An Event Routing Algorithm in Content-based Publish/Subscribe System for E-Government Applications

Xudong Liu   **Peng Lu**   **Xuelian Lin**   **Jun Han**

Liuxd@buaa.edu.cn   Lupeng@act.buaa.edu.cn   Linxl@buaa.edu.cn
Jun_han@buaa.edu.cn

Computer School of Beihang University
Beijing Haidian District Xueyuan Road No.37,China

1   Motivation

The Internet has considerably changed the scale of E-Government Systems. E-Government systems now involve thousands of entities—potentially distributed all over the country—whose location and behavior may greatly vary throughout the lifetime of the system. Though most E-Government data exchanges today are "point-to-point", such as e-mails, Web, or FTP, such synchronous communications lead to rigid and static applications. They also make the development of dynamic large-scale applications cumbersome. The "publish/subscribe" interaction scheme is claimed to provide a loosely coupled form of interactions required in such large-scale settings. Much research has been done on this novel form of interaction scheme [1, 2, 3].

Examples of publish/subscribe applications are government news notification, traffic information, comprehensive management of taxation, comprehensive management of public security, financial attestation, and credit applications. These applications cover government notifications or general information dissemination to many clients. Those notifications are generated by different local agencies and are distributed to many government bureaus all over the country. The general model behind these applications is based on gathering information from a set of data sources and delivering it to all users, based on their interest. Users of a publish/subscribe system prefer to only receive information that they are interested in and do not want to deal with the complexity of having the knowledge about all users. The system is expected to handle a huge number of concurrent users, with frequent information publication and dynamic changes in users' interest. These new features result in a requirement of loosely-coupled interactions among the participants in the environment. The publish/subscribe paradigm can fully decouple the information producers and consumers in time, space and flow, so it is a desirable solution for these new E-Government applications.

Publish/subscribe systems have a number of interesting characteristics. Firstly, producers do not need to address consumers and vice versa. Instead, consumers simply specify the types of notifications that they are interested in. This loosely-coupled approach facilitates flexibility and extensibility because new consumers and producers can be added, moved, or removed easily. Secondly, communication is asynchronous, thereby removing the disadvantages and inflexibility of synchronous communication in the point-to-point paradigm. Thirdly, producers and consumers do not need to be available at the same time. This means that a subscription causes notifications to be delivered even if producers join after the subscription was issued. Finally, publish/subscribe directly reflects the intrinsic behavior of information-driven applications because communication is initiated by producers of information.

2   Our work

We have implemented a middleware in ACT-IIP which is a publish/subscribe system. Publish/subscribe routing technology is the key technology for publish/subscribe systems [4, 5, 6, 7, 8]. The routing efficiency of the traditional reverse path forwarding method is $O(N)$ [4].The method which is based on our design, event space partition, improves the efficiency to $O(N^{1/d})$ [9]. In this paper, we briefly describe a new routing algorithm named Spanhop to improve routing performance in publish/subscribe systems. In this algorithm, a new data structure named "ancestor queue" is proposed to save neighbor relations among different routing areas in the virtual overlay network, and it can aid to implement the Spanhop routing in an efficient way. Routing

performance analyses shows that the Spanhop routing algorithm improves the routing efficiency to $O(lnN)$ at the cost of a little storage increase. Also, it eliminates the effect of the number of event space dimensions which affect routing efficiency. The result reveals that the Spanhop routing algorithm improves the routing efficiency of content-based publish/subscribe system for data exchange in E-Government in a wide area network. The algorithm has been implemented in the ACT-IIP data exchange middleware product (developed in Beihang University) for E-Government applications.

The key idea of the Spanhop routing algorithm can be described as below. If each K-D tree-based midway event space partition is taken as a virtual broker network, we get an overlay network formed by all partition states. Each partition forms a self-governed greedy routing network .With the exception of current routing network, all routing networks vanish as the adjacent broker information is updated. The adjacency relations between these routing areas are determined by the adjacency relations between their ancestors as well as the elements or routing area of the parent partition. Therefore, Spanhop routing includes two steps: to identify the routing area where the destination broker is located, and to route events in that routing area.

The proposed Algorithm has been implemented in the ACT-IIP middleware product for wide area E-Government data exchange applications. ACT-IIP has two layers: the lower event transport network layer is used to provide reliable event transmission in the form of SOAP messages and the upper layer is the pure publish/subscribe system. There are two main components in ACT-IIP: event broker and client. The client can be a publisher or a subscriber and it sends publications or subscriptions through a data adapter for SOAP messages. The event broker network acts as an event server handling large amounts of events from many clients distributed among the system. A client needs not keep synchronization with the event broker; it sends data asynchronously. This product has been used in the E-Government Systems of Heilongjiang province which is in the Northeast China on December 2005.

3   Future work

As an event driven architecture, content-based publish/subscribe system is the best choice of data exchange in a wide-area oriented E-Government system. ACT-IIP makes such systems easy to implement. With the price of little storage increase, Spanhop improves the routing efficiency which is the key technology in content-based publish/subscribe system to $O(lnN)$. At the same time, the dimension of event space needs not to be considered and thus the computational complexity is reduced. Future work are to study the multicast algorithm based on Spanhop and to address the load balancing problem in the publish/subscribe system.

4   REFERENCES

1. P. T. Eugster, P. Felber, R. Guerraoui, and A. M. Kermarrec. The Many Faces of Publish/Subscribe. *ACM Computing Surveys*, 35(2):114–131, 2003.
2. A. Carzaniga, D. S. Rosenblum, and A. L. Wolf. Design and Evaluation of a Wide-Area Notification Service. *ACM Transactions on Computer Systems*, 19(3):332–383, Aug.2001.
3. P. Pietzuch and J. Bacon. Hermes: A Distributed Event-Based Middleware Architecture. In *Proceedings of the 1st International Workshop on Distributed Event-Based Systems(DEBS'02)*, pages 611-618, Vienna, Austria, July 2002.
4. Tao Xue, Boqin Feng. Research on content Publish/Subscribe system routing algorithm and self-configure policy. *Software Joural*, 16(2):251-259, 2005.
5. Fengyun Cao and Jaswinder Pal Singh. Efficient Event Routing in Content-based Publish-Subscribe Service Networks. In *Proc. of IEEE INFOCOM 2004*, 929-940, Hong Kong, China, 2004.
6. Y. M. Wang, L. Qiu, and D. Achlioptas. Subscription partitioning and routing in content-based publish/subscribe networks. In *16th International Symposium on Distributed Computing*, 28-30, Toulouse, France, 2002.
7. A. Riabov, Zhen Liu, J. L. Wolf. Clustering Algorithms for Content-Based Publication-Subscription Systems. In *Proceedings 22nd International Conference on Distributed Computing Systems (ICDCS'02)*, 133-142, Vienna, Austria, July 2002.
8. A. Riabov, Z. Liu, J. Wolf, P. Yu and L. Zhang. New Algorithms for content-based publication subscription systems. In *Proceedings 22nd International Conference on Distributed Computing Systems (ICDCS'02),* 678-686, Providence, RI, USA, May 2003.
9. S. Ratnasamy, P. Francis, M. Handley, R. M. Karp, S. Schenker. A scalable content-addressable

network. *ACM SIGCOMM Computer Communication Review*, 31(4):161-172, 2001.