Sociotechnical Roles for Sociotechnical Systems - A Perspective from Social and Computer Sciences

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Abstract

The notion of roles is common to sociology, organizational management and computer science. Although these disciplines partially converge in the field of computer-supported cooperative work, their different perspectives on roles remain largely unconnected. In this paper, we examine the characteristics of roles from different angles and propose an integrative approach to the conceptualization of roles in computer systems supporting cooperation.

1. Introduction

Roles are of vital importance to cooperation: put simply, they help to describe how cooperating actors are expected to behave, depending on their functions and tasks. Being closely related to social interactions and expectations, roles provide a rich context *scaffolding* collaboration. This is especially important in scenarios of computer-supported distributed work, which are often burdened with additional workload resulting from the effort necessary to build up a common ground for collaboration.

However, in computer science and the field of computer-supported cooperative work (CSCW), roles are often merely used as a means to administer access permissions to a system's data and functionalities (e.g. Sandhu et al. 1996). This conceptualization narrows down the comprehensive perspective on roles provided by sociology, resulting in an unnecessary loss of context. One problem is that the dynamics of roles can not be sufficiently understood and supported in technical systems. It is difficult to determine the appropriate degree of making role taking and role making explicit.

Always being a part of a socio-technical system, a CSCW-system may profit from a broader conceptualization of roles, reducing the efforts in collaboration. Adopting this tenet, in this paper we advocate a new *socio-technical* concept of roles combining the different views mentioned above.

Section 2 of this paper characterizes the notion of roles from the perspectives of sociology, organizational management and CSCW in detail. Based on the findings presented, in section 3 we introduce the main features of a socio-technical conceptualization of roles, focusing on recommendations for the design of groupware systems. Section 4 concludes and offers some notes on future activities.

2. Different perspective on the notion of roles

As we have already stated, the notion of roles is common to sociology, organizational management and computer science. In this section, we will examine the corresponding conceptualizations and describe their main features.

2.1 The term "role" from the viewpoint of sociology and organizational management

The term "role" has a long tradition. It is first formally mentioned in the work of Mead (1934), a protagonist of a role concept in the context of symbolic interaction. Mead assumed that society is composed of interactions. These interactions develop role structures. In contrast, the functionalistic perspective (e.g. Linton 1936, Parsons 1951, and Dahrendorf 1958) is characterized by the idea that society determines roles, which are defined by a set of normative expectations and sanctions.

After lengthy debate, role theory was no longer considered as a sociological theory, but the term role was simply integrated as a basic term in contemporary social science: Luhmann's theory (Luhmann 1995) in particular includes "role" as a basic term, as do other recent publications (e.g. Ashforth 2001; Montgomery 1998).

Roles are often defined as sets of activities performed by individuals (Goffman 1959). *"A role is a set of prescriptions defining what the behavior of a position member should be"* (Biddle 1966, p. 29). However, this is an inadequate description. A role is the sum of all behavioral expectations of a social system of the concrete owner of a role. The role actor is in a certain position linked to tasks and functions. We can identify the following four *role dimensions*:

1. *Position*: A role always refers to a position in a social system linked to functions and tasks. The 'position'

shows the relation to other positions e.g. depicted by an organizational chart, and means the static aspect of a system structure (Linton 1936). This is also valid for informal, emerging roles.

2. *Functions and Tasks*: The position implies special functions and tasks, usually in the form of explicit and documented expectations, rights and obligations, which are addressed to the role owner by the social system (e.g. job descriptions, work contract and task assignment). Ilgen & Hollenbeck (1991) differentiate between job and role. If we examine virtual communities, we find the same phenomenon: e.g. administrators, authors, lurkers and contributors (persons who discuss something, see Herrmann et al. 2004).

Both dimensions 1 and 2 are reflected in the view of roles common to computer science. However, this is not enough to understand role behavior. A role is a more complex phenomenon than a task or job since it develops in a network of social expectations and possibilities for positive or negative sanction. "*Roles exist in the minds of people*", because "*expectations are beliefs or cognitions held by individuals*" (Ilgen & Hollenbeck 1991). The work of Ilgen and Hollenbeck (1991) distinguishes between jobs and roles as structure of an organization. "*Jobs are viewed as a set of established task elements*" that are objective, bureaucratic and quasi static. Roles also include informal implicit expectations based on social interaction.

3. *Behavioral Expectations*: The role concept covers more than merely the formal job description. There are also expectations that are not explicit. It includes informal notions and agreements (Harrison 1972). For example, contributors to a discussion forum should acknowledge certain conventions, e.g. how to contribute without annoying someone, what is off-topic and does not belongs to the forum, how to formulate polity, what are "emoticons" etc.. Violating the conventions causes negative sanctions, leading even to exclusion from the community.
4. *Social interaction*: Within the limits of the social systems, the role owner can actively shape the role they have taken. However, this shaping is dependent upon interaction with other participants in the social system by means of communication processes. Roles are the result of a negotiation between the role owner and those with whom he or she interacts (face-to-face or computer mediated). The role owner *transforms* the role expectations into concrete behavior (role making). Thus, each participant fills the same role (slightly) differently. Roles are modifiable.

An organization is based on both explicit formal roles and informal, emerging, implicitly developing roles. Both, formal or informal roles require a kind of role-development. Therefore web-based systems require a different support: a solution that enables socio-technical roles and role-development in CSCW.

2.2 Role mechanism

Roles are gradually developed to support the stability of organization by repetition of social interaction patterns of expectations. The development of roles is accompanied by the shaping of interaction patterns for role-taking and role-making etc. These patterns can metaphorically be described as "*role mechanisms"* (Herrmann et al. 2004):

(a) Role-Taking: For a person acting with respect to the expectations of a specific role, we use the term role taking. "*Role taking (…) is a process of looking at or anticipating another's behavior by viewing it in the context of a role imputed to that other*" (Turner 1956, p. 316). Role taking is related to expectations which can be potentially enforced by sanctions being imposed on the role actor. A person can decide to take a role. They have the opportunity of accepting the role or not.[1]; also the reference group can decide about the role taking to be allowed or not. Furthermore, the distinction between class – an abstract role, which may be taken by various persons – and instance – a role being taken by a concrete person (role owner) – has to be considered. In Communities, the existence of a "facilitator role" can generally be accepted at the level of the class. Nevertheless, not every person is allowed to take this role, e.g. newcomers.
(b) Role-Assignment: One or more persons assign a concrete role to a certain person, give the role to a concrete person. The person can decide to take the role or not.
(c) Role-Change: in principle, a person can hold various different roles at the same time or in sequence (role-set, Merton 1949). Role-change is taking a new role while giving up another. For example, he or she can be a *scaffolder* in a community, structuring a discussion, but also a regular contributor.
(d) Role-Making characterizes how a person *lives* (plays) a role, and how they transforms the expectations into concrete behavior. Role-making is embedded in social interaction: Role-making refers to two or more participants who negotiate the expectations being significant for a role (Goffman 1959). The problem (from an organization's point of view) is that the role actor has a certain attitude to the role (role-distance) and this attitude can differ from original expectations (Goffman 1972, *intra-role-conflict*).
(e) Inter-Role-Conflict: If a person takes more than one role, a conflict between these roles can occur. For the participants of a CSCW it is important to understand the potential inter-role-conflicts (Merton 1949). These result from the different demands of different roles.
(f) Role-Definition: Existing roles are dynamic and not static such as the position. Roles can be changed. A role has the function of executing certain tasks. These, as well

[1] It is not possible to freely decide every type of role taking, e.g. taking biological roles (such as father or mother) can be considered as mandatory.

as the expectations from the reference group, vary with time, e.g. new tasks are added; some tasks are modified and/or the reference group expects new behavior. Sometime the new expectations and social requirements produce new roles.

To make role-mechanisms comprehensible support, human actors orientate their behaviour in real as well as virtual organizations. According Strijbos et al. (2003), roles increase participants' awareness of interaction and efficiency through cohesion and responsibility. Thus, roles may also support knowledge exchange and collaborative learning. (see also Herrmann et al., 2004).

2.3 On the notion of roles in CSCW

If we look at roles from the perspective of CSCW, we find that – in addition to being an analytic category when assessing requirements for systems design and analyzing the usage of a CSCW system (cf. Guzdial et al. 2000) – the term has been strongly influenced by the work on access control mechanisms.

In computer science, the notion of *Role-Based Access Control (RBAC)* refers to a well-known approach to the design of these mechanisms. In the broadest sense, in information and communication technology (ICT) we can describe an access control mechanism as a means to restrict a user's access to a system's functionalities or data. It is of vital importance to the concept of RBAC that users do not have discretionary access to the functions or data provided by a system (Ferraiolo et al. 1995): instead, roles are used as a *mediating* construct, each one of them offering a specific set of access permissions. As we have already mentioned in the preceding section, in RBAC the term role is therefore often used in a to some extend *narrowed* sense, being almost solely described in terms of its position, associated functions and tasks. For instance, take the following definition coined by Sandhu et al. (1996): *"A role is a job function or job title within the organization with some associated semantics regarding the authority and responsibility conferred on a member of the role."* Here, roles are characterized as entities referring to a position within an organization, describing the functions and tasks that are linked to this position.

To make use of roles in the context of ICT system access control mechanisms it is foremost necessary to operationalize the concept of functions and tasks. We may do so by introducing the notion of *privileges*: starting with a definition by Nyanchama & Osborn (1999), a privilege is a tuple consisting of a reference to either an instance or class of an object and a permitted or – in the case of a *negative* privilege – impermissible access mode (i.e., a functionality) for this object.

Given this proposition, for the concerns of RBAC we may now define a role as a named set of privileges to which users can be assigned (Nyanchama & Osborn 1999). It is obvious that in doing so the conceptualization of roles is additionally narrowed down by the nature of privileges as privileges can only refer to tasks and functionalities that can be formalized within an ICT system. Consequently, there is no possibility to express properties of a role that exceed the boundaries of the technical system, e.g. expectations on how a person is considered to enact a role and if he or she meets these expectations or not.

The preceding considerations exemplify that the conceptualizations of a *sociological role* within an organization and a role in RBAC are not identical, although the latter is often derived from aspects of the operational and organizational structure of an organization and can therefore be interpreted as subset of the former.

Furthermore, it is noteworthy that roles serve as a rather static concept to describe a position's functions and tasks in such a way as that they are defined independent from persons filling this position. From the perspective of RBAC, people *are assigned* to a set of usually predefined roles depending on their duties and responsibilities – they do not *make up or define* (new) roles from social interaction, there is no support for the gradual development of roles as it is common to social systems. Table 1 shows the difference of role mechanism in social and technical systems.

We claim that to date this proposition remains valid, regardless of the vast majority of extensions to the core concept of RBAC characterized above, e.g. dealing with the implementation of separation of concerns, conflicts of interests and hierarchical ordering of roles, cf. (Nyanchama & Osborn 1999), (Simon & Zurko, 1997), (Gavrila & Barkley, 1998), (Sandhu et al., 1996).

3. The appliance of roles in computer-supported collaboration

As we have already pointed out, we believe that an extended conceptualization of roles in ICT that additionally accounts for aspects of roles derived from sociology and organizational management may foster knowledge exchange and learning in computer-supported collaborative settings. The basic idea is that by trying to preserve the diversity of the sociological conceptualization of roles when applying them to computer-supported collaboration, we can build up an environment that helps to reduce the amount of disadvantageous ambiguity present in collaboration and trim down frictional loss accordingly. In the remainder of this section, we sketch the main features of such a concept that exceeds the "classic" view of roles as advocated by RBAC, exemplifying its potential benefits by applying it to a system supporting collaborative learning processes.[2]

[2] We refer to these systems by the notion of computer-supported collaborative learning (CSCL), cf. Dillenbourg (1999). Note that for the argument of this paper it is feasible to interpret a CSCL system as a specialized CSCW appliance.

in social systems	in technical systems
Role-Taking	
Although roles are often assigned by others to a certain person, this person has still freely to decide whether s/he takes the role or not. It depends on the role-taker how far he or she accepts the rights and duties associated with a role.	A person can log into a system as a certain user to whom certain roles (which typically are conceptualized to be a named set of privileges) are assigned. A well-defined set of roles usually is taken with the login procedure. Although role changes within a single session are supported by some systems, this is not common: usually, a set of roles is strictly assigned to the session context.
Role-Assignment	
Roles are assigned by others to a person (e.g. by a contract). That means that the person is allowed to take the role or is urged to take it under certain conditions. It may also be the case that someone assigns a role to themselves. Whether the assignment of a role takes place or is successful is often a matter of negotiation	The assignment, as well as the withdrawal of roles, is handled very formally in technical systems and can best be described as a left-total relation between user accounts and roles, usually defined by an administrator. Therefore, assigning and withdrawing a role can be realized much easier than in social processes. Assigning a role to someone is arranged by giving someone the right to use the system with a certain user-identification. Therefore assigning a role and withdrawing the assignment can be handled very formally and is far easier to enact than in social processes.
Role-Change	
Giving-up one role and taking another can be a very fluid transition which is not always visible to others, since it depends very much on the decision of the role taker. Role change can be realized in a tentative way, while checking how the social environment reacts – e.g. if some one moves from the role of a boss to a mentor.	Role changes within systems are very definite. They take place in one step and are highly visible. It is clearly defined whether someone can keep old roles when taking a new one or not.
Role-Making	
A role owner can fulfill the role in their own way with respect to the expectations, and can give new aspects of possible behavior while interacting in the role with others. Role making includes the possibility of being inventive in the way rights and duties are handled.	The privileges assigned to a role are highly determined and formally controlled by the system. There is no degree of freedom for the user to adapt the rights, for instance with respect to learning processes.
Inter-Role-Conflict	
The different rights and duties of different roles being assigned to a person can lead to conflicts especially in the case of frequent changes. A certain duty of role A can be in opposition with a duty of role B. This might lead to conflicts that also have emotional impact for the role owner.	Inter-role conflicts are not and cannot be handled by the owner of the conflicting role. They are mostly of logical but not emotional character. However, the administrators or the system's managers have to decide how to reconfigure the system to avoid or diminish conflict.
Role-Definition	
Social interactions cause change to existing roles or create new roles. The potential owners of new roles are often integrated in the social process creating this role.	Role definition is more or less a technical process conducted by technically oriented administrators, often based on formal descriptions of an organizational structure. The role owner is not necessarily involved and details of how a role is defined are often hidden in the system's logical constraints.

Table 1: Support and nature of role mechanisms in social and technical systems

3.1 RBAC as a basic means of supporting collaboration

We have already characterized RBAC as a well-known concept in computer science providing a means of restricting access to a system's functionalities and data. Notwithstanding their inherent limitations concerning the representation of roles, we initially applied "classical" RABC mechanisms to a CSCL system. When extending and using the CSCL environment KOLUMBUS 2 that serves as a prototype for our conceptualization of roles accordingly, we concluded that CSCL-systems in particular, as well as computer-supported cooperation in general, could benefit from RBAC mechanisms in at least two ways. Firstly, compared to discretionary or mandatory access control systems the approach advocated by RBAC simplifies the administration of access control rights and makes it less error-prone (Sandhu et al., 2000). Secondly, RBAC offers a means of configuring a CSCL system's access control mechanisms according to aspects of the operational and organizational structure of a particular collaborative learning scenario. By doing so, we may influence usage of the system's functionalities in a *desired* way. We believe that such *scaffolding* promotes situations

in which collaborative learning is most likely to occur, cf. (Dillenbourg, 1999).

3.2 Representing expectations by relations

If we look at the qualities roles have in the fields of sociology and organizational management, we find *expectations* to be a prominent feature. Although these expectations often include informal notions and agreements (cf. section 2) and thus cannot be formalized completely, we advocate that a technical system should provide the means to articulate them at least partially. We propose using *describable relations* to represent the following types of expectations:

- The notion of *inter-role expectations* refers to expectations on a role shaped by another role, e.g. if a *student* expects a *tutor* to explain the content of teaching concisely. We may interpret an inter-role expectation as directed relation between any two roles[3], providing additional, semi-formal information on the expectation's subject: for instance, we may define a relation between the roles *student* and *tutor* associated to the descriptive text *'explain the content of teaching concisely'*.
- In addition to inter-role expectations, we can identify a second category of expectations that do not clearly originate from another role, or that address the *interplay* of roles, not their discrete qualities. We refer to this type of expectations by the notion of *systemic expectations*, insinuating that they normally originate from largely agreed-upon rules of conduct explicitly or implicitly present in social as well as in socio-technical systems. For example, static and dynamic separations of duties are common relation-based concepts to RBAC that allow the expression of systemic expectations of a certain kind, i.e. if at the same time two roles may be assigned to the same person or if she may use these roles simultaneously, respectively.

Although separation of duty concerns can easily be expressed by formal means within a RBAC system, it is important to note that there is another important variant of systemic expectations that cannot or can only partially be formalized. Consider a community collaboratively working on a document. It may well be that they have mutually agreed upon a mode of collaboration that on one hand allows each author to edit the document in order to correct spelling mistakes without having to inform their co-workers, but that on the other hand requires changes of the document's content to be discussed an agreed upon by the majority of authors. It is nearly impossible to enforce such a rule by technical means: the system otherwise would have to determine if changes to the document result from an author's attempt to change it syntactically or semantically which often cannot be easily decided.

In order to represent the above-mentioned types of expectations, a system should support the establishment of describable relations between any two roles as well as between a role and an arbitrary artifact, e.g. a descriptive text. It is eligible to be able to describe the nature of a relation using arbitrary artifacts as well.

3.3 Implementing role mechanisms using negotiations

As we have seen, the development of roles in social systems is an inherently interactive procedure depending on communication processes that can often be described in terms of a discussion or negotiation. For instance, a community may discuss if a participant shall be assigned to a particular role (cf. role-assignment, role taking) or if a role has to be modified in a certain way (cf. role-definition). We suggest supporting these activities by offering negotiation mechanisms[4] that allow for the discussion of different proposals concerning the assignment and modification of roles and that furthermore foster the development of a mutually agreed-upon solution. For an example, consider the case of a community that has to appoint a moderator for an online discussion forum: at first, different candidates may be nominated and the alternatives may be discussed. If a proposal might obtain a majority, a voting process can be initiated to determine if the corresponding candidate shall be assigned to the role of the moderator or not. Later on, the community may negotiate to modify the tasks or privileges of the moderator, e.g. they may decide if a moderator is allowed to delete or modify other people's contributions to a discussion (see also section 2: *role-definition*).

Besides being an appropriate means to reach an agreement upon the assignment or modification of roles, negotiations may be also used to establish and adapt relations between them.

4. Conclusion and further work

In this paper, we have examined the notion of roles from the perspectives of sociology and – placing emphasis on access control mechanisms – CSCW. We have found the different characterizations to be complementary: whereas sociology highlights the gradual development of roles in social interactions and their close intertwining with expectations, the field of CSCW tends to operationalize roles as a means of establishing access control policies in ICT systems. Drawing upon this conclusion, we formulated the basic principles of a role concept for computer-supported collaboration combining the aforementioned approaches. Applying this concept to

[3] Note that beyond providing a means to express *generalized* behavioural expectations as described in section 3.2, relations of the type characterized here as well allow to disclose expectations referring to *role making* and *role taking* activities performed by a person.

[4] There is an adequate amount of work addressing the integration of negotiation mechanisms into groupware and CSCL-systems respectively, cf. (Stahl & Herrmann 1999), (Stahl 2003).

CSCW- and CSCL-systems, we expect to reduce the efforts necessary in collaboration and improve the exchange of knowledge amongst co-workers and co-learners respectively.
We have gained first-hand practical experience integrating some of the role-based functionalities described in section 2 into the CSCL-system KOLUMBUS 2 and are currently working to incorporate negotiation mechanisms that allow for the assignment and modification of roles.
Further work will also aim to scrutinize empirically the claim that a deliberate support of roles in groupware systems as presented in this paper helps to improve collaboration.

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