

Gustavo Alonso (Ed.)

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# Middleware 2005

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Grenoble, France, November/December 2005  
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Volume Editor

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## Preface

Today, middleware is a key part of almost any application. Gone are the days when middleware was only used in the IT industry for high-end applications. Rather than middleware being part of the IT world, today IT applications represent only one aspect of middleware. With the increase in distribution, network capacity, and widespread deployment of computing devices (in homes, automobiles, mobile phones, etc.), middleware has surpassed the importance of operating systems as the platform where application development and deployment take place. This makes middleware very exciting as a research area but also a very challenging one since it encompasses many different concepts and techniques from a wide variety of fields: networking, distributed systems, software engineering, performance analysis, computer architecture, and data management.

Middleware 2005 in Grenoble, France, was the 6th edition of an increasingly successful conference. The scope of the conference has been slowly widening with every edition to accommodate new fields and applications. This year we made a considerable effort to reach out to other communities who are also active in the general area of middleware — sensor networks, networks in general, databases, software engineering — a fact that is reflected in the variety of submissions.

The program this year was selected from over 112 submissions. From these, the Program Committee selected 18 full papers and 6 short papers. Each paper had at least four reviews and the selection was made based on technical merit, relevance, originality of the contribution, and degree of innovation. Preference was given to papers with new ideas or covering novel application areas. Among the accepted papers, there was a fair number of PC papers. For the record, PC papers had to be clearly above other papers to be considered for acceptance. In this Call for Papers, we did not include work-in-progress papers. Instead, we introduced short papers — selected from the regular submissions as papers that had interesting ideas but were not ready for publication as full papers — and a demo session with a separate Call for Papers — which should give a venue to present systems-oriented research.

As in the past, the review process was highly selective and the source of many interesting discussions on the nature of middleware and its general applicability. The exciting program that was prepared reflects these discussions and created the perfect background for similar discussions during the conference. Together with the workshops that accompanied the conference, Middleware 2005 covered a wide range of issues and topics related to all aspects of middleware, from software engineering to low-level implementation details.

Finally, I would like to thank Richard van de Stadt, in charge of the conference review system, who was at all moments most helpful and made sure the review process ran flawlessly. I would also like to thank all the Program Committee members and external reviewers for their time and effort during the review

process. Writing good, informative, and fair reviews is not easy and takes a considerable amount of time. I am proud to say that this year's PC has done an excellent job with the reviews, thereby continuing the tradition of excellence in the Middleware conferences. The result of their efforts is an excellent and very interesting program that no doubt made the 2005 edition of the conference a success.

April 2005

Gustavo Alonso  
Middleware 2005 Program Chair

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# Securing Publish/Subscribe for Multi-domain Systems

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**Abstract.** Two convincing paradigms have emerged for achieving scalability in widely distributed systems: *role-based*, policy-driven control of access to the system by applications and for system management purposes; and *publish/subscribe communication* between loosely coupled components. Publish/subscribe provides efficient support for mutually anonymous, many-to-many communication between loosely coupled entities. In this paper we focus on securing such a communication service (1) by specifying and enforcing access control policy at the service API, and (2) by enforcing the security and privacy aspects of these policies within the service itself. We envisage independent but related administration domains that share a pub/sub communications infrastructure, typical of public-sector systems. Roles are named within each domain and role-related privileges for using the pub/sub service are specified. Intra- and inter-domain, controlled interaction is supported by negotiated policies. In a large-scale publish/subscribe service, domains are not expected to trust all message brokers fully. Attribute encryption allows a single publication to carry both confidential and public information safely, even via untrusted message brokers across a vulnerable communications substrate. Our approach provides the application designer with fine-grained expressiveness while, at the same time, improving system fault tolerance by allowing a single shared messaging network to route both public and confidential information. Early simulations show that our approach reduces the overall traffic compared with a secure publish/subscribe scheme that encrypts whole messages.

**Keywords:** publish/subscribe, loosely coupled applications, content-based routing, role-based access control, attribute encryption, message confidentiality, trust.

## 1 Introduction

We are concerned with how communication within and between large-scale, independent, widely distributed application domains should be supported and managed. Two recently emerging paradigms for achieving scalability are asynchronous, publish/subscribe-based communication and role-based access control (RBAC). In the EDSAC21 project we aim to extend and integrate these

paradigms to achieve a scalable, secure middleware capable of supporting fine-grained control of communication within and between domains. In this paper we present our multi-domain architecture and an interim evaluation based on simulation.

We define a domain to be an independently administered unit in which a domain manager has, or may delegate, responsibility for naming and policy specification. The following motivating scenarios have in common a communication infrastructure shared by independently administered domains, some of which are strongly related and have similarly named roles. The bulk of the communication is likely to be within a domain but there is also a clear need for inter-domain communication. (1) A global company has branches (e.g. sales) in California, London and Tokyo. Some (sales) data and events should be shared between branches. (2) A number of county-level police domains need support for intra- and inter-domain messages. (3) A national health service’s communication infrastructure is shared by many independent hospitals, clinics, primary-care practices etc. (4) An “active city” has independent public services such as police, fire, ambulance, hospital, and utilities. As well as communicating with similar services nationally (e.g. police with police) the different services need to cooperate, especially in emergencies. Examples are common in the public sector, where systems have been particularly susceptible to expensive failure or curtailment.

The concept of role is well established for providing scalable security administration. Role-based access control (RBAC) separates the administration of people, and their association with roles, from the control of privileges for the use of services (including service-managed data). Service developers need only be concerned with specifying access policy in terms of roles, and not with individual users. Here we focus on securing the communication service. Domain managers, or their delegates, specify communication policy in terms of message types and roles; that is, which roles may create, advertise, send and receive which types of message. Inter-domain communication is achieved through negotiated agreements, expressed as access control policy, on which role(s) of one domain may receive (which attributes of) which types of message of another.

Publish/subscribe [1] is emerging as an appropriate communication paradigm for large-scale systems. It allows loose coupling between mutually anonymous components and supports many-to-many communication. In this paper we focus on securing publish/subscribe within and between domains. For consistency with other publish/subscribe systems we use *event* as synonymous with the more general term *message*. The notion of role is ideally suited to a multicast communication style. For example, the Cambridge police domain may define a role *sergeant-on-duty* and message topics such as *traffic-accident (attribute-list)*. Authorisation policy will indicate which roles can advertise, subscribe to and publish each topic. Inter-domain communication is supported, after human negotiation, by indicating in policy that a specified role of some domain may subscribe to certain (attributes of) topics published by some other domain.

Authentication into roles must be securely enforced to control the use of all protected services. We have addressed this in earlier papers. For the communi-



cation service, RBAC policy indicates the visibility (to roles, intra- and inter-domain) of specified attributes of message types. The fact that advertisement is required before messages can be published, and both are RBAC-controlled, prevents the spam that pervades email communication between humans. Without such control denial-of-service through publication or subscription flooding could degrade large-scale inter-software communication in the same way that it consumes resources in email management. In our system a spammer could only be an authorised, authenticated member of a role and therefore could be held accountable.

If the network and message brokers could be guaranteed 100% secure and trustworthy, then RBAC would achieve precisely the visibility specified by policy. In practice, we have to protect confidential data on the wire and in the brokers by means of encryption. We offer fine-grained security, in that message attributes are encrypted selectively, with key management transparent to the client level. We assume that some form of message encryption is always needed, since nodes of a communication service are not likely to be trusted universally with all data and the network is vulnerable to listeners. Encryption overhead per se does not need to be justified, and our evaluation indicates that our approach incurs less overhead than using whole-message encryption.

The contribution of this paper is to show how role-based access control, together with fine-grained data encryption and the associated key management, can be integrated with publish/subscribe based communication to create a secure middleware suitable for a wide range of large-scale, widely distributed application domains. First, we set the scene by discussing related research on secured publish/subscribe in Section 2. Section 3 gives background in publish/subscribe systems and role-based access control, emphasising, without loss of generality, the systems we have used for our implementation and evaluation, Hermes and OASIS. We then outline how RBAC and publish/subscribe are integrated. Section 4 presents our multi-domain architecture in more detail. Section 5 uses a multi-domain, networked city as a case study and describes the scenarios evaluated in Section 6. Section 7 presents our conclusions in the context of our ongoing and future research.

## 2 Related Work

To our knowledge, the architecture we outlined in [2] was the first to consider access control for a publish/subscribe service. There, we took a typical private-sector application, a newsfeed service, comprising a single naming and protection domain. We did not consider public-sector, multi-domain examples, where it becomes natural for a message-broker substrate to be shared, and where different levels of trust in brokers must be accommodated. This work did not address data encryption and key management.

Some authors explicitly exclude security as being orthogonal to the design issues of publish/subscribe [3]. Others have limited their work to the communications level [4]. Others have discussed how publish/subscribe systems might be