Chapter 30
Virtual Hierarchical Tree Grid Organizations (VIRGO)

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ABSTRACT
The currently two types of main P2P technologies—unstructured and structured approaches do not care about the semantic meaning of the nodes. They do not care about the nodes whose users may take different roles in social groups in the communities. Here, a semantic P2P Network-Virtual Hierarchical Tree Grid Organizations (VIRGO) is described. VIRGO is a hybrid of unstructured P2P and structured P2P technologies by merging a multi-tuple Virtual Hierarchical Overlay Network and random cached network. It has the following properties: Decentralization—VIRGO is fully distributed, robust, and easy-managed; Load balance—Cached nodes in route table help to solve the problem of the load balance in the tree structure; Scalability—Time complexity, space complexity and message-cost of lookup protocol of VIRGO is $O(\log N)$, where $N$ is the total number of nodes in the network; Availability—There is at least one path between every two nodes. This chapter gives audience the concepts, framework, protocols and applications about Virtual Hierarchical Tree Grid Organizations (VIRGO). It will point out why VIRGO should exist among lots of P2P technologies.

INTRODUCTION
Although client/server technology has been successful in many IT fields, it has many shortcomings. It is un-scalable, with a single point of failure, and does not fully use resources at the network edge. P2P technology is now considered as the next generation computing model. It is scalable, with efficient use of resources, and processing power at the edge of the network.

There are two types of P2P technologies. Industrial P2P applications such as FreeNet(http://freenet.sourceforge.net/) use an unstructured approach which routes nodes by a “flooding” algorithm. This kind of P2P has the advantages of partial-match querying and robustness, but may cause excess
network traffic, and lacks guaranteed search. The structured approach is mostly based on Distributed Hash Table (DHT) technologies such as Pastry (Rowstron & Druschel, 2001), CAN (Ratnasamy, Francis, Handley, Karp & Shenker, 2001), and CHORD (Stoica, Morris, Karger, Kaashoek & Balakrishnan, 2001), and is effective in time complexity, but lack partial-match query capability and locality aspects.

The other aspect of the above types of P2P is that they do not care about the semantic meaning of the nodes. They do not care about the nodes whose users may take different roles in social groups in the communities. This leads to lack of powerful solutions for resource discovery by complicated conditions as SQL statement.

Here, a semantic P2P Network—Virtual Hierarchical Tree Grid Organizations (VIRGO) (Huang, 2005) is described. VIRGO is domain related P2P network, which keeps the nodes’ semantic meaning and hybrids structured P2P and unstructured P2P. It contains a virtual group tree overlay topology and a random cached netlike topology. It is equally effective in routing messages as structured P2P, but retains the partial-match query and robustness aspects of unstructured P2P. The time complexity, space complexity and message-cost of the VIRGO lookup protocol is \(O(\log N)\), where \(N\) is the total number of nodes in the network. Due to the LRU replacement strategies for caching route nodes, VIRGO is also a load-balanced network.

Grid (Foster, Kesselman & Tuecke, 2001; Foster & Kesselman, 1997) technology is one of the most important one come forth in recent years. In the service-oriented architecture of Grid, how to find Grid services is an important issue. The strategy publishing and discovering services with centralized mode has bad scalability and a single point of failure. P2P (Clark, 2001) has good scalability, but it has some challenges such as security, network bandwidth, and architecture designs, and has difficult to search services which are described by many entities, especially by ontology terms. Service discovery based on Virtual Hierarchical Tree Gird Organizations (VIRGO) can overcome the above shortages, and can query scope services through SQL-like statements.

DNS becomes a vital component in today’s Internet infrastructure. But the existing DNS architecture may encounter problems for the growth of the Internet in the coming IPv6 network. In IPv6 network, there are huge IP address spaces. Therefore, it is reasonable to suppose there are huge numbers of Domain Names. Furthermore, pervasive computing requires more DNS queries. Those above will result in traffic load and latency of DNS lookups. VIRGO_DNS is VIRGO based distributed DNS in IPv6. The DNS servers constructs VIRGO network according to Domain Name Zones (Mockapetris, 1987). The performance of DNS lookups may reach \(O(1)\) due to Zipf’s law (Huang, 2008b; Jung, Sit, Balakrishnan & Morris, 2001).

In this chapter, we first give backgrounds of related technologies with VIRGO, especially virtual and dynamic hierarchical architecture (VDHA) (Huang, Wu & Pan, 2002; Huang, Wu & Pan, 2003); then presents the framework, protocols and applications of VIRGO in details. Through this chapter the audience should learn the concepts, framework, protocols and applications about VIRGO, and know VIRGO’s advantages such as SQL-like scope query compared with lots of other P2P technologies.

**BACKGROUND**

P2P computing is the computing models whose systems share computer resources and services directly. In P2P system, all nodes are both clients and servers. It provides as well as consumes data. It has no centralized data source; and it manages P2P system autonomously. Unlike Client/Server model, any node can initiate a connection with any others. P2P computing can leverage their collective power by taking advantage of existing computing power, computer storage and networking connectivity.
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