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Modelling Purchasing Processes From Quality Aspects

Arsovski Zora[1)]
Milanovic Igor[2)]

[1)]*Faculty of Economics, University of Kragujevac*
[2)]*Faculty of Economics, University of Kragujevac*

Abstract:*Management has a fundamental task to identify and direct primary and specific processes within purchasing function, applying the up-to-date information infrastructure. ISO 9001:2000 defines a process as a number of interrelated or interactive activities transforming inputs and outputs, and the '**process approach**' as a systematic identification in management processes employed with the organization and particularly – relationships among the processes. To direct a quality management system using process approach, the organization is to determine the map of its general (basic) processes. Primary processes are determined on the grounds of their interrelationship and impact on satisfying customers' needs. To make a proper choice of general business processes, it is necessary to determine the entire business flow, beginning with the customer demand up to the delivery of products or service provided. In the next step the process model is to be converted into **data model** which is essential for implementation of the information system enabling automation, monitoring, measuring, inspection, analysis and improvement of key purchase processes. In this paper are given methodology and some results of investigation of development of IS for purchasing process from aspects of quality.*

Keywords*: quality, process, purchasing, modelling, system analysis, software engineering*

1.INTRODUCTION

Software systems develop within complex information systems. Complexity being essential feature of information systems results from both complexity of domains and their environment. Key components of the environment are related to methods, language and operating systems. Software systems are programming systems in industrial and financial operating procedures which are necessary and highly indispensable. They are designed for a particular task and require considerable investment. They need to be of reliable, safe and predictable behaviour. Their maintenance is getting more difficult, thus suitable methodologies need to be applied in order to untangle software 'chaos'. System (functional and structural) and object-oriented methodologies are currently most applied. [1, 2, 7, 8]

Nowadays a vast array of products and services greatly depends on the software complexity, so their high quality is inconceivable without good quality software. Process model in software engineering comprises activities performed while designing and software implementation and products related to these activities. [7, 8].No standard requirements determine the identification

method of purchase process. To identify and then analyze the processes, the starting point is the following definition: An activity using resources, and managed in order to enable the transformation of inputs into outputs, can be considered as a process where the output from one process directly forms the input to the next.

In practice process identification is more readily attainable after identification of inputs and outputs. Input (output) in general case may be a superior's order, a business system note (organizational unit), a written communication from the environment etc. Of course, it is always an identifiable document while analyzing the system and can be presented through data flows and data storage (flows in stationary phase).

This paper deals with modelling purchasing processes on the base of the quality requirements given in Standard ISO 9001:2000. [9] Base for modelling is big sample of analyzed purchased processed (100) and appropriate information system (IS). At the end of the paper is presented quality metrics of designed IS.

2.QUALITY REQUIREMENTS FOR PURCHASING PROCESS

Worldwide well-known companies have introduced the *principle of supplier quality assurance system* in order to provide quality of products purchased. Requirements and criteria of supplier quality assurance are determined using appropriate methodologies in each company. Assessment and ranking of supplier quality system is a key factor while entering into agreement.

A part of the quality assurance system related to product purchase from suppliers has been described in the section **7.4 Purchase**, Standard ISO 9001:2001. This actually means that only the product purchase in compliance with the requirements fulfil the standard criteria. Foundations of this system are documented procedures currently applied.

Instructions for performance improvement related to purchase function are given in section **7.4 Purchase**, Standard ISO 9004:2001. The standard requirements are here thoroughly discussed and explained, including the instructions for practical realization.

3.PURCHASING PROCESS ANALYSIS

Staff in an organization could offer a variety of responses if asked to answer what the purchase process is. For an employee in Purchase Department the purchase process begins when they receive a purchase requirement and it ends up with the delivery agreed with supplier. From this point of view, input, output and activities utilizing resources and providing management to enable transformation of inputs into outputs (supplier identification, their ability to satisfy customers' needs, ranking of suppliers and choosing the best among the suppliers' bids) may be identified. For a Warehouse worker, the end of the process is not well-designed. Verification process and reception of goods in the warehouse are necessary after the agreement reached. In Planning Department purchase does not begin with purchase requirement, but with purchase need identified. For employees in Financial Department, at the very end, purchase also involves processes of inspection, certification and payment of invoices, as well as their keeping.

Success of an organization, as a business system, depends on their management's ability to identify and control the processes in it. Beginning with process approach as a general concept of Standard ISO 9001:2000, all the processes may be classified in three categories: (1) primary processes, (2) specific (supporting) processes and (3) management processes.

These three categories of processes more or less exist in each organization manufacturing and selling any of for kinds of products (services, software, hardware and process materials).

Through primary processes organization realizes its mission and aim to realize and sell its products described in product specifications or service specifications, in order to satisfy customers' needs and expectations.

Most specific processes to be identified are located in particular functions of the organization. These processes have two

main tasks: (1) to support primary processes and so enhance their effectiveness and efficiency and (2) to enable the organization to meet all the requirements in Standard ISO 9001:2000.

Management processes are used by senior management to create strategy and further development of the organization with greater certainty and, at the same time, to successfully control, manage and supervise realization of general and specific processes in order to promptly take actions for continuous improvements.

Besides process identification it is necessary to identify duties for the employees responsible for the processes. All managers ought to be authorized for the processes they are responsible for. Thus, their responsibility is clearly defined.

Since main task of the purchase process is to provide the enterprise with products and services of the quality needed (at acceptable price, just in time and in quantity needed), all factors determining material resource market are to be known for the task realization. Enterprises offering products of variable quality and conditions of sale exist in supply market, so – bearing in mind the requirements of the manufacturing process and sale market – in purchase process all the alternatives in supplying the manufacturing process with materials, components, spare parts and services must be thoroughly investigated. Thus purchase investigation is an unavoidable prerequisite for the realization of its tasks. This is why it must take care about: suppliers' availability, their concentration and negotiating power, quality level, trends in substitute development, prices, geographic location, transport costs, purchase conditions, available arrangements etc. Consequently, purchase management, i.e. providing the enterprise with raw materials, materials, spare parts and services must be based on thorough industrial market research.

Like sales people apply versatile marketing strategies to acquire customers, purchase marketing has to gain suppliers' affection. This is why is important to know if it is a buyer's or a seller's market. When supply is greater than demand there is a buyer's market, and when supply is restricted and demand is greater there is a seller's market and then purchase process involves complex requirements.

A key question in purchase is choice of suppliers. This issue must be given particular attention for the consequences to the enterprise, and lots of requirements and information must be taken into account while selecting suppliers and building relationships with them.

By organizational documents duties are outlined upon the functions (within the functions themselves) and they determine responsibilities and powers. Quality system procedures determine the way of carrying out, responsible functions, employees for its realization and documents used.

Purchase function is a key function providing quality of purchased products. In most organizational models this function makes a unique organizational whole, although in more complex and bigger enterprises purchase function may consist of several units making the unique organizational purchase whole.

Some of the tasks and duties in purchase function are the following:

- Identifying possible suppliers,
- Evaluation of suppliers' suitability regarding meeting the requirements prescribed,
- Reconsidering claims for new product development,
- Defining and placing purchase requirement,
- Obtaining and analyzing bids,
- Coordination of prices,
- Regulating obligation relationships with suppliers,
- Preparation and coordination of agreements,
- Coordination and monitoring new products development and verification,
- Designing of purchase plan,
- Placing orders,
- Monitoring purchase realization,
- Resolution of complaints,
- Taking part and resolving possible disputes with suppliers,
- Building close cooperation and feedback with suppliers,
- Monitoring suppliers' quality and suggestions for better quality etc.

4.ANALYSIS OF INFORMATION SYSTEM IN PURCHASING PROCESSES

The analysis relies on the results obtained in stage of strategic planning of information system, first of all, well-established organizational model, analysis of targets and problems within the organization, critical factors of success, critical assumptions, critical decisions and information. In the context of architectural frame and result obtained in the analyses, each separated business area is profoundly analyzed in order to facilitate the information sub-systems design within the system as a whole; requests are specified regarding particular sub-systems and the whole system, and information needs which ought to be satisfied by the system-to-be in an effective and efficient way are detected, defined and established.

Diagrams may be used for system analysis. It should not be too complex or time-consuming. There are four kinds of diagrams used in the analysis:

a) Process Decomposition Diagrams,
b) Data Modelling Diagrams,
c) Process Flow Diagrams and
d) Data Flow Diagrams.

Diagrams generated, customers' information needs identified and samples of input/output documents are necessary and required for the following stage – system design (projecting).

In designing process model and data model their interactive connections necessary for efficient and effective operation become noticeable. Analysis is based on the existing object and information system, but it should not depend on the existing organizational structure and existing information system.

Technology is getting change and developed very fast, but processes – however – remain stable organizational structure, no matter the technological environment they are carried out in. Organizational structure and formal communication system also change. Primary processes and data classes (entities), nevertheless, remain relatively the same, so data model and process model should be valid and independent enough from the existing organizational structure. The existing information system should not affect the construction of model and data flow, process model and their connections. Finding answers for questions such as: what decisions must be made in a particular operation area, what information is necessary and why, who makes decisions, what communications are rational; almost always result in changes of business procedure, organizational structure and information system. New integral information system based on up-to-date information architecture in most cases requires new organizational forms substantially different in comparison with the previous ones.

System analysis [1, 2, 3, 4, 5, 6] in this methodology is aimed at:

a) Process modelling,
b) Data modelling,
c) Analysis of data flow and information flow in the system and
d) Customers' information needs research.

One of the most essential characteristics of the system theory is that each whole should be taken as a part of a larger whole. Using Top-Down methodology, a complex system is decomposed into simpler components and this way they are resolved. Here **functional modelling** is performed using Standard ***IDEF0*** *(Business Process Modelling)* and ***DFD*** *(Data Flow Diagramming)*. ***BPwin*** (Business Process for Windows) by *Logic Works* is a software and CASE tool available for this purpose. Using Bottom-Up methodology **information modelling** applies two standards ***IDEFIX*** (*Integration DEFinition for Information Modelling*) or ***IE*** (*Information Engineering*). A CASE tool which significantly simplifies information modelling is ***ERwin*** (*Entity Relations for Windows).* [13, 14].
Functional modelling (Top-Down) is performed from the standpoint of the management, using interview method. Then aims, processes, resources etc. are determined. Reversibly, Bottom-Up methodology (document analysis) is performed by database generating. Top-Down methodology provides wider approach, and Bottom-Up methodology provides precision.

5. MODELLING OF PURCHASING PROCESS

Primary processes are connected with entities i.e. data classes they create, update and use. Applying an algorithm in cluster analysis each unique and integral operating area is defined. Initial model in strategic information planning is further analyzed.

This analysis deals with **'purchase'** sub-system. Strategic information planning identifies the following primary processes:

1. PURCHASING PLANNING
2. PURCHASING AGREEMENT
3. PURCHASING REALIZATION

First step of process modelling is decomposition of primary processes into lower-level processes up to elementary ones presenting the smallest business operations from the final customer's view. Each system is decomposable into sub-systems and elements. Simultaneously, each system makes part of a larger system. Hierarchism should be taken into account while behaviour investigation, functioning, development, building and running the system.

Hierarchism is presented through the decomposition diagram showing hierarchy of defined activities with no arrows and enables functional decomposition and insight into deep connections among the activities. *Vertical relations* among processes are so defined, and the data flow diagram establishes *horizontal relations* among processes of the same level.

Decomposition is performed through the tree structure diagram. 'Parent' is in the root, and 'offspring' branches producing from it give a complete description. This is worth emphasizing, since in lots tree structures this rule is not enforced. Creating a diagram 'it-consists-of' goes on up to elementary processes that are not further decomposable. Primary processes are designated by nominal (purchase, finance, marketing etc.), and their sub-processes ('offspring') are designated by gerund (purchasing, delivering, planning etc.) or by syntagma suggesting the activity within the process observed (purchase requirement receipt, call for bids etc.). Name of the process should always suggest what the process involves.

Following example is related to process decomposition in purchase sub-system:

1. PURCHASE PLANNING

1.1. Resource Purchase Planning
- 1.1.1. Purchase requirement receipt
- 1.1.2. Purchase requirement analysis
- 1.1.3. Purchase plan creation and approval
- 1.1.4. Current purchase agreements analysis

1.2. Call for Bids
- 1.2.1. Call for bids preparation
- 1.2.2. Adjustments with suppliers
- 1.2.3. Acceptance and registration of bids

2.PURCHASE AGREEMENT

2.1Choice of suppliers
- 2.1.1 Gathering and processing data on possible suppliers
  - 2.1.1.1 Gathering data on supplier
  - 2.1.1.2 Supplier data analysis
- 2.1.2 Evaluation and choice of suitable suppliers
  - 2.1.2.1 Supplier Evaluation
    - 2.1.2.1.1.1 Evaluation Team Building
    - 2.1.2.1.1.2 Inspection Plan Evaluation
    - 2.1.2.1.1.3 Quality System Assessment
    - 2.1.2.1.1.4 Corrective Measures Inspection
    - 2.1.2.1.1.5 Monitoring Delivery Quality
  - 2.1.2.2 Supplier Ranking

2.2 Bid Agreement
- 2.2.1 Creating Contract Relationship
  - 2.2.1.1 Bids Analysis
  - 2.2.1.2 Best Bid Choice
  - 2.2.1.3 Contract Agreement
- 2.2.2 Batch Production/Delivery Agreed
  - 2.2.2.1 Planning on Launching New Products

2.2.2.2 First Sample Verification
2.2.2.3 Sample Delivery Verification

3.PURCHASE REALIZATION

3.1Ordering and Receiving

3.1.1Ordering
3.2.2Invoice Control and Approval
3.3.3Quantitative Receipt
3.3.4Qualitative Receipt

3.2Complaints

3.2.1Receipt Minutes Analysis
3.2.2Additional Processing / Selection Request Analysis
3.2.3Additional Processing / Selection Realization

Decomposed processes are inherited from a single 'parent'. They are never isolated and are always related to others. The may not exist if there was not a process existing prior to them. There is always a chain of successive and interdependent processes. Several processes are joined into the one ahead and a single process may induce couple of other processes. A dependent process following the previous one may be carried out a few times, once or never. Similarly, a dependent process may follow multiple performing of the previous one.

Possible mutual exclusivity need to be bored in mind. Either one or another process must be carried out, but not both necessarily. Some processes are caused by the others, which is very common, but not always. Some processes are intentional consequences of certain events. For example, sending an information questionnaire to supplier may initiate its filling in and sending it to Purchase Function, its analysis and creating supplier's record of service.

Dependent processes diagram, as a process model, may allow a considerable extension with input and output process data. Then a new diagram is created – **data flow process diagram**. **This diagram is not the same and differs from the ordinary data flow diagram.** It shows basic logical interactions which are necessary among processes. However, it does not show what documents pass immediately from one process to another, or if one process updates a part of the base and then another process reads data and use it. Since ordinary data flow diagram is more comprehensive, creation of process data flow diagram is often omitted, and this paper follows suit.

Arrows in the diagram of the highest level (context diagram) are transferred into lower-level decomposition diagram. This means that the arrows defined in previous function (parent) are border arrows in lower-level decomposition diagram, i.e. arrows appearing outside the diagram observed. Within lower-level diagrams there are explicit or internal arrows interconnecting the activities of the same level. Decomposition diagram without internal arrows suggests organizational approach to decomposition, but not the functional one.

Modelling is based on the need for improvement and optimization of system operating, for the purposes of operating costs decrease. Business process modelling provides a well-determined structure along with clearly defined rules for the processes.

Results obtained from planning and analysis of the information system controlling purchasing processes are given in CRUD matrix and detailed data flow diagrams for some decomposition processes in the following text (table 1).

CRUD matrix is given in its final stage, after clusterization supposing processes listed in the first column by order of appearance in the system analyzed. Processes in the third level of decomposition and appropriate data classes are given by order of their creation (figure 1, 2, 3 and 4). This results in diagonal matrix with separate parts presenting processes of the first level of decomposition. Obviously enough, no data classes are created outside the unit observed on the matrix diagonal. Data classes which are not created within the purchasing sub-system but obtained from the environment are also given, such as purchase request, normative and product specification, inventory level, production plan and the Public Procurement Law. Although not responsible for their creation, purchasing function must file them and, according to circumstances, use and analyze them.

Table 1 - CRUD matrix

Processes \ Data classes	Purchase request	Normative and product specification	Inventory level	Manufacturing plan	Purchase plan	Public Procurement Law	Call for bids	Supplier's Bid	Supplier record	Information questionnaire	Suitability assessment request	Evaluation team	Inspection plan	Quality system assessment report	Delivery assessment	Agreement and Annex	Master request	Master plan	Verification program	Verification report	Verification record	Purchasing realization record	Reception record	Order	Invoice	Bill of lading	Complaint	Verification plan	Return order	Additional Processing / Selection request	Additional Processing / Selection procedure	Additional Processing / Selection order	Invoice request	Additional Processing / Selection report
Purchase requirement receipt	C	C																																
Purchase requirement analysis	U	U																																
Purchase plan creation and approval	R	R	C	C	C																													
Current purchase agreements analysis					U											R																		
Call for bids preparation	R	R	R	R	R	C	C		R																									
Adjustments with suppliers	U	U					U																											
Acceptance and registration of bids								C																										
Gathering and processing data on possible suppliers									C	C	C																							
Evaluation and choice of suitable suppliers					R				U		R	C	C	C	C	R																		
Creating Contract Relationship						R		R	U		C					C																		
Batch Production/Delivery agreed		U							U							R	C	C	C	C	C	C	C											
Ordering		R			R				U							R						U		C										
Invoice Control and Approval																								R	C		C							
Quantitative Receipt																						U	U	R	R	C	C							
Qualitative Receipt																						U	R			R	C	C						
Receipt Minutes Analysis																							U				U		C	C				
Additional Processing / Selection Request Analysis		U																					U						U	C	C			
Additional Processing / Selection Realization		U																					U							U	R	C	C	

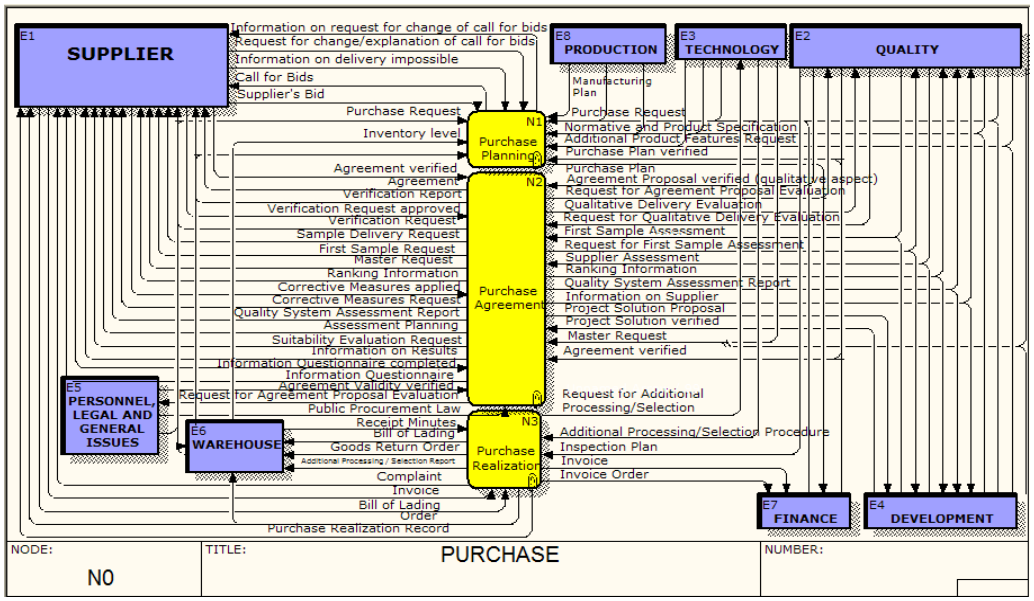

Figure 1. Root diagram

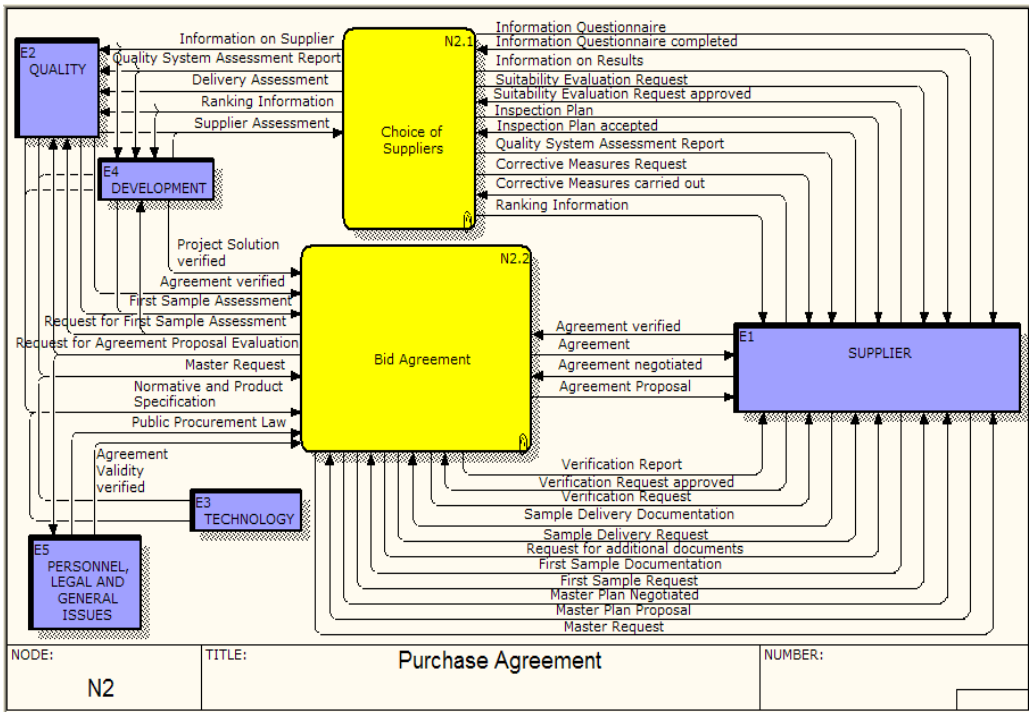

Figure 2. Purchase Agreement

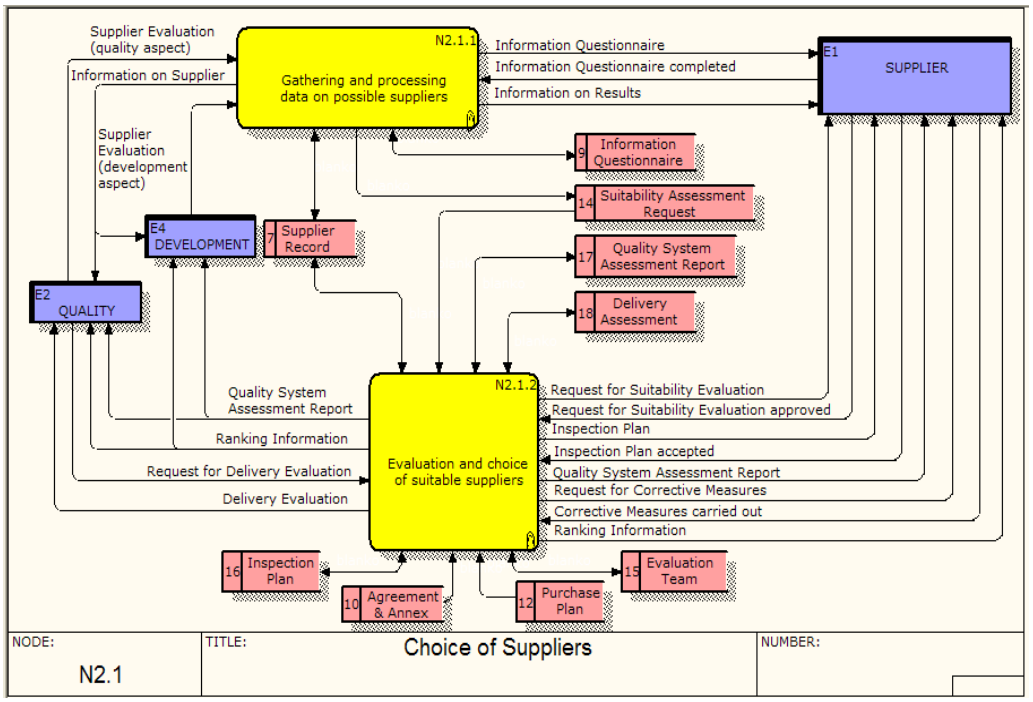

Figure 3. Choice of Suppliers

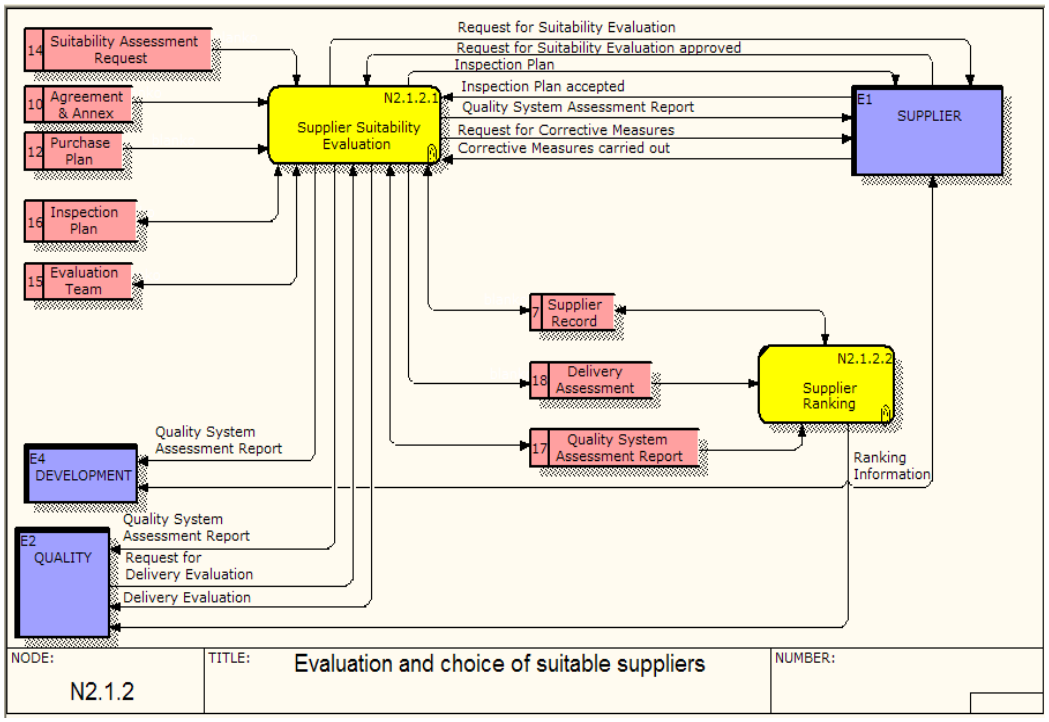

Figure 4. Evaluation and choice of suitable suppliers

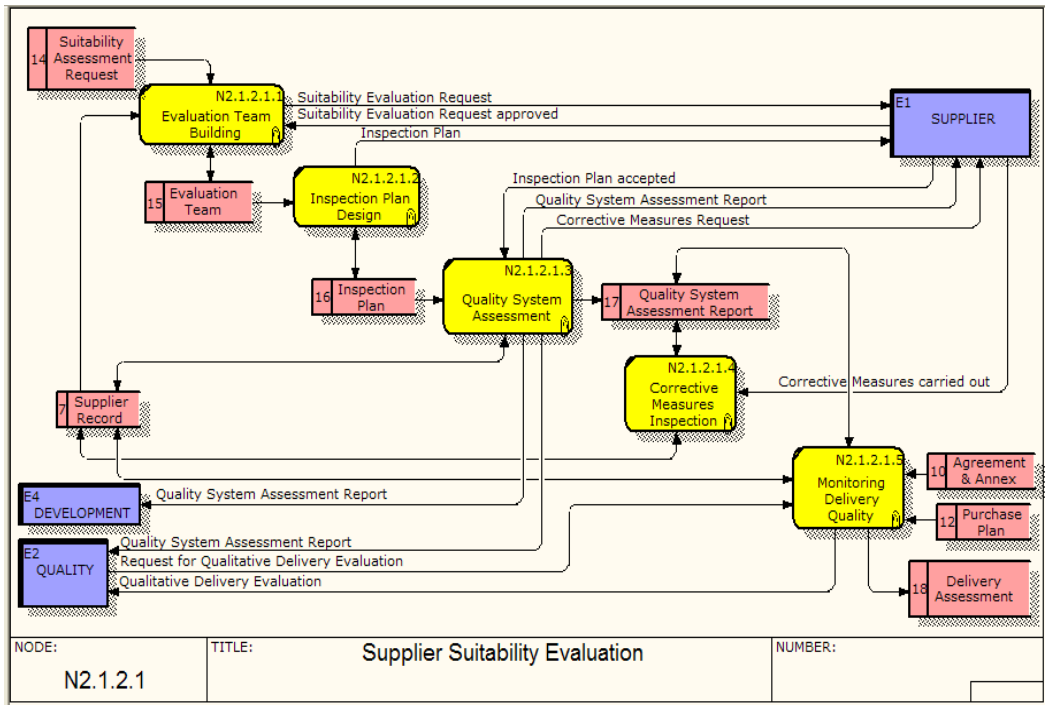

Figure 5. Supplier Suitability Evaluation

On the basis of proposed methodology is generated IS for support ad purchasing process in accordance with quality requirements. In table 2 are given quality metrics of designed IS. In this case, using ORACLE environment level of quality of IS for support of purchasing process is 6.25, what is expected and satisfactory value for next improvement.

Table 2 – Characteristics of quality of IS for support of purchasing process

% of covered sub processes	***Level of integration of quality requirements into IS***	***Level of integration of IS for purchasing process into QIS***	***Quality of software for purchasing process***	***Estimation***
95-100	1	1	10	10
85-94	2	2	9	9
75-84	3	3	8	8
65-74	4	4	7	7
55-64	5	5	6	6
45-54	6	6	5	5
35-44	7	7	4	4
25-34	8	8	3	3
15-24	9	9	2	2
<15	10	10	1	1
0.25	0.25	0.25	0.25	weight
1.75	2.00	1.50	2.00	
			total	6.25

6. CONCLUSION

Process models in software engineering appeared simultaneously with Standard ISO 9001:2000. Great number of different methods appeared in the late XX century along with review of the previous standard ISO9001:1994 becoming **process-oriented.**

System theory fundamental for both quality management system and information system development, has led us to the point of adjustment of both processes.

From previous investigation we can gather following conclusion:

- Purchasing process is very important for business and QMS
- Information systems for support of purchasing process can vary in forms, degree of support, kind of information technology
- From quality aspects are designed quality metrics which involves as characteristics percent of covered sub processes, level of integration of quality requirements into IS, level of integration of IS for purchasing into quality information systems (QIS), quality of software for purchasing process
- Proposed methodology for design and realization of IS for purchasing process can be based on process oriented and object oriented approach of software engineering, with using case tools.

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