Knowledge Sharing in Organizational Structures

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Abstract. The organizational structure is usually defined using the best experience and there is a minimum of formal approach involved. This paper shows the possibilities of the theory of concept analysis that can help to understand organizational structure based on solid mathematical foundations. This theory is extended by the concept of knowledge sharing and diversity that enables to evaluate the organizational structure. In this paper we also compare formal concept analyze with alternative approach of hierarchical clustering.

1. Introduction

Business processes represent the core of the company behavior. There are many possibilities how these processes can be defined. Although usually all modeling tools are focused on various kinds of business process aspects based on what abstraction is considered as the main, there are some standards in business modeling. Most of them are focused on: structural view, behavioral view a functional view.

Unfortunately, none of these views captures organization structure of roles implemented by human resources participating in processes being modeled. The next chapters will show how the theory of concepts might remove the gap between process models and organizational structure.

2. Concept Analysis

Concept analysis theory can be used for grouping of *objects* that have common *attributes* [2]. Concept analysis begins with a binary relation, or boolean table, T between a set of objects $\mathbf{O}$ and set of attributes $\mathbf{A}$. It means that $T \subseteq \mathbf{O} \times \mathbf{A}$. For any set of objects $O \subseteq \mathbf{O}$, their set of common attributes is defined as

$$\sigma(O) = \left\{ a \in \mathbf{A} \mid \forall o \in O : (o, a) \in T \right\}. \quad (1)$$

For any set of attributes $A \subseteq \mathbf{A}$, their set of common objects is

$$\tau(A) = \{o \in \mathbf{O} \mid \forall a \in A : (o,a) \in T\} . \quad (2)$$

A pair (O, A) is called a *concept* if

$$A = \sigma(O) \wedge O = \tau(A) . \quad (3)$$

The very important property is that all concepts of a given table form a *partial order* via

$$(O_1, A_1) \leq (O_2, A_2) \underset{def}{\Leftrightarrow} O_1 \subseteq O_2 . \quad (4)$$

It was proven that such set of concepts constitutes a complete lattice called con*cept lattice* $L(T)$. For two elements (O_1, A_1) and (O_2, A_2) in the concept lattice, their *meet* $(O_1, A_1) \wedge (O_2, A_2)$ is defined as

$$(O_1 \cap O_2, \sigma\tau(A_1 \cup A_2)) \quad (5)$$

and their *join* $(O_1, A_1) \vee (O_2, A_2)$ as

$$(\tau\sigma(O_1 \cup O_2), A_1 \cap A_2) . \quad (6)$$

A concept $c = (O, A)$ has *extent* $e(c) = O$ and *intent* $i(c) = A$. More about concept analysis can be found in [2,3,4].

Concept lattice can be depicted by the usual as a lattice diagram. It would however be too messy to label each concept by its extent and its intent. A much simpler *reduced labeling* is achieved if each object and each attribute is entered only once in the diagram. The name of object O is attached to the lower half of the corresponding object concept

$$c = (\tau(\sigma(O)), \sigma(O)) , \quad (7)$$

while the name of attribute A is located at the upper half of the attribute concept

$$c = (\tau(A), \sigma(\tau(A))) . \quad (8)$$

3. Organizational Structure Modeling

This theory can be used for purposed of organizational structure modeling and analysis by the simple mapping of objects to roles and attributes to activities. Unfortunately, this approach produces quite large concept lattices in case of analysis

of real life examples. For the purposes of better visualization of such complex examples new paradigm of knowledge sharing was introduced and implemented

4. Knowledge Sharing and Diversity

The nodes in concept lattice can be considered as a potential source of how the organizational units can be defined. The question is how to evaluate identified concept from point of view if they should or should not be the source of organizational units? In other words, is it appropriate to put together these roles with the common set of activities or not? Let us assume that we would like to have in one organizational unit activities that have something in common. This "something in common" we would call *Knowledge Sharing* and we can it formally defined as

$$K_{share}\left(a_i, a_j\right) = 1 \tag{9}$$

for activities a_i and a_j that share the knowledge,

$$K_{share}\left(a_i, a_j\right) = 0 \tag{10}$$

otherwise. It is obvious that this relation is symmetric and reflexive, i.e.

$$K_{share}\left(a_i, a_j\right) = K_{share}\left(a_j, a_i\right) \tag{10}$$

and

$$K_{share}\left(a_i, a_j\right) = 1 \quad \text{for} \quad i = j \ . \tag{11}$$

The knowledge sharing among activities can be used to evaluate each concept from point of view how wide knowledge is required by a group of roles common to this concept (potentially organizational unit) to cover all its activities. Let us introduce the new notion of *Knowledge Diversity* that reflects the width of knowledge required by the concept (O, A) and that is formally defined as

$$K_{div}\left(O, A\right) = 1 - \frac{\sum_{(a_i, a_j) \in A \times A} K_{share}\left(a_i, a_j\right)}{\left|A\right|^2} \ , \tag{12}$$

where $\left|A\right|$ is a cardinality of the set of attributes related to a given concept. The highest possible knowledge diversity has value 1 and the lowest one is equal to 0.

Obviously, the highest knowledge diversity has the concept with all activities associated.

Values of knowledge diversity can add third dimension to our graph of organizational units represented by the darkness of each node. The higher is the knowledge diversity the darker is the node representing the concept

5. “Real life” example

Whole presented example is in [5] and represents process in some kind of insurance company. This fictive insurance company C *process claims* that result from traffic accidents where customers of C are involved in. The company employs people playing the following roles: *manager, claim handler, assistant of claim handler, accountant* and *secretary*. The process is specified using activity diagram (Fig. 1).

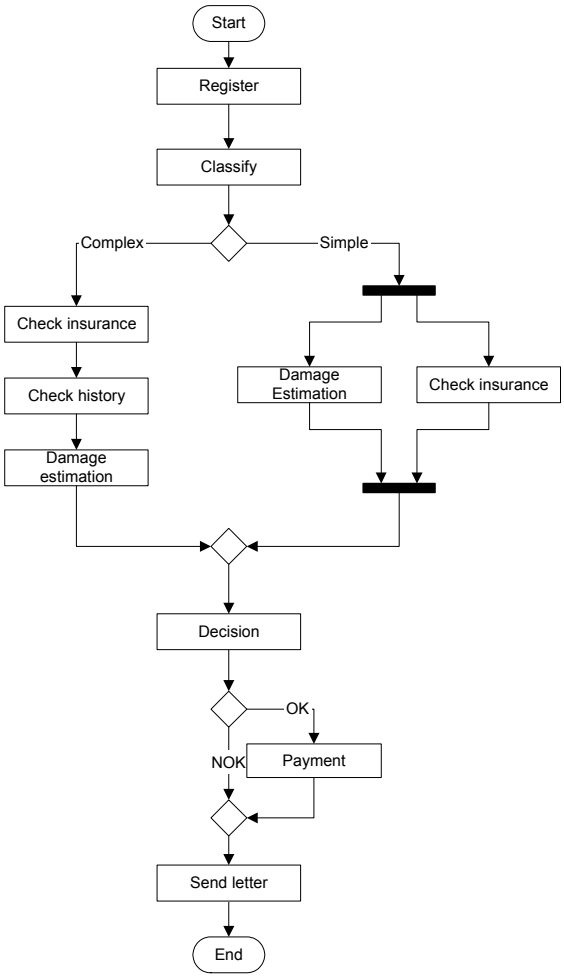

Fig. 1. Insurance company.

We don't show another steps as assigning roles to activities or knowledge sharing definition among activities. We only show for illustrating purpose result concept lattice with *knowledge sharing* (Fig. 2).

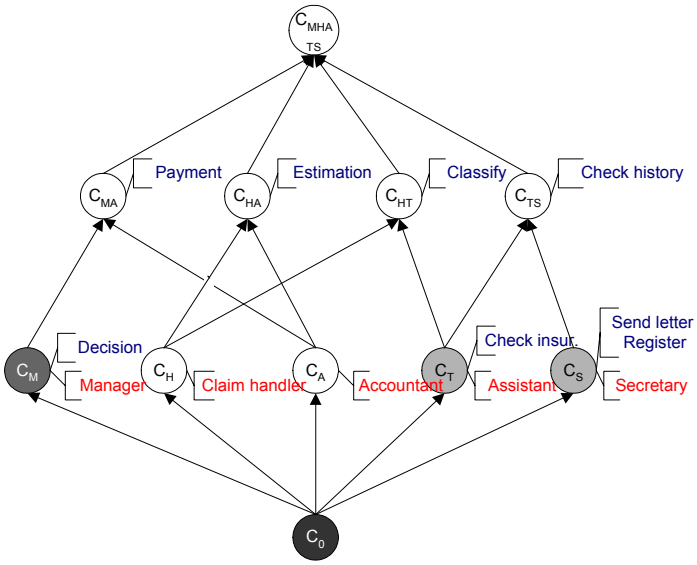

Fig. 2. Concept lattice with associated knowledge diversity.

6. Alternative approach

Concept lattice is not the only one approach how to model and analyze organizational structures. Another possibility is to use cluster analysis for the same purposes. The method based on *hierarchical clustering* seems to be the right one because its output shows clearly how the organizational structure should look.

Hierarchical aggregation is based on a similarity of objects (roles in our case). There are many options how the metrics of such similarity can be defined. We chose the *association coefficients* between two roles defined in [7].

Dendogram is a graphical representation of the resulting hierarchical clustering. It shows aggregation of roles based on what activities they have in common (Fig. 3).

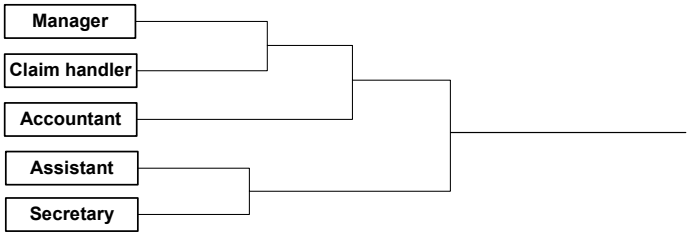

Fig 3 Dendogram of Claim Handle process.

7. Conclusions

The presented method of concept analysis provides exact and formally well-defined way how the organizational structure can be analyzed and re-designed. The examples used in our paper were simplified but they demonstrated sufficiently the potential of concept lattices and the way that this theory can be adopted for purposes of organizational structure analysis. The problem is how to identify organizational structure itself. For that purpose the use of hierarchical aggregation seems to be a better tool because as well as the organizational structures they both employ hierarchy as the main abstraction. On the other hand the theory of concept lattice shows better why the roles are grouped together and thus it serves as a better tool for understanding how the knowledge is shared among roles. We consider both approaches as complementary to each other and the future research is going to be focused on how they can be integrated together. Publication of this work is in [5,6].

8. Reference

1. DeMarco T.: Structured Analysis and System Specification. Prentice-Hall, Englewood Cliffs, New Jersey (1979)
2. Ganter B., Wille R.: Formal Concept Analysis, Mathematical Foundation. Springer-Verlag (1999)
3. Snelting G., Tip F.: Reengineering Class Hierarchies Using Concept Analysis. Research Report RC 21164(94592) 24APR97, IBM Research Division, USA (1997)
4. Wille R.: "Restructuring lattice theory: an approach based on hierarchies of concepts". In: I. Rival (ed.): Ordered sets. Reidel, Dordrecht-Boston (1982) 445-470
5. Vondrak I., Kozusznik J.: Using Modified Concept Lattices for Organizational Structure Modeling and Analysis. In annual of ECEC '03 (Plymouth, GB), ISBN: 90-77381-02-3, 5-9
6. Vondrak I., Kozusznik J.: "Using Modified Concept Lattices for Organizational Structure Analysis." ISIM 03 (Brno, Czech Republic),
7. Lukasová A., Šarmanová J. : „Metody shlukové analýzy." SNTL – Nakladatelství technické literatury, Praha(1985)