

# Effectual Alliance with Information Division in Virtual Universities

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**Abstract**—A global education system, as a key area in future IT, has fostered developers to provide various learning systems with low cost. While a variety of e-learning advantages has been recognized for a long time and many advances in e-learning systems have been implemented, the needs for effective information sharing in a secure manner have to date been largely ignored, especially for virtual university collaborative environments. Information sharing of virtual universities usually occurs in broad, highly dynamic network-based environments, and formally accessing the resources in a secure manner poses a difficult and vital challenge. This paper aims to build a new rule-based framework to identify and address issues of sharing in virtual university environments through role-based access control (RBAC) management. The framework includes a role-based group delegation granting model, group delegation revocation model, authorization granting, and authorization revocation. We analyze various revocations and the impact of revocations on role hierarchies. The implementation with XML-based tools demonstrates the feasibility of the framework and authorization methods. Finally, the current proposal is compared with other related work.

**Index Terms**—E-learning, RBAC, role-based delegation, revocation.

## I. INTRODUCTION

E-LEARNING, as a significant modern education and learning approach and tool, is defined as learning activities performed over electronic devices. E-learning has the potential to become a lower cost and efficient education tool, and one of the key e-commerce applications with a rapidly growing commercial market in the near future [16]. Virtual universities as an example of e-learning have been implemented in many countries, for instance, Canadian Virtual University (<http://www.cvu-uvic.ca/>) is a group of Canada's leading universities in distance and online learning. Human interaction administration, as a shortcoming of e-learning, is a critical component of the e-learning market, especially in virtual university environments. There are situations in which learning resources cannot be updated and delivered due to insufficient collaborative management arrangements between partners of virtual universities. It is still an open question how efficiently technical skills can be trained in distributed e-learning environments [30], [31]. Virtual universities are becoming strongly networked and fundamental changes in the organization of education are occurring. Geographical isolation is no longer a factor for virtual universities. Students may study courses and complete qualifications from all over the world without leaving their homes or work offices. In a virtual university, each partner (e.g., a university in Canadian Virtual University) usually has its own accredited subjects, which are admired by students. The large numbers of students and their various requirements increasingly encourages collaboration of partners to offer their best subjects to students. The collaboration within a virtual university is found to be a beneficial and enjoyable component of offering a course, but a source of frustration at

the same time. Students' evaluations show that the perceived best and worst aspect of the course is communications between and within each partner in the virtual university [15]. Students are sincerely motivated by the expertise of lecturers but obviously dissatisfied with their collaborations regarding access and updating study materials. The major problem is that students find it difficult to coordinate their schedules at their own university when study materials provided by the university is postponed. Furthermore, the collaborative partners in the virtual university are often distributed and their collaboration occurs across highly dynamic Internet-based environments, and formally accessing the subject materials in a secure manner poses a difficult and vital challenge.

Therefore, effective and efficient communication with distant collaborators is required for the collaboration between and within a virtual university environment. This paper aims to develop a policy-based framework for information sharing in a distributed collaborative virtual university environment with role-based delegation. The inclusion of role-based delegation and revocation allows users themselves to delegate role authorities to others to process some authorized functions and later remove those authorities. Role-based delegation and revocation models are developed with comparison to established technical analysis, laboratory experiments, support hierarchical roles,

and multistep delegation. The models are implemented to demonstrate the feasibility of the framework and secure protocols for managing delegations and revocations.

Delegation is the process whereby an active entity in a distributed environment grants access resource permissions to another entity. In today's highly dynamic distributed systems, a user often needs to act on another user's behalf with part of the user's rights. To solve such delegation requirements, ad hoc mechanisms are used in most systems by compromising existing disorganized policies or additional components to their applications [21], [39]. The most common delegation types are user-to-machine, user-to-user, and machine-to-machine delegations [1], [7], [23]. They all have the same consequence, namely the propagation of access permission. Propagation of access rights in decentralized collaborative systems presents challenges for traditional access mechanisms because authorization decisions are made based on the identity of the resource requester. Unfortunately, access control based on identity may be ineffective when the requester is unknown to the resource owner [34]. Recently, some distributed access control mechanisms have been proposed in distributed e-learning environments: Lowe et al. [22] presented a formal access model for vicarious learning based on an informal model arising out of a particular project and implementation of the model with a tool support system; Mendling et al. [25]

described business models for e-learning with a delegation mechanism to support access management in a distributed education environment. Weippl [37] and Weippl and Quirschmayr [38] have shown the security importance in e-learning environments since e-learning systems are production systems used by many people.

The National Institute of Standards and Technology proposed a role-based access control (RBAC) prototype and published a formal model [12]. RBAC enables managing and enforcing security in large-scale and enterprise-wide systems and its applications depend on specific system requirements. Many enhancements of RBAC models have been developed in the past decade. For example, Joshi et al. introduced a generalized temporal RBAC (GTRBAC) model that is an extension of the RBAC model [19], [20]. In RBAC models, permissions are associated with roles, users are assigned to appropriate roles, and users acquire permissions through roles. Users can be easily reassigned from one role to another. Roles can be granted additional permissions and permissions can be easily revoked from roles as needed. Therefore, RBAC provides a means for empowering individual users through role-based delegation in distributed virtual university collaboration environments.

The importance of delegation in e-learning has been recognized for a long time [30], [37], but the concept has not been supported in RBAC models [13], [14]. An IT administrator (security officer) has to assign a role to the delegated lecturer if the role is required to be delegated to the lecturer. Such a model significantly increases the management efforts in a collaborative virtual university environment because of the dynamic of delegations and the continuous involvement from IT administrators. This paper provides a bridge to the gap between delegation techniques and RBAC models in distributed virtual university environments.

The remainder of this paper is organized as follows: Section 2 presents the related work associated with delegation models and RBAC. As a result of this section, we find that both group-based delegation within RBAC and its implementation with XML have not been presented and analyzed in the literature. Section 3 proposes a delegation framework, which includes the structures of role-based delegation, role-based group delegation, and revocation models. Section 4 discusses the dimensions of revocation and various types of delegating revocations. The impacts of revocation on the original role delegation are analyzed in detail. Section 5 provides delegation authorizations. Granting authorization with prerequisite conditions and revocation authorization are discussed in this section. Definitions of Can delegate, Can revoke, and role range are introduced and authorization rules for delegation and revocation are presented. Section 6 describes the implementation of the role-based group delegation using XML technology, and Section 7 compares the work in this paper to related previous work. Finally, the conclusion of this paper is in Section 8.

## II. MOTIVATIONS

Effective collaboration is a common and significant process in a virtual university, and delegation is an important feature to achieve the collaborative goal. Effective delegation is defined as “the key aspect of good supervision” in [24]. Effective

delegation not only shows that people in groups work more efficiently and productive but also frees the delegating users and groups to more important issues [42]. For example, imagine that the University of Southern Queensland (USQ), the Victoria University of Technology (VUT), and La Trobe University (LaU) are three partners in a virtual university. Lecturer A from USQ as a course examiner in the virtual university wants to apply two weeks off to attend a conference and to delegate the examiner role to Lecturer B at VUT. The normal procedures are

1. Lecturer A fills an application form sent to his/her department,
2. the form approved by the department then needs to be delivered to the faculty,
3. the form signed by the dean of the faculty will be sent to the HR and administrative office at USQ,
4. the HR will send the application to VUT for approval, and
5. administrators assign the examiner role to Lecturer B after the form was signed by the department and the faculty at VUT.

The procedure takes a few weeks and costs a lot. This kind of leave application is very common in a university, especially in the virtual university.

USQ is developing partnerships between VUT and LaU to address possible problems including the complex leave application. The three universities are able to provide available study materials and also prevent illegal resource access if they efficiently collaborate with the people in other universities. A problem-oriented collaboration system (POCS) is proposed to improve the service to students as a part of the ongoing community efforts including identifying potential problems and resolving them before they become significant. With efficient delegation, staff members respond quickly to urgent accidents and increase the time spent confronting problems.

In POCS, lecturers might be involved in many concurrent activities such as conducting initial majors, analyzing student involvement, preparing coordinator reports, and assessing students' employee market reports. In order to achieve this, lecturers may have one or more roles such as head supervisor, participant supervisor, or reporter. In this example, Tony, a director at USQ, needs to coordinate analyzing student involvement in the virtual university courses and assessing employee market reports. Collaboration is necessary for information sharing with members in other universities from these two projects. To collaborate closely and make two projects more successful, Tony would like to delegate certain responsibilities to Christine and her staff at VUT. The prerequisite conditions are to secure these processes and to monitor the progress of the delegation. Furthermore, Christine may need to delegate her delegated role to other staff as necessary or to delegate a role to all members of a group at the same time. Without delegation skill, IT administrators have to do excessive work because of their involvement in every single collaborative activity. The major requirements and challenges of role-based delegation within this collaborative virtual university example are:

1. Group-based delegation means that a delegating user (a lecturer) may need to delegate a role to all members of a group at the same time.

2. Multistep delegation occurs when a delegation can be further delegated. Single-step delegation means that the delegated role cannot be further delegated.
3. Revocation schemes are an important feature of collaborative virtual university systems. They take away the delegated permissions. There are different revoking schemes; among them are strong and weak revocations, cascading and noncascading revocations, as well as grant-dependent and grant-independent revocations [33].
4. Constraints are an important factor in RBAC for laying out higher level organizational policies. They define whether or not the delegation or revocation process is valid.
5. Partial delegation means that only subsets of the permissions are delegated while total delegation means that all permissions are delegated. Partial delegation is an important feature because it allows users only to delegate required permissions. The well-known least privilege security principle can be implemented through partial delegation.

Although the concept of delegation is not new in authorizations [6], [11], [36], [38], role-based delegation has received attention only recently [40], [41]. Aura [6] introduced key-oriented discretionary access control systems that are based on delegation of access rights with public-key certificates. The systems emphasized decentralization of authority and operations, but their approach is a form of discretionary access control. Hence, they can neither express mandatory policies like the Bell-La Padula model [9] nor is it possible to verify that someone does not have a certificate. Furthermore, some important policies such as separation of duty policies cannot be expressed only with certificates. They need some additional mechanism to maintain the previously granted rights, and the histories must be updated in real time when new certificates are issued. Delegation is also applied in decentralized trust management [8], [17].

Some researchers have worked on the semantics of authorization, delegation, and revocation [1]. Hagstrom et al. [18] studied various problems of revoking in an ownership-based framework, but their attempt was still not sufficient to model all the revocations required in role-based delegation, for example, strong revocation and weak revocation. Zhang et al. [40], [41] proposed a rule-based framework for role-based delegation. The framework was based on a simple delegation model supporting only flat roles (i.e., no role hierarchy) and single-step delegation. Furthermore, as a delegation model, it does not support group-based delegation. The model does not analyze how original role assignment changes impact on

delegations or implement with XML-based language. All these previous works were not successful in addressing the requirements of role-based delegation in virtual university environments.

This paper focuses exclusively on a role-based delegation model, which supports group-based delegation in virtual university environments and its implementation with XML technology. We propose a delegation framework including delegation granting and revocation models, and group-based delegation. To provide sufficient functions with the framework, this paper analyzes how changes to original role assignment impact upon delegation results. This kind of role-based group delegation and its implementation with XML have not been studied before.

### III. THE ROLE-BASED DELEGATION AND REVOCATION FRAMEWORK

In this section, we propose a role-based group delegation framework called RBGDF, which supports role hierarchy and group delegation by introducing a delegation relation.

#### 3.1 Role-Based Access Control

The basic elements and relations in RBAC are depicted in Fig. 1. RBAC involves individual users being associated with roles, as well as roles being associated with permissions (each permission is a pair of objects and operations). As such, a role is used to associate users and permissions. A user in this model of the virtual university environment is a human being, such as a lecturer or professor. A role is a job function or job title within the organization associated with authority and responsibility. There are two types of roles: regular role and administrative role. We only address regular roles in this paper. Roles have hierarchy structure in the RBAC model. Senior roles inherit all permissions from junior roles. Therefore, a senior-junior relationship exists in the figure. Permission is an approval for a particular operation to be performed on one or more objects. As shown in the figure, User\_name, Role\_name, Perm\_name, Oper\_name, and Object\_name are attributes of User, Role, Permission, Operation, and Object, respectively. Four relationships between users and roles, between roles and permissions, between roles and roles, and between operations and objects are many to many. The security policy of the organization determines role membership and the allocation of each role's capabilities [35].