. Usage of these weight coefficients allows us, e.g., to take into account an appropriate importance grade in several types of ITSMS-customers (see Fig. 2) to provide IM - services for them.

In order to get all information resources needed for a completed solution of tasks (i)-(iv), we propose to apply some *e-Learning* models and technologies within an ITSMS, especially, for skills training and experience gathering by ITSMS-staff, designated in the *Onto-IM* ontology as *Incident Manager, ServiceDeskEmployee, Specialist* [21]. For this purpose an e-Learning ontology (*Onto-EL*) can be used, e.g., in [23] the *Onto-EL* is elaborated to build for learners their personal paths in e-learning environment, according to the selected *curriculum* (*Incident Management* in terms of *Onto-IM*), *syllabus* (*Incident Record*) and *subject* (*Incident Entity*).

Summarizing aforementioned issues concerning the tasks listed in (i)-(iv), the conceptual mechanism to provide an *advanced incidents management* (AIM) in ITSMS can be represented at the high-architectural level as the UML-package diagram shown in Fig.4.

Below the approach to resolve the task (1) from their list given in Section 2 is illustrated using the real case-study within our research and practice activities to apply ITSMS to manage IT-infrastructure of National Technical University “Kharkov Polytechnic Institute” (www.kharkov.ua) referred in following as NTU “KhPI”.

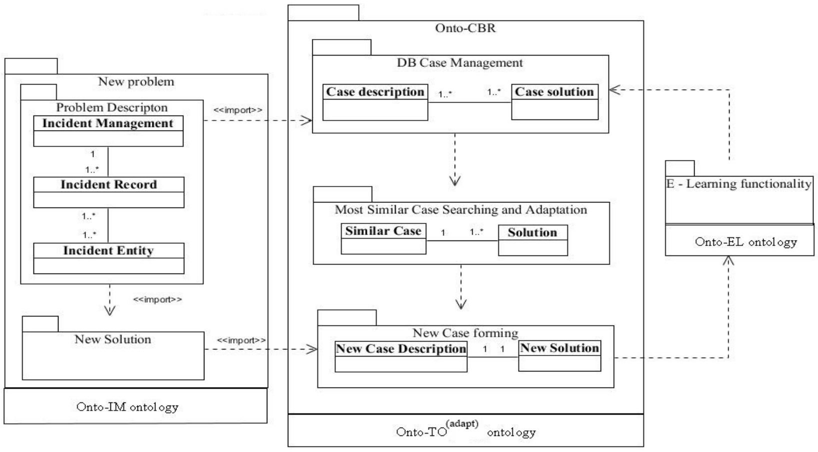


**Fig. 4**. The AIM – architectural framework (to compare with the scheme given in [24])

## 6 University Case-Study: Effective ITSM-Modules Configuring

It is to mention that exactly university- and /or a campus-domains are considered from many authors as a suitable example of ITSMS-usage (see, e.g., in [25-26]), because intensive research- and educational activities obviously require a modern and well-organized IT-environment. That is why we also proved our approach to effectiveness estimation of alternative configurations of ITSM-modules using the test-case data collected at the NTU “KhPI”.

### 6.1 Application domain description: IT-infrastructure of NTU “KhPI”

The NTU “KhPI” is one of the largest technical universities of Ukraine located in the city of Kharkiv, which is the important industrial and cultural center at the East of the country. The university has about 22000 students, ca. 3500 of faculty members, and accordingly there is the advanced IT-infrastructure to support all educational and research tasks. The main characteristics of IT-operating at the NTU “KhPI” are summarized in Table 3.

**Table 3.** Some technical data about IT-infrastructure NTU “KhPI”

| Parameters | Values |
|---|---|
| PCs in the network configuration | 1525 |
| User’s accounts | 2700 |
| Buildings | 23 |
| Servers | 60 |
| Routers | 80 |
| Peripheral units | 6000 |
| IT-specialists in the central office | 11 |
| Incidences per day (registered) | 5-7 |

In cooperation with the IT-staff at the University IT control office we have analyzed retrospective data about some typical problem situations occurred, and about the corresponded incidents, which daily have been resolved within the direct communication with IT-service customers. In this way the main types of ITSM-incidents and their initial problem situations were identified, and they are described in Table 4.

**Table 4**. Main types of ITSM-incidents and their related problem situations

| № | Incident type | Cause ( problem situation) |
|---|---|---|
| 1 | No Internet-connection at Dept or on local PC | - router was turned off;<br>- network cable breaked or failure on router hardware;<br>- incorrect network setup;<br>- problems with software on local PC |
| № | Incident type | Cause ( problem situation) |
| 2 | High-loading of PC processor with a small number of active user's programs | - computer viruses<br>- high degree of PC hard driver's de-fragmentation. |
| 3 | Installing problems for new software | - computer viruses<br>- absence of additional (middleware) software needed for installation. |
| 4 | Failure to send email | -incorrect setup of local network server (proxy)<br>-problems with central e-mail server. |
| 5 | Troubles in the use of third-party software | -lack of specific configuration,<br>- improper use of system services. |

Basing on the analysis results obtained, we can apply the elaborated method to estimate alternative ITSMS-module configurations (see Section 3).

### 6.2 Customizing of the elaborated estimation method: alternative configurations and criteria definition

According to the *Step 1* of the method presented in Section 2.2, the list of alternative ITSM-module configurations have to be defined, and in our case they are presented:

$X_1$ = Service Desk subsystem (SDS) and Incident Management Module

$X_2$ = SDS, Incident Management Module and Configuration Management Module

$X_3$ = SDS, Incident Management Module and Change Management module

$X_4$ = SDS, Incident Management Module and Problem Management Module

On the next *Step 2,* according to the formulas (4) - (10), we determine the criteria for the quantitative evaluation of the proposed alternatives and their performance indicators, which are shown in Table.5. These criteria and their indicators (metrics) are taken from [35], and they are recommended to evaluate effectiveness of IT-infrastructure in any business organization.

**Table 5**. List of values for global and local criteria (fragment)

| Global and local criteria | Semantics performance measurement criteria and target values | Insecure value | Effective value | Scope of values |
|---|---|---|---|---|
| $K_1$ | Effectiveness of incident management | | | |
| $k_{11}$ | Average time incident resolution →min | >30 min. | 15 min. | 9999min. |
| $k_{12}$ | Percentage of incidents resolved proactively →max | 0% | 15% | 0-100% |
| Global and local criteria | Semantics performance measurement criteria and target values | Insecure value | Effective value | Scope of values |
| $k_{13}$ | Percentage of incidents resolved at the first level of support →max | <65% | 85% | 0-100% |
| $k_{14}$ | Percentage of incidents that have been resolver from the first time →max | <75% | 90% | 0-100% |
| $K_2$ | Effectiveness of problem management | | | |
| $k_{21}$ | The ratio of the number of solved problems to total problems (%)→max | <10% | 35% | 0-100% |
| …….. | ………. | | | |

For example, a value of 10 for an alternative $X_3$ to criteria $k_{14}$ (see Table 5) means, that the implementation of *Service Desk* and *Incident Management Module* will help to increase the ratio of incidents, which are resolved successfully, to its effective value of 90%, etc. The obtained in this way results are given in Table 6.

**Table 6.** Estimated values for the alternatives with respect to the defined criteria (fragment)

| | $K_1$ : Effective incident management → opt | | | |
|---|---|---|---|---|
| | $k_{11}$ (opt =20м) | $k_{12}$ (15%) | $k_{13}$ (85%) | $k_{14}$ (90%) |
| $X_1$ | 5 | 5 | 5 | 6 |
| $X_2$ | 6 | 7 | 6 | 6 |
| $X_3$ | 5 | 5 | 5 | 6 |
| $X_4$ | 7 | 6 | 8 | 7 |
| … | …………… | | | |
| | … | … | … | |

In order to implement the elaborated method with customized data introduced above, the special software tool was developed.

## 6.3 Results of estimation and their analysis

To continue the usage of our method presented in Section 2.2 (*Step 3* and *Step 4* respectively) using the pair-wise comparison the weight coefficients of relative importance (WCRI designated as $w(k_{i,j})$ ) for the local criteria regarding their global ones were determined:

- The WCRI values of the local criteria for the global criterion $K_1$: $w(k_{11})$ = 0,239458, $w(k_{12})$ = 0,239458, $w(k_{13})$ = 0,432749, $w(k_{14})$ = 0,088335
- The WCRI values of the local criteria for the global criterion $K_2$: $w(k_{21})$ = 0,68334, $w(k_{22})$ = 0,19981, $w(k_{23})$ = 0,11685
- The WCRI values of the local criteria for the global criterion $K_3$: $w(k_{31})$ = 0,332516, $w(k_{32})$ = 0,527836, $w(k_{33})$ = 0,139648
- The summarized WCRI values for the global criterion $K_i$: $K_1$ = 0,527836, $K_2$ = 0,332516, $K_3$ = 0,139648

And finally, according to *Step 5* of this method (see Section 3.2), and using the multi-criteria ranking formulas (11) - (12), we obtain the following ultimate results of the effectiveness assessment for the considered alternatives (see Table 5), namely

$$X_1 = 0.537, X_2 = 0.671, X_3 = 0.578, X_4 = 0.727 \tag{17}$$

To confirm the reliability of the results given in (17), the comparative analysis with some "best practices" in ITSMS implementation was carried out, using the data of IDC-company [28]. In particular, IDC has reviewed approx. 600 organizations worldwide, which used ITSM for over a year, and in this study especially the prioritization issues of different ITSM-modules implementation were analyzed. In Fig. 5 the result of the performed comparison is shown.

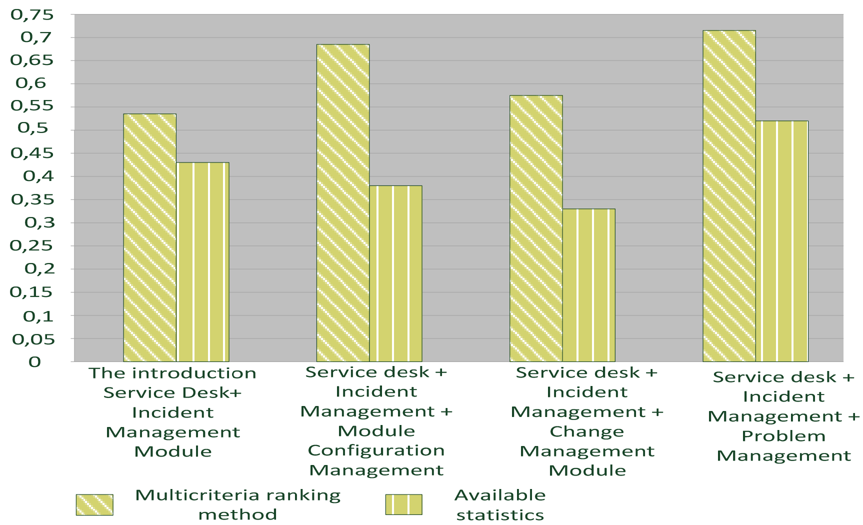


**Fig. 5.** Graphical representation of the obtained results

As we can see, to provide *Change Management* and *Configuration Management* is necessary to have within an IT-infrastructure database (DB) of IT-configurations, and DB of problem situations as well, these facilities are rather costly for the University, and therefore the implementation of these modules is not a priority task. The most effective ITSM-modules configuration for NTU "KhPI" includes an *Incident Management* module and a *Service Desk* subsystem.

## 7 Conclusions and Future Work

In this paper we have presented the intelligent approach to increase efficiency of ITSMS, which has to resolve 3 interconnected tasks for its effective usage in a target organization: 1) providing an effective configuration of ITSM-modules according to its specific features and needs; 2) elaboration an integration framework for a given ITSMS with existing EA; 3) advanced incidents management in ITSMS. To solve these tasks in a comprehensive way the interdisciplinary framework is elaborated, which includes: the expert method for multi-criteria ranking of alternative ITSM-modules configurations, the ontological specifications for ITSMS-EA integration, and the approach to enhanced incident management based on the combination of adaptive ontologies and CBR-methodology. To implement the first part of this approach the appropriate software tool was elaborated, and its applicability was tested successfully within the case-study at the NTU "Kharkov Polytechnic Institute".

In future we are going to implement and to test the appropriate software solutions for other tasks in the proposed framework, using such technologies as OWL, BPMN, XML /XLST, and Web-services.

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