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USING UML AND PETRI NETS FOR VISUALIZATION OF BUSINESS DOCUMENT FLOW

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Abstract

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The article deals with two principles of business workflow modeling, Petri nets and UML notation, that are the acceptable approaches to business modeling and can be used also for business documents workflow. The special type of Petri nets, WF-nets and UML activity diagrams are used in this article and both modeling ways are presented on the concrete business workflow and then there are presented and specified their advantage and disadvantage for business documents flows.
At beginning it is explained the word workflow in context business documents, its features, principles and using in business environment. After that it is clarified that the UML is OMG's most-used specification, and the way the world models not only application structure, behavior, and architecture, but also business process, workflows and data structure. Activity diagram UML is good way to show how different workflows in the business are managed, how they start, go and stop. Diagrams also show many different decision paths that can be taken from start to finish. State charts can be used as a detail the transitions or changes of states when documents can go through in the business. They show how a documents moves from one state to another and the rules that govern that change.
Petri-nets offer a graphical notation for stepwise processes that include choice, iteration, and concurrent execution. Unlike UML Petri nets have an exact mathematical definition of their execution semantics, with a well-developed mathematical theory for process analysis. In the article there are modeled a special type of Petri nets, the WF-nets.
The practical part of article incorporates two models of concrete business documents workflows presented in these notations, their comparison and recommendation for using these diagrams in business process management.

workflow, UML, activity diagram, Petri net, WF net, business process, Business Process Management

Business Process Management (BPM) offers tools for management, optimization, automation, and transparency of both enterprise and customer processes. Regardless whether talking about internal processing of invoices, business trip requests, vacation requests, or insurance claims adjustment. Prerequisites for productiveness and efficiency of processes are satisfied if persons, company applications, and information content work in mutual harmony.

Every organization should focus on optimizing the workflows while ensuring compliance with regulations and dynamically responding to the market situation and customer requirements. Only more efficient processes add value to the products and deliver a competitive advantage. BPM is a complex tool for management and administration of internal and business processes for the entire period of their lifecycle. The main requirement relating to implementation of this solution in a company is to increase the transparency of activity

and information flows. A manager thus obtains a considerably faster and higher quality response to tasks assigned to individual workers thanks to the interconnection with various enterprise applications (Intext, 2011).

A model is an abstraction or representation of some subject matter. A symbolic model is a representation of some physical or conceptual subject matter that is not intended to look like the subject. Symbolic models often represent concepts that can´t actually be observed. Both models in this article are made up of boxes, lines and texts that bear no resemblance to the people, documents and in-boxes that they represent. They picture two approach of visualization of workflow systems (emphasis is on the document flow). The first approach is presented with using of UML activities diagrams and the second approach is presented with using special type of Petri-nets, WF-nets. The issues are discussed at the end of article. Article deals with using of workflow models for business competitiveness accomplishment.

MATERIALS AND METHODS

Why is used BPM in enterprises?

BPM integrates the roles of users, legislation, administration, and enterprise applications into a single composite solution and the important object is business document. A lot of enterprise applications run the business processes through roles of individual users with limited access to the documents and processes. Thanks to the open character of the system and support of internationally accepted standards, as well as thanks to integration with other products from Open Text portfolio, managers always have the required information at the right place in the right time. BPM enables integration with a broad scale of external systems: various databases, ERP systems (for example SAP), SCM and CRM, Office applications, Microsoft Outlook, etc. The workflow modeling is the important phase of BPM transition, support and development.

What is Workflow?

According to the Workflow Management Coalition (WfMC, 1999), workflow represents "the automation of a business process, in whole or part, during which documents, information or tasks are passed from one participant (resource, human or machine) to another for action, according to a set of procedural rules". The Workflow Management Coalition has developed a framework for the establishment of workflow standards. This framework includes five categories of interoperability and communication standards that will allow multiple workflow products to coexist and interoperate within a user's environment.

A key aspect of many workflow systems is the incorporation in an organizational model, enabling workflow procedures to be defined relative to organizational roles and responsibilities. These may be separately maintained, for example by means of a directory subsystem, with associated role privileges.

Integration complexity arises from the requirements of most workflow systems to interact with numerous other software components, ranging from standard desktop tools such as forms, spreadsheets and word-processors, to server applications such as document repositories and legacy applications.

We can specify workflows with helping of several parameters:

- Activities that are parts of business process. Activity is controlled sequence of jobs that is made for achievement of business goals.
- Users or groups of users that perform jobs or are responsible for them.
- Relationships between these users.
- Documents that the workflow elaborates.

The Key Benefits of Workflow

1. Improved efficiency – automation of many business processes results in the elimination of many unnecessary steps
2. Better process control – improved management of business processes achieved through standardizing working methods and the availability of audit trails
3. Improved customer service – consistency in the processes leads to greater predictability in levels of response to customers
4. Flexibility – software control over processes enables their redesign in line with changing business needs
5. Business process improvement – focus on business processes leads to their streamlining and simplification

In brief, workflow clarifies and controls existing business processes and helps to simplification, increasing of competitiveness and shortening of whole process. Automation places high requirements at accuracy and unambiguous documentation of process specification. It is able to interpret the process definition, to communicate with workflow stakeholders or to run others process and to make own action. In light of technology it is very interesting concept, because it connects principles, methods and technologies of different areas of informatics and management – concept client/server, email, DBMS, job monitoring, documents and knowledge workflow, modeling and monitoring of process etc. (AIIM, 2011, CCA, 2011).

UML in modeling of workflows

UML (Arlow, 2007) is standard notation for information system analysis and modeling. In this article is used only one type of UML diagram that is

optimal for business process modeling. In common, activity diagrams are used to model the behaviors of a system, and the way in which these behaviors are related in an overall flow of the system. The logical paths in process follows, based on various conditions, concurrent processing, data access, interruptions and other logical.

An activity specifies the coordination of executions of subordinate behaviors, using a control and data flow model. The subordinate behaviors coordinated by these models may be initiated because other behaviors in the model finish executing, because objects and data become available or because events occur external to the flow. The flow of execution is modeled as activity nodes connected by activity edges. A node can be the execution of a subordinate behavior, such as an arithmetic computation, a call to an operation, or manipulation of object contents. Activity nodes also include flow-of-control constructs, such as synchronization, decision, and concurrency control. Activities can form invocation hierarchies invoking other activities, ultimately resolving to individual actions. In an object-oriented model, activities are usually invoked indirectly as methods bound to operations that are directly invoked. Activities can also be used for information system modeling to specify system level processes. Activities make with documents and they are connected with them in every process. Actions have no further decomposition in the activity containing them. However, the execution of a single action may induce the execution of many other actions. For example, a call action invokes an operation that is implemented by an activity containing actions that execute before the call action completes.

In activity diagram in Fig. 1 is used except form activities and their transitions also swimmlanes. Swimmlanes are vertical or horizontal bands in a activity diagram that divide the diagram into logical areas or partitions. In the example below the activities relating to particular entities within the model (such as the user, or enterprise department or responsible business people) are placed within a containing swimmlane to indicate their association. Swimmlanes highlight the relevant variables – who, what and when – in a simple diagram of activities. Activity diagram can show a workflow at any level, from a very high view down to one showing each individual task. In practice virtually no one ever understands a complete business workflow, or even has a fully accurate understanding of its neighborhood. In activity diagrams we can map, measure and interpret all aspect of workflows and business documents.

Modeling of business processes in general and in detail are described in articles (Rábová, 2003, 2008). In Figure 1 workflow is formalized with the help of activity diagram together with swimmlanes. Activity diagrams present internal proceeding of document in succession with a view to process structure and time sequence of particular activities but also at role of people in business that are accountable for activities perform, that is for approving, signature, version changing, or archiving of document. Documents are modeled with UML notation and with UML artifacts of object or commentary. Workflow Order making is large and it includes more documents as objects (order, good, invoice).

It is possible to formalize also the dynamics of these three documents. This is described in (Rábová, Jedlička, 2011). We used there state diagrams that shows life cycle of documents and their transition from one to other state.

Petri Nets and WF-nets in modeling of workflows

According to (AALST, 2004) the classical Petri-net is a directed bipartite graph with two node types called places and transitions the nodes are connected via directed arcs. Connections between two nodes of the same type are not allowed. Places are represented by circles and transitions by rectangles.

Definition: A Petri Net is a triple (P,T,F):

- P is a finite set of places
- T is a finite set of transitions ($P \cap T = 0$); and
- $F \supseteq (P \times T) \cup (T \times P)$ is a set of arcs (flow relation).

A place p is called an input place of transition t if (if and only if) there exists a directed arc from p to t. Place p is called an output place of transition t if there exists a directed arc from t to p We use $\bullet T$ to denote the set of input places for transition t. The notation $t\bullet$, $\bullet p$ and $p\bullet$ have similar meaning that is $p\bullet$ is the set of transitions sharing p as an input place. In the context of workflow procedures it makes no sense to have other weights because places correspond to conditions.

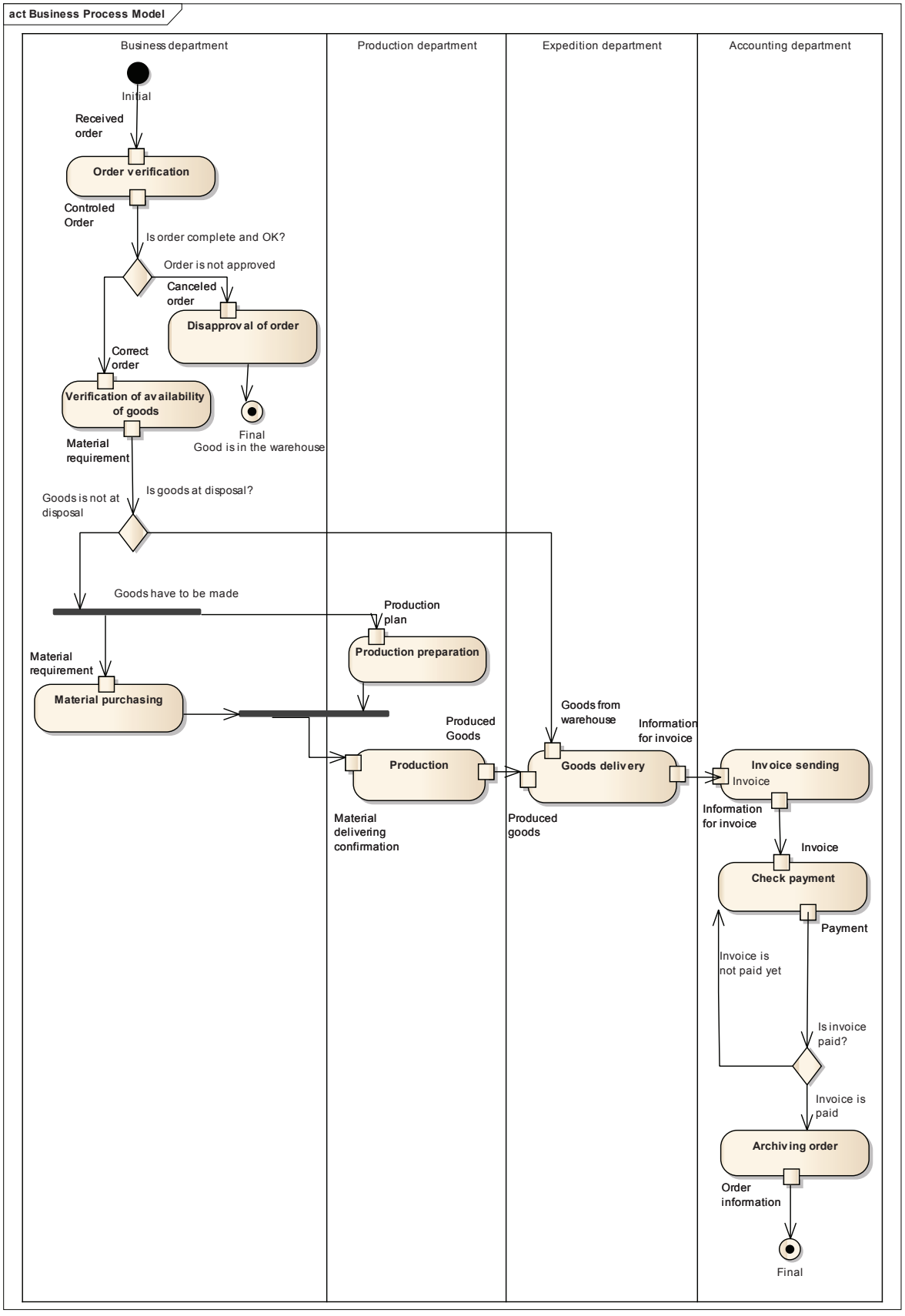
At any time a place contains zero or more tokens, drawn as black dots. State M, often referred to as marking, is the distribution of token over place that is $MP\ IN$. We can represent a state as follows: $1p_1 + 2p_2 + 1p_3 + 0p_4$ is the state with one token in place p_1. Two tokens in p_2, one token p_3 and no token in p_4. We can also represent this state as follows: $p_1 + 2p_2 + p_3$. To compare states we define a partial ordering. For any two states M_1 and M_2, M_1M_2 if for all pP: $M_1(p)\ M_2(p)$, where $M(p)$ denotes the number of tokens in place p in state M.

The number of tokens may change during the execution of the net. Transitions are the active components in a Petri net: they change the state of the net according to the following firing rule:

- A transition t is said to be enabled if each input place p of t contains at least one token.
- An enabled transition may fire. If transition t fires than consumes one token from each input place p of t and produces one token for each out place p of t.

Workflow-net a special type of Petri-net

A WF-net (Workflow-net) has one input place *(i)* and one output place *(o)* because any case handles by the procedure represented by the WF-net is



1: *UML activity diagram of process Order making*

created when it enters the WFMS and is deleted once it is completely handled by the WFMS; in order words, the WF–net specifies the lifecycle of a case. Given the definition of WF-net it is easy to derive the following properties.

Let $PN = (P, T, F)$ be a PN (Petri-net). If PN is a WF-net with source place i, then for any place $p \in P$: $\bullet p \neq 0$ *or* $p = i$, i.e., i is the only source place;

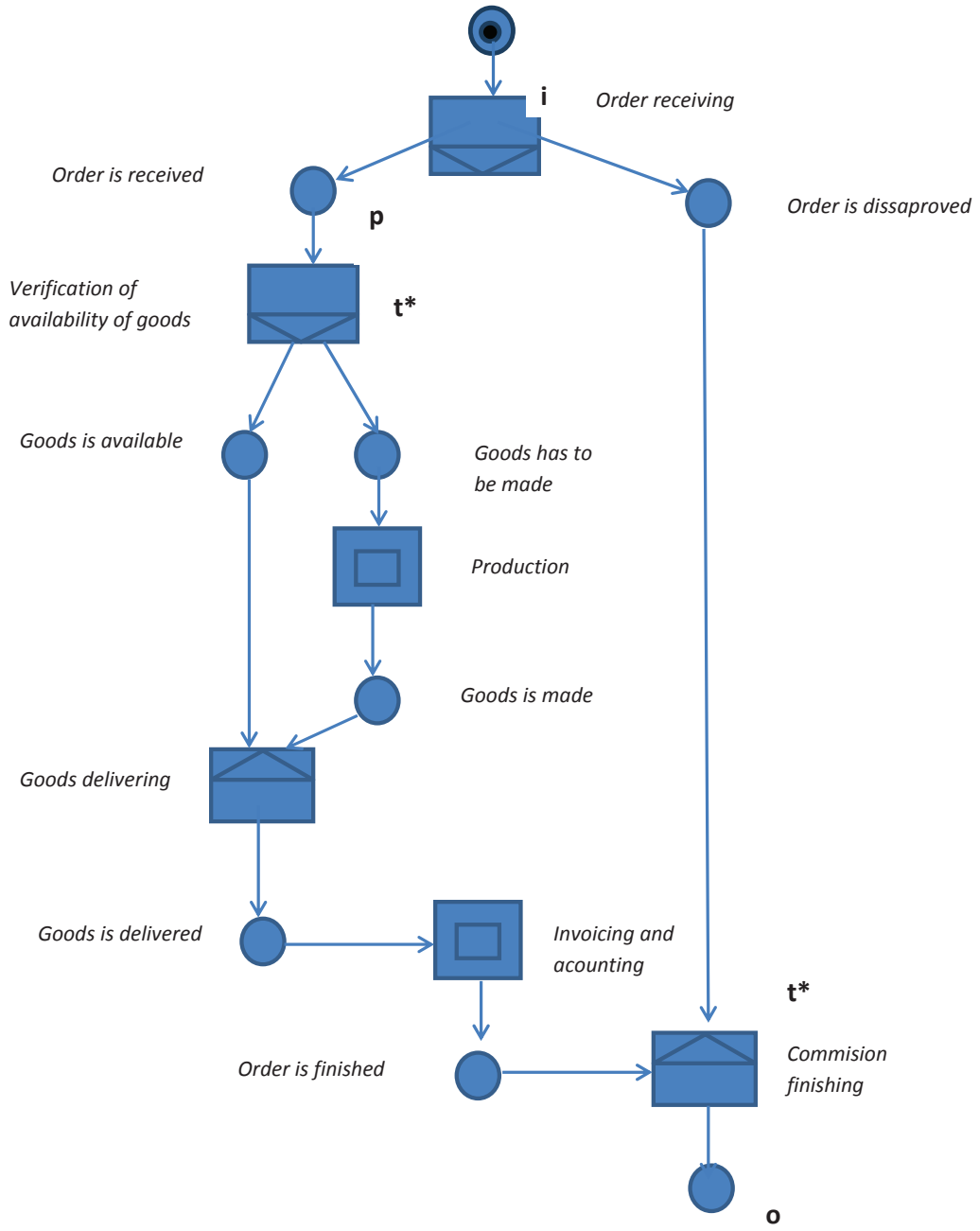
If PN is a WF-net with sink place o, then for any place $p \in P$: $p \neq 0$ *or* $p = 0$, i.e., o is the only sink place;

If PN is a WF-net and we add a transition t^* to PN with connects sink place o with source place i (i.e., $\bullet t^* = \{o\}$ *and* $t^* \bullet = \{i\}$), then the resulting Petri-net is strongly connected;

If PN has a source place i and a sink place o and adding a transition t^* which connects sink place o with source place i yields a strongly connected net, then every node $x \in P \cup T$ is on a path from i to o in PN and PN is a WF-net.

Fig. 2 shows a simplified WF-net that models the processing of order complaints with source place I and with sink place o.

Petri-net can be used for modeling of business workflows and business documents flows when we need to simulating activities of modeling system



2: *WF-net for process of Order makingI: Comparison of UML diagrams and Petri net from several views*

and when we can to analyze important features of system. These features then could serve to system (process) optimization. In general, it is accepted that when we use higher and complicated type of Petri-net we can model more accurate the real system (in our case it is business document flow) but its analysis is more difficult. In any cases it is possibly to make the analysis by computers and to describe Petri-net into suitable format that enables its reading and running in program. To this purpose it was created special language OPMNL. OPNML (Object Petri Nets Markup Language) (Jedlička, 2004) belongs to a group of XML languages and they are useful for analysis. In this approach we don't need OPMNL. We need only the model of real process and its objects as a documents and the common goal of contribution is the visualization of complexity of process.

It is apparently that the Petri-net brings to UML diagrams its own net-chart that allows reading not only time sequence of parts of operations but also conditions of their running and the impact. Graphs of large processes are possible to model in hierarchy and to increase their clarity. The features from models analysis can give much valuable information about workflows and documents. These are for example capacities of computers memory for documents archiving, minimal time for work of document in framework of business rules and business processes, and can detect non logic business rules when some conditions can't be realizable for some operation with document running.

RESULTS AND DISCUSSION

Article deals with modeling of business document workflows. The above explained and showed approaches are compared. The comparison is divided into several views.

- Object notation UML proposes two views at whole area and customer of model can see detail of operations in workflow with responsibilities of workgroups. WF-net gives detailed view at operations in processes. The disadvantage of Petri-net is the time consuming modeling and its difficulty. The Petri-nets are not for beginner, it is not comfortable formalism in contrast to UML diagrams. But when we adapt a little our formalism of Petri-nets (for our case), model can be good readable and intelligible for users and business manager.
- View of software support and high of formalism for modeling of process document flow is interesting for analytics and modelers. We can say that Petri-nets have their own mathematical support (showed above). On the other hand UML diagrams are "user friendly" and they are open to extensions and adaptability. Activity diagram is diagram of activities sequence and peoples as a worker, Petri-nets are focused more at transition and conditions for transition between states of documents in business and their view is more detail.
- For modeling of Petri-nets there exist many tools for presentation, simulation and analysis (Heitmann, 2011). The most extend format for exchange of models between these tools is PNML (Pnml.org, 2009) that is from February 2011 standardized in second part of ISO/IEC 15909. Many experts create own tools for modeling their models and using for simulation and analysis. UML notation is supported by many CASE (SPARXSYSTEM, 2011) tools that are free, trial or commerce. But only some of them can simulate. For example CASEWISE Corporate Modeler could be used for monitoring and then also simulation and

I: *Comparison of UML diagrams and Petri net from several views*

	Views of approach	UML	WF Petri net
1	Modeling of whole process	Yes	Yes, but the model is unreadable
2	Modeling of responsibility of workers	Yes	No
3	Modeling of operation in workflow	Yes	Yes in more detail
4	Difficulty of modeling	No	Yes
5	Suitable for modeller-beginners	Yes	No
6	Comprehension of models for business managers	Yes	No
7	Targeting on document	No	Yes, on document elaboration
8	Number of diagrams of model	More than one	Only one
9	SW supporting	Many CASE tools	Too little tools for modeling
10	Own mathematical formalism	No	Yes
11	Open to extension and adaptability	Yes	No
12	Possibility of process simulation	No	Yes
13	Possibility to process optimisation	No	Yes
14	Language for model presentation	Yes	Yes, but too difficult
15	Possibility of generation of process automation	No	Yes

optimization of business document flow. These activities are very usable in nowadays business environment. Some CASE tools offer generating code for process automation. UML diagrams have lower formalism and it is not possible expressed them in mathematics but they are understandable for non-informatics experts from business and analytics can learn UML better then Petri-net.

- In UML we can express and model one document flow in more than one diagram but Petri-net has only one way of expressing.
- The UML diagram is more focused on whole process, on its complexity, structure and segmentation, time sequence of activities and responsible business workers or business department. It strictly corresponds to understanding of business users. In WF-net is possible to better target on document, its attributes, and excepting detail description of document can give Petri-nets also conditions and procedure of document elaborating. Petri-nets are more oriented on document.

Let me now generalize gains and recommendation for effective and error free deployment of managed document flow and for its visualization.

Why should the business have the document flow in fact?

Thanks to the simplified, dynamic nature of modeling approach our models provide a number of benefits over the BPM solutions:

1. The simplified model gives businesses the opportunity to go from discovery to full automation faster than was previously possible.
2. Responsible workers have proactive response. The business can predict a future problem, adapt to changing circumstances, and succeed in overcoming those obstacles.
3. Business processes can respond rapidly to changing requirements. CASE tools as a software support for workflow modeling are configured through a simple, intuitive graphical interface, requiring no programming skills and make it possible for processes to change at the speed of your business.
4. Business has centralized administration of documents and assuring of information accuracy and unambiguous approach.
5. Managers have faster and better business decision.
6. Workers in business have the rapid location of business documents and detection of its state of running.

Why should the business have the model of document flow?

1. Manager can present information unanimously and in context of whole enterprise.
2. Manager can make fast accomplishment of business objectives and faster allocate responsibility to activities of business worker.
3. Manager has higher security of document confidence and can avoid its exploitation.
4. Manager can decrease possibility of los and unwanted change of documents.
5. Manager can learn and file person that is accountable for issues in decision running.

I bring together *the common contributions* for user of managed and well-established document flow in enterprise into several points:

1. It improves customer service and partner relationship and improves the communication.
2. In increases worker effectiveness and minimalizes risks.
3. It contributes to state legislative observation, improves creating and using business assets and ensures business process effectiveness
4. It decreases costs of documents transportation, printing and storing and creates infrastructure for enterprise document management and for strategies support of business content.

CONCLUSIONS

The business process includes people, information and applications. When these three elements cooperate together in integrated environment, is possible to increase productivity and value of cooperation the whole chain. The common goal of process management is process optimization so that organization is able to react on the dynamic change of market and customer requirements. Process management in firms is often complicated. Correctly configured business document flow simplifies and accelerates many activities.

The setting of electronic flow of documents in business is not simple. The initial modeling and visualization can abbreviate the realization of process and the difficult manipulation with paper documents falls off. Workflow brings more effectiveness of business work and also control of their flow in business. Which are the documents? Receiving mail, agreements, offers, orders, invoices,, the all documents that are made by more people. The running is for example connivance, due dates, expiration of an agreement, penalty, date for actions etc. Faster end simpler processes, their monitoring and precise mapping of throughput saves time and cost.

The article deals with possibilities of modeling and visualization of document flow and document management. It was presented two principles with using activities diagram UML and with using special type Petri-nets, Workflow-nets. Models were working out for concrete case of document flow. The both approaches were compared. The generalization of issues was discussed with respect to praxis.

SUMMARY

The article deals with two principles in business workflow modeling, Petri-nets and UML notation. Both are the good approaches to business process modeling and they can be used also for enterprise documents flow. We use in our presentation the objects Petri nets and UML diagrams activity and state diagrams. We discuss the both modeling ways on the concrete business workflow and specify advantage and disadvantage. At beginning we explain the word workflow in context business documents, its features, principles and using in business environment. After it we clarify that the UML is OMG's most-used specification, and the way the world models not only application structure, behavior, and architecture, but also business process and data structure. Activity diagram UML is good way to show how different workflows in the business are managed, how they start and the possibly many decision paths that can be taken from start to finish. State charts are used to detail the transitions or changes of states when documents can go through in the business. They show how a documents moves from one state to another and the rules that govern that change. Petri nets offer a graphical notation for stepwise processes that include choice, iteration, and concurrent execution. Unlike UML Petri-nets have an exact mathematical definition of their execution semantics, with a well-developed mathematical theory for process analysis. The practical part of our article incorporates several models of concrete business documents workflows presented in both notations and its comparison.

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