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## Extensible document and business process models of the enterprise

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### Abstract

A specific type of Internet based information systems (IBIS) [1] realization and enterprise integrated management systems (EIMS) [2] – are considered. This paper describes the first stage of EIMS design – enterprise modeling. A unique enterprise structure is suggested for its application when enterprise modeling. Basic concepts of enterprise functioning are specified. Extensible document model (EDM) and business process (BP) models are suggested for realization of enterprise informational and functional infrastructures development, their analysis and improvement. A real example of a business process is described.

**Keywords:** integrated enterprise management system, enterprise structure, extensible document model, business-process model.

## Rozszerzalne modele dokumentów i procesów w przedsiębiorstwach

### Streszczenie

W artykule przedstawiono realizację systemu informacyjnego opartego na internecie (IBIS) oraz zintegrowanych systemów zarządzania przedsiębiorstwami (EIMS) [1]. Przedsiębiorstwo o złożonej strukturze, o różnych powiązaniach produkcyjnych i serwisowych, którego działalność jest oparta na Internecie, jest bardzo złożonym obiektem sterowania. Funkcjonowanie nowoczesnego przedsiębiorstwa wymaga zamodelowania przynajmniej dwu głównych elementów: przepływu dokumentów funkcjonowania przedsiębiorstwa i procesów biznesowych. W pracy przedstawiono pierwszy etap projektu EIMS, tj. modelowanie przedsiębiorstwa. Proponowana jest unikatowa struktura zadania do jego modelowania. Wyszczególnione są podstawowe elementy funkcjonowania przedsiębiorstwa. Zaproponowano rozszerzalny model dokumentu (EDM) oraz model procesu biznesowego (BP) do realizacji, rozwoju analizy i udoskonalania infrastruktury informacyjnej i funkcjonalnej. Metodykę zilustrowano przykładem rzeczywistego procesu biznesowego. Jako środowisko działania systemu IBIS wybrano księgi internetową, prowadzącą sprzedaż książek przez Internet.

**Słowa kluczowe:** zintegrowane systemy zarządzania przedsiębiorstwami, struktura przedsiębiorstwa, rozszerzalny model dokumentu, model procesu biznesowego.

## 1. Introduction

A specific type of system IBIS realization, called enterprise integrated management systems is described for considering and improved the process of their design and implementation.

EIMS is a technical-organizational complex, providing enterprise management on the basis of using mathematical and economic methods and also computer techniques. The enterprise, which is oriented for working in the Internet, with its complex structure and multiple production and service ties, is considered to be the most complex control object. Complexity of control object results in the necessity of control functions automation, i.e. in the development of EIMS.

The main requirements, made to EIMS during their design are: data centralization in integrated database; close to real-time operating conditions; storing common control model for different types of enterprises; support of distributed structures; functioning on the wide scope of software and hardware platforms and database management systems.

EIMS is a set of methods and tools, integrated according to the specificity of their application and solving the tasks in all their functional subsystems.

According to the suggested method of IBIS (and thereafter - EIMS) design [3], its first stage is the modeling of enterprise functioning, where the designed system is to be implemented. This stage is considered in the paper.

## 2. Main part

When modeling the enterprise functioning, first of all its structure should be defined.

### Enterprise structure

In general case, the enterprise, regardless of its activities field (production of goods, providing the services, distribution, or all together), contains mandatory and optional departments (units). The mandatory units include: production unit; financial unit; management unit; clients and suppliers unit (which can be divided into two units, subject to enterprise size); providing unit (means providing the infrastructure, required for enterprise functioning). The optional units include: transport/logistics unit; marketing and advertising unit; human resources unit; Internet-relations unit (portal, CRM).

Availability or unavailability of optional units doesn't means unavailability of functions, they provide. Defining them as optional ones only means that functions they provide, can be realized by mandatory modules or using external resources and services.

Enterprise functioning is based on the business processes and permanent data exchange inside and outside of the enterprise. As for the business processes, it can be specified as: basic BP production, services, commerce (depends on the type of enterprise); provision BP; management. As for the data, which are under constant exchange inside and outside of the enterprise, and taking into account the necessity of data exchange formalization, the document flow would be considered, which adequately describes data exchange between enterprise units under its functioning.

Thus, functioning of the up-to-date enterprise is based on the business processes and document flow, which is a very important component of BP realization. That's why the correct modeling of the enterprise functioning requires modeling at least two main components, providing its functioning: document flow modeling and BP modeling.

### Document flow modeling

Document flow represents enterprise informational infrastructure and is considered as one of basic components of BP. The unit of document flow is also a document. Thus, modeling of document flow is considered as modeling of documents set. In such case, the model of document should be developed.

There exist different approaches to document flow modeling [4, 5], including graph model of document flow [6], but as it was specified above, the model of document, not of document flow, should be represented for correct development of enterprise information structure. The document model is also important during BP modeling and analysis.

The document model is suggested, where the document template concept is used. The main document parameters are specified, which are required for enterprise informational structure development and BP modeling. The document model is extensible and based on the graphical notation and mathematical apparatus of semischeme [7]. Main basic concepts of mathematical apparatus, used for document model development are represented below.

Mathematical apparatus of semischeme. Basic concepts.

$N$  is a finite set, elements of which correspond to document template names,  $R$  is a finite set, elements of which correspond to realized document names.

The following symbols are introduced:

$M(R,N)$  – is a set of partial mapping from  $R$  to  $N$ . Elements of the set  $M(R,N)$  are called variants of realization.

$dom(f)$  – definitional domain of mapping  $f \in M(R,N)$ .

$\varepsilon$  – mapping on void definitional domain.

$R^*$  – set of all words above  $R$  (including void word),

$R^+$  – set of nonvoid words above  $R$ ,

$e$  – void word.

Semischeme of the documents is a triplet

$$S=(N,R,D) \quad (1)$$

where  $N,R$  – finite sets,  $D \subset N \times M(R,N)$ , for which the following conditions are fulfilled:

1) for any  $n \in N$ , if  $(n,\varepsilon) \in D$ , then  $\{f \in M(R,N) \mid (n,f) \in D\} = \{\varepsilon\}$ ;

2) for any  $n \in N$ , and for any two variants of definition  $f,g \in M(R,N)$  such as  $(n,f) \in D$ ,  $(n,g) \in D$  and  $r \in dom(f) \cap dom(g)$ , where  $r \in R$ , the characteristic  $f(r)=g(r)$  is executed.

The key concept in the used apparatus is the definition of document pattern, which represents the specific realization of the document. If the specific realization of the document (specific document pattern) exists, then the document is correctly defined, as a certain data structure, described by the pattern, corresponding to the document. Using the mathematical apparatus of semischeme, we represent document model as set of document templates and their specific realization.

The use only mathematical apparatus of semischeme for document model development it is not enough for modeling document flow, as the set of required document parameters is not specified. That's why, chosen mathematical apparatus should be extended with set of additional document parameters, which are represented in Tab. 1.

Tab. 1. Characteristics of document parameters  
Tab. 1. Charakterystyka parametrów dokumentu

Parameter name	Symbol	Admitted region	Significance
Document name	$N = \{Ni\}$ ,	$i = \overline{1,n}, n \in R$	Time reduction for preparing the documents and for enterprise informational structure development
Unit, to which document belongs	$D = \{Dk\}$	$k = \overline{1,n}, n \in R$	
Document type	$T = \{Tj\}$	$j = \overline{1,n}, n \in R$	
Set of operations, which can operate with the document	$O = \{Op\}$	$p = \overline{1,n}, n \in R$	Correctness of BP modeling
Set of document states	$C = \{Ct\}$	$t = \overline{1,n}, n \in R$	Correctness of BP modeling
Set of additional parameters of extension	$E = \{Ea\}$	$a = \overline{1,n}, n \in R$	Ability of document model extension when it is used in further stages of EIMS design

The mathematical model of the document can be represented in the following way:

$$S_d = (N, D, T, O, C, E), \quad i = \overline{1,n}, n \in R \quad (2)$$

Thus, suggested document model is a document pattern of exact enterprise unit. Each unit has its own set of document patterns. In turn, each document pattern is characterized by set of parameters, the number of which can be changed, depending on the tasks, which should be solved when modeling the enterprise functioning at further stages of EIMS design.

### Business process modeling

Second main aspect of enterprise functioning modeling is BP modeling. According to the suggested BP model, the BP:

- consists of the separate functional elements, which are operation;
- can contain parallel executed operations, which are represented as a stage of execution;
- has name;
- is characterized with the set of input and output documents, which allow to describe enterprise document flow;
- is characterized with execution time and resources, required for its execution [8].

The characteristics of BP parameters is presented in Tab. 2.

The graphical notation, used for BP modeling is described in [9]. The developed BP model can be represented as it is shown in Fig. 1.

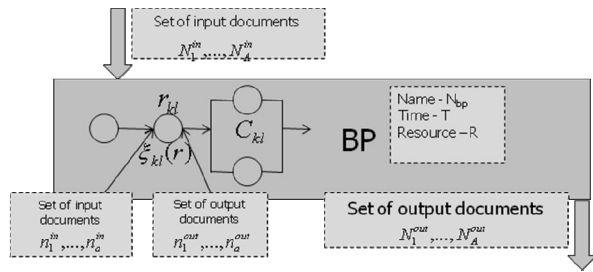


Fig. 1. Developed BP model  
Rys. 1. Opracowany model BP

Tab. 2. Characteristics of BP parameters  
Tab. 2. Charakterystyka parametrów BP

Parameter name	Symbol	Admitted region	Significance
BP name	$N_{bp} = \{Nr\}$	$r = \overline{1, n}, n \in R$	Resource analysis and efficient distribution
Resource, required for BP execution	$R = \{r_{kl}\}$	$\{n_{k,l} \ k = 1..n, l = 1..m\}$	
Execution time	$T = \sum_k \max_i \xi_{kl}(r_{kl})$	$\{r_{k,l} \ k = 1..n, l = 1..m\}$	BP analysis and improvement
Time of execution of operation l of stage k	$\xi_{kl}(r)$	$\{k = 1..n, l = 1..m\}$	
Type of operation	$Top = \{Tz\}$	$z = \overline{1, n}, n \in R$	Verification of operation-document interaction
Set of BP input documents	$N_1^{in}, \dots, N_A^{in}$	$N = \overline{1, A}, A \in R$	Correctness of document flow and BP modeling
Set of BP output documents	$N_1^{out}, \dots, N_B^{out}$	$N = \overline{1, B}, B \in R$	
Set of operation input documents	$n_1^{in}, \dots, n_a^{in}$	$n = \overline{1, a}, a \in R$	
Set of operation output documents	$n_1^{out}, \dots, n_b^{out}$	$n = \overline{1, b}, b \in R$	
Operation ability to be automated	$C_{kl}$	True or False	Automating the process of EIMS functionality development

According to the introduced concepts and parameters, characterizing BP, mathematical model of BP Operations and BP can be represented as:

$$BP = (N_{bp}; T; R; N_1^{in}, \dots, N_A^{in}; N_1^{out}, \dots, N_B^{out}) \quad (3)$$

or

$$BP = (N_{bp}; \sum_k \max_l \xi_{kl}(r_{kl}); \{r_{kl}\}; N_1^{in}, \dots, N_A^{in}; N_1^{out}, \dots, N_B^{out}) \quad (4)$$

$$O = (N_{op}; T_{op}; \xi; r; n_1^{in}, \dots, n_a^{in}; n_1^{out}, \dots, n_b^{out}) \quad (5)$$

**Example of a business process**

A real example of a business process is described for illustrating the model and for enhanced validation. As the environment of

IBIS functioning the Internet Book Shop is taken. The business process in Sells department, which is selling a book via Internet, is considered. BP time and resource values are taken from practice ( $\xi$  [minutes];  $r$  [\$]). BP model, using suggested notation [9], is shown in Fig. 2.

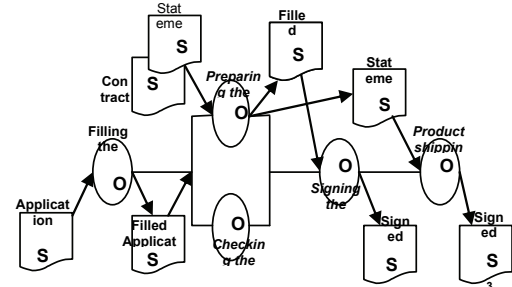


Fig. 2. Model of selling a book via Internet  
Rys. 2. Model sprzedaży książek przez Internet

The process of selling a book via Internet requires using such documents as: an application form for ordering the product; a contract for making sails agreement with a customer; a statement, approving that product is bought and delivered.

Document models.

Book application form belongs to Sells department, has type, called Application Form, can be read or filled and can have two states: pattern and filled. Book application form is presented in Tab. 3 and expressions (6), (7).

Tab. 3. Application form models  
Tab. 3. Modele formularzy aplikacyjnych

$S_1$ – Application form	$N$ =Book Application Form (Apb)	$D$ =Sails	$T$ =Application Form	$O$ = {Read, Fill}	$C$ = {Pattern; Filled}	E
$S_{10}$	Apb	SL	AF	Read, Fill	Pattern (0)	-
$S_{11}$	Apb	SL	AF	Read, Fill	Filled (1)	-

$$S_{10} = (Apb; SL; AF; Read, Fill; 0) \quad (6)$$

$$S_{11} = (Apb; SL; AF; Read, Fill; 1) \quad (7)$$

Book contract belongs to Sells department, has type, called Contract, can be read, filled or signed and can have three states: pattern, filled, signed. Book contract is presented in Tab. 4 and expressions (8), (9), (10).

Tab. 4. Contract models  
Tab. 4. Modele kontraktu

$S_2$ - Contract	$N$ =Book Contract (Ctb)	$D$ =Sails	$T$ =Contract	$O$ = {Fill, Sign}	$C$ = {Pattern; Filled}	E
$S_{20}$	Ctb	SL	Ct	Read, Fill, Sign	Pattern (0)	-
$S_{21}$	Ctb	SL	Ct	Read, Fill, Sign	Filled (1)	-
$S_{22}$	Ctb	SL	Ct	Read, Fill, Sign	Signed (2)	-

$$S_{20} = (Ctb; SL; AF; Read, Fill, Sign; 0) \quad (8)$$

$$S_{21} = (Ctb; SL; AF; Read, Fill, Sign; 1) \quad (9)$$

$$S_{22} = (Ctb; SL; AF; Read, Fill, Sign; 2) \quad (10)$$

Book statement belongs to Sells department, has type, called Statement, can be read, filled or signed and can have three states: pattern, filled, signed. Book contract is represented in Tab. 5 and expressions (11), (12), (13).

Tab. 5. Statement model  
Tab. 5. Model deklaracji

$S_3$ – Statement	$N$ =Book Statement (Stb)	$D$ = Sails	$T$ = Statement	$O$ = {Fill, Sign}	$C$ = {Pattern; Filled}	E
$S_{30}$	Stb	SL	St	Read, Fill, Sign	Pattern (0);	-
$S_{31}$	Stb	SL	St	Read, Fill, Sign	Filled (1)	-
$S_{32}$	Stb	SL	St	Read, Fill, Sign	Signed (2)	-

$$S_{30} = (\text{Stb}; \text{SL}; \text{AF}; \text{Read, Fill, Sign}; 0) \quad (11)$$

$$S_{31} = (\text{Stb}; \text{SL}; \text{AF}; \text{Read, Fill, Sign}; 1) \quad (12)$$

$$S_{32} = (\text{Stb}; \text{SL}; \text{AF}; \text{Read, Fill, Sign}; 2) \quad (13)$$

Operation models are presented in Tab. 6 and expressions (14-18).

Tab. 6. Operations models  
Tab. 6. Modele operacji

Operations	$N_{op}$	$T$ = {Fille, Read, Sing}	$\zeta$ = {1..N}	$r$ = {1..N}	$min$ = {n1...na}	$nout$ = {n1...nb}
$O_1$	FO	Fill	10	1	$S_{10}$	$S_{11}$
$O_2$	PCh	Read	10	0,5	$S_{11}$	$S_{11}$
$O_3$	AgP	Fill	60	5	$S_{11}, S_{20}, S_{30}$	$S_{21}, S_{31}$
$O_4$	AgS	Sign	45	3	$S_{21}$	$S_{22}$
$O_5$	PS	Sign	120	10	$S_{31}$	$S_{32}$

$$O_1 = (\text{FO}; \text{Fill}; 10; 1; S_{10}; S_{11}) \quad (14)$$

$$O_2 = (\text{PCh}; \text{Read}; 10; 0,5; S_{11}; S_{11}) \quad (15)$$

$$O_3 = (\text{AgP}; \text{Fill}; 60; 5; S_{11}, S_{20}, S_{30}; S_{21}, S_{31}) \quad (16)$$

$$O_4 = (\text{AgS}; \text{Sign}; 45; 3; S_{21}; S_{22}) \quad (17)$$

$$O_5 = (\text{PS}; \text{Sign}; 120; 10; S_{31}; S_{32}) \quad (18)$$

Using represented above models of documents and operations, BP model can be presented in the following way (Tab.7) and expression (19).

Tab. 7. BP model  
Tab. 7. Model BP

BP - Selling a book	$N_{bp}$	$T$ = $\sum_i \max_i \xi_{it}(r_{it})$	$R$ = $\sum r_{it}$	$N^{in}$ = {N1...Nn}	$N^{out}$ = {N1...Nn}
BP <sub>1</sub>	BS	135	19,5	$S_{10}, S_{20}, S_{30}$	$S_{11}, S_{22}, S_{32}$

$$BP_1 = (\text{BS}; 135; 19,5; S_{10}, S_{20}, S_{30}; S_{11}, S_{22}, S_{32}) \quad (19)$$

### 3. Conclusions

The unique enterprise structure is suggested, which is to be used on the stage of modeling the problem domain area. The basic components of enterprise functioning are specified, which are informational (document flow) and functional (business processes) infrastructure.

The extensible document model is suggested, which is to be used for enterprise informational infrastructure development and on further stages of EIMS design. EDM is developed, using mathematical apparatus of semischeme and developing set of document parameters, providing the possibility of storing document metadata in database, correctness of document flow and business process modeling.

BP model is developed, which allows to provide correctness of modeling the enterprise functionality and document flow; to reduce faults when enterprise functionality development and improvement; to except faulty usage of documents and document patterns; to find time and resources, required for BP execution; to redistribute resources between operations efficiently and reduce time of BP execution.

Suggested models should be implemented in a Case-tool for IBIS design, which will provide: modeling the environment of IBIS functioning; BP and documents modeling; analysis and improvement of developed models; models transformation: BP to IBIS functions and function chains, extending document models; IBIS prototyping.

### 4. References

- [1] Globa L., Kot T.: Internet Based Information Systems. Functioning and Architecture. Proc. of the 10th Jubilee Int. Conf. Modern Problems of Radio Engineering, Telecommunications and Computer Science, TCSET'2010, 23 – 27 Feb. 2010, Lviv-Slavske, Ukraine.
- [2] Harazov.V.G.: Integrated systems of production control and management. SPb.: Professiya, 2009.
- [3] Globa L., Kot T., Schill A.: Method of IBIS design and workflow realization. Strunk A.: Polish J. of Environ. Stud., Vol. 18, no. 4a 2009, p.35 – 38.
- [4] Korolyov P.E.: Model of the workflow at the enterprise. Automation and modern technologies. 2008, no 9. p. 38 – 40.
- [5] Pavlov A.A., Telenik C.F.: Information technologies and algorithmization in management. Monograph: K. Tehnika, 2002, 344 p.
- [6] Krukovskyy M.Yu.: Graph model of composite workflow. Mathematical machines and systems. 2005, no 3, p. 149 – 163.
- [7] Semenova T.V.: Morphisms of semischemes and their application. Bulletin of Kharkov National University. Series: Mathematical Modelling. Information Technologies. Automated management systems. Kh.:KhNU, 2005, no 703, p. 198 – 206.
- [8] Globa L., Schill A., Kot T.: Business-processes optimization while information systems design. Polish J. of Environ. Stud. Vol. 17, no.4c, 2008, p. 213 – 216.
- [9] Globa L., Kot T., Strunk A.: Business processes modeling, transformation and realization. 19-th Int. Crimean Conf. Microwave and Telecommunication Technology (CriMiCo'2009), Sept. 14 – 18, Sevastopol, Ukraine.

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