Overlay Computers/Networks, and Resource Discovery

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The Global Computing Communication Paradigm, computation via a seamless, geographically distributed, open-ended network of bounded resources by agents (called Global Computers) acting with partial knowledge and no central coordination is probably one of the most interesting challenges for the next decade. The paradigm provides uniform services with variable guarantees. Aggregating many Global Computers sharing similar or different resources leads to a Virtual Organization, also called Overlay Computer: abstraction that can be implemented on top of a Global Computer to yield another Global Computer .. Finally, organizing many Overlay Computers, using, tree- or graph-based topology leads to an Overlay Network, the possibility of programming a collaborative Global Internet over the plain Internet.

The main challenge in this new field of research is how single resources, offered by the Global-Overlay Computers are discovered. The process is called Resource Discovery: it requires an up-to-date information about widely-distributed resources. This is a challenging problem for very large distributed systems particularly when taking into account the continuously changing state of resources offered by Global/Overlay Computers and the possibility of tolerating intermittent participation and dynamically changing status/availability of the latter.

Reciprocity and hierarchical organization of the Virtual Organization in Colonies, governed by a clear leader (called Global Broker) are the main achievements of the model. Global Computers belong to only one Colony, and requests for services and resources located in the same or in another Colony traverse a broker-2-broker negotiation whose security is guaranteed via standard PKI mechanisms. Once the resource offered by a Global Computer has been found by the Overlay Network, the real resource exchange will be performed out of the model itself, in a P2P fashion.

As such, the main concern of the design of an Overlay Network is how to provide a decentralized, asynchronous, and generic Resource Discovery. Once a Global Computer has issued a request for some services, the system finds some Global Computers (or, recursively, some SubColonies) that can offer the resources needed , and communicates their identities to the (client) Global Computer as soon as they are found.

The model also offers some mechanisms to dynamically adapt to dynamic topology changes of the Overlay Network, by allowing an Individual (Global Computer or SubColony) to log/delog in/from a Colony. This essentially means that the process of routing request/responses may lead to failure, because some Individuals delogged or because they are temporarily unavailable (recall that Individuals are not slaves). This may lead to temporarily denies of service or, more drastically, to the complete delogging of an Individual from a given Colony in the case where the former does not provide enough services to the latter.

Symmetrically, the leader of a Colony should arbitrarily unregister an Individual from its Colony, because, of its bad performance when dealing with some requests, or because of its high number of "embarrassing" requests for the Colony. This mechanism/strategy reminiscent of the roman do ut des, is nowadays called, in Game Theory, "tit-for-tat" . The strategy is commonly used in economics, social sciences, and it has been implemented by a computer program as a winning strategy in a chess-play challenge against humans (see also the well known prisoner dilemma). In computer science, the tit-for-tat strategy is the main principle of Bittorrent (P2P) protocol .

Dealing only with with Resource Discovery has one important advantage: the complete generality and independence of any given requested resource. In this way we could fit with various scenarios in the Global Computing arena, from classical P2P applications, like file sharing, or band-sharing, to more sophisticated GRID applications, like remote and distributed big (and

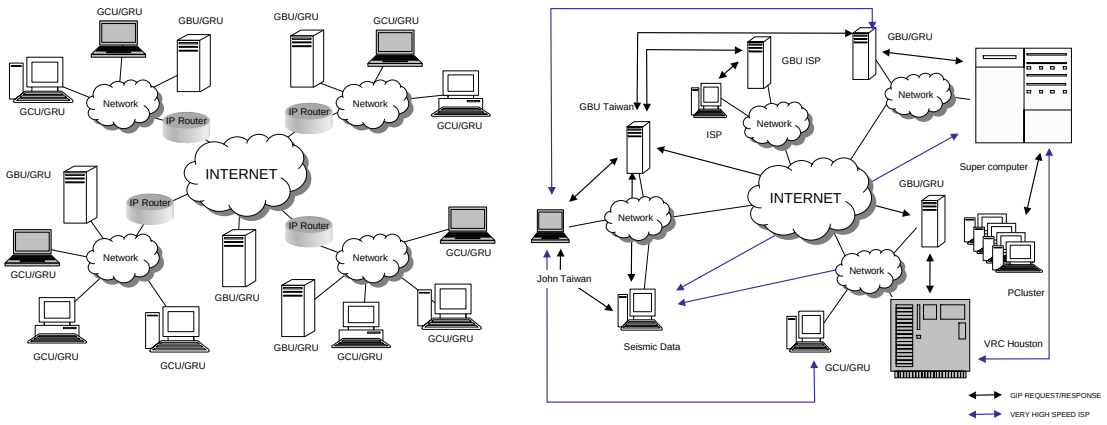

Figure 1: Arinet and a GRID Scenario for Seismic Monitoring using Arinet

small) computations, until possible, futuristic migration computations, transfer of a non completed local run in another GCU, the latter scenario being useful in case of catastrophic scenarios, like fire, terrorist attack, earthquake etc, in the vein of Global programming languages Obliq or Telescript.

Related Work. Many technologies, algorithms, and protocols have been proposed recently on Resource Discovery. Some of them focus on GRID or P2P oriented applications, but none of those targets the full generality of the model that deals only with Generic Resource Discovery for buiding an Overlay Network of Global Computers, structured via a Virtual Organization and clear distint roles between leader and Individuals.

The closest technology is The Globus Toolkit, is an open source set of technology, protocols and middleware, used for building GRID systems and applications. Possible applications range from sharing computing power to distributed databases in a heterogeneous Overlay Network, where security is seriously taken into account. The toolkit includes stand alone software for security, information infrastructure, resource management, data management, communication, fault detection, and portability.

Another close technology, promoted by Sun, the JXTA technology is a set of open peer-to-peer protocols that enable any device to communicate, collaborate and share resources. After a peer discovery process, any peer can interact directly with other peers. Hence the overlay network of peers induced by the JXTA technology is flat. Moreover, the main concern of the proposed model is Resource Discovery, while the main concern of the JXTA technology is to offer some tools to implement a P2P model.

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