Business Process Quantification and Modeling – Linguistic Approach – Several Theoretical Aspects

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Abstract

This paper deals with theoretical aspects closely related to business process quantification and modeling based on linguistic approach. It contains an explanation of appropriate terms and principles concerned to relations between business strategy objectives and target and main business processes running within actual firm or company, while business process horizontal and vertical structure conceptual modeling plays a role of great importance there. On the other hand, the business strategy objectives together with appropriate business processes are described via logical sentences written in a natural language and may also contain a set of images. Therefore, the principles concerned to semantic text and image analysis with the use of fuzzy set apparatus, which enables creating of linguistic variables and functions are important for linguistic approach to business process quantification and modeling too. However, an example of simple business process linguistic modeling and a generation of Business process diagram based on previous linguistic variables create an integral part of the paper as well.

Introduction

At present, there are a lot of approaches, methods and techniques concerned to business process modeling (BPMo), which create an integral part of business process management system (BPM). In most cases, the BPMo approaches and methods are based on graphs or diagrams and some of them may be accompanied by several mathematic expressions representing deterministic relations actually. However, the business processes, which indicate a deterministic behavior in a very few cases.

Before launching into formal definitions related to business process structure and functionality, it might be useful to sketch the intuitive ontology briefly that we will be trying to capture with those definitions. Some of the intuitions behind this ontology can arguably be traced back to Aristotle, but they probably comport most faithfully with the picture developed by Wittgenstein [11]. Central to this picture is the notion of a *fact* or, more broadly, a *state of affairs*. Those states of affairs that do obtain are known as *facts [3]*. Wittgenstein's picture is appealing as far as it goes, but, like a lot of early contemporary philosophy, it largely ignores issues of time and change.

The state of affairs at any given moment in its history determines which *propositions* are true at that moment. Propositions are not data, like sentences or bit streams. Rather, they are the *content*, or *meaning*, of such data, the *information* that the data carry (under some conventional interpretation). A proposition *is said to be true at a given time when it is "good" information—if, as far as it goes, it accu*rately represents the state of the world at that time; if, that is, it "fits the facts [3][1]". A *process*[2], then, can be seen as a structured collection of activities whose instances, when occurring in accordance with the structure of the process, jointly carry the world from one state to another in a predictable and, in the case of engineered processes anyway, more or less controlled fashion. Rather, it will be enough simply to define a rigorous (syntactic) notion of a process specification and its (semantic) realization [3][3].

When considering a set of business processes as a collection of activities or functions, which enable fulfillment of business, strategy goals, their vertical and horizontal structure, shall be considered, respected and represented.

[1] Ibid.
[2] In this paper, the terms process and business process are considered to be the same from semantic point of view.
[3] Ibid.

There are more approaches related to business process structure and functionality representation, while one of them is denoted as linguistic approach.

This paper main aim is making proposal of business process conceptual modeling based on logical sentences written in a natural language e.g. English, Slovak, etc. (hereinafter known as NLA sentences), while they may be decomposed into a set of appropriate linguistic variables and functions, which may be quantified via fuzzy set apparatus in order to describe the business process structure and functionality. In order to achieve the main goal, several partial goals shall be postulated and fulfilled. With respect to the fact, that the business process shall be represented by a set of NLA sentences, appropriate methods and techniques related to semantic text analysis and quantification shall be proposed.

On the other hand, if a graphic representation of business process structure and functionality based on the above-mentioned linguistic variables and functions is required, a set of appropriate methods and techniques related to semantic image analysis and quantification shall be proposed as well. An example of simple business process linguistic modeling and a generation of Business process diagram based on previous linguistic variables are closing the paper content, as a result of that.

2. Linguistic Approach in Business Process Quantification and Modeling

2.1 Business Process Quantification and Modeling -Terms and Principles

In general, business and engineering processes are described at that type level, when a process model characterizes a certain general process *structure*. That structure, in turn, might admit of many instances, which — depending on how constrained the structure is — might differ considerably from one another. A robust foundation for process modeling, therefore, should be able to characterize both a general process structure described by a model as well as by the class of possible *instances* related to that structure.

For when time is factored in, what Wittgenstein calls “the world”, viz., the current totality of all the facts, the current configuration of all the objects there are, just seems like a momentary “slice” of the world—the world as configured *now*. Call such a slice of the world (regardless of whether there ever actually has been or will be such a slice, as long as it is *possible*) a *world state*, or *state*, for short. We will call any series of states that the world could exhibit over time in this way a *history [3]*.

Propositions are things that can be true at a time; *activities* are things that can *happen*, or *occur*, over intervals of time. Just as the same proposition can be true at different times, the same activity — e.g., *baking a cake* or *painting a car body*— can occur over different intervals. Thus, activities proper are a type of *universal* and are not bound by time.

By contrast, their instances, which we will call *events*, or *occurrences*
— the actual backings and paintings— have distinct temporal boundaries, a *beginning point* in time and an *ending point*.1 Our ontology thus includes an *occurrence-of* relation that holds between a time bound event and the general activity of which it is an *instance[3]*[4].

Intuitively, events can be thought of as things that jointly *bring about* future states in the history of the world from past states. A baking brings the world to a state involving a cake; a painting to a state in which a certain object has a certain color.

When considering a process, where further splitting-up is not possible or is meaningless from practical point of view (hereinafter known as an *elementary process*) and we try understanding its functionality as a whole or functionality of appropriate functions, which the actual elementary process consists of, we try to create its *conceptual model*, which represents the process specification and its (semantic) realization. A definition of appropriate activities, phase and steps, which lead to the actual process conceptual model design is called *Business Process Conceptual Modeling,* and is closely related to *business process horizontal and vertical structure*[5].

[4] Ibid.

[5] This type of modeling is considered to be one part of BP modeling and may be denoted as *BP horizontal structure conceptual modeling.*

However, a set of elementary processes may create bulk or cluster having an adequate structure as well, while that cluster is denoted as a *supervisory process*. A set of supervisory processes may create further supervisory processes with a higher hierarchic level and they may be assigned objectives closely related to the firm or company strategy goals determined by its mission statement. These types of business processes are denoted as the *main* or the *target business processes*. This is a *down-top approach* to creation of the business process vertical structure. However, a reverse sequence may be applied as well, when defining the business vertical structure: *objectives, target or main processes, subordinated and elementary processes.*

In that case, the subordinated processes are equal to supervisory processes defined within down-top approach. The above-mentioned approach is denoted as *top-down approach*. A conceptual modeling, which closely related to business process vertical structure representation creates the second part of Business Process Conceptual Modeling and may be denoted as *BP vertical structure conceptual modeling.*

2.2 Business Strategy Objective and Business Process Modeling – Linguistic Approach

In general, business strategy mission statement and objectives are described in a verbal form, it means via set of sentences written in a natural language - NL sentences (e.g. English, Slovak, etc.).

Let us consider the company denoted as $P_{s,}$ the mission statement of which is described via NL – sentences, while a semantic structure of any sentence may be represented via Tbe, Pet and Ret terms, the following formula may be postulated [5, 6]:

$$\{Tbe\} = f\,[Pet\,(i),\ Ret(j)] \qquad (2.1)$$

where

Pet (i) - is a set of Pet terms concerned to business objectives

Ret (j) - is a set of relations among business objectives and

Tbe - is a set of terms, which create basis for P_s firm or company business mission statement written in a natural language

while $i=1, 2.....n_1$ a $j=1.......n_2$

These terms are defined and interpreted as follows [7]:

- *Pet – terms* – the principal terms, which are applied in order to explain new terms, denoted as the Terms to be explained or *Tbe terms*. Usually, a set of simple or developed nouns may be applied for creation of Pet – terms
- *Ret terms* – relating terms, which represent relations among objects e.g. Pet or Tbe terms

In order to fill in a set of the firm or company business objectives Pet (i) a set of appropriate business processes P (i, 1), P (i, 2) ....P (i, n_3) shall be running and executed, while the following formula may be postulated:

$$\forall\ Pet\,(i)\ \exists\ P(i,k)\ \Rightarrow\ Pet\,(i) \Rightarrow\ P(i,k) \cap Ret_p(i,k') \qquad (2.2)$$

for $i=1, 2.....n_1$ & $k=1, 2..... n_3$ & $k'=1, 2 ....n_4$

where

$Ret_p(i, k')$ – is considered to be a set of relations among business processes P(i, k), which shall be running, executed and managed in order to fill in the business objectives Pet (i) [5, 6]. As mentioned above, any business process may be described via one or more sentences written in natural language, while the following formula may be postulated:

$$V(i) = V[\{Tbex^{6}(i)\},\ \{Petx\,(i,j)\},\{Retx\,(i,k)\}] \Rightarrow S_{hv}\,(i) \qquad (2.3)$$

where S_{hv} is considered to be a semantic value of the sentence V(i) written in a natural language and has a nature of fuzzy set and formula (6) may be postulated

$$S_{hv}\,(i) : V(i) \rightarrow\ L = <0, 1> \qquad (2.4)$$

[6] The sets denoted as Petx, Px, Tbex, Retx are concerned to the business process $P_e(i,j)$ horizontal structure

Where

1. L is considered to an affiliation measure, which indicates an approximate measure how tightly the natural language sentence describes a business process, the structure of which is described via appropriate sets Tbex, Petx and Retx containing adequate Tbe, Pet and Ret terms, from semantic point of view.
2. It means, if the above-mentioned natural language sentence semantic meaning represented by Tbe, Pet a Ret terms contained within sets denoted as Tbex(i), Petx(i, j), and Retx (i, k), really corresponds to structure and functionality of the business process to be investigated.
3. On the other hand, if we postulate the sets Tbex(i), Petx(i, j), and Retx (i, k) containing adequate Tbe, Pet and Ret terms, we ought to be able to generate rules, which reflect an adequate description of structure and functionality of the business process to be investigated from semantic point of view.

The statements postulated above (via points 1, 2 and 3) create the principal statements related to definition of *linguistic approach business process modeling*.

2.3 Business Strategy Objective Linguistic Modeling principles, with respect to Balanced Scorecard Method, are described within further sections of that published issue

Now let us try comparing this definition with *linguistic approach business process modeling* definitions postulated by other authors.

The Tbe, Pet and Ret terms may be compared with conceptual modeling language (CML) modeling grammars postulated as [4]:

a) Vocabulary
b) Rules

This may be reasoned by the fact, that a conceptual modeling language (CML) is applied to capture the relevant knowledge about a domain [10]. Its objective is not to characterize or to specify a formal system. Rather, it is used to represent facts about the real world. The specification of a CML is denoted as conceptual modeling grammar here, while Tbe, Pet and Ret terms are applied in order to represent facts about the real world and represent fundamental modeling *constructs* as well. Especially, *Pet* and *Tbe* terms may play a role of fundamental modeling *constructs* and may represent *functions* or events on one hand[7], and the *Ret* terms may represent control flows or data flows stand for relations, on the other hand. As a result of that the Tbe, Pet and Ret terms may be considered to be *vocabulary* elements.

Conceptual modeling grammars contain a collection of *rules* that describe how the constructs can be combined to create well-formed statements about the world. As part of the rules it is specified what constructs *may be connected to* each other [4]. On the other hand, the principal equation (2.5), which represents a functionality of any business process, also contains the Ret terms, while it creates basis for generation of business process functionality rules as well [5, 6]. With respect to the above-mentioned fact, the Ret terms ma be considered to be a subset of rules postulated in [12].

$$\text{Petx}(i, j) \otimes P_e(i, k) = \text{Tbex}(i, k) \cap \text{Retx}'(i, k) \qquad (2.5)$$

2.4 Business Process Horizontal and Vertical Structure Conceptual Modeling

A Business Process Horizontal and Vertical Structure Conceptual Modeling means a creation of *BP functional (BPF) model*, which BP vertical structure and *BP process oriented (BPP) model*, describes and BPP model describes BP horizontal structure. With respect to BP modeling methodology developed by Professor August Wilhelm Sheer and applied in IdS Scheer Company[8], the BPF Model is closely related to BP functional and organizational view and the BPP model is concerned to data and process or process-product view, respectively.

Business Process Domain Conceptual Modeling means a creation of model closely related to business process strategy *BPS Model*, which is usually based on Balanced Scorecard Principles.

[7] The Pet and Tbe terms may be compared with language EPC elements postulated by Prof. Scheer

[8] At presents this company is denoted as Software A.G. and this name will be used in further sections of the paper.

A model, which closely related to a complex system for Business Process Functionality *BPFy – Model* consists of the following models:

Business Process Strategy Creation & Controlling

a) *BPS Model* – model closely related to business process strategy.
   a. *BPSC* - business process strategy creator
   b. *BPSS* - business process strategy simulator
   c. *BPSO* - business process strategy optimizer

b) *BPCS Model* – model closely related to business strategy fulfillment controlling

Business Process Design

c) *BPF- Model* – model, which describes BP vertical structure (functional and organizational view).
   a. *BPVSD* – business process vertical structure designer
   b. *BPVSS* – business process vertical structure simulator
   c. *BPVSO* – business process vertical structure optimizer

d) *BPP- Model* – model, which describes BP horizontal structure (data and process or process-product view)
   a. *BPHSD* – business process horizontal structure designer
   b. *BPHSS* – business process horizontal structure simulator
   c. *BPHSO* – business process horizontal structure optimizer

Business Process Implementation

e) *BPIS -Model* – model, which describes BP implementation via SAP System
f) *BPII – Model* – model, which describes BP information support design & implementation, incl. appropriate interfaces
g) *BPSOA* – Model – model, which describes BP implementation via adequate SOA Systems

Business Process Controlling

h) *BPCO Model* – model closely related to business process monitoring and evaluation, incl. BP diagnostic and BP improvement, incl. compliance and risk management
   a. *BPCOME Model* – model closely related to business process monitoring and evaluation
   b. *BPCOD Model* – model closely related to business process diagnostics
   c. *BPCOI Model* – model closely related to business process improvement
   d. *BPCOMP Model* – model closely related to business process compliance management
   e. *BPCORI Model* – model closely related to business process risk management

2.5 Business Process Quantification and Modeling versus Text and Image Semantic Analysis

Text Semantic Analysis

The documents, which contain information set closely related to the firm or company mission statement, business objectives or business strategy goals or aims, are usually represented via set of logical sentences written in a natural language (e.g. English, Slovak, German, etc.), while those sentences cover a content of the above-mentioned business objectives or business strategy goals.

When reading text of logical sentences, we are usually looking for the terms, which enable us to understand the text content and generate a set of new primary knowledge, while the Tbe and Ret terms may be considered to be principal terms closely related to the read text content understanding and the content may concern the other objectives, not only business processes, as well. Let us consider a strategy management level, where the Balanced Scorecard System (hereinafter known as the BSC System) application plays a role of great importance, at present.

A semantic approach to a creation BSC System frame, which indicates an interconnection between knowledge life cycle and Growth and Learning Perspective (hereinafter known as Growth Perspective or GP) within so called Technological Perspective, enables representing a set of required knowledge via adequate set of logical sentences written in a natural language (e.g. English, Slovak, German, etc.). At the beginning, the knowledge core concerned to requirements of customers is being converted to the firm or company business strategy goals or aims and to core, main and support business processes subsequently. However, those business process progress and fulfillment determines a fulfillment of the above-mentioned strategic goals proximately as well [1].

When considering that area, further important knowledge set, closely related to structure, features, progress and information support of business processes shall be considered and respected. On one hand, that knowledge set is considered to be *firm or company know-how subset*, on the other hand is closely related to Growth Perspective and to Technological Perspective as well, while both of these perspectives create the BSC System integral part too. In general, these sets are of a stochastic nature, and the fuzzy set apparatus may be applied for their quantification, as a result of that.

With respect to the above-mentioned facts, the principles closely related to BSC system fuzzy set apparatus implementation might be postulated via set of considerations postulated as follows [1]:

Consideration no.1 (C1)

Transfer of customer's requirements to the firm or company business strategy goals or aims and a quantification of appropriate perspectives.

Consideration no.2 (C2)

Transfer of customer's requirements to the firm or company business strategy goals or aims. A comparison of customer's requirements with goals or aims shall be determined in order to satisfy the requirements of customers.

Consideration no.3 (C3)

The consideration no. 3 is concerned to representation of customer's requirements and goals or aims, which shall be determined and fulfilled in order to match the customer's requirements. They usually are being represented in a natural language (e. g. English, Slovak, German, etc.).

Consideration no.4 (C4)

This consideration is concerned to representation of business processes being in progress within firm or company to be investigated, while the perspective denoted as Internal Business Process Perspective.

Consideration no.5 (C5) – *is concerned to interpreting a content of appropriate sets closely related to Growth Perspective from practical point of view.*

Consideration no. 6 (C6*)* - *is concerned to transfer of strategic business aims and goals that shall be set and fulfilled, in order to satisfy customer's requirements, in core, support and management processes.*

Consideration no. 7 (C7*)* - *is related to representation of business processes running within firm or company to be investigated covered by Internal Business Process and Growth Perspective*.

Subsequently a set of appropriate fuzzy sets is assigned to the above-mentioned considerations, which will be discussed in more details within further chapters and sections of this published issue.

On the other hand, the Tbe, Pet and Ret terms, create and important basis for quantification of business processes [6, 7] and appropriate interfaces [8] among them.

Image semantic analysis

In general, the business process functional, process, data or organizational view is represented with the use of different graphs and diagrams, which consist of roots and edges and may be considered to be the image elements as well.

When considering an image semantic analysis, the image to be analyzed from that point of view consists of segments Sg(1), Sg(2), …. Sg(n), while each segment of the investigated image consists of clusters Cl (i, j) i=1, 2,…..n, j=1, 2 …m_1 and gasps Gsp (i, k) i=1, 2,…..n, k=1, 2 …m_2 .

Let a segment Sg(i) is represented by a fuzzy set Fseg(i), i=1,2,….n, while the fuzzy set Fseg(i) elements are clusters Cl (i, j) i=1, 2,…..n, j=1, 2 …m_1 and gasps Gsp (i, k) i=1, 2,…..n, k=1, 2 …m_2 and L < ∨, ∧, 0, 1>. The fuzzy set may be defined via formula (1.6)

However, the Tbe, Pet and Ret terms, create and important basis for semantic analysis of static and dynamic image as well.

$$\text{Fseg (i)} = \{{}^{\text{Fseg(i), Cl(i, j)}}/_{\text{Cl(i, j),}}\ {}^{\text{Fseg(i), Gspl(i, k)}}/_{\text{Gspl(i, k)}}\} \qquad (2.6)$$

while

$$\text{Fseg(i), Cl(i, j)} = L^i_{\ j} \qquad L^i_{\ j} \in L \qquad (2.7)$$

However, the cluster and gasp semantic meaning may be described via fuzzy sets and formulas (2.8 and 2.9) may be postulated

$$\text{Cl(i, j)} = F_{\text{Cl(i, j)}}{}^{9} \qquad (2.8)$$

$$\text{Gsp(i, j)} = F_{\text{Gsp(i,k)}}{}^{10} \qquad (2.9)$$

In general, any cluster o gasp may contain points, to which appropriate Tbe terms may be assigned. These points are called Tbe term points and have a direct relation to fuzzy sets, which represent clusters and gasps via formulas (2.10, 2.11, 2.12) [8]

$$F_{\text{Cl(i, j)}} = \{{}^{\text{F Cl(i, j), Tbe(i,j,p)}}/_{\text{Tbe(i,j,p)}}\} \qquad (2.10)$$

$$F_{\text{Gsp(i, j)}} = \{{}^{\text{F Gspl(i, k), Tbe(i,j,p)}}/_{\text{Tbe(i,j,p)}}\} \qquad (2.11)$$

$$\text{Fseg(i)} = F_{\text{Cl(i, j)}} \cap F_{\text{Gsp(i, k)}} \qquad (2.12)$$

Furthermore, let us consider business process diagrams closely related to functional, process, data and organizational view and let us try describing a semantic meaning of the above-mentioned views with the use of formulas postulated previously.

Business process functional view diagram

In general, the business process functional view diagram represents a vertical structure of the actual main business process, while the structure contains a set of subordinated and elementary processes and may be represented in a hierarchic form (see also Fig. 2-1).

[9] $F_{\text{Cl(i, j)}}$ – the fuzzy set, which represents the image cluster

[10] $F_{\text{Gsp(i, j)}}$ – the fuzzy set, which represents the image gasp

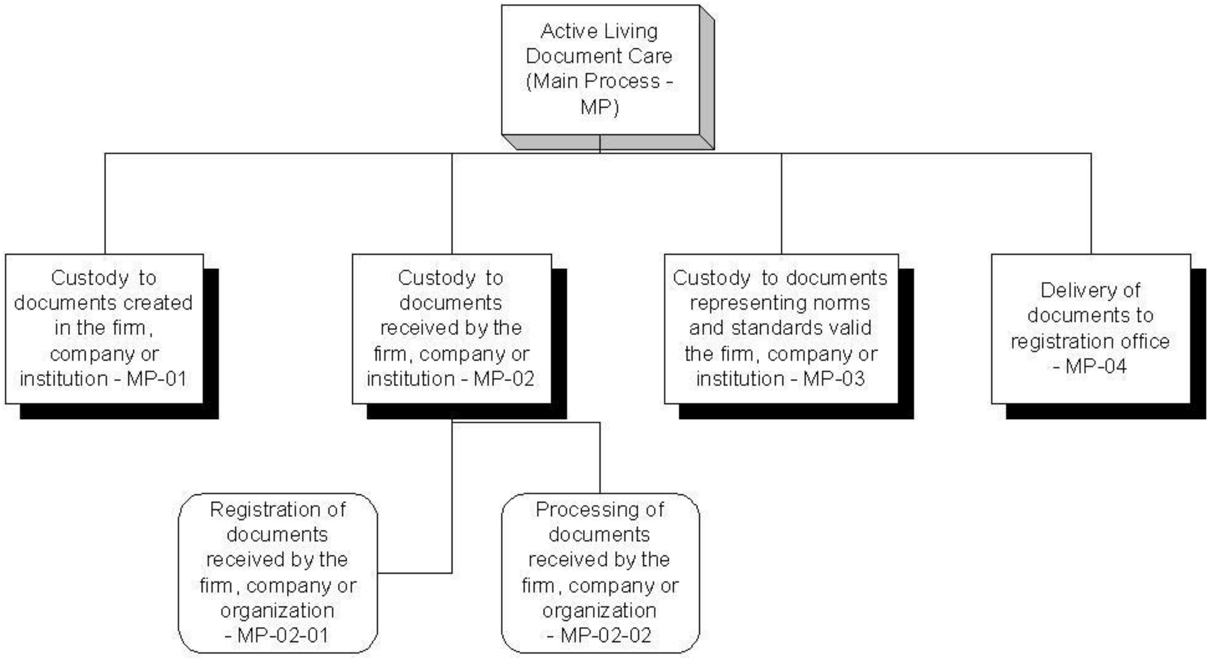

Fig.2-1: Business process functional view diagram – vertical structure

Let us consider a diagram of the main business process, which consists of subordinated and elementary processes, while the entire diagram has a hierarchic structure (see also Fig. 2-1). Subsequently, any of those business processes has its own horizontal structure (see also Fig. 2-2) and generates a set of appropriate main outputs (Tbex[11]) and appropriate collateral or secondary outputs (Retx[12]') based on adequate (Petx[13]) inputs and a creation of Tbex and Retx outputs based on Petx inputs may be quantified via equation (2.5).

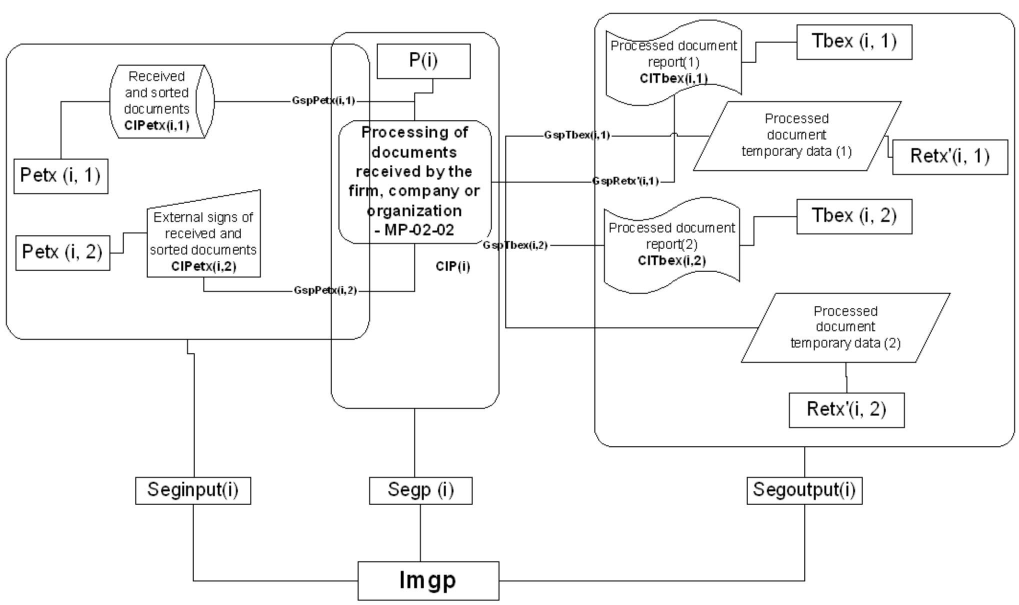

Fig.2-2: Business process functional view diagram – horizontal structure

[11] Tbex outputs are described via Tbe terms
[12] Retx' outputs are described via Ret terms
[13] Petx inputs are described via Pet terms

When looking at equation. 2.5, we can see that the image segment $Seg_{output}(i)$ consists of the main output Tbex (i, k) the and secondary outputs Retx , which may be represented by clusters $Cl_{TbexRet}$ (i, j), while formulas (2.13) may be postulated.

$$Seg_{output}(i) = \prod_{j} Cl_{TbexRet}(i, j) \otimes Gsp_{TbexRet}(i, j) = \prod_{j,k} (Tbex(i, j) \otimes Ret'(i, k)) \quad (2.13)$$

However, when looking at Fig. 1.5, we can see that the image segment $Seg_{input}(i)$ consists of Petx (i, j) and functions Pe(i, k), while the functions create an integral part of the business process (see also formula 2.14)

$$P(i) = \prod_{k} Pe(i, k) \quad (2.14)$$

$$Seg_{input}(i) = \prod_{j} Cl_{PetxPe}(i, j) \otimes Gsp_{PetxPe}(i, j) = \prod_{j,k} Petx(i, j) \otimes Pe(i, k) \quad (2.15)$$

$$Seg_{p}(i) = \prod_{j} Cl_{Pe}(i, j) \otimes Gsp_{Pe}(i, j) = \prod_{j,k} Pe(i, k) \quad (2.16)$$

$$Imgp = \prod_{i} Seg_{input}(i) \cap Seg_{p}(i) \cap Seg_{input}(i) \quad (2.17)$$

$$For\ (p=1.....m_{x,},\ r=1.....m_{y,}\ j=1...\ m1,\ I, j, k) \quad (2.18)$$

With respect to formulas (2.6 up to 2.18) the following theorem may be postulated:

Let us consider the business process P (i), which consist of functions Pe (i, k) ($P(i) = \prod Pe(i, k)$), which generates appropriate primary (Tbex (i, j) and secondary Ret' (i, k) products based on adequate inputs denoted as Petx (i, j). Subsequently, let us consider that, the business process P (i) inputs, outputs and functionality may be described via logical sentence or set of logical sentences written in natural language (e.g. English, Slovak, German, etc.).

When providing a text semantic analysis of the sentence or sentences, a set of Pet, Ret and Tbe terms may be generated as a result of that semantic analysis, while the Pet terms are closely related to business process P (i) inputs denoted as Petx (i, j) and describe Petx inputs, Ret terms are closely related to business process P (i) secondary outputs denoted as Retx' (i, j) and described the Retx (i, j) outputs and Tbe terms are closely related to business process P (i) primary or main outputs denoted as Tbex (i, j) and describe the Tbex (i, j) outputs.

When assigning the appropriate graphic elements in form of clusters Cl (i, j) and connecting elements Gsp (i, j) a set of adequate static image segments may be generated, which create an integral part of the P(i) business process diagram representing a functionality of the P(i) business process, incl. adequate inputs and primary and secondary outputs. As a result of that, the formulas (2.6 – 2.18) create basis for design and implementation of algorithm, which enables generating the business process functional view diagram.

3 . Business Process Quantification and Modeling Apparatus and Tools

3.1 Linguistic oriented Business Process Modeling System (LBP – System)

Let us consider a business process model, which represents the business process vertical or horizontal structure (see also Fig.2-1, Fig.2-2), while a linguistic approach is applied in order to create that business process model. The P (i) business process inputs Petx (i, j) are described via couples [Peta (i, j), Petv (i, j)], while the P (i) business process primary outputs Tbex (i, j) are described via couples [Tbea (i, j), Tbev (i, j)] terms and the secondary outputs of that process Retx' (i, j) are described via couples [Reta'(i, j), Retv'(i, j)]. Simultaneously, the couples create an integral part of semantics related to any logical sentence written in natural language or a set of such sentences, which may describe structure, features and functionality of any business process and they may be considered to be the *text linguistic variables*.

However, the linguistic variables create ordered couples as well, while they are represented by appropriate *text linguistic variable attributes* and *text linguistic variable attribute values* (see also formulas 2.18a, 2.18b, 2.18c)

Petx (i, j) = [Peta (i, j), Petv (i, j)] (2.18a)
Retx'(i, j) = [Reta'(i, j), Retv'(i, j)] (2.18b)
Tbex (i, j) = [Tbea (i, j), Tbea (i, j)] (2.18c)

The linguistic variables[14] create basis for business process linguistic representation not only related to functional or process view, however related to data view as well. The above-mentioned linguistic business process modeling approach is denoted as *Linguistic oriented Business Process Modeling System* (hereinafter known as *LBP – System*).

We fully subscribe to the argument that the right (process modeling) languages enable developers to be significantly more productive. Besides we agree with the requirement that "we need the ability to rapidly design and integrate semantically rich languages in a unified way". This means on the one hand that each domain may and finally has to create its individual, specific language (domain specific language). On the other hand, it means that a common starting point for these language developments is assumed. It is important to sustain – despite the diversity of domain specific languages –a kind of comparability and compatibility between them. We finally agree that Meta modeling provides capabilities to achieve that [2].

Now, the question is: "How Linguistic oriented Business Process Model Language compared with other meta-modeling techniques, based on the logical meta-model stack, and may be applied for description of any business process model?" An adequate answer may be postulated as follows:

"A set of logical sentences written in a natural language and a set of diagrams create basis for any business process model description, while a set of Pet (i, j), Ret' (i, j) and Tbe (i, j) terms (and its derivatives, together with a set of graphic forms, which enable representing a business process functional, process, data and organizational view create basis for the business process meta-model description[15]" (see also Fig.2-3).

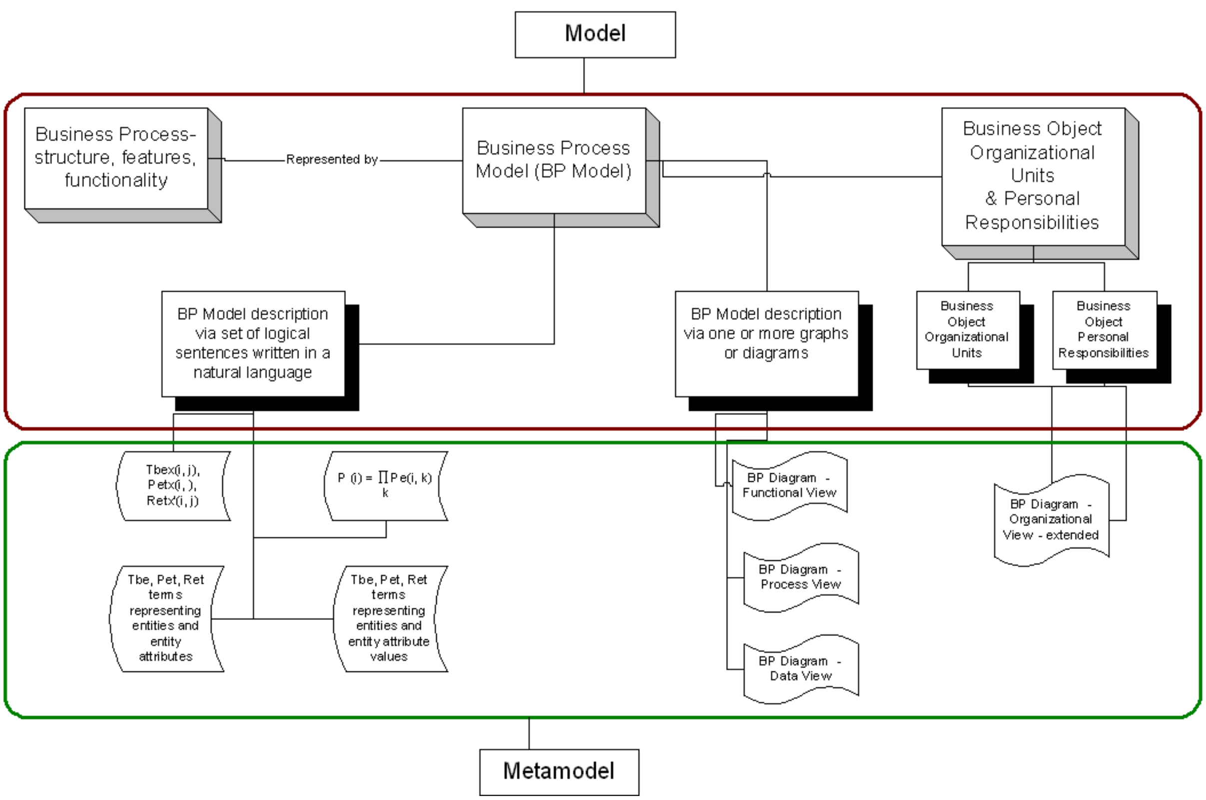

Fig. 2-3 Business Process Model versus Business Process Meta-model

[14] More detailed discussion concerned to linguistic variables creates an integral part of material [5]
[15] A detailed consideration, which leads to the above-mentioned postulate, is described in material [6].

The LBP System operates with text documents, which contain a description of business process structure, features and functionality of the business process (or processes) to be investigated, while the text is written in a natural language (e.g. English, Slovak, German, etc.). However, these texts contain many more nouns, verbs, adverbs, and adjectives than are useful in an object identification effort. These words are necessary in prose and conversation to fluently describe the context and manner in which a system is to be used, as well and correspond to system of classes. The LBP System consists of three types of classes postulated as follows:

- *Pet class*, which contains a set of Pet – terms and its derivatives
- *Ret class,* which contains a set of Pet – terms and its derivatives
- *Tbe class, which* contains a set of Tbe – terms and its derivatives.

In other words, knowing how the system of Pet, Ret and Tbe classes helps the analyst identify which classes are relevant, and which objects in the environment are usefully identified as the system class members and how they may be applied, when creating the investigated business process (processes) diagram (diagrams) or when generating new (primary) rules concerned to the investigated business process (processes) structure, features or functionality. In this direction, the LBP System concept absolutely corresponds to LIDA[16] System concept. The above-mentioned three classes correspond to text semantic analysis, which correspond to the text content describing structure, features and functionality of business process or business processes to be investigated. However, the LBP system class elements are able to co-operate with sets of graphical signs, which create basis of the graphical business process model as well. These aspects are described in the next section.

3.2 Text linguistic variables versus image linguistic variables

However, these linguistic variables enable creating the business process diagram as well via adequate clusters Cl (i, j) and gasps Gsp (i, j) (see also Section 1.4) and the clusters and gasps may be considered to be the *image linguistic variables*.

Let us consider a business process P (i) to be investigated, which consists of functions denoted as Pe(i, k) – see also formula (2.13)

$$P(i) = \prod_{K} Pe(i, k) \qquad (2.24)$$

Furthermore, let us consider a set of business process P (i) *inputs Petx (i, j)* incl. its derivatives described via formulas 2.18a, 2.18b, 2.18c, 2.19, 2.20a, 2.20b, 2.20c, 2.23a, a set of business process P (i) primary outputs denoted as Tbex (i, j), incl. its derivatives described via formulas 2.21a, 2.21b, 2.21c, and a set of business process P (i) secondary outputs denoted as Retx' (i, j), incl. its derivatives described via formulas 2.22a, 2.22b, 2.22c. All of the above-mentioned variables are concerned to text linguistic variables describing the structure, features and functionality related to P (i) business process. However, the P (i) business process structure, features and functionality, incl. its inputs and outputs (primary and secondary) may be represent via set of appropriate diagrams as well, while each of that diagram is considered to be an image, which consist of adequate clusters Cl (i, j) and gasps Gsp (i, j).

The question consists of two subordinated questions (Sub-questions):

Sub-question no.1

"What about the relation(s) exists (exist) among, Petx (i, j), Retx'(i, j) and Tbex (i, j) terms and set of adequate clusters Cl (i, j) and gasps Gsp (i, j), which create integral parts of P (i) business process to be investigated, while the Petx (i, j), Retx'(i, j) and Tbex (i, j) terms are being described via simple or developed Pet, Ret and Tbe terms, together with terms which describe functions Pe(i, k) and the business process P(i) alone (these terms are denoted as Pe- terms) and all of the above-mentioned terms create an integral part of logical sentence (sentence) written in a natural language, describing structure, features and functionality of the business process P(i)?"

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[16] LIDA- Linguistic assistant for Domain Analysis

Sub-question no.2

How the relation(s) shall be quantified so that, the co-operation existing among Petx (i, j), Retx'(i, j) , Tbex (i, j), their derivatives represented by simple or developed Pet, Ret and Tbe terms, the business process P(i) functions Pe (i, j), represented by simple or developed Pe terms and sets of adequate clusters Cl (i, j) and gasps Gsp (i, j), enables designing an appropriate P(i) diagrams, which could correspond to the business process P(i) functional, data, process or organization view?

A set of adequate answers to Sub-question no.1 and Sub-question no.2 could create the basis for design of algorithm (algorithms) and implementation of the application program (s), which could enable generating appropriate P(i) diagrams postulated within Sub-question no.2.

The outgoing and very simplified considerations andormulas closely related to solution of problems postulated within *Sub-question no.1* and *Sub-question no.2* may be found in a section denoted as "Image semantic analysis". Of course, they require a strong further development, which is a subject of further published issues.

3.3 Fuzzy Sets and Fuzzy Logic

The description of reality in natural language generates intrinsic (also: verbal or linguistic) fuzziness. The creation of a linguistic model and the context sensitivity of linguistic statements contribute to the creation of this fuzziness. The inaccuracy in linguistic comparisons is closely connected with this. An example for this is the statement "the object value is much higher than x". Here, the cause of fuzziness is not in the language itself, but rather in the limitation and subjectivity human reality perception. The subjective conception of a circumstance by the person describing is expressed using language and no uniform definition for the terms used for the description exists.

The fuzzy set theory attempts to overcome the separation between the necessary model and procedural precision on the one hand and the empirically desirable consideration of qualitative information on the other hand and to tolerate a portion of the precision that is lacking, as well as the vagueness and uncertainty in modeling processes

For each element ω of a given (crisp) basic set Ω the grade of membership to a subset $A \in \Omega$ is expressed through the value $\mu_A(\omega)$ of a mapping [0:1] $\mu_A : \Omega \rightarrow [0:1]$. These grades of membership are selected from the interval [0:1] and the following interpretation results: the higher the membership grade of an element regarding a (fuzzy) set is, the more it belongs to this set. *A* μ is called the "membership function" of the fuzzy set $\{(\omega, \mu_A(\omega)) | \omega \in \Omega$ [11] [17]}. Linguistic variables can be formulated with fuzzy sets, which take on expressions in natural language – so called linguistic terms – as values. Fig. 3-1 shows the linguistic variable "order value". It has the terms "low", "medium" and "high". The membership of an object value to these fuzzy sets is expressed by the membership functions low μ, medium μ and high μ. The object value 70,000 € belongs for example, to 0.5 to the fuzzy-set "medium", as well as to the fuzzy-set "high".

This mapping of crisp values on fuzzy values is called "fuzzification". In a crisp context, it is only be possible for example, to characterize an object value up from 70,000 € as a "high" order value, while 69,999 € would already pass for "medium"[18].

[17] Thomas, O.- Dollman, T. – Loos, P.:Towards Enhanced Business Process Models Based on Fuzzy Attributes and Rules, p.3 www.sigpam.org/wp-content/uploads/2007/08/oliver.pdf,

[18] Thomas, O.- Dollman, T. – Loos, P.:Towards Enhanced Business Process Models Based on Fuzzy Attributes and Rules www.sigpam.org/wp-content/uploads/2007/08/oliver.pdf

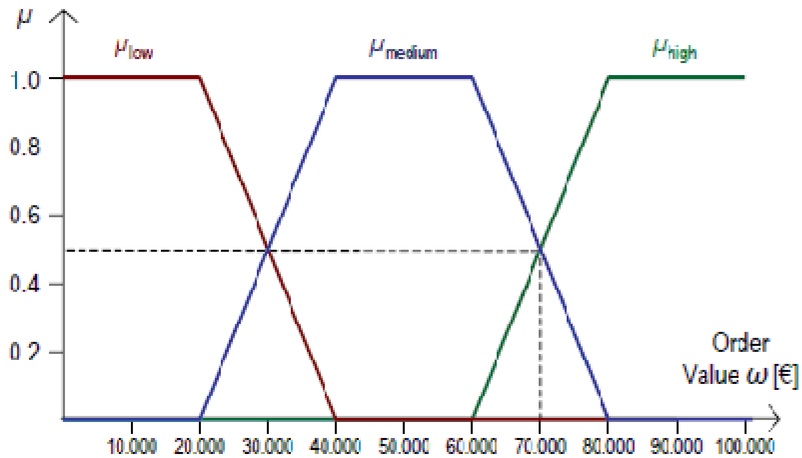

Fig. 3-1 Linguistic variable "Order value [19]"

A fuzzy system has a fixed set of input and output variables, whose respective terms are connected with fuzzy rules consisting of a condition and a conclusion part, for example "WHEN customer assessment = middle AND order value = very high THEN order assessment = high". The value domains of the (linguistic) variables are partitioned by fuzzy sets, which serve the representation of the linguistic terms. A fuzzy rule can be represented formally as (μ (1) ,…,μ (*n*) ,ν) . μ (1) ,…,μ (*n*) are fuzzy sets over the value domain of the input variables and ν is a fuzzy set over the value domain of the output variables. The input and output variables are assigned to each other by inference mechanisms. If 1 *n X* = *X* ×…. × *X* is the input space and
Y the output space, then a fuzzy system *FS* can be formally represented as a mapping *FS: X* →*Y* (Borgelt et al., 2003, S.162 f in[20]).

The fuzzy rule base defines the structure of the fuzzy systems. Based on a vector of input entities $\vec{x} = (x_1, \ldots, x_n) \in X$, the (crisp) default value of a typical fuzzy system $y = FS(\vec{x})$ can be calculated in several steps. First, the degree of performance for each individual rule is found by determining the value of the grade of membership to the corresponding fuzzy set. Then the corresponding grades of membership must be connected conjunctively with a suitable fuzzy operator. From each individual rule result several fuzzy sets. These must be combined disjunctively for the determination of the output of the fuzzy system. A crisp value for the output variable is required for an executable action, for example "determine priority". A defuzzification step delivers this crisp value $y \in Y$ from the output fuzzy set.

If the output variable is not a continuous entity, but rather a categorical variable that can take on any discrete values (classes), then one speaks of a classification problem. A rule-based classification can be modeled with a fuzzy system by understanding each class as a special fuzzy set and selecting the class with the highest grade of membership as a default value for the fuzzy system in a defuzzification step[21].

Consideration no.8

The Petx (i, j), P_e(i, k), Res1 (i, j, k), Tbex (i, j'), Retx' (i, k'), Res2 (i, j', k') terms may be considered to be fuzzy sets

[19] Thomas, O.- Dollman, T. – Loos, P.:Towards Enhanced Business Process Models Based on Fuzzy Attributes and Rules www.sigpam.org/wp-content/uploads/2007/08/oliver.pdf
[20] Thomas, O.- Dollman, T. – Loos, P.:Towards Enhanced Business Process Models Based on Fuzzy Attributes and Rules www.sigpam.org/wp-content/uploads/2007/08/oliver.pdf
[21] Thomas, O.- Dollman, T. – Loos, P.:Towards Enhanced Business Process Models Based on Fuzzy Attributes and Rules www.sigpam.org/wp-content/uploads/2007/08/oliver.pdf

Let us try applying considerations postulated within two previous sections related to input and output variables, which create an integral part of equations (2.14) and (2.20) and confirm that, these variables may be considered to be fuzzy sets.

Let us decompose equation (2.24) and postulate two appropriate equations.

Petx (i, j) ⊗ P_e(i, k) = Res1 (i, j, k) (2.25a)

Tbex (i, j') ∩ Retx' (i, k') = Res2 (i, j', k') (2.25b)

i = 1…..n, j=1……m1, k=1…..m2, j'=1…… m1', k=1……m2'

For each element Petx (i, j) and P_e(i, k) of a given (crisp) basic set Res1 (i, j, k) the grade of membership to a subset
Res1 (i, j', k') ∈ Res2 (i, j', k') is expressed through the value Tbex (i, j') and Retx' (i, k') of mapping [Tbex (i, j') & Retx' (i, k')] : Res1 (i, j, k) →[0, 1]. These grades of membership are selected from the interval [0:1] and the following interpretation results: the higher the membership grade of an element regarding a (fuzzy) set is, the more it belongs to this set. With respect to formula (2.25b) Res2 (i, j', k') is called the *membership function* of the fuzzy set { [Petx (i, j) and P_e(i, k)], Res1 (Petx (i, j) and P_e(i, k)) | (Petx (i, j) & P_e(i, k)) ∈ Res1 (i, j', k')).

With respect to Consideration no. 2, the variables Petx (i, j), P_e(i, k), Res1 (i, j, k), Tbex (i, j'), Retx' (i, k'), Res2 (i, j', k') terms may be considered to be fuzzy sets and all relating rules and postulates should be respected and applied, when working with those variables.

3.4 An example of simple business process linguistic modeling and a generation of Business process diagram based on previous linguistic variables

Let us consider a business process denoted as "Glassmaking - Glm", which closely related to the customer's order fulfillment, while the order is denoted as Orgl and contains three items postulated as follows:

Table 3.1 Customer's order – Orgl

Item No.	Item description	Measure unit	Quantity	Business Process	
1	Bowles	Piece	100	Pe(1, 1)	
2	Bottles	Piece	50	Pe(1, 2)	
3.	Cups	Piece	30	Pe(1, 3)	

The articles postulated within Table 1.1 are considered to be the required primary products and the Glm business process is being quantified by equation (2.26)

Petx (i, j) ⊗ P_e(i, k) = Tbex (i, j') ∩ Retx' (i, k') (2.26)

Now, let us specify a set of appropriate Tbex terms with respect to Orgl content specified via Table 1.1.

{Tbex (i, j)} = {[Tbex (1, 100)], [Tbex (2, 50)], [Tbex (3, 30)]} (2.27)

In order to satisfy, the customer's requirements postulated within his/her Orgl –order, a set of appropriate business process shall be running. When looking at formula (2.26), we may see, that the required primary products represented via Tbex (i, j) terms, cannot be produced without adequate inputs represented by Petx (i, j) terms. Therefore, a set of those inputs shall be specified as well (see also formula (2.28).

{Petx (i, j)} = {[Petx (1, Melt, Melt_qua], [Petx (1, Form, Form_numb],
[Petx (1, Pipe, Pipe_numb], [Petx (1, Glsm, Glsm_numb]} (2.28)

However, only the above-mentioned inputs alones are not sufficient for production of required primary outputs and a set of appropriate business processes shall be in progress in order to achieve that aim.

In general, that set of business process may be postulated via formula (2.29). When looking at Table 3.1 and at formula (2.27), we can see, that producing of bowls requires that approach, producing bottles requires other and producing of cups requires quite another approach.

$$P\ (i) = \prod_{k} Pe(i,\ k) \qquad (2.29)$$

As a result of that, formula (1.29) may be transferred into other form (1.30).

$$\{P\ (i)\} = \{[\ Pe(1,\ 1)],\ [Pe(1,\ 2)],\ [Pe(1,\ 3)],\ [Pe(1,\ 4)]\} \qquad (2.30)$$

see also Tab.1.1.

Let us trying to answer the question concerned to semantic content of Retx' (i, j) terms. When looking at Table 3.1, we can see that a producing of primary product may be accompanied by producing of such products, which do not have an appropriate quality and shall be repaired or create waste. As a result of that, the item Retx' (i, j) shall include the Retxr' (i, j) and Retxw'(i, j), while the following formula may be postulated:

$$\{Retx'(i,\ j)\} = \{[Retxr'\ (i,\ j)] \cap [Retxw'(i,\ j)]\} \qquad (2.31)$$

With respect to formula (1.31), the equation (1.14) may be postulated as follows:

$$Petx\ (i,\ j) \otimes P_e(i,\ k) = \{[Tbex\ (i,\ k) \cap Retxr'\ (i,\ k)]\} \cap \{[Tbex\ (i,\ k) \cap Retxr'\ (i,k)]\} \qquad (2.32)$$

See also Tab.3.2.

Table 3.2 A set of components related to Glassmaking linguistic process model

Item No.	Item description	Quantity (Pieces)	Inputs	Business Process	Outputs (primary)	Outputs (secondary - repair)	Outputs (secondary - waste)
1	Bowles	100	Petx (1, Melt, Melt_qua), Petx (1, Form, Form_numb), Petx (1, Pipe, Pipe_numb), Petx (1, Glsm, Glsm_numb)	Pe(1, 1)	Tbex (1, 100)	Retxr' (1, 0)	Retxr' (1, 10)
2	Bottles	50		Pe(1, 2)	Tbex (1, 50)	Retxr' (2, 0)	Retxr' (2, 5)
3.	Cups	30		Pe(1, 3)	Tbex (1, 30)	Retxr' (3, 0)	Retxr' (3,15)

$$\{Petx\ (i,\ j)\} = \{[Petx\ (1,\ Melt,\ Melt\_qua)],\ [Petx\ (1,\ Form,\ Form\_numb)],\ [Petx\ (1,\ Pipe,\ Pipe\_numb)],\ [Petx\ (1,\ Glsm,\ Glsm\_numb)]\} \qquad (2.33)$$

4. Conclusion

The proposal of business process conceptual modeling based on NLA sentences is considered to be the objective, which deals the paper with, while that type of modeling creates basis for such software design and implementation, which should enable representing of business processes via adequate graphic images closely related to the above-mentioned business process representation views. It contains a set of mathematic relations and formulas based fuzzy set apparatus application, which creates basis for conceptual model related to algorithm, which enables representing of business processes via adequate graphic images.

The *BPFy – Model* , the structure of which is postulated in section 2.4 represents the principal layout and set of steps for further development of business process modeling based on the linguistic approach.

However, an example of simple business process linguistic modeling and a generation of Business process diagram based on previous linguistic variables are closing the paper content as well. In spite of that, the paper deals with theoretical aspects of business process modeling provided based on linguistic approach, the above-mentioned example may create a very good basis for *BPFy – Model* further development and design and implementation of adequate applications as well.

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