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Performing Enterprise Organizational Structure Redesign through Structural Analysis and Simplicial Complexes Framework

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Abstract: Academic and scientific research often involve the construction of formal and numerical models to solve scientific and engineering problems. Many organizations are evaluating and migrating toward new trends in information systems and IT infrastructure. Now the challenges are less technological and become more cultural as related to governance issues. The paper deals with improving an enterprise's organization by establishing agile and adaptable enterprise system architecture. That not only facilitates new development but also allows for optimizing existing information technology infrastructure to redesign a new enterprise organization structure. For this purpose, we use a canonical approach to implement structural analysis and simplicial complex framework to assess an enterprise's organization. Several methods have been used in this domain like social networks analysis and lattice theory. However Q-analysis method has not been yet exploited in this aim scope. It catches our interest with its topology to capture organizational structure and its strong point that it shows communication inside the same structure. Besides, Q-analysis allows us to diagnose the actual organizational structure of an enterprise and to compare it with the real one. We use different measure indicators like eccentricity, complexity and traffic pattern of a system. A Q-analysis method based on structural analysis and simplicial complexes proves how to ensure synchronization between formal organizational structure and the emergent one, due to perceived changes in business processes. The proposed solution architecture improves organizational structure of an enterprise in order to be more efficient and more aligned with the current processes organization.

Keywords: Structural analysis, enterprise system modeling, Q-analysis, organization structure NoSQL, organizational processes.

INTRODUCTION

Among different reasons why strategic plans fail, we found a failure to coordinate i.e., reporting and control relationships are not adequate so organizational structure is not enough flexible. Then failure to manage change because of the lack of vision on the relationships between processes, technology and organization. Companies tend to improve their organizational structures to be more effective and efficient. To carry out change toward a structure that aligns with projects and strategies of a company, we need to define the ontology's organization then make its structural analysis to implement a meta-model of a learning organization that aligns and meets the strategic objectives of the company. Therefore, organizational issues are of high priority and should be of general interest. Also enterprises need to know how far their organization is stable. This paper presents structural analysis and simplicial complex framework for enterprise organizational structure redesign which takes into consideration our proposed enterprise meta-model and solution architecture. To improve enterprise's organization, we study and use structural analysis for optimizing and redesign a new enterprise organization structure. For this reason, we use a canonical approach to implement structural analysis and simplicial complex framework to assess and diagnose enterprise's organization. Several methods have been used in this domain like social network analysis (SNA) and the Galois lattice but Q-analysis method catches our interest with its algebraic topology to capture the organizational structure. Its strong point is that shows communication inside the structure. The Q-analysis allows us to diagnose the actual organizational structure of an enterprise and compare it with the real one. We use different measure indicators like eccentricity, complexity and traffic of the system. These measure indicators help to ensure synchronization between formal organizational structure and the emergent one, due to perceived changes in business processes.

Through Not Only Structured Query Language (NoSQL) system, we store the enterprise repository in a graph database (Neo4J). Because we consider organizational structure as a graph, relationship between performers and a business process also. Then we extract data from the repository for structural analysis using a specific Neo4J's query language, Cypher. We can export results in different file formats: Extensible Markup Language (XML); Comma-separated values (CSV) or JavaScript Object Notation (JSON). These

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extracted data will be the object of a structural analysis. We obtain the actual organization that it is necessary to compare its conformance with regard to the real organizational structure.

MATERIALS AND METHODOLOGY

In this work, we propose the results of our research conducted in the Mohammedia Computer Lab. These concern work for the PhD project of Zineb BESRI under the supervision of Professor BOULMAKOUL during the period 2011-2014. This paper presents a novel approach to enterprise organizational structure re-engineering based on some algebraic structure in combinatorial topology. It provides application of a system-theoretic approach called Q-analysis, by giving an audit process of the structural complexity of the organizational structure of a company and also proposes a brief discussion of the advantages and limitations of this approach.

This work is structured as follows, after a short introduction, in section II, we present the ontological organization; in section III, we discuss related work in existing enterprise modeling. Then we propose our enterprise meta-model for organizational matters in section IV. In section V we outline the proposed system architecture solution. Section VI describes and completes our proposed model and presents the structural approach used to assess the organizational structure. With a case study as an example given in section VII, we illustrate the use of Q-analysis method and the results included in the performance diagnosis provided in section VIII. Finally, section IX concludes the paper and emphasizes our future works.

ORGANIZATION ONTOLOGY

In this section we give briefly the concepts of the organization by recalling the definition of the organization and the intelligent organization.

Organization

All organizations have a management structure that determines relationships between functions and positions, subdivides and delegates roles, responsibilities, and authority to carry out defined tasks. Organization is a set of constraints on the activities performed by a set of collaborating agents [1]. Using the unified foundational ontology, the organization is considered as a system including organizational activities structured in business process and services, information systems supporting organizational activities [2,3] underlying information technology infrastructures and organizational structures.

Intelligent Organization

Corporations are concerned about organizational structure. In other hand, a learning organization is one skilled in acquiring, creating, transferring and retaining knowledge as well as transforming that knowledge into improved performance or innovative products and services. All these activities depend on human interaction that are members on it and are, on average, intelligent and capable of learning. i.e., organizational intelligence cannot simply be equated with human intelligence [4]. Therefore, how can we conceive enterprise organization so as to be adapted to an intelligent and dynamic behavior? In our view, structural analysis with its foundation and holistic practices based on algebraic topology contributes to organizational intelligence paradigm. This work permit to establish a framework for the design and development of intelligent organizations founded on advanced models of enterprise architecture and complexity management. Next we give some existing enterprise modeling practices.

ENTERPRISE MODELING

Enterprise models have a critical role in this study, enabling better designs for enterprises, analysis of their performances, and management of their operations. Modeling is at once organizational, informational and human. We study initially existing modeling techniques, to locate the standardization and normalization efforts [5,6]. There are many enterprise models such as, IDEF (Integrated DEFinition Methods) used for modeling activities necessary to support system analysis, design, improvement or integration [7]. Then GIM and GRAY models, here an enterprise consist of a physical system, a decision system and an information system. An enterprise can be described using four views: functional, physical, decision and informational view. Also CIMOSA (Computer Integrated Manufacturing Open Systems Architecture) defines a model-based enterprise engineering method which categorizes manufacturing operations into generic and specific functions [8]. The advanced models are COBIT, ISO 19440 extend in the works [9], ARIS framework (Architecture of Integrated Information Systems), etc. Table **1** shows an example of enterprise modeling in different fields: enterprise architecture; enterprise architecture methods and frameworks and architecture languages.

Table 1. Enterprise Modeling

Enterprise Architecture	• IT Governance: COBIT • IT Service delivery and support: ITIL • IT Implementation CMMI
Enterprise Architecture Methods and Frameworks	• Zachman Framework (1987) • TOGAF: The open Group Architecture Framework (1995) • ISO 19440 Extended (2012) A. Boulmakoul & Al
Architecture Languages	• IDEF (Integration Definition for function modeling) • UEML (unified enterprise modeling language) • ARIS (Architecture of Integrated Information Systems)

RELATED WORKS

Many organizations, large or small industrial corporations, service companies, administrative organizations, or government agencies, face the need to more frequently re-engineer their organization's structure, review the alignment of their IT systems with their business goals, and improve their efficiency to cope with changing business conditions.

The need to build agile Interoperable enterprise systems requires tools and methods to be able to re-engineer the organization or a networked organization with a service orientation coupled with the more traditional business process orientation.

There are many fields of applications and research in the same purpose to explore knowledge of organization, enterprise architecture such as organization enterprise architecture and their dynamics for enterprise modeling and business process mining; organizational culture that is about the study of the collective behavior of humans who are part of an organization [10]. Track experience of employees to base job assignments on up-to-date information about their knowledge [5]; how to use results of structural analysis for re-engineer organization by the IBM Research Division [11]; deploying holistic meta-model for strategic information system alignment [9] and intelligent organization, structural analysis frameworks for enterprise organizational re-engineering [12]. Methods for soft computing are highly relevant to this work. In real-life applications of various soft computing techniques in different fields were used, such as the followings: image processing [13], engineering applications of artificial intelligence [14], predicting using artificial neural network [15-17], and optimization techniques [18].

PROPOSED META MODEL

In our study we have been inspired by (Architecture of Integrated Information Systems) ARIS method, it provides unified organization foundation ontology. ARIS is an approach to enterprise modeling. It offers methods for analyzing processes and taking a holistic view of process design, management, workflow, and application processing. See works given in [19]. ARIS enterprise architecture framework defines organization as a system including: organizational activities structured in business processes and services; Information system supporting organizational activities; Information technology infrastructures and Organizational structures. Organizational view in the requirement definition layers includes modeling concepts for the enterprise's structure. Fig. (**1A-D**) show fragments of proposed organizational meta-model. It defines the following packages. **Organizational package** (Fig. **1A**) which includes the generic classes: ***Organizational Unit***: entity responsible for achieving organizational goals; ***Position***: the smallest organizational unit; ***Performer:*** represents a person assigned to an organization; ***Location***: a geographical location of an organization unit, a person, position or organization cell; Then **Objective package** (Fig. **1B**) that introduces ***Objective***: includes explicit goals and targets set by the enterprise, while indicators are associated with assessing the enterprise's progress towards its objective. Finally **Process and Resource packages** (Fig. **1C**, **D**) which define ***Activity:*** the fundamental business entities that represent actions taken by the enterprise. Activities can be composed of sub-activities thus can be combined with other business to represent business ***Process*;** besides ***Resources*:** business entities that can be used or consumed during the performance of an activity

SYSTEM ARCHITECTURE

Our proposed system architecture for an intelligent organization based on the structural analysis framework is organized in five layers: Repository, Extractor, Structural Analysis, Viewer and Organizational Structure Database. In the following we describe each layer of the proposed architecture shown in Fig. (**2**).

- **Repository** includes organization structure, processes, activities and different kinds of resources. We use big-data to store company information's in a graph database *Neo4J* [20]. This layer will be the input of our system.

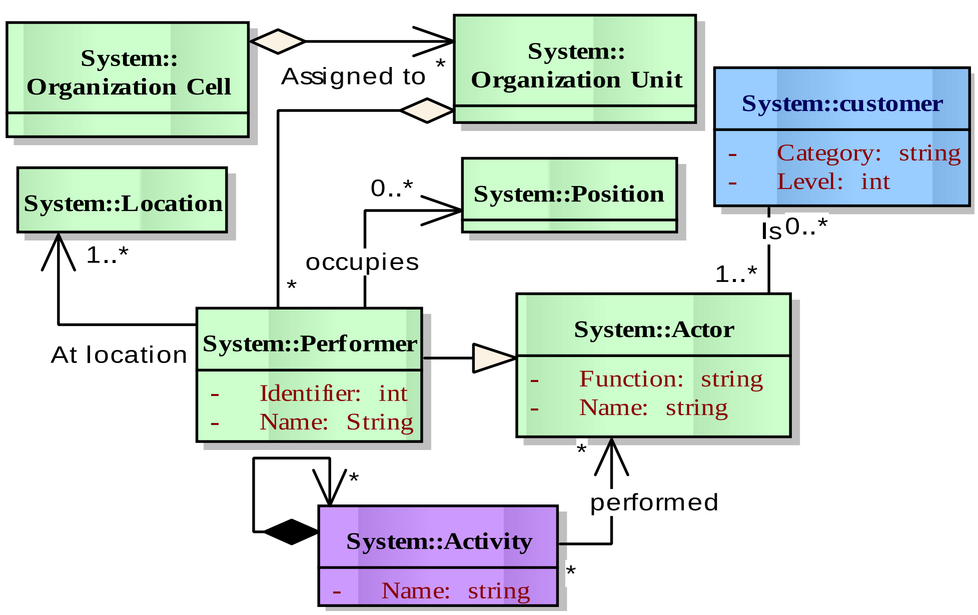

Fig. (1A). Organization view package.

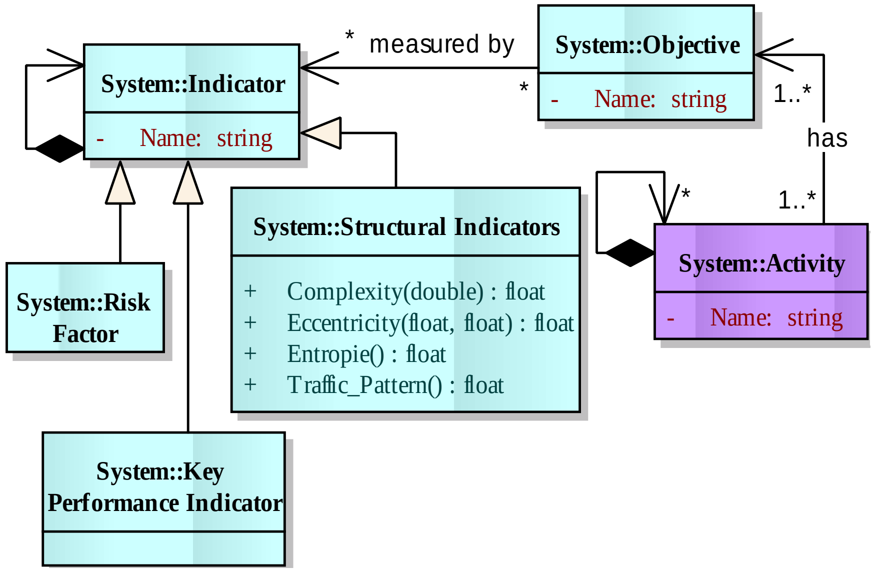

Fig. (1B). Objective view package.

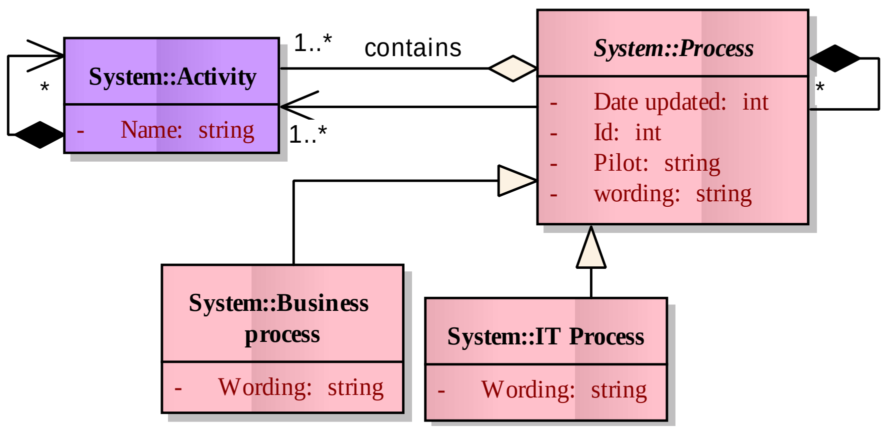

Fig. (1C). Process view package.

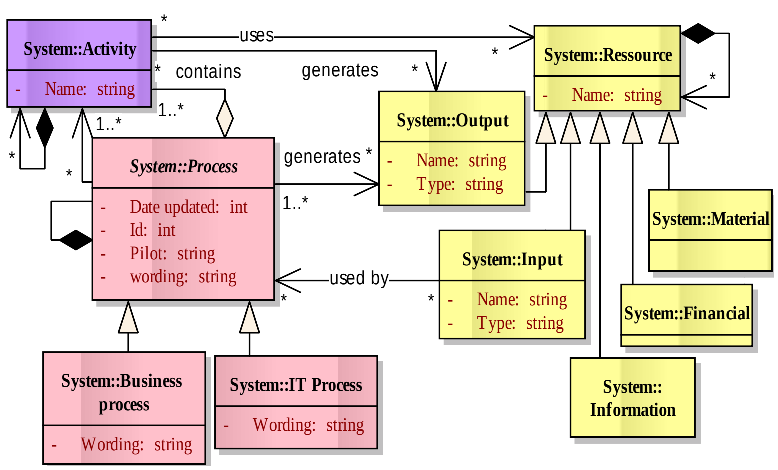

Fig. (1D). Resource view package.

- **SETL**, Structural Extract Transform and Load, allow us to extract cleaned and useful information for a given analysis. It also provides the possibility to visualize the result of SETL processing using *Neoclipse* [21]. We can query with *Cypher* language specialize for Neo4J graph database, visualize and export the result in XML JSON or CSV file.

- **Structural Analysis Framework** is the aim layer in our proposed system architecture. It takes as input the extract useful information from the repository so as to do structural analysis. It consists of diagnosis organizational structure and interaction with business processes by measure of complexity, eccentricity and other organizational indicators in order to make a diagnosis of the current state of the enterprise organization and see if it is stable or requires improvement to make it more stable and aligned with the enterprise goal. In this stage we use Java programming language to implement the framework.

  This programming language allows to provide animated graphical user interface, platform-independent and Easy to deploy on the web. Java can be perceived as significantly slower and more memory-consuming than natively compiled languages. However using Neo4J graph database and its Java API for data access, ask directly to the Neo4j's graph engine directly in JVM based application. There is full feature parity with Neo4j Server, including HA clustering.

- **Viewer/Selector** to display and show the results of the structural analysis framework, for the visualization.

- **Organizational structure** database where we save data and future results of **new stable organizational structures**. Both are persisted in graph databases of eventual re-engineering.

STRUCTURAL ANALYSIS

Structural analysis provides an interactive, analytical environment for a user to scan an information system from multiple dimensions for analyzing the qualitative or structural aspects. The concept of structural analysis of enterprise is a simple notion of showing the user different views of an enterprise: who does what, where and how. It provides an interactive, analytical environment for a user to view the different entities in an enterprise in many ways [22]. We focus on Q-analysis method to improve the organizational structure of an enterprise. Let P be a set of processes and R is a set of resources. D is a database of business processes (**BP**), where each BP has a unique identifier (**rid**) and contains a set of processes. The set of all rids is denoted as R. The input database is a binary relation $\lambda \subseteq PxR$. The example given in Table **2** represents an illustration of the database and its adjacency matrix of a BP.

Table 2. Structural Presentation of Business Process

Resource	Process	Adjacency Matrix
r_1	P_3	$\begin{array}{c\|ccccc} & P_1 & P_2 & P_3 & P_4 & P_5 \\ r_1 & 0 & 0 & 1 & 0 & 0 \\ r_2 & 1 & 0 & 0 & 1 & 0 \\ r_3 & 1 & 1 & 1 & 0 & 1 \\ r_4 & 1 & 0 & 1 & 1 & 1 \end{array}$
r_2	P_1P_4	
r_3	$P_1P_2P_3P_5$	
r_4	$P_1P_3P_4P_5$	

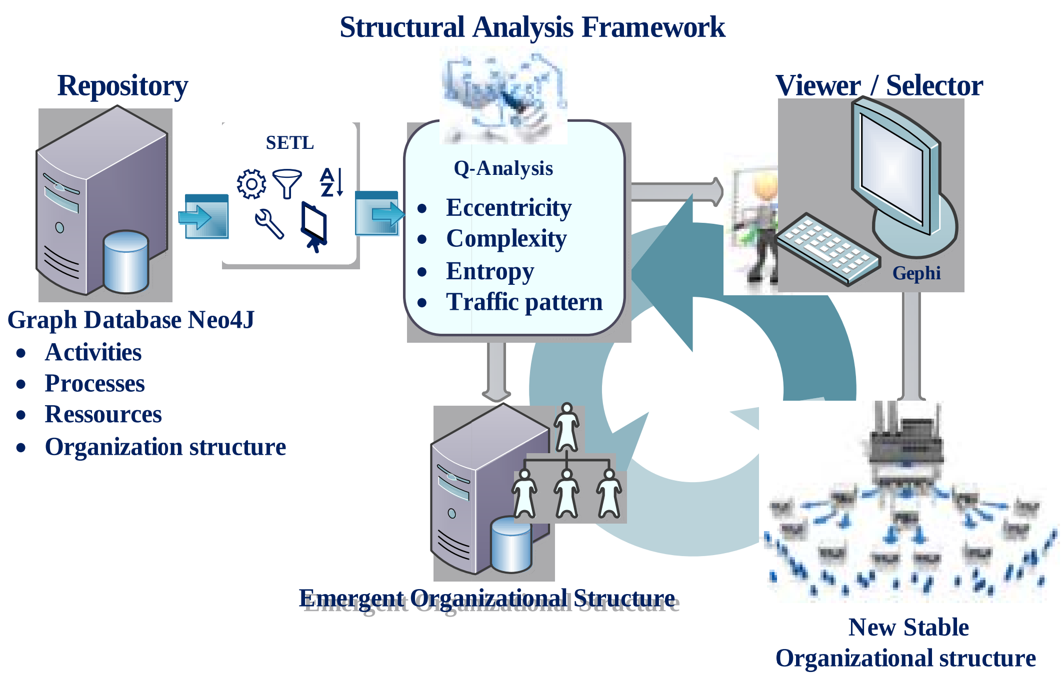

Fig. (2). Global solution architecture.

Simplicial Complexes K: is a set of vertices, $X=\{x_1 \ldots x_n\}$ and a set of subsets of X. The subset σpi with p+1vertices is called a p-simplex. σ_{pi} is said to have dimension p (one less than the number of vertices). The superscript i is an index (more than one simplex has dimension p). A simplex σ_q is said to be a q-dimensional face of σ_p, if and only if every vertex of σ_q is also a vertex of σ_p. K satisfies the condition that all the faces of its simplicies are also in K. The dimension of K is the largest value of p for which there exists σ_{pi}. The simplicies can be represented by a spatial structure usually shown as a polyhedral one. Gluing such polyhedra of mixed dimension forms the complex [23,24]. A complex KY(X;λ) can be represented in Euclidean space E^H in the following way, for a suitable choice of H. Each p-simplex, typically $\sigma_p = <x_1,\ldots, x_{p+1}>$, is made to correspond to a convex polyhedron in E^H with (p+1) vertices which themselves correspond to $x_1,\ldots, x_{p+1}$. Thus, in an intuitive sense, in E^H the simplex σ_p is represented by the solid polyhedron with (p+1) vertices. The complex K is then represented by collection of polyhedra suitably connected to each other by sharing faces (or sub-polyhedra) (see Fig. **3**).

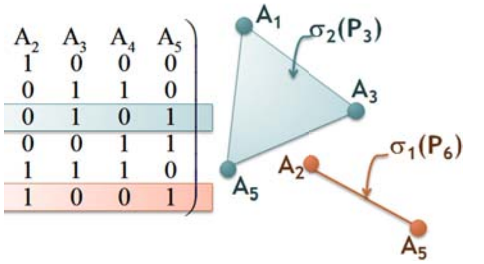

Fig. (3). Adjacency Matrix of the Activity/Performer relationship λ, Simplicies of different dimensionality.

Chain of q-connection in K: Given two simplicies σ_p, σ_r in K we shall say they are joined by a chain of connection if there exists a finite sequence of simplicies $\sigma_{\alpha 1}, \sigma_{\alpha 2},\ldots, \sigma_{\alpha h}$ such that: (i): $\sigma_{\alpha 1} \leq \sigma_p$; (ii): $\sigma_{\alpha h} \leq \sigma_r$; (iii): $\sigma_{\alpha i}$, $\sigma_{\alpha i+1}$ share a common face (say) $\sigma_{\beta i}$ (i=1,…, h-1). This sequence is a chain of q-connection (q-connectivity) if q is the least of the integers $\sigma_{\alpha 1}, \sigma_{\alpha 2},\ldots, \sigma_{\alpha h}$. The length of the chain will be taken as (h-1) and, when needed the chain may be denoted by $[\sigma_p,, \sigma_r]_q$.

Q-analysis: is based on the q-nearness and q-connectivity relations between the simplicies of a given complex (or simplicial complex) [25,26]. A Q-analysis of a complex K determines the number of distinct equivalence classes, or q-connected components, for each level of dimension q ranging from 0 to q-1. The equivalence classes are decided by a rule as follows. If two simplicies are q-connected (either q-near or q-connected), then they are in a same class. To see this we introduce, for a fixed q, a relation γ_q on the simplicies of K, defined by: $(\sigma_p, \sigma_r) \in \gamma_q$ if and only if σ_p is q-connected to σ_r. This γ_q is reflexive, symmetric and transitive and therefore an equivalence relation. The equivalence classes, under γ_q are the members of the quotient set K/γ_q, and constitutes a partition of all simplicies of K which are of order ≥ q. We denote the cardinality of K/γ_q by Q_q. This equals the number of distinct q-connected components in K. When we analyze K by finding all the values of Q_0, Q_1, $Q_2,\ldots Q_N$ where $N = \dim K$, we say that we have performed a Q-analysis on K. To find the shared face q-value between all pairs of the Y's in KY(X;λ), the following steps could be performed: (i) form ΛxΛT, (ii) evaluate $\Lambda \times \Lambda^T - \Omega = (\omega_{ij})$ and $\omega_{ij} = 1$. For example, the Q-analysis of the complex in example 1 leads to the following equivalence classes at the different dimensional levels of q=0, q=1, q=2 and q=3. Each equivalence class is enclosed in the curly brackets. The sign "-" in the matrix stands for -1, and shows that r_1 and r_4 are disconnected (see Table **3**).

Table 3. Q-Analysis of KY(X,λ) Given in Example 1

At **q = 3** we have $Q_3 = 2$; $\{r_3\}$, $\{r_4\}$ At **q = 2** we have $Q_2 = 1$; $\{r_3, r_4\}$ At **q = 1** we have $Q_1 = 2$; $\{r_2, r_4\}$, $\{r_3, r_4\}$ At **q = 0** we have $Q_0 = 1$; all $\{r_1, r_2, r_3, r_4\}$	$\Lambda \times \Lambda^T - \Omega = \begin{pmatrix} & r_1 & r_2 & r_3 & r_4 \\ r_1 & 0 & - & 0 & - \\ r_2 & & 1 & 0 & 1 \\ r_3 & & & 3 & 2 \\ r_4 & & & & 3 \end{pmatrix}$

Q-analysis has proved particularly useful for solving problems involving complex systems. The method requires a rigorous definition of the entity sets and their relationships and promotes the study of consequences of connectivity within the system. Q-analysis involves relatively simple computations, once the structural matrix (adjacency matrix) is assessed; no additional information about the system is needed. The operational basis of Q-analysis is given by a shared faces matrix.

CASE STUDY

This example is conducted from an entity-oriented bank that centralizes the processing of all its operations. In fact, our analysis takes as its target the structural organization of the branch banking business linked to a regional management companies. The latter is attached to the commercial pole. In this section, we list all organizational units. The processes undertaken by this structure, as well as the activities that arise and resources used to achieve the desired objectives. In our example, we apply a structural analysis of relationships existing among the major organizational units in order to assess the degree of strategic alignment within this structure. Fig. (**4a**) describes an organization chart typifies points of sale as undertaken agency. It shows relationships between employees and their. The business process is performed by employees who are part of organizational structure. Fig. (**4b**, **c**) illustrate relationships between Business process and organizational units. The given example has three organizational units: Agency management, customer relationship management (CRM) and Head of the service operation teller. Each activity is performed by one or a group of performers. Later we use this workflow to extract adjacency matrix for Q-analysis.

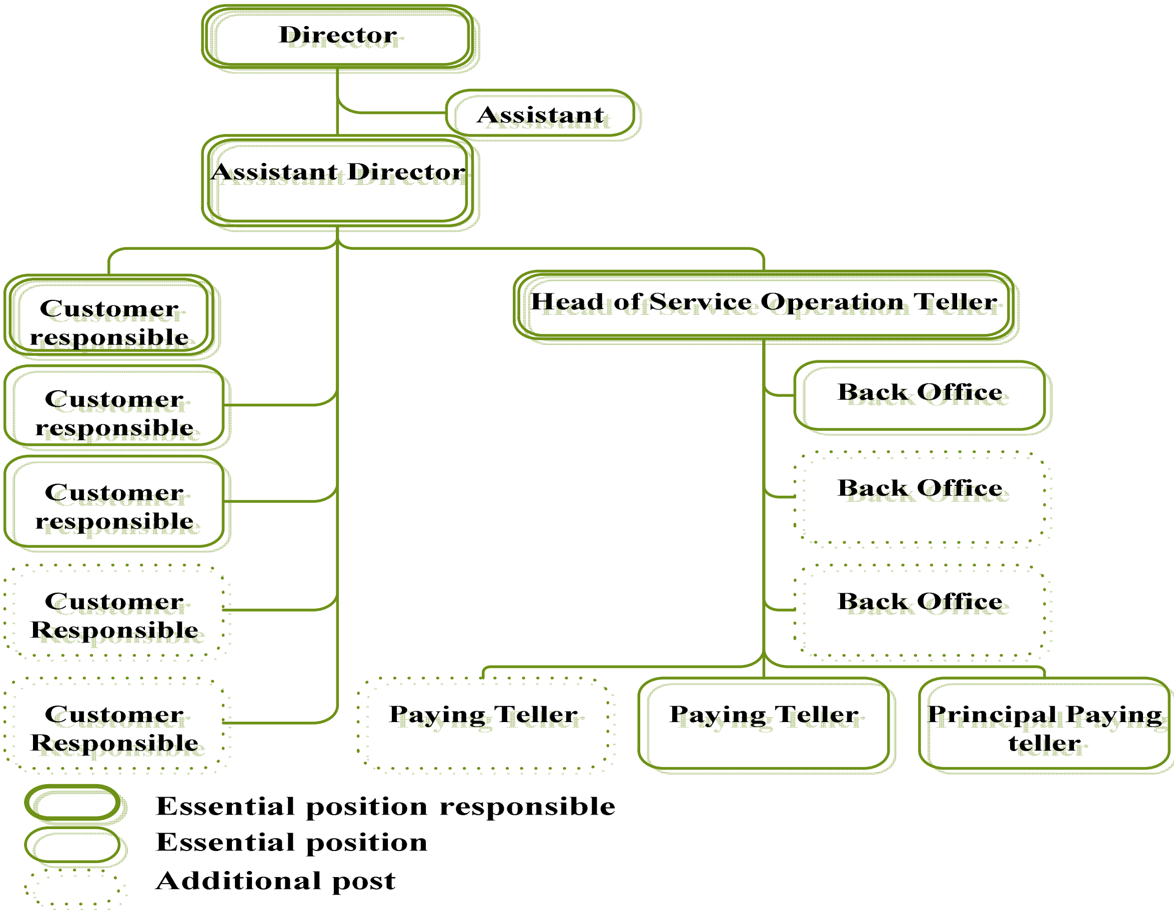

Fig. (4a). Organization chart typifies points of sale (type: undertaken Agency).

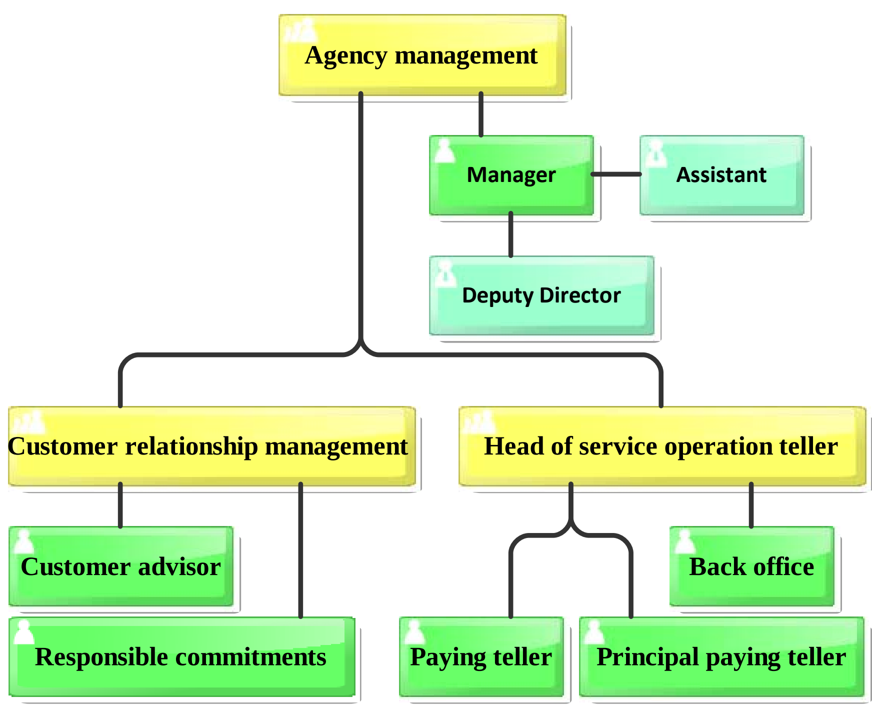

Fig. (4b). Organization chart typifies points of sale (type: undertaken Agency).

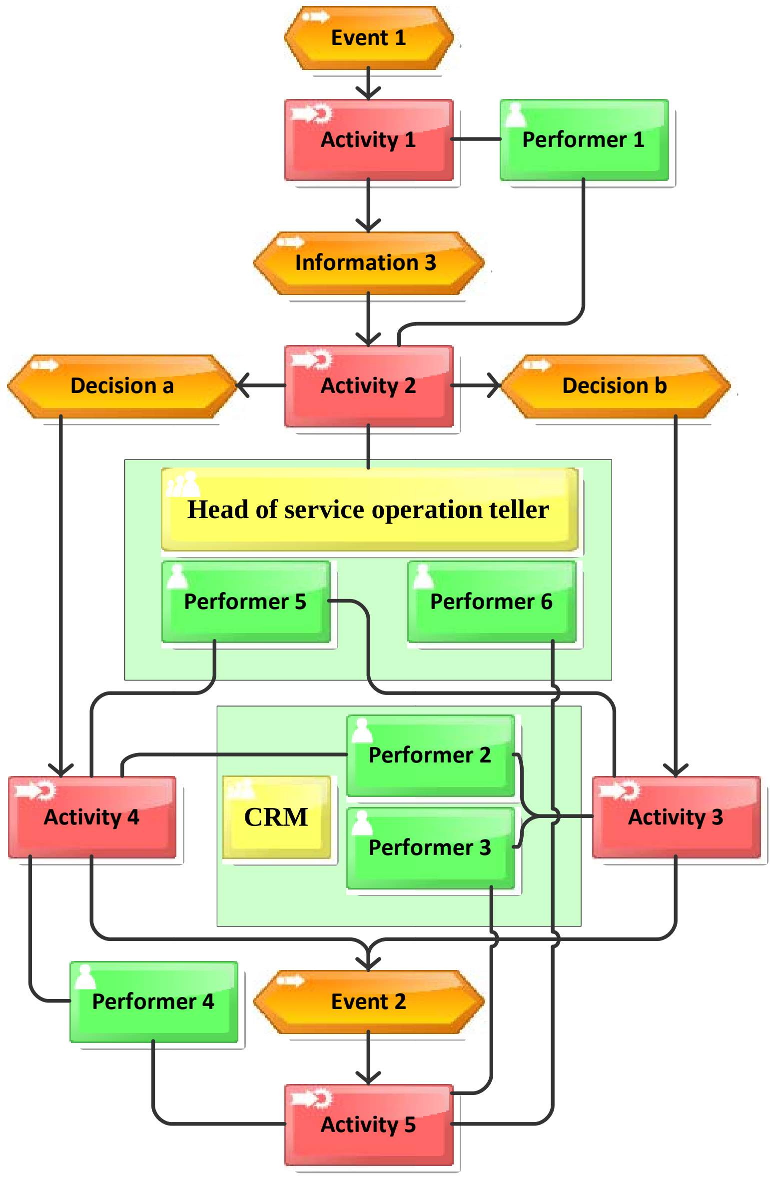

Fig. (4c). Relationship between business process and organization units.

The proposed meta-model has been instantiated with this example using the new concept of persistent database, Big data where **Big Data**: is the frontier of a firm's ability to store, process, and access all the data it needs to operate effectively, make decisions, reduce risks, and serve customers [27,28]. Then we store repository of this case study in No SQL System.

Why use No-SQL system? No-SQL is an alternative to using traditional Database Management System (DBMS). It provides flexible schema than the rigid relational model which can be useful when it is not easy to get a data into a structure table format. It tends to be quicker/ cheaper to set up. They are designed for massive scalability, both on amount data also with the efficiency of the operation on that data. They don't necessarily have transaction guarantees; in general what they do is relaxed consistency offered by the system and turns in higher performance and higher availability of the system. Several incarnations of No-SQL systems are divided into four category *column families like OLAP*, *key-value stores like OLTP*, *Document store* and *Graph database systems* [29].

Graph database system for enterprise organization matters? Graphs are everywhere. Organizations of all sizes, from large enterprise to new startups, are embracing graph databases as the fastest way to query and store graph data. Fig. (**4**) is represented by a graph structure with nodes, edges and properties. As our case study takes a professional network so it is evident to choose a graph database system. With a graph database, the focus is on the connections between data. Telling the database in advance that things are connected and how, and representing those relationships physically, as opposed to storing them in tables and relating them through indexes. Several graph databases used to store big data (*Neo4J*, *InfiniteGraph*, *OrientDB* … etc). To represent and store information with large scale, we choose Neo4J graph database.

Neo4J graph database: It is an open source solution to manage our information's study case. As a robust, scalable and high-performance database, Neo4j is suitable for full enterprise deployment or a subset of the full server can be used in lightweight projects. It features true ACID (Atomicity, Consistency, Isolation and Durability) transactions; high availability; scales to billions of nodes and relationships and high speed querying through traversals. It runs as a server, as embedded Java, scales to 34bn nodes, licensed like *MySQL*. Besides providing ACID transactions and integrates *Lucene* index and it traversals 1 M/s. There is a special query language for a No4J NoSQL graph database called *Cypher*. Their goals are: declarative, pattern matching, ASCII art pattern, closures, SQL familiarly and external DSL.

Fig. (**5**) shows the stored repository in Neo4J graph database using graphic interface neoclipse. The graph representation allows us to instantiate the meta-model using nodes and relationships with an index and an id of each element of the graph. For example Organizational unit is a node with specific Id and properties with values from the case study (Org-Unit-label, type). It has a relationship with the performer node as *ASSIGNED_TO* relationship_type. Relationship_type represents associations between classes of the instantiated meta-model. The different relationship types are: *ASSIGNED_TO*, *PERFORMED_BY*, *OCCUPIES*, *AT_LOCATION*, *UPPER_HIERARCHICAL*, *HAS*, *GENERATE*.

STRUCTURAL ANALYSIS APPLICATION

Using Cypher graph database query language (Table **4**), we extract records to get an adjacency matrix of relationship λ between performers $\boldsymbol{P}$ and activities $\boldsymbol{A}$. The query has as inputs all performers' nodes, organizational unit's nodes, activity's node and objectives of activity too. The output of this query is for each organization units has its performers and attached activities. The query has Match clause to indicate relationships between nodes. Query result can be extracted as XML, CSV or JSON file. We use q-analysis method, defined in section V, with an input shared face matrix for $KP(A;\lambda)$ (Table **5**, second column) from the extracted XML file, we get a q-connectivities (also called q-chains).

Q-connectivities are revealed formally by a Q-analysis of the complex and this is given in Table **6**. It also generates the structured vector Q (last line in Table **6** first column) of the simplicial complex.

To examine the q-nearness of all pairs of simplicies, we construct a shared-face matrix (Table **6**). This is clearly a

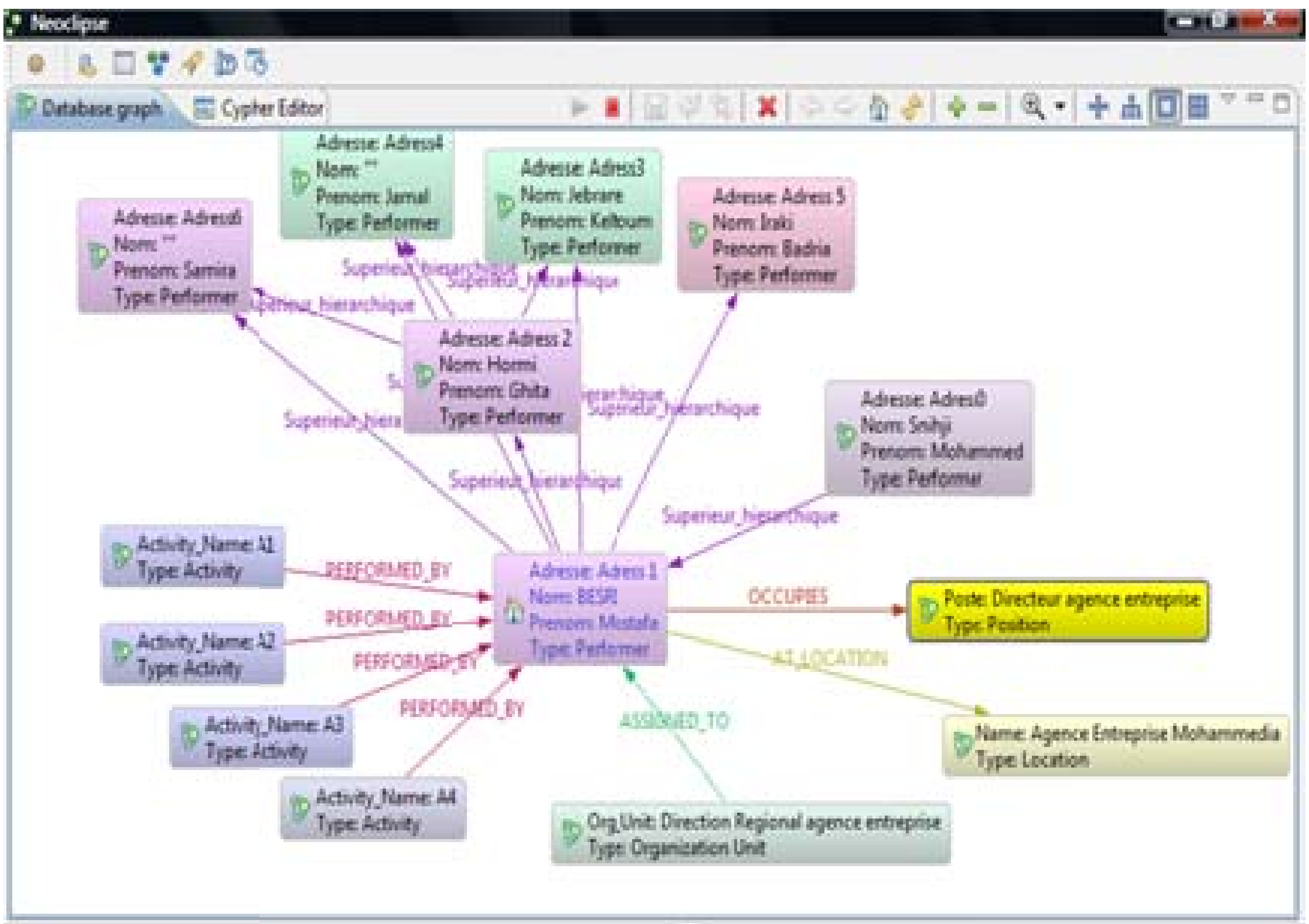

Fig. (5). Case study graph database using Neo4J with neoclipse.

symmetric matrix. The entries of simplicies indicate the direct connections between pairs of simplicies. A zero means that a pair of simplicies shares a single vertex. For no faced shared is represented by -1. The diagonal entries are the dimensionalities of the simplicies. The q-connectivities are revealed formally by Q-analysis of the complex and this is given in first column Table **6**. Each component is enclosed by curly brackets.

Table. 4. Cypher Query to Extract Relationships Between Performers of Each Organizational Unit and Activities

```
START p1=node(*), p3=node(*), p2=node(*), p4=node(*)
MATCH p3-[*]->p1 <-[*]-p2<-[*]-p4
WHERE p1.Type="Performer" AND p3.Type="Organization Unit" AND p2.Type="Activity" AND p4.Type="Objective"
RETURN p1.Prenom as Performer, p3.Org_Unit as Organization_Unit, p2.Activity_Name as Activity, p4.Objective_label as Objective, count(p3) as Occurrences
```

Table 5. Q-Analysis of KP(A;λ) First Column. Shared Face Matrix for KP(A;λ) Second Column

Performers	Activities	Adjacency Matrix
P_1	A_1A_2	
P_2	A_3A_4	
P_3	$A_1A_3A_5$	
P_4	A_4A_5	
P_5	$A_2A_3A_4$	
P_6	A_2A_5	

$$\begin{pmatrix} & A_1 & A_2 & A_3 & A_4 & A_5 \\ P_1 & 1 & 1 & 0 & 0 & 0 \\ P_2 & 0 & 0 & 1 & 1 & 0 \\ P_3 & 1 & 0 & 1 & 0 & 1 \\ P_4 & 0 & 0 & 0 & 1 & 1 \\ P_5 & 0 & 1 & 1 & 1 & 0 \\ P_6 & 0 & 1 & 0 & 0 & 1 \end{pmatrix}$$

Table 6. Q-Analysis of Business Process Extracted

At **q = 2** we have $Q_2 = 2$; $\{P_3\}$ $\{P_5\}$

At **q = 1** we have $Q_1 = 5$; $\{P_1\}$ $\{P_2, P_5\}$ $\{P_4\}$ $\{P_6\}$ $\{P_3\}$

At **q = 0** we have $Q_0 = 1$; all; $\{P_1, P_2, P_3, P_4, P_5, P_6\}$

$$Q = \{\overset{2}{2}\ \overset{1}{5}\ \overset{0}{1}\}$$

$$M = \Lambda \times \Lambda^T - \Omega$$

$$M = \begin{pmatrix} & P_1 & P_2 & P_3 & P_4 & P_5 & P_6 \\ P_1 & 1 & - & 0 & - & 0 & 0 \\ P_2 & & 1 & 0 & 0 & 1 & - \\ P_3 & & & 2 & 0 & 0 & 0 \\ P_4 & & & & 1 & 0 & 0 \\ P_5 & & & & & 2 & 0 \\ P_6 & & & & & & 1 \end{pmatrix}$$

Our interest lies more in the structure of the entire complex rather than that of individual components we may speak of global structure and describe this by counting the number of components at each q-level. We can present this information as a structure vector, Q which is in our example: $Q = \{\overset{2}{2}\ \overset{1}{5}\ \overset{0}{1}\}$. We found 3 equivalence classes Q_2, Q_1 and Q_0 for each class with a number of simplex embedded (Table **6**).

PERFORMANCE DIAGNOSIS

Whereas the structure vectors and the obstruction vector describe global structural properties, eccentricity indicates the degree of integration of a specific simplex into the whole complex. The eccentricity index is defined by the relation between a dimension where an object is disconnected and another dimension where the object is integrated.

Eccentricity describes the status of an individual simplex within the entire complex. It indicates the degree of integration of a specific simplex into the whole complex K. Atkins suggest a measure of eccentricity [23]; denoted as ecc (equation 1):

$$Ecc(\sigma) = \frac{\hat{q} - \breve{q}}{\breve{q} + 1} \quad (1)$$

where top-q $\hat{q}$ the dimensional level at which a simplex first appears in the simplicial complex. Bottom-q $\breve{q}$ is the level at which simplex first becomes connected in a component with another simplex. A simplex is eccentric when it is badly embedded within the complex. [24, 30-33] suggest another measure of eccentricity called ecc' (equation 2)

$$\text{ecc}'(\sigma) = \frac{2\sum_i q_i / \sigma_i}{q_{max}(q_{max} + 1)} \quad (2)$$

where q_i each q-level where σ appears, σi is the number of elements in σ_i's equivalence class at level q_i and q_{max} the maximum level of the complex. In the proposed business process example and using eccentricity measures we found the following results. The difference between ecc and ecc' is that ecc depends on the other simplicies and takes values in the interval of [0, ∞]. In this case study, we obtain the following values given in Table **7** and graphic result (Fig. **6**).

Table 7. Eccentricity of Each Performer

Simplex	Ecc	Ecc'
$\sigma_1(P_1)$	1	1
$\sigma_1(P_2)$	0	0.5
$\sigma_2(P_3)$	2	1.33
$\sigma_1(P_4)$	1	1
$\sigma_2(P_5)$	0.5	0.83
$\sigma_1(P_6)$	1	1

We can observe that the simplex $\sigma_1(P_2)$ has an eccentricity $ecc(\sigma_1(P_2)) = 0$ i.e. the performer P_2 is very connected to its activity and Organizational unit. Also for P_5 it has an eccentricity with a value of 0,5 which mean the performer P_5 is relatively connected to its activities and organizational units. However, the performer P_3 is the most eccentric one because it has the high value of the measure $ecc(\sigma_2(P_3)) = 2$. We can conclude that the performer P_3 is dispatched between all activities and organizational unit. The second measure ecc' shows the eccentricity between simplexes. We can confirm that the performer P_3 is the eccentric one among the other performers. The results of Q-analysis can also be used to describe the complexity of the system structure. Numerous definitions of system

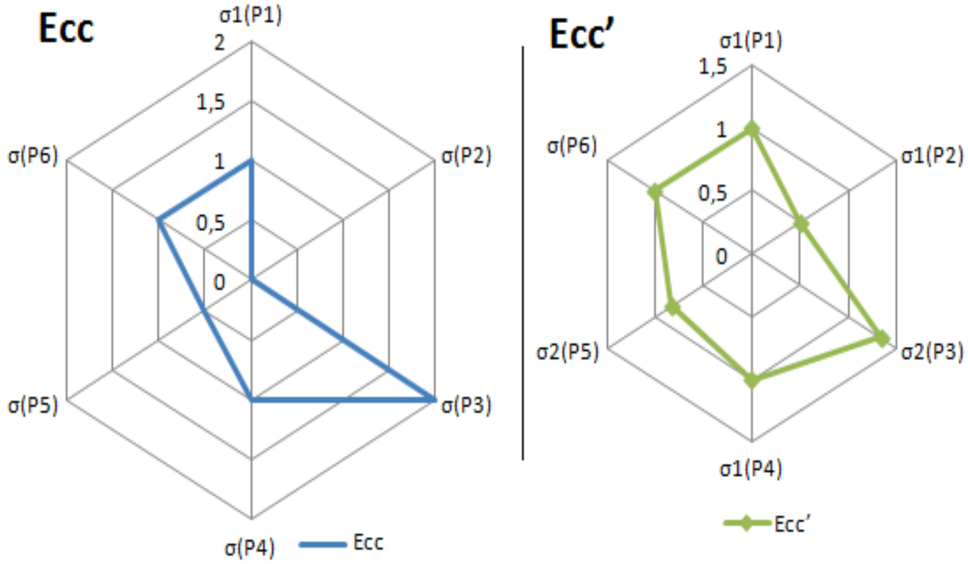

Fig. (6). Eccentricity of each performer.

complexity can be found in the literature; the appropriate definition depends on the type of problem considered.

Complexity: The complexity of the system structure of this example can be described by the complexity measure Ψ(K) suggested by [26] in the equation 3:

$$\Psi(K) = 2\left[\sum_{k=0}^{\dim K} (k+1)Q_k \Big/ (\dim K + 1)(\dim K + 2)\right] \quad (3)$$

where Q_k is the k^{th} component of the complex K. In the proposed example the complexity of a system's structure is: $\Psi(K) = 2.26$

Traffic: Traffic defines what kind of behavior existing on the backcloth (simplicial complex) defined by a relation of performers and activities in every organizational unit and looking for regularity across such diverse patterns of change. The backcloth supports traffic. Each simplex in the backcloth is determined by the vertices, i.e., the level of protest made in each organization unit depends upon the activities, which is not appropriate to the performer and disturb that organizational unit. Relatively high-dimensional organizational units are capable of supporting more traffic by generating more protests than low-dimensional. Traffic is presented with a pattern denoted by π, is a mapping of the simplicies in the complex into the set of integer numbers (j) [33]. We attach to each simplex a number which denotes the amount of traffic carried by that simplex. The pattern is usually written as a pattern polynomial, which describes the number of complaints associated with activities that define the simplicies (organizational units). In this example we have:

$\pi = 2\langle A_1\rangle + 5\langle A_1, A_2\rangle + 8\langle A_1, A_3\rangle + 11\langle A_1, A_2, A_3, A_4\rangle + 8\langle A_2, A_4, A_5\rangle + 9\langle A_5, A_6, A_3\rangle$

where $2\langle A_1\rangle$ means that tow complaints are associated with the simplex $\sigma_1(P_1)$ and so on. Besides because simplicies have different dimensions the traffic too is dimensionally graded. To denote the fact that traffic exists at different dimensional levels we write:

$\pi^0 = 2\langle A_1\rangle$

$\pi^1 = 5\langle A_1, A_2\rangle + 8\langle A_1, A_3\rangle$

$\pi^2 = 8\langle A_2, A_4, A_5\rangle + 9\langle A_5, A_6, A_3\rangle$

$\pi^3 = 11\langle A_1, A_2, A_3, A_4\rangle$

Q-analysis is able to give some conclusions about such complaints data because it emphasizes the connectedness of the organizational structure under investigation. It is the connectivities which may allow traffic to be q-transmitted through the structure [34]. This case shows that several simplicies are poorly embedded within the complex we might say they are eccentric. Instead of treating the performers as simplicies and activities as vertices, we might look at the question of organizational structure from the viewpoint of the facilities and treat them as simplicies defined by the organizational units their impact. This means that we make a reverse engineering of the organization to get less eccentric components with less complexity.

After re-engineer of organizational structure, we have a new Adjacency matrix and new values of Q-analysis as follows (see Tables **8-10**).

Table 8. New Adjacency Matrix

<table>
<tr><th>Performers</th><th>Activities</th><th>Adjacency Matrix</th></tr>
<tr><td>P_1</td><td>A_1A_2</td><td rowspan="6">$$\begin{array}{c|ccccc} & A_1 & A_2 & A_3 & A_4 & A_5 \\ \hline P_1 & 1 & 1 & 0 & 0 & 0 \\ P_2 & 0 & 0 & 1 & 1 & 0 \\ P_3 & 0 & 1 & 0 & 0 & 1 \\ P_4 & 0 & 0 & 0 & 1 & 1 \\ P_5 & 0 & 1 & 1 & 1 & 0 \\ P_6 & 1 & 0 & 1 & 0 & 1 \end{array}$$</td></tr>
<tr><td>P_2</td><td>A_3A_4</td></tr>
<tr><td>P_3</td><td>A_2A_5</td></tr>
<tr><td>P_4</td><td>A_4A_5</td></tr>
<tr><td>P_5</td><td>$A_2A_3A_4$</td></tr>
<tr><td>P_6</td><td>$A_1A_3A_5$</td></tr>
</table>

Table 9. New Values of Q-Analysis

At **q = 4** we have $Q_4 = 1$;{P_6} At **q = 3** we have $Q_3 = 1$; {P_6} At q = 2 we have $Q_2 = 5$; {P_6}{P_1} {P_3} {P_3, P_6}{P_2, P_5, P_6} At q = 1 we have $Q_1 = 3$; {P_1, P_4, P_6}{P_2, P_5, P_6}{P_4} At **q = 0** we have $Q_0 = 1$; all; {P_1, P_2, P_3, P_4, P_5, P_6} $Q = \overset{4\,3\,2\,1\,0}{\{1\,1\,5\,3\,1\}}$	$M = \Lambda \times \Lambda^T - \Omega$ $M = \begin{pmatrix} & P_1 & P_2 & P_3 & P_4 & P_5 & P_6 \\ P_1 & 2 & - & 0 & - & 0 & 1 \\ P_2 & & 1 & 0 & 0 & 1 & 1 \\ P_3 & & & 2 & 0 & 0 & 2 \\ P_4 & & & & 1 & 0 & 1 \\ P_5 & & & & & 2 & 2 \\ P_6 & & & & & & 4 \end{pmatrix}$

Table 10. New Values of Measures

Simplex	Ecc	Ecc'
$\sigma_1(P_1)$	0.5	0.24
$\sigma_1(P_2)$	0	0.24
$\sigma_1(P_3)$	0	0.13
$\sigma_1(P_4)$	0	0.33
$\sigma_2(P_5)$	0	0.24
$\sigma_2(P_6)$	0.6	0.77

The new value of complexity is $\Psi(K) = 2.06$. The difference with the old complexity is about 0.2. The emergent organizational structure is more stable than the old one and has a lower complexity.

In this paper, we have addressed the using of Q-analysis to assess enterprise organization complexity. By using an organizational mining approach based on business process organization, we can discover the organizational structure adequate to the actual activities of the company. In order to study how the simplicies conform to the complex (enterprise organization) and to determine whether there are any simplicies that are totally disconnected, the following indicators have been proposed: q-connectivity, structure and obstruction vectors, eccentricity, and complexity.

Q-Connectivity describes the global relationship between equivalence classes. The structure and obstruction vector indicate the potential for simplifying the representation of the relationships. Q-analysis provides a canonical view of the structural relationship between performers and organization units, adding more indicator measures (see Figs. **8**, **9**).

CONCLUSION

It is of great importance for IT organizations to bring about technological improvements to the enterprise systems. The process organization obtained by the analysis of business processes observed in practice will be used to generate a new organization [12]. This emerging organization must be confronted with the formal organization to measure conformance. Our Framework tends to achieve a re-engineering of enterprise organization by the use of a canonical method of Q-Analysis.

The Q-analysis method provides an algebraic topological framework for structural modeling of the systems. For this purpose, indicators such as connectivity level, eccentricity and complexity can be defined and interpreted. Q-analysis can be coupled with the analysis of dynamic patterns supported by the structural framework; this type of analysis is based on a polyhedral dynamics disciplinary area. The advantages of the Q-analysis process are as follows. The first advantage is that it is a holistic approach. It is simple to use, requiring only structural relation. It is flexible; there is no problem in changing slicing levels or criteria definitions. It provides canonical results; for instance, q-levels, eccentricity, complexity, equivalence classes, obstruction vector, etc. The method is undertaken to reveal latent structures in enterprise repository. It helps in strategic decision making by diagnose business processes relationships with organization structure. The Q-analysis provides a canonical multidimensional view of the structural relationship between two sets, here the set of performers and the set of activities. This is not a limitation; the auditor may

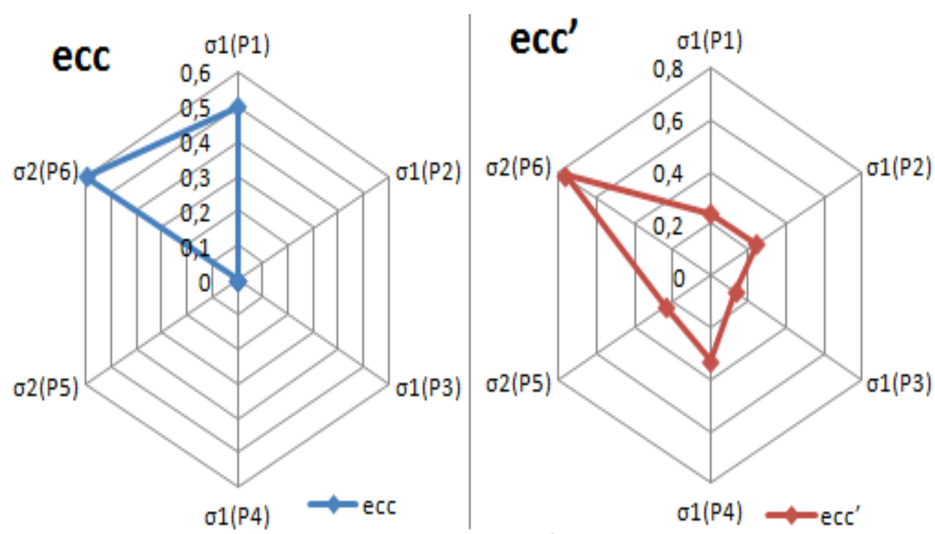

Fig. (7). New value of eccentricities (ecc and ecc').

identify the point of view of the system to study and to define the appropriate coupling matrix.

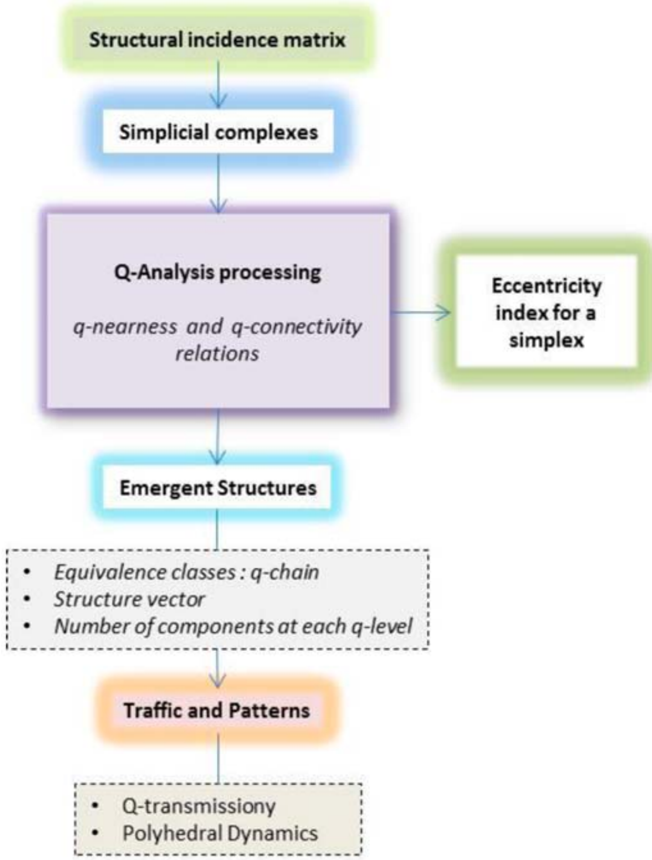

Fig. (8). Q-analysis process.

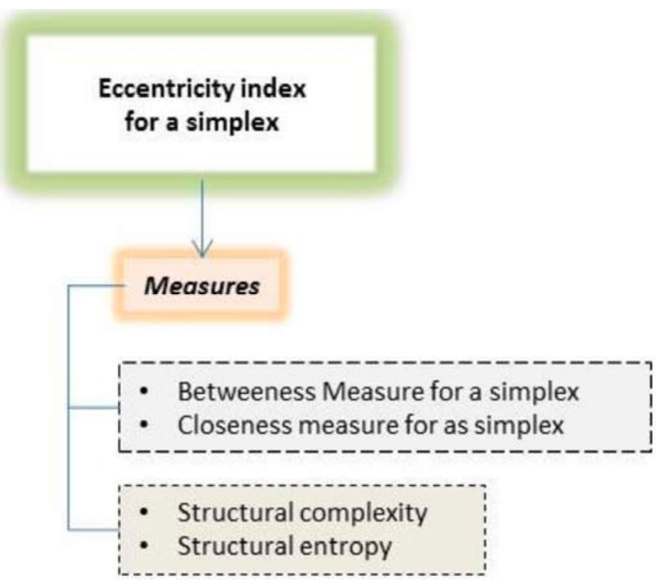

Fig. (9). Q-analysis measures.

The paper shows the use of NoSQL system to instantiate the meta-model for structural analysis of the example provided. The advantages provided by NoSQL system, especially graph database for enterprise organization structure and relationships between its components performers, business process, organizational unit or activities. Then we use a measure indicator of traffic in the system to illustrate communication and the behavior of these components in the enterprise organizational structure. Future works will complete implementation of the software solution for mining enterprise organization and will also allow re-engineer processes to ensure conformance between organization structure and process organization. Our contribution will open up new lines of systemic research for social systems understanding and exploit social network analysis for enterprise organization's matters.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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