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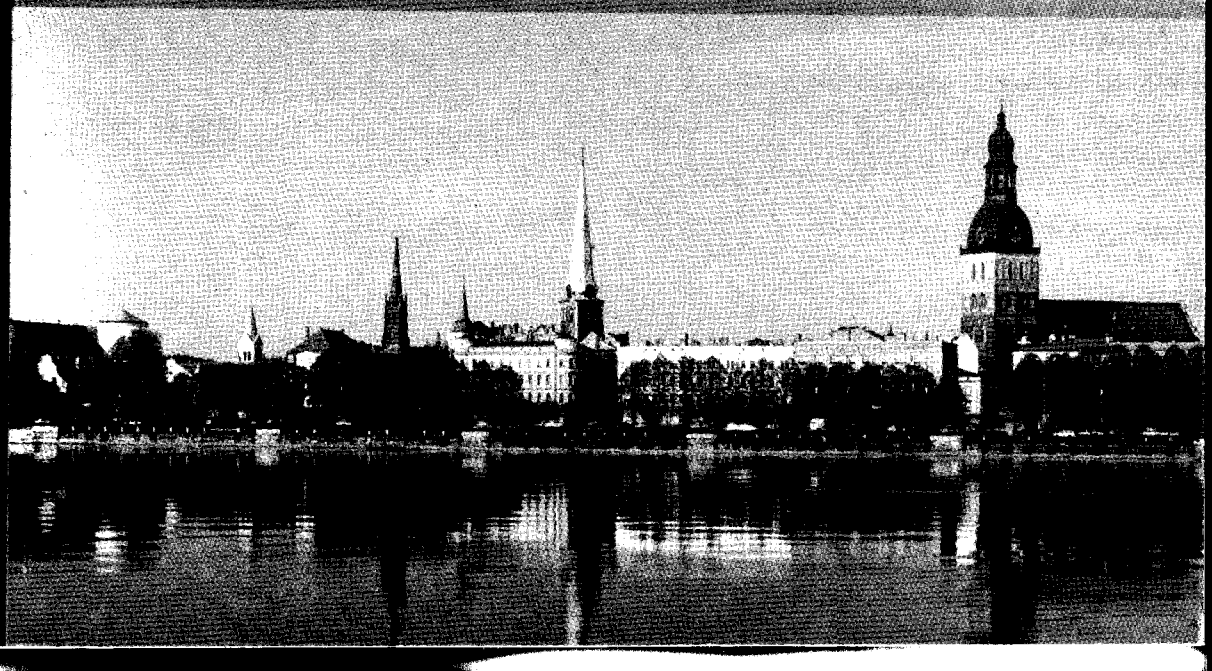

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COMPARISON OF TECHNIQUES FOR BUSINESS PROCESS MODELING

J. Grundspenkis, A. Anohina

Business process modeling, perspectives of the process representation

1. Introduction

The modern firms and companies perform their missions in dynamically changing external environments. So, if an organization wants to be competitive, it must keep up with these changes. A development following the changes is possible if the organization has a deep understanding of its business processes and their performance is effective and efficient. At present many techniques, that enable to document, analyse and design the business processes, have been developed. An organization that doesn't have an experience in the modelling of the business processes could have some difficulties choosing a suitable technique for the business process modelling in a specific situation. So there is a need to develop a framework that would allow to compare the techniques. The framework must take into account information which each of the techniques allows to represent. This paper tries to solve the comparison task on the basis of the five perspectives of the process representation. Four of the perspectives had been developed in [1] and initially were applied for the comparison of the modelling tools of software processes. This paper presents the extension of the mentioned work. The objectives of the paper are twofold. First, we introduce the fifth perspective called the external perspective to meet all needs for representation of business processes. Second, we use the suggested framework for comparison of several well known techniques.

The paper is organized as follows. Introduction examines the need for the comparison of the modelling techniques of the business processes. The second section gives short overview of the examined techniques. A basis of the comparison, i.e. those five perspectives of the process representation and their elements, is presented in the third section. The fourth section at first examines how the particular symbols of the notation of the each technique fit in the concrete perspective. A full picture about how techniques support all five perspectives follows as pie charts. The conclusions outline some directions of the future work.

2. Short overview of the examined techniques

Two strategies have been applied in order to determine an existing set of techniques that allow to represent the business processes:

- available books and articles in the fields of the business process modelling, analysis and reengineering have been examined;
- a search of the Internet has been accomplished using such keywords as diagram, diagramming techniques, process analysis/ modelling, system analysis/ modelling etc.

As a result those techniques that are frequently mentioned by different authors or which they regard as the most widely used have been selected for the comparison. Ten techniques have been chosen on these bases.

Process Flow Diagram. The description of this technique is available at the site [2]. The diagram represents both the interconnection of the organization business processes, describing

how the data and the material flows move between activities, and the interaction of the business processes with an external environment. This technique allows to reveal the parts of the process that are directly related to customers of an organization and that are responsible for their satisfaction. Defining the position of the person or the name of the organization unit performing each activity it shows how the responsibilities are shared in the organization. Moreover, it shows which interfaces exist between the organization units and helps to identify the internal supplier/ customer relationships. The diagram also allows to evaluate computer systems or technologies which are used in the organization. However, this technique doesn't show where data and materials are stored. It requires too much time and resources to construct the correct and precise model.

Process Flowcharts. This technique highlights the components of the business process and the logical relationships between them. Many symbols have been developed for construction of the flowcharts, but a lot of them are used very rarely. The following concepts are enough to represent the business process: *start/ stop* of a process, *activity, decision point*, process *input/ output, document, database, manual operation* There are some kinds of the flowcharts, which vary with the number of details about process. *The Basic Flowcharts* identify all major activities in a process, start and stop points. *The Detailed Flowcharts* represent all the steps of a process, decision points and documents. *The Deployment Flowcharts* use the same information as the Detailed Flowcharts, but locate each activity under the appropriate column that shows who is involved in the activity. *The Opportunity Flowcharts* represent the steps of a process both when everything is all right and when something is wrong. This work focuses particularly on the Deployment Flowcharts because they are more informative then others. These flowcharts highlight the internal supplier/ customer relationships, the sharing of the responsibilities and the interactions with the external environment in an organization. The models allow to see the complete cycle of a process and to evaluate its implementation time. However, the Deployment Flowchart could be very complicated particularly in the case if many activities cross many columns. In addition, the external and internal environments of the process aren't obvious for people who aren't involved in the field. More information about the flowcharts is available at the sites [3, 4, 5,6].

IDEF0. This technique was derived from Structured Analysis and Design Technique (SADT), that had been developed by D.Ross (SoftTech, Inc.) for USA Air Force program. It describes the activities of an organization in terms of *input, output, control* and *mechanism.* The notation of the technique is very simple: it uses only two symbols- a rectangle and an arrow. The labels of the arrows highlight the potential entities that could be useful in data modelling. The mechanisms enable to identify the resources that are used by particular activity and then to evaluate costs which are related with each activity. Some difficulties may be arisen while distinguishing between controls and inputs.

IDEF3. This technique provides both the process- centred and object- centred views of an organization. It includes two kinds of the diagrams. *Process Flow Description* represents the information about business processes and their temporal, causal and logical relations. *Object State Transition Network* specifies how the objects of various kinds are transformed into other objects through a process, which kind of the relations exists between them and how objects change their states. A process model that is used without the appropriate Object State Transition Network gives very little information about the process. The descriptions of IDEF0 and IDEF3 can be found at the site [7].

Process Map. This diagram is mentioned in Adair's and Murray's book [8] and its description is available at the site [9]. Process Map documents the steps of the business process in the regular chronological sequence. It also allows if necessary to map to each step,

if it is necessary, the measurements of the performance such as amount of time that a person spends working on the transaction or the number of transaction that go through this step in a year and so on. The notation consists only of two symbols: a rectangle for the process step or activity, an arrow for the flow direction. Marking the step symbol in the different ways, it is possible to represent how much value this step adds to the output. Afterwards, this information may be used for conducting the analysis of the value- added activities. This technique is very useful if the process has complicated flows with many feedbacks and it is necessary to get a complete picture about the distribution of flows. It also presents a complete cycle of the process performance and highlights a nature of the steps which may be performed consequently or in parallel manner. However, often the information of the Process Map isn't enough for the analysis of the business processes.

Role- Activity Diagram. This technique allows to examine the business process from the viewpoint of the individual role. It focuses attention on the interaction between roles and identifies the possible states of the roles. The diagram highlights the activities that a particular role carries out in isolation and their performance logic. The role itself can be of different kinds: unique functional group or position, job, person etc. Role- Activity Diagram doesn't regard the outside world as the precisely structured thing. So it permits certain freedom and many perspectives in its modelling. This technique is especially suitable for capturing the communications. However, it has several drawbacks: the notation isn't intuitive and the strict boundary between the external and internal environments of a process doesn't exist. More information about Role- Activity Diagram can be found in the Ould's book [10], as well as in [11, 12, 13].

Data Flow Diagram. The diagram represents how business processes interact with each other and with an external environment, how data items flow in the organization and where they are stored. Many different systems of symbols have been developed for this technique that have the same meaning of concepts: *data flow, process element* (process, procedure, function), *external entity* or *terminator*, *data storage*. Data Flow Diagram often is used not only at the business process level, but also at the information system level. This technique is investigated in depth in [14].

Business Activity Map, Relational Diagram. Morris and Brandon[15, 16] have developed both these techniques. Relational diagram in the detailed way represents the information about the *work activities* and *flows* that are captured in Business Activity Map. So both techniques often are used jointly.

Business Activity Map identifies the activities that are performed in a process and flows between them. It also focuses attention on the *decision points, initiating events* and *terminators of the flow*. This diagram has a distinguishing feature: it is necessary to annotate each activity and flow of a process with certain key items of the information. At the same those models which have much additional information and represent complex processes, could be difficultly comprehended. The vague semantics of the flow terminator is a drawback of this technique.

Relational Diagram consists of three columns. *Operational flow column* represents all manually performed tasks and all physical outputs (screen, reports etc.) from the computer system. *System activity flow* column highlights all tasks of a computer system and the logic related with them. *Action description column* describes all tasks and flows from previous two columns in the text form. An opportunity to evaluate technologies that are used in the organization is the main advantage of this technique.

Event- driven process chains. This technique describes business processes representing the chronological and logical relationships of business functions and events. It also identifies the

information objects that are used by a process and specifies the organization units that take part in the performance of the function. It is possible to construct the models at two levels. The level of the *business scenario* describes a relatively broad functional area in terms of processes. The *process level* presents the elementary functions. The created models highlight the complete cycle of the process performance and, as a consequence, they enable to evaluate time that is needed for accomplishing of the cycle. The organization units that are attached to the functions represent the internal supplier/ customer relationships, but don't show the basis of these relations, because the information about how the business entities flow through a process and change their states, is secondary. More information about Event-driven process chains is available at the sites [17, 18].

3. Perspectives of business process representation

Comparison of techniques listed above is based on five perspectives of the process representation. Four of them have been proposed in [1]. These perspectives are:

- *functional perspective* represents which process elements are being performed, and what flows of informational entities (e.g., data, artifacts, products), are relevant to these process elements;
- *behavioural perspective* represents when process elements are performed (e.g., sequencing), as well as aspects of how they are performed through feedback loops, iteration, complex decision- making conditions, entry and exit criteria, and so forth;
- *organizational perspective* represents where and by whom in the organization elements of a process are performed, the physical communication mechanisms used for transfer of entities, and the physical media and locations used for storing entities;
- *informational perspective* represents the informational entities produced or manipulated by a process; these entities include data, artifacts, products (intermediate and end), and objects; this perspective includes both the structure of informational entities and the relationships among them.

Any business process could be modelled using these four perspectives. However, this framework isn't complete for business description. There is one more perspective that is important for a business process. We call it an *external perspective.* It represents how a business process interacts with an external environment or, in others words, which relationships exist between an organization and its customers and suppliers. The customers are all those who receive the organization products or services. They determine existence of the organization and provide its profits. For this reason the organization must care about its customers and their satisfaction level with offered products and services. In turn, the suppliers also must care about the customers providing resources for the activities of the organization. The organization will be able to improve its performance if it improves relationships both with the customers and the suppliers.

Thus, five perspectives are suggested for the comparison of the business process modelling techniques. The elements that are examined within each of them are the following:

1. The functional perspective:
   - process elements (activities, steps, operations, tasks, functions and so on).
   - labelled flows of the entities. It should be noted that it is important to name flows because only in this case one will have information about used entities. In other case they only represent connections between the elements of a process. Some techniques attach the business entities (documents, information objects) directly to the components of the

process (Event-driven process chains, Process Flowcharts). In this situation they show which entities are important for the process functioning. Unfortunately, at the same time the information about how these entities flow through a process and change their states is lacking. This case isn't considered in the comparison.

2. The behavioural perspective:
- feedbacks and iterations;
- decision points and appropriate conditions;
- flow logic/ junctions, sequence/ precedence of the process elements in the performance;
- information about the states, transitions and appropriate conditions for the objects;
- information about the states, transitions and appropriate conditions for the roles;
- events, triggers, initiators of a flow.

3. The organizational perspective:
- performers of the process elements (persons, functional areas, organization units, etc.);
- physical medias and places where the business entities are stored;
- physical communication medias.

4. The informational perspective:
- information entities;
- structure of the entities;
- relations between the entities.

5. The external perspective. It considers whether a technique has means for describing an external environment.

4. Comparison of techniques

This section presents mapping of each notation and symbol of the particular technique to the definite perspective. Commentaries are given where it is necessary.

4.1. The functional perspective

Process Flow Diagram:	activity; system function (it represents an activity that is automated and which is performed by a computer system or machine); labeled data flow; labeled material flow
Process Flowcharts:	activity; manual operation
IDEF0:	activity; labeled input, output, control flows
IDEF3 process flow description:	unit of behaviour (it often is related to such concepts as a function, process, activity, operation and so on)

IDEF3 object state transition network: referent to unit of behaviour

Process Map:	process step
Role Activity Diagram:	action; interaction (it is an activity that is carried out in sequence with another activity in another role); interaction driver (its semantics is the same as for interaction, but in a special way hatched symbol signifies which role initiates an interaction)

Data Flow Diagram:	process; labelled data flow
Business Activity Map:	action; business function (it is an action at the lowest level of decomposition); labelled flow
Relational Diagram:	work task (manual or automated)
Event- driven Process Chains:	function

4.2. The behavioral perspective

Process Flow Diagram:	feedback symbol
Process Flowcharts:	feedback is allowed in the flowcharts; decision point; process start (it often represents an event that initiates a performance of a process); process end (it often represents an event that results from a process performance or which initiates the next process in a system)
IDEF0:	feedback to input; feedback to control
IDEF3 process flow description:	feedback to a previous unit of behaviour is allowed; junctions (they specify the logic of process branching, that is, they capture sequencing relationships between the multiple process paths); the precedence of the units of behaviour can be represented by the various kinds of links
IDEF3 object state transition network:	feedback to a previous state is allowed; junctions; transition links; object state; entry, exit, state, transition conditions
Process Map:	feedback is allowed in the map; it's possible to represent which steps of a process are performed consequently and which in parallel manner
Role Activity Diagram:	drawing a loop back to a previous point, can show iteration; choice of action (there may be any number of alternative threads but only one of the threads may be chosen depending on satisfied condition. The semantics is similar with a decision.); parallel action (there are some threads, each of them represents a part of the process path and the threads all join again after the split denoting that all paths have been completed); state of the role; external event (it often serves as the trigger event)
Data Flow Diagram:	doesn't support this perspective
Business Activity Map:	decision; initiator of a flow (it often represents an event that initiates a flow of a process)

Relational Diagram:	feedback is allowed in the diagram; decision; initiator of a flow (it often represents an event that initiates a flow of a process)
Event- driven Process Chains:	feedback is allowed in the diagram; logical linking operators (they represent logical links between events and functions); control flow (it represents the chronological and logical relationships of events and functions)

4.3. The organizational perspective

Process Flow Diagram:	activity symbol contains a field where it is possible to point out the name of the performer; field of the system title in the system activity symbol; system support activity symbol (it contains the title of a computer system that supports some of the activities in a process. Often such system stores data)
Process Flowcharts:	columns of the deployment flowchart specify the performers of the activities; database
IDEF0:	mechanism (it enables to show the staff, who conducts the activity, and the systems, equipment necessary to accomplish the activity)
IDEF3:	doesn't support this perspective
Process Map:	doesn't support this perspective
Role Activity Diagram:	role symbol (it represents the performers of the actions)
Data Flow Diagram:	data storage
Business Activity Map:	data file/ report (it highlights where the information or data are stored)
Relational Diagram:	data file, computer terminal or screen, report file (folder or filing cabinet)
Event- driven Process Chains:	system organization unit (it represents who or what is responsible for performance of a function)

4.4. The informational perspective

Process Flow Diagram:	doesn't support this perspective
Process Flowcharts:	process input/ output (it represents the information that is available for processing or which is produced by a process); document
IDEF0:	doesn't support this perspective
IDEF3:	doesn't support this perspective
Process Map:	doesn't support this perspective
Role Activity Diagram:	doesn't support this perspective

Data Flow Diagram:	doesn't support this perspective
Business Activity Map:	doesn't support this perspective
Relational Diagram:	report (it represents the variety of the means for representation of the reports, including the printed documents and microforms)
Event- driven Process Chains:	information object

4.5. The external perspective

Process Flow Diagram:	outside entity; external customer; external process linkage symbol
Process Flowcharts:	an appropriate column in the deployment flowchart can show an external environment
IDEF0:	doesn't support this perspective
IDEF3:	doesn't support this perspective
Process Map:	doesn't support this perspective
Role Activity Diagram:	external environment can be shown by an appropriate role symbol
Data Flow Diagram:	external entity
Business Activity Map:	doesn't support this perspective
Relational Diagram:	doesn't support this perspective
Event- driven Process Chains:	doesn't support this perspective

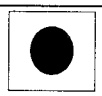
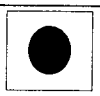
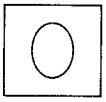
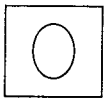
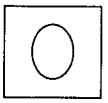
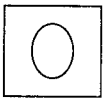
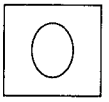
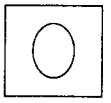
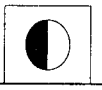
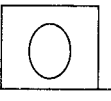
All collected information is summarized in Table 1. Information is presented in the form of pie charts. White circle indicates that a technique doesn't support the given perspective. Black circle represents a case, when the technique completely supports the given perspective, that is it includes the means for specification of all elements of the perspective. In other cases painted sectors of the circle correspond to the number of elements which the technique supports in a given perspective.

The proposed framework could supply guidelines for choosing a suitable set of techniques for a particular purpose. An organization must clearly determine what is important for it. Then it could make different combinations of the techniques trying to meet its needs in the best way and with minimal set of means. It is clear from Table 1 that only Process Flowcharts to some extent support all five perspectives. In their turn, Process Flow Diagram, Role- Activity Diagram, Relational Diagram and Event- driven Process Chains lack one of perspectives.

Process Flow Diagram, Data Flow Diagram, Business Activity Map and IDEF0 offer the best representation of the functional perspective. Role- Activity Diagram almost completely supports the behavioural perspective. This perspective also is well presented in Process Flowcharts, Event- driven Process Chains, IDEF3 object state transition network and Relational Diagram. Process Flowcharts and Process Flow Diagram both provide the best representation of the organizational perspective. Process Flowcharts, Relational Diagram, and Event- driven Process Chains partly support the informational perspective. Only several techniques highlight the interaction between a process and an external environment. Those are Process Flow Diagram, Process Flowcharts, Role- Activity Diagram and Data Flow Diagram.

In general, only two perspectives are well supported by the presented set of techniques, namely the functional and the behavioral perspectives. At the same time the informational perspective is the worst supported of all perspectives.

Table 1. Relative fit of business process modelling techniques in five perspectives of process presentation

Name of the technique	*Functional perspective*	*Behavioral perspective*	*Organizational perspective*	*Informational perspective*	*External perspective*
1. Process Flow Diagram					
2.Process Flowcharts					
3. IDEF0					
4.IDEF3- process flow description					
5.IDEF3- object state transition network					
6.Process Map					
7.Role- Activity Diagram					
8.Data Flow Diagram					
9.Business Activity Map					
10. Relational Diagram					
11.Event- driven process chains					

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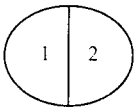
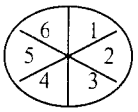
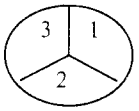


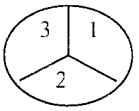
1.process elements
2.labelled flows



1.feedbacks
2.decisions
3.flow logic, sequence
4.states, transitions for the objects
5.states, transitions for the roles
6.events, triggers, flow initiators



1.performers
2.physical medias and places for entity storage
3.physical communication medias



1.information entities
2.entities structure
3.relations between entities

It should be stressed that each technique has some specific properties. In this way Role-Activity Diagram uses a distinguishing approach. It takes a viewpoint of the communication process as the basis for modeling. In their turn, Process Flow Diagram and Relational Diagram are the only two techniques that highlight the computer systems, which are used in the organization. They allow to have information about the activities that are supported by systems and to focus attention on the other areas that can be automated. Process Flow Diagram, comparing with other techniques, more widely considers an external environment of a process. It provides some kinds of an external entities such as outside entity, external customer, and external process. The control flow in IDEF0 represents what conduct or control the activities. IDEF3 is the technique, which points out that an instance of one unit of behavior must be preceded/ followed by an instance of another unit of behavior. Data Flow Diagram offers the broad semantics of the data storage. This isn't limited by a computer file or database but supports a representation of any kind of places where business entities could be stored. Such techniques as Process Flow Diagram, Data Flow Diagram and IDEF0 represent how data and materials flow through a process and how they are transformed into products and services. Therefore, these techniques show what work is done in the organization. Process Flowcharts, IDEF3 process flow description, Process Map, Relational Diagram and Event- driven Process Chains focus attention on how the work is done. They represent the major components of a process and their sequence. Business Activity Map tries to combine these two viewpoints. It represents both how the flows are transformed and which decisions and process initiating events occur in a system. Therefore, it is critically to determine what is important to the concrete organization and then to choose the right set of the techniques.

The comparison that is presented in Table 1 enables an investigation of two problems:

1.What could be a minimal set of techniques that covers all five perspectives and, therefore, allow to describe a business process from the multiple aspects;

2.How the information that is captured in the diagram of one technique could be reuse in the models of another technique.

This paper examines only the first problem. It is worth to note that two perspectives can't be completely supported:

- there isn't a technique that represents the physical communication medias in the organizational perspective;
- the presented set of techniques doesn't highlight the structure and the relations of the business entities.

The scheme for choosing the minimal set of techniques is depicted in Figure 1. Each block of the scheme involves the techniques that support or refine the representation of the specific perspective. Role- Activity Diagram offers the best representation of the behavioural perspective excluding information about how the objects change their states. Moreover, it highlights an external environment of a process but the strict boundary between external and internal environments of a process doesn't exist. The techniques from the second block together with Role- Activity Diagram provide complete representation of the organizational perspective, the informational perspective or of these both perspectives depending on the chosen branch in the scheme. The third block consists of techniques that completely support the functional perspective and that refine the representation of an external environment of a process. Moreover, the techniques from this block also may support the organizational perspective depending on the chosen branch in the scheme. IDEF3 technique highlights how

the objects change their states. It is necessary to choose one technique from each block, for example, Role- Activity Diagram+ Relational Diagram+ IDEF0 + IDEF3.

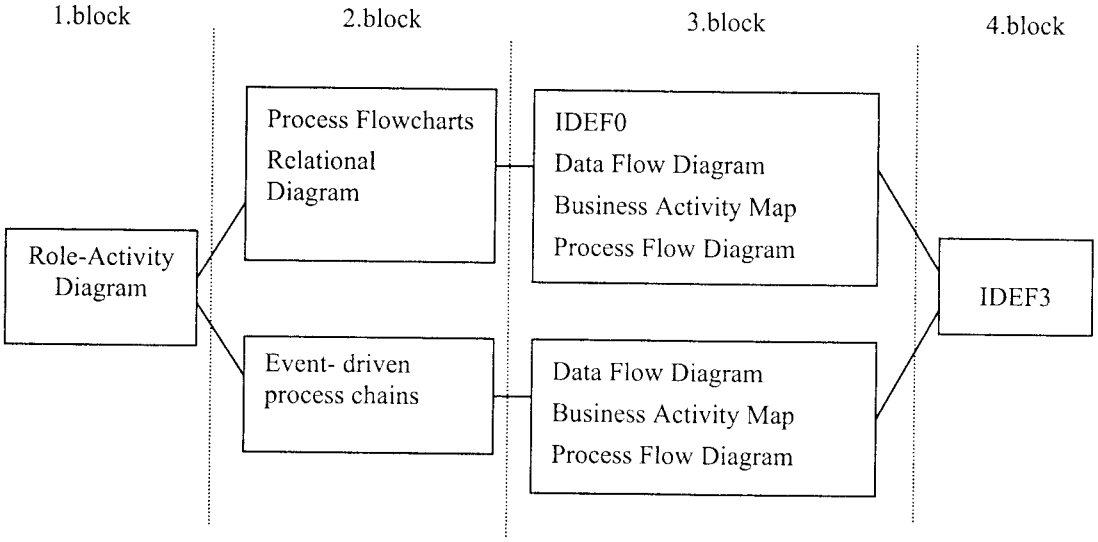


Figure 1. The scheme for choosing the minimal set of techniques

Certainly this scheme isn't universal, because it is based only on the techniques that were considered in this work. Despite the fact that included techniques are popular and well known the appearance of any new technique will cause the reconsideration of the scheme. For complete support of all five perspectives it is necessary to add at least two techniques; one for representation of physical communication medias and another for showing the structure and relations of the business entities. It should be noted that the sets, which contain Business Activity Map or IDEF0 techniques, have one drawback: they clearly don't show boundary between an external and internal process environments. A role symbol of Role- Activity Diagram or a appropriate column of The Deployment Flowcharts allow to represent an external environment but the strict boundary doesn't exist.

5. Conclusions

Comparison of the well known techniques for business process modeling is presented in this paper. The results of this comparison can help to choose an appropriate technique or set of techniques for the particular purpose of modelling. The future work has two directions. First, the opportunities completely to represent the organizational and the informational perspectives will be investigated. Second, the information system on the basis of the presented set of techniques will be developed. Five perspectives of the process representation will be used for the implementation of the mechanisms for searching and classification of techniques.

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Grundspeņķis J., Anohina A. Biznesa procesu modelēšanas tehniku salīdzinājums
Dotajā darbā ir piedāvāta struktūra biznesa procesu modelēšanas tehniku salīdzināšanai. Šī struktūra paplašina procesu atspoguļošanas perspektīvas, kura bija izskaitas [1]. Ir specificēti gan pašas procesu atspoguļošanas perspektīvas, gan to veidojošie elementi. Vairākas labi pazīstamas biznesa procesu modelēšanas tehnikas ir salīdzinātas, izmantojot izstrādāto struktūru.

Grundspenkis J., Anohina A. Comparison of techniques for business process modelling
This paper presents the framework for the comparison of techniques for business process modelling. The suggested framework is the extension of the perspectives for the process representation that have been examined in [1]. The five perspectives of the process representation and their elements are specified. Several well known techniques for business process modelling are compared using the developed framework.

Грундспенкис Я., Анохина А. Сравнение техник моделирования процессов бизнеса
В данной работе представлена структура для сравнения техник моделирования процессов бизнеса. Предложенная структура является расширением перспектив отображения процессов, которые были рассмотрены в [1]. Описаны как сами перспективы отображения процессов, так и составляющие их элементы. Произведено сравнение некоторых хорошо известных техник моделирования процессов бизнеса, используя разработанную структуру.