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Abstract

Knowledge intensive service providers are highly dependent on human workers who possess specialized knowledge and skills. A client project typically requires a number of different specialists and a project manager coordinating all activities. For many purposes such as supervision, execution of chosen business strategies, and employee well-being, the knowledge workers have to be organized in a structure that is more permanent than project teams. The optimal design of such an organization is not entirely clear as the requirements of the project-based work and other organizational needs such as skill development are not necessarily aligned. In addition, many knowledge intensive services do not need specialized physical facilities and their organizations therefore have few physical constraints. All of these make the organization design problem harder, but at the same time provide a better opportunity for a more effective organization design. To help design an organization that is conducive to achieving the business objectives of the enterprise, we propose a systematic procedure based on the clustering of attributes of the knowledge workers and their relationships with other entities in the organization. This approach provides reasonable starting points

for a human expert to modify into a final design, gives better insight into the impact of strategic objectives on the organization design, and serves as a catalyst for hybrid designs that do not follow common structures.

1. Introduction & Motivation

Many knowledge intensive service providers are highly dependent on human workers who possess specialized knowledge and skills. A number of business-to-business industries fall into this category, such as management consulting, accounting and auditing, information technology services, legal services, or various design services including architecture and interior design, and product and packaging design. The day-to-day operation of these industries is largely project-based, with their employees working on a number of different client projects at any one time. Each employee typically works on one or few projects simultaneously, and moves from project to project (which may be for the same or different clients) over time. A single client project usually requires a number of different specialists in a relatively small team and a project manager coordinating all activities. Each client project may require a different set of skills and hence possibly a different set of employees of the service provider.

To organize the employees effectively, the nature of such an operation presents a number of challenges that are different from those of a traditional manufacturing firm. First, because a knowledge worker moves from project team to project team and each team's composition is dependent on the particular client project, the traditional functional structure is less applicable. The same reasoning holds for organizing by business process, since the process of executing a client project depends on the project content.

Second, many of these projects are carried out at client sites or remotely from the vendor's base locations. At the same time knowledge workers are mostly mobile workers, without physical constraints imposed by heavy or unique equipment needs. There is therefore no strong reason to organize by physical locations or physical centers of activities. A service provider can potentially take advantage of this freedom from physical constraints in developing a more effective organization structure.

Third, a knowledge worker's sense of belonging to a group or even to the company is naturally weaker because he is constantly moving between teams of people, physical locations, often clients, and types of projects, and the fact that he is often the only person with a particular kind of knowledge or skill (a "subject matter expert") due to the tendency towards small teams. It is generally harder to manage such employees, and at the same time it is easy for an employee to lack a sense of belonging and feels frustrated. Therefore it is all the more important that the employee belongs to a sensibly organized structure which is more permanent than the typical project team, so that he is effectively managed and as well enjoys professional satisfaction. Employee satisfaction directly influences employee turnover which is expensive for knowledge-intensive providers. In recent years there has also been wide recognition that employee satisfaction has a strong tendency to drive customer satisfaction and other business outcomes such as profitability (e.g., Harter et al. 2002).

Organization design in practice remains an art to this day. Intuitively a large number of factors determine an organization design, including the business strategy chosen, the existing and planned products or services and the operations required to deliver them, the capabilities and personalities of the employees, customer requirements (or perceived ones), costs associated with different designs, company culture, regulatory requirements, and the competitive environment. Many guidelines and approaches exist in the literature, as reflected by the many practical books published on this subject, e.g., Burton et al. (2006), Galbraith et al. (2002), Stanford (2007). It is safe to say that all businesses take on a hierarchical structure. Within this hierarchy, several basic forms of organization structure are dominant, such as the aforementioned functional form, product line form, and geographical form. The latter two forms usually consist of a few centralized groups responsible for common functions across products or geographies, such as information technology. These basic forms are combined or arranged in a "matrix" form (i.e., multiple hierarchies on the same set of people) in some way to reach the final design.

Adding to the inherent difficulty of developing an effective (let alone optimal) organization design are two practical considerations. Creating an organization design for a substantial company is a manual exercise (except for computer based drawing tools) that is time consuming and expensive due to the inevitable involvement of management staff. Due to the high cost in terms of both time and money, typically not many alternative designs will be generated for consideration, leading to more conventional or obvious designs. To reduce complexity, rarely will any business redesign its entire organization or even a large fraction of its organization at any one time. Rather, designs are done for individual employees within a department, or for group of departments treating a department as a single entity. The design is most often the decision of the head of the department or the group of departments under consideration. Using such a decentralized (but practical) approach under limited time, we will be hard pressed to solve satisfactorily a problem that is elusive in nature.

In this paper we propose a clustering approach to systematically generate alternative organization designs based on a user-defined criterion. These generated designs can serve as starting points for a human resources expert or a business line manager to develop a final organization structure. This computer-aided design process is more effective, in that:

1. A number of different alternative, initial designs can be generated by changing the design criterion and, when combined with constraints or conditions that are not captured in the specified criterion (such as personalities of some of the people in the organization, or historical results of some teams of people), can produce a more effective organization design.
2. Strategic goals of the business can be taken into consideration directly through well-defined relationships of the design with the goals.
3. New or hybrid structures to the aforementioned traditional organization structures can be systematically discovered using combinations of goals or criteria.

Because the present study touches on several diverse fields, we give a review of relevant work after the main body of the paper, in Section 4. A key contribution of this study is to bring together very diverse fields of knowledge (organization design, business architecture, clustering) and show that a new but useful method can be fruitfully developed from the meeting of these fields. Section 2 introduces organization design as a clustering problem. A hypothetical but realistic example of using the proposed approach to develop initial organization designs for an insurance company is contained in Section 3. We conclude with some remarks in Section 5.

2. Organization Design as a Clustering Problem

As mentioned above, a business and in particular a service business invariably has a hierarchical organization structure. Even though it may have a complex matrix organization with multiple layers of structure, there will always be a basic layer of hierarchy. From an individual knowledge worker's point of view, the most important level is perhaps the lowest level which indicates his immediate group members. This is most often the hardest level to form, since the number of entities (people at this level) is the largest and each group needs to have a clear mission or job that aligns with a higher organizational objective or strategy and preferably with minimal overlap in mission with other groups. For the rest of this study, we focus on this lowest level, sometimes called a "first-line" level and the groups called "first-line" groups.

A hierarchical organization structure can be thought of as a set of repeated clusters of entities. In particular, the lowest or first-line level consists of clusters of roles. A role can be assigned to one or more people. The number of people fulfilling a role is determined by the work load or the volume of the business. The full assignment, together with the hierarchy, is the familiar organization chart. A role has its own set of attributes, such as physical and intellectual skills needed, physical requirements (e.g., the person has to be of a certain minimum height), and location of the work. A role may have certain relationships with other roles, such as the delivery of the work to certain other roles, the receipt of work from certain other roles, and the need to communicate with certain other roles regularly, or the sharing of some equipment with other roles. As the last example suggests, a role may have relationships with other entities in an organization (equipment or machine in this case). To model other entities in an organization, we have found an enterprise ontology (Uschold et al 1998), or more generally, a business architecture (e.g., Whittle and Myrick 2004) to be useful.

A business architecture is a model of a business that defines all entities found in the business. For example, in the language (called Archimate) used by the standard business architecture framework adopted by the Open Group, it includes the following entities that are relevant to us: product, business process, business function, business role, business actor. Because each industry is specialized, industry-specific standardized business architectures exist, e.g., eTOM for the telecommunications industry.

Clustering or cluster analysis (e.g., Everitt 1993, Kaufman and Rousseeuw 2005) is the assignment of objects into groups called clusters. Objects within a cluster are more similar to each other than objects from other clusters. The "similarity" of two objects is determined by a distance function or distance measure that mathematically defines how similarity is calculated between two objects. For example, if an object has a set of N numerical attributes, the numerical attributes as a set can be viewed as a coordinate in N-dimensional space and a distance function can be the geometric distance between the respective coordinates of the two objects. With a well-defined distance function, a number of clustering algorithms exist. The most well-known ones include the k-means algorithm, the hierarchical clustering algorithm, Kohonen neural network, or mathematical optimization based method. In the last method, the clustering problem is formulated as a discrete optimization problem where the main decision variables are the assignments of the objects to groups and the objective function is some appropriate function of the average distance between objects in the same group and/or the average distance between the centers of the groups.

An organization design can be obtained by clustering roles based on their attributes and relationships with other entities in the business architecture of the organization. A simple example is as follows. Suppose we wish to have an organization structure aligned by business processes. In the business architecture, each business process is performed by a number of roles. Representing roles in rows and processes in columns, we can develop a 0-1 matrix to denote the business process-role relationship, with "1" representing the process being performed by the role. The first-line groups can be obtained by clustering the roles using this 0-1 matrix. For example, a simple clustering approach is to sort the rows of the matrix according to its row of zeros and ones treated as a string. In this way, roles serving the same set of processes will be clustered together. In practice, because of single roles serving multiple processes, we may not find cleanly divided, diagonal blocks of ones in the sorted matrix. Nevertheless the sorted matrix serves as a useful starting point for manual adjustment to obtain the final clusters. This particular example is analogous to the machine cell formation problem in group technology in manufacturing (e.g., Selim et al. 1998).

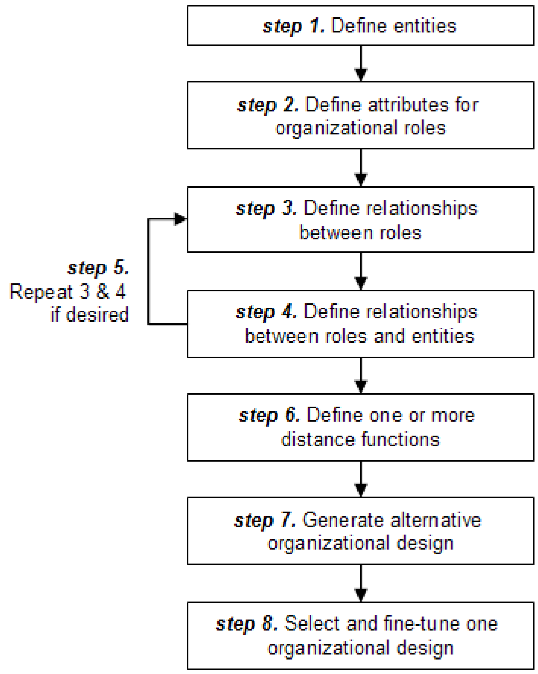

Figure 1. Clustering Method for Organization Design

The Proposed Clustering Procedure

In general, we propose the following procedure to form first-line groups in an organization design (see Figure 1).

1. Define entity types (including at least organizational roles; other roles can be business processes, machines, information systems, etc.) for the enterprise at hand. Define entities for each entity type. An entity is a specific instance of an entity type and inherits its attributes from that of the entity type. For example, for entity type business process, one might have an order management process as an entity in this type.
2. Define attributes for organizational roles. Entity-attribute relationship is best represented by a range or set of numerical values. For example, an

attribute may be the required level of proficiency in java programming for the role, ranging from 1 (highest) to 5 (lowest). This completes the top row and leftmost column of Table 2.1. Determine the values of the attributes of each role. In Table 2.1, A_{ij} denotes the value of attribute *j* for role *i*.

3. Define relationships between roles. For each role, determine the values of its relationships with other roles. This is denoted by R_{ij} for role *i* and role *j* in Table 2.1. Role-role relationship is best represented by a range or set of numerical values. For example, the relationship may be represented by the average number of communications per day between the two roles. The relationships should be chosen to reflect the business strategy or objective at hand. For example, if the strategy is to be a nimble organization that can respond to changes quickly and effectively, the aforementioned number of communications per day between roles will be an appropriate relationship (among others).
4. Define relationships between roles and entities. For each role, determine the values of the relationships between each entity. This is denoted by E_{ij} for role *i* and entity *j* in Table 2.1. Entity-entity relationship is best represented by a range or set of numerical values. For example, a set of entities may be business processes and the role-entity relationship is the number of activities in that process that are performed by a role. Or the relationship is simply 0-1 depending on whether the role participates in the process. In business architecture, many entity-entity relationships are 0-1

depending on whether the entity is associated with the other. Similar to that in step 3, the relationships should be chosen to reflect the business strategy or objective at hand.

5. Steps 3 and 4 can be repeated if desired. In other words, the relationship between two roles or between a role and an entity can be represented by multiple dimensions. For example, besides the number of communications per day, an additional dimension may be the number of past projects the two roles have worked together on. Table 2.1 can be extended to include multiple blocks of role-role or role-entity relationships as needed.

6. Define one or more distance functions based on the role-entity, entity-entity relationship, and role-attribute values to represent the "proximity" of the entities for organization design purposes. A proximity should have a meaningful interpretation. For example, for the previously mentioned attributes representing the required level of proficiency of a set of skills, a distance function may be the Euclidean distance between the attribute values of two roles. This means that roles which require the same skills and skill levels are considered closely related and will tend to be placed in the same group – similar to that of a functional organization. Note that a distance function may or may not include all relationships defined. Typically a distance function represents some weighted average of different relationship sets, with the weights chosen by the user to reflect the business strategy or objective at hand.

7. Alternative organizational designs are generated by clustering roles according to selected distance functions or parameters of distance functions.
8. One design is selected from the generated alternatives and it is fine tuned manually to obtain the final desired outcome. Additionally, different elements of alternative designs can be combined manually to obtain a new design.

Table 2.1. Role-Entity-Attribute Matrix

	Role 1	Role 2	…	Role N	Entity 1	…	Entity M	Attribute 1	…	Attribute K
Role 1	-	R_{12}	…	R_{1N}	E_{11}	…	E_{1M}	A_{11}	…	A_{1K}
Role 2	R_{21}	-		R_{2N}	E_{21}		E_{2M}	A_{21}		A_{2K}
…										
Role N	R_{N1}	R_{N2}		-	E_{N1}		E_{NM}	A_{N1}		A_{NK}

3. Illustrative Examples Using an Insurance Business Architecture

Background

In this section we apply the proposed method to develop a few organization designs for a hypothetical insurance provider to further illustrate the approach. An insurance business is a service business that is highly dependent on skilled knowledge workers ranging from sales, underwriting, claims handling, product development to actuary. The business is entirely information based and organization design is potentially very important to its success. The insurance industry has been studied in services research in the past, e.g., Apte et al. (2007).

To obtain a realistic list of entities for an insurance business, we utilize a standard business architecture for the insurance industry called Insurance Application Architecture (IAA, Huschens and Rumpold-Preining 2006). IAA was originally developed to provide common structures capable of representing the various business requirements from the worldwide insurance industry. A standard business architecture allows insurance companies to mix and match software components to suit their needs. About 40 insurance companies from Europe, U.S.A., and Asia, together with IBM, participated in the development of IAA, starting in the 1990's. In the examples below, we utilize the business processes and their actors specified in IAA. (Note that roles are known as actors in the IAA specification and we use these two terms interchangeably in this section.)

For attributes of the actors, we turn to another industry standard. The Occupational Information Network (O*NET, The Occupational Information Network 2010a) is a unique, comprehensive database of worker competencies, job requirements, and other related information for over 950 occupations. The occupations are indexed by the current version of the Standard Occupational Classification (SOC) system. For each SOC code, the database contains, among other information, the associated skills, abilities, knowledge, work activities, and interests. The database is continually updated by surveying workers from each occupation. The effort is sponsored by the U.S. Department of Labor's Employment and Training Administration and is managed by the National Center for O*NET Development.

Of direct relevance to knowledge-intensive service businesses are knowledge and skills for the occupations that are available in the O*NET database (The Occupational Information Network 2010b). Skills and knowledge belong to worker requirements in O*NET which “represent developed or acquired attributes of an individual that may be related to work performance.” “Knowledge represents the acquisition of facts and principles about a domain of information. Experience lays the foundation for establishing procedures to work with given knowledge. These procedures are more commonly known as skills. Skills may be further divided into basic skills and cross-functional skills. Basic skills, such as reading, facilitate the acquisition of new knowledge. Cross-functional skills, such as problem solving, extend across several domains of activities” (The Occupational Information Network 2010b). To use O*NET information in the context of an insurance business as represented by IAA, we manually map each actor specified by IAA to SOC codes used in O*NET, thus obtaining the knowledge and skills required by each actor in IAA.

Three Design Examples

We now discuss three hypothetical examples of developing an organization design based on a business strategy chosen. The organization design of the insurance business is represented by groups of actors specified in IAA. For simplicity we chose to use only the life insurance part of IAA. In each of the example, from a given business strategy we derive (qualitatively) a role-entity-attribute table using the format shown in Table 2.1 and select suitable values for the role-entity relationships and the role-attributes. The values selected have to be coordinated with the distance measure and we chose the commonly used Euclidean distance between the rows of values in the role-entity-attribute relationship table as the distance function. Using the role-entity-attribute table of values the actors are then clustered using the k-means algorithm (e.g., Bock 2008). Since the k-means algorithm is fairly standard, the actual computation was performed using a commercial software package (SPSS).

1. Suppose the firm is in a commodity business and its strategic goal is to focus on process efficiency. One alternative to improve process efficiency is to have one group manages and executes a business process as much as possible. There are several key advantages to this approach – there is a clear responsibility of an entire business process; there is a smaller chance of work “fallen in the cracks”; there is strong incentive for the employees to perform the tasks right at the first time; customer satisfaction is likely to be higher. To facilitate this approach, we attempt to design an organization so that actors participating in the same process will be grouped together. The emphasis here is therefore on actor-process relationships.

   In IAA, a business process is decomposed into activities and activities are associated with actors. We can therefore obtain a list of processes which a given actor participates in. This list of processes is the list of entities in the title row of Table 2.1. (There is no role and no attribute for roles in this example.) The relationship value E_{ij} between role i and process j is chosen as follows. First, the relationship value contributed by an activity k in a process j is calculated as:

$$E_{ijk} = \begin{cases} 10^{(L_{\max} - L_{ijk} + 1)} & , \quad \text{where process } j \text{ is the level } L_{ijk} \text{ parent of activity } k \text{ performed by actor } i \\ 0 & , \quad \text{otherwise} \end{cases}$$

   ($L_{\max}$ denotes the maximum number of levels of activities in a process and in IAA it is 4.) Then, the relationship value between actor *i* and process *j* is the sum across all activities in that process, i.e.,

$$E_{ij} = \sum_k E_{ijk} \ .$$

Table 3.1 shows a partial list of the actors and the associated processes used in this example.

2. Suppose the firm occupies a niche and is highly specialized in certain aspects of the insurance business. For example, it may be particularly knowledgeable in a specialty insurance business (e.g., insuring actors from accidents during filming), or may be particularly efficient in handling automobile repair claims. For such firms that rely on deep knowledge in one or few selected areas, the classical functional organization is a viable alternative. The emphasis here is on actor-knowledge and actor-skill relationships.

   In this example, Table 2.1 consists only of role-attributes, with each attribute representing a subject of knowledge or a skill required of the actor. In O*NET, the knowledge and skills are specified with a level rating (1 to 5), the higher the rating a more advanced level of that knowledge or skill is required. The role-attribute relationship value is chosen to be simply the level rating of that knowledge or skill required of the actor. Table 3.2 shows a partial list of the actors and the associated knowledge or skills used in this example.

3. In this case, the firm wants to strike a balance between the above two strategies. It will be interesting to see how the organization design will change as one's emphasis shifts from a commodity business focusing on process efficiency to a

niche business relying on highly specialized knowledge. The emphasis here is on a combination of actor-process and actor-knowledge / actor-skill relationships.

In this example, the role-entity-attribute table is the combination of that in examples 1 and 2. The relationship value is a scaled version of that in examples 1 and 2, so that the relative contribution of the actor-process relationship vs. that of the actor-skill/knowledge relationship can be chosen by the user through the specification of the scaling weights.

Table 3.1. Partial List of Actor and Their Associated Process Relationship Values

		BPB0101	BPB0102	BPB0103	BPB0104	BPB0105	BPB0107	BPB0109	BPB0115	BPB0116	BPB0117	. . .
Actor ID	Actor Name	Analyse product develop-ment require-ments	Record first notice of loss in auto insurance	Record claim	Evaluate product regula-tory compli-ance	Operate fund switch by customer	Validate claim	Under-write agree-ment	Enquire inter-mediary account	Enquire bill infor-mation	Enquire account balance	. . .
ACB0001	Agent	10000	0	0	0	24300	0	12000	14000	1000	1000	
ACB0005	Accounting	0	0	10000	0	26630	0	13000	0	21000	34300	
ACB0006	Accounts receivable administrator	0	0	0	0	0	0	0	0	0	0	
ACB0007	Actuary	1000	0	0	0	0	0	0	0	0	0	
ACB0008	Agreement administrator	0	0	0	0	26630	0	33000	0	11000	34300	
ACB0009	Call centre	10000	0	0	0	25310	0	1000	0	10000	11100	
ACB0010	Claim adjuster	0	33300	20000	0	1000	80000	1000	0	0	0	. . .
	. . .											

Table 3.2. Partial List of Actors and Their Associated Knowledge Relationship Values

		2.C.1.a	2.C.1.b	2.C.1.c	2.C.1.d	2.C.1.e	2.C.1.f	. . .
Actor ID	Actor Name	Adminis-tration & Manage-ment	Clerical	Econo-mics & Account-ing	Sales & Marketing	Customer & Personal Service	Person-nel & Human Re-sources	. . .
ACB0001	Agent	3.53	3.95	3.85	5.15	5.89	3.06	
ACB0005	Accounting	3.11	5.51	5.12	1.69	4.59	3.46	
ACB0006	Accounts receivable administrator	2.53	4.99	2.64	1.32	4.49	2.48	
ACB0007	Actuary	4.07	3.38	4.48	3.73	3.25	3.51	
ACB0008	Agreement administrator	2.69	5.75	2.4	2.7	5.19	1.31	
ACB0009	Call centre	2.98	3.9	1.56	2.35	5.26	1.89	
ACB0010	Claim adjuster	2.97	4.35	1.71	2.28	5.84	2.44	. . .
	. . .							

Designs Generated by the Clustering Procedure

Figure 3.1 shows a sample set of results for the organization designs generated by the proposed approach in the above three examples. The list of actors shown in each example represents only a subsets of all actors found in IAA or in a typical life insurance business, since some of the required data to calculate Table 2.1 is not available in IAA or O*NET. In practice, these missing data will have to be filled out by subject matter experts in the industry. Nevertheless, there are enough data to show the differences in the organization designs across the examples.

Referring to Fig. 3.1, we see that in the results for the first example the actors agent, call center, and underwriter are grouped together based on their process relationship values. An examination of the actor-process relationship values confirms that these three actors are in proximity to each other. Table 3.3 shows a partial view of the process relationship values. (There are a total of 249 processes defined for the life insurance business.) In the second example, we see from Fig. 3.1 that the actors agent, claim adjuster, marketer, sales manager, and distribution channel manager are grouped together based on their knowledge relationship values. We confirm this by examining the knowledge relationship values of these five actors. Table 3.4 shows a partial view of the knowledge relationship values. (There are a total of 33 knowledge for all the actors in the life insurance business.) For the results shown for Example 3 in Fig. 3.1, we use a scaling factor of 1000 for the knowledge relationship values to bring them to the same order of magnitude of the process relationship values. Roughly, such a scale factor puts about equal weights to the processes and knowledge. We can see from Fig. 3.1 that the resulting grouping is a combination of that in Example 1 and 2.

Example 1

Agent Call centre Underwriter
Accounts receivable administrator Actuary Claim adjuster Medical expert Agent support Investment manager Claim processor Reinsurance administrator Financial administrator Broker Compliance specialist Distribution channel manager Instructor Claim manager Product development manager Risk manager
Accounting Agreement administrator
Legal counsellor Marketeer Product developer Sales manager Customer service representative Statistics reporter

Example 2

Agent Claim adjuster Marketeer Sales manager Distribution channel manager
Accounts receivable administrator Agreement administrator Call centre Underwriter Customer service representative Claim processor
Legal counsellor Provider administrator
Agent support
Actuary Product developer
Accounting Risk manager

Example 3

Agent Call centre Underwriter
Medical expert Investment manager Reinsurance administrator Financial administrator Statistics reporter Broker Compliance specialist Instructor Claim manager Product development manager
Accounts receivable administrator Actuary Claim adjuster Agent support Claim processor Distribution channel manager Risk manager
Accounting Agreement administrator
Legal counsellor Marketeer Product developer Sales manager Customer service representative

Figure 3.1. Organization Designs Generated by the Proposed Method For the Three Examples Stated

Table 3.3. Partial View of Actor-Process Table for Agent, Call Centre, Underwriter

		BPB0101	BPB0102	BPB0103	BPB0104	BPB0105	BPB0107	BPB0109	BPB0115	BPB0116	BPB0117	BPB0118
ACB0001	Agent	10000	0	0	0	24300	0	12000	14000	1000	1000	0
ACB0009	Call centre	10000	0	0	0	25310	0	1000	0	10000	11100	0
ACB0020	Underwriter	70000	0	0	0	13200	0	178000	0	1000	1000	0

Table 3.4. Partial View of Actor-Knowledge Table for Agent, Claim Adjuster, Marketeer, Sales Manager, Distribution Channel Manager

		2_C_1_a	2_C_1_b	2_C_1_c	2_C_1_d	2_C_1_e	2_C_1_f	2_C_10	2_C_2_a	2_C_2_b	2_C_3_a	2_C_3_b
ACB0001	Agent	3.53	3.95	3.85	5.15	5.89	3.06	2.1	2.24	0.24	4.16	1.24
ACB0010	Claim adjuster	2.97	4.35	1.71	2.28	5.84	2.44	1.34	1.81	0.52	4.26	1.02
ACB0014	Marketeer	4.24	4	2.96	5.92	5.4	3.84	1.8	2.28	0	3.28	2.16
ACB0019	Sales Manager	4.62	4.1	3.35	5.9	5.26	4.55	1.43	1.95	0.24	3.52	1.48
ACB0086	Distribution Channel Manager	4.62	4.1	3.35	5.9	5.26	4.55	1.43	1.95	0.24	3.52	1.48

A further look at the overall team structure illustrated in Figure 3.1 reveals that the team numbers and sizes of the three examples differ. The first example, aiming at increasing process efficiency by grouping together the employees working on the same set of processes, shows four different teams: i.e., two small teams, one medium team and one large team. The majority of the employees, grouped in the largest team, work on (roughly) one particular set of business processes.

Against this, the second example, aiming at clustering employees with similar knowledge, shows a different team structure. The teams are significantly smaller than in the first example while the number of teams is higher. This is explained by the fact that employees of this company have very diverse knowledge.

The team structure of the third example aiming simultaneously at process efficiency and specialty resembles the first example. However, instead of four teams, five teams were identified. The main reason for this is that the large team of example 1, which was created aiming at process efficiency, has been further decomposed into two teams. The employees in each of these two teams are grouped according to a similar set of knowledge.

The three examples illustrate the impact different business goals will have on the organization structure. Thereby, the focus can be laid on one single goal or a combination of goals. Automatically creating various organization alternatives will assist business stakeholders to analyze the impact each alternative has on the company and help them develop a more effective final design.

4. Related Work

In this section we discuss works in three diverse fields that are relevant to our study. Each of these is an entire research area in itself so our review will be limited to a few past works that we have found to be important introductions to the area.

Organization Design

Organization design is a practical problem that has been well written on. Besides the several practical, "hands-on" books referred to in Section 1, we briefly mention three key papers over the years. Duncan (1979) is an earlier work which discusses key factors influencing an organization design and strategies for organization design using design forms commonly seen (e.g., functional, decentralized, matrix). In the end it proposes a simple decision tree heuristic to choose a design depending on the nature of the business. Some symptoms of inappropriate organizational structure are also discussed.

Hax and Majluf (1981) provides a more comprehensive and detailed survey of aspects of organization design, including an overall perspective, typical organization structures, and organization design theories. It proposes a step-by-step approach of organization design, starting with an organization strategy, then defining a basic organization structure, and finally a detailed organization structure. It suggests alternative designs be made in the detailed design step and a set of questions to be asked during this step is given to help with choosing a final design. Similar to Duncan (1979), the work ends with a discussion of symptoms of an inadequate organization structure.

A more recent survey is Galbraith (2008). It gives a historical perspective of organization design, starting with Frederick Taylor's ideas on the design of work and going onto discuss key developments in organization design research over the last century. It also reflects more recent thinking on organization design, such as the concept of a front-back structure. There is also some brief but interesting discussion on examples of real organization structures, including that of IBM and Proctor and Gamble.

While most organization research works are qualitative in nature, there have been some studies that take a quantitative approach. For example, Malone (1987) models the production, coordination, and vulnerability costs of a selected set of common organization structures and compares them. It also contains a review of past mathematical models relevant to the comparison problem studied. Takahashi (1988) develops mathematical models for a pyramid organization and a matrix organization and use the models to investigate conditions under which the organization is efficient. To validate the theoretical results, a survey was conducted in Japan to test hypotheses generalized from the precise mathematical results.

Of note is a relatively young field of computational organization theory (e.g., Carley 2002, Carley and Gasser 1999). Agent-based models are built to study the behavior of an organization, composing of individual agents (representing people or information systems) that possess their own characteristics and behavior. Simulation is used to predict the performance of the organization as a whole.

Business Architecture

Business Architecture (BA) was first developed in the context of Enterprise Architecture to model comprehensively the as-is as well as the to-be situation of a company including its business, applications, technologies and data (Spewak and Hill 1993, Minoli 2008). Since then, various BA concepts with different foci have been created to document, communicate and analyze the business. For instance, the Business Concepts in McDavid (1999) or Archimate's business layer (The Open Group 2008) provide business elements to create a high level company view, the Business Process Modeling Notation (BPMN) offers detailed process elements to model business processes (OMG 2009), the Business Motivation Model (OMG 2006) and the Enterprise Business Motivation Model (Malik 2009a, 2009b) define strategy and goal elements to explain the reasoning behind the company's business actions. To model the organization structure of an enterprise OMG's Organization Structure Metamodel can be used (OMG 2005). Recently, concepts of BA have been shown to be useful outside the enterprise architecture field (Leung and Bockstedt 2009).

As mentioned before, the development of a business architecture is a laborious task executed manually by numerous stakeholders in several sequential cycles (The Open Group 2008). The business architecture thereby evolves in the development and feedback phases of each cycle. Architecture drawing tools support the architect in defining the business elements and in creating the connections between them according to the required BA syntax. For instance, the tool may warn an architect if a connection is not syntactically correct (Glissmann and Sanz 2010).

Only little automation, such as the following, facilitates the work of the architect. In the area of business process modeling, enterprise architecture tools often offer the functionality to simulate modeled business processes (Hlupic and Robinson 1998). This way existing or planned business process can be analyzed for inefficiencies and idle times. Based on these analyses the processes can be redesigned. In recent years, different approaches to business process mining have been published and realized in BPM tools (e.g. van der Aalst et al. 2007, van Dongen et al. 2005). These approaches analyze event logs from information system to model the current as-is business processes.

Cluster Analysis

While the application of cluster analysis is new in the context of organizational design, it is a common technique for statistical data analysis used in many fields, such as market research, biology, medicine, or web mining (Kaufman and Rousseeuw 2005).

In market research cluster analysis is applied to segment markets, customers, organizations with similar characteristics, such as attitudes, purchase propensities or media habits (Punj and Stewart 1983). Furthermore, clustering is often used to seek a better understanding of buyer behavior, or to develop new product opportunities. Another application area of cluster analysis is the selection of test markets, or as data reduction technique to develop aggregates of market data.

In Biology and medicine, clustering analysis has become a common approach to reason various data sets (Kaufman and Rousseeuw 2005). For instance, cluster analytics is widely used to recognize gene groups with related expression patterns, or to group sequences into gene families. In the area of plant and animal ecology, cluster analysis is applied to group organisms at the species, genus or higher level. A new application area in medicine is the medical imaging to analyze three dimensional images of different blood and tissue types.

In recent years, cluster analysis has gained in importance for reasoning the growing number of data published on the World Wide Web. Most commonly clustering is used to group search results into categories and sub-categories to assists a user's exploration of the query result. Besides this, clustering helps to categorize social tags as recommendation for users (Shepitsen et al. 2008), or to explore social networks (Sun et al. 2009).

5. Concluding Remarks

In this paper we propose a systematic approach to generate organization designs using well-defined relationships between entities or between entities and their attributes found in a business. The relationship values are defined based on the business strategy chosen, so that different organization designs can be generated according to different business strategies. These designs can serve as starting point for a human expert to modify to obtain a final design, taking into consideration factors that are not embodied in the relationships defined. It is possible to use one generated design as a base design and another one as the overlaying matrix design. The proposed computed-aide organization design process appears to be entirely new in the relevant research literature.

We demonstrated the feasibility of the proposed method using a hypothetical business formed from industry standard data for business architecture and occupations. The examples represent natural choices for a feasibility study and will lend themselves easily to many variations for further research. For example, in a process-focused organization, we can also take into account the business volume of the different processes performed, so that greater weight is placed on processes which are performed more frequently. Another interesting example will be a traditionally process-focused firm that wants to be a leader in new offerings or new ways of doing business. To foster innovation it may want to experiment putting people of different knowledge or skills in the same group. In this case we can use the same role-entity-attribute relationship table as that in example 3 in Section 4, but with a distance function between actors defined by a linear combination of the Euclidean distance between actors using actor-process relationships and the reciprocal of the Euclidean distance between actors using actor-knowledge / skill relationships.

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