IDEON: Integrated Distributed Environment with Overlay Network

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1 Toward Unrestrained and Imaginative Rendezvous, Location and Routing

IDEON (Integrated Distributed Environment with Overlay Network) is a working group that pursues autonomy in the designs of distributed systems.

We believe that network designs should encourage self-generation of activities which utilize resources spread over different locations (hence, *integrated distributed environment*) by allowing spontaneous creation of layers of abstract network over the IP layer (hence, *with overlay network*).

Putting more stress on autonomy changes how the three ingredients of communication are performed:

1. Rendezvous (or how to identify the peer)

   The word "rendezvous" means a prearranged meeting place. In computer communications, such a meeting place can be a name space or a space for identifiers. Rendezvous performed under autonomy may allow spontaneous naming and resolution among the participating nodes themselves.

2. Location (or how to locate the peer)

   This is to locate the node that represents the identifier. The node is typically identified by the identifier in the lower layer of the network. Autonomous location may involve identifying the closest copy of information among redundant copies spread over the network with help from participating nodes in vicinity.

3. Routing (or how to reach the peer)

   This is to traverse the topology of the network so that a message can reach the peer. Location and routing may be done in the same procedure because it may be necessary to traverse the topology of the network to locate the peer. Autonomous routing may involve creation of topology in an ad-hoc manner.

We would like to propose alternative networking designs so that each of these can be performed in unrestrained and imaginative ways.

By "unrestrained and imaginative" we mean that no restraint should be made by the network as to which object can become the target for communication, without intervention of any authorities or privileged intermediate nodes,

and that new ways of communication can be developed by the creativities of the participants of the network.

Since autonomy implies that there is no authority to guarantee the truthfulness of information (or that such an authority is weak), trust becomes an important issue.

2 Summary of the Research

In the IDEON working group we produced four major research outputs. Youki Kadobayashi extends Kademlia algorithm, Kenji Saito works on trust management and its applications, Takaaki Ishida made a simulator for spatially sticky information distribution algorithm for RF communication, and Yusuke Doi introduced bloom filters to enable peer group management on DHT.

The research by Youki Kadobayashi contributes for heterogeneous structures of DHT networking. Youki's extension on Kademlia algorithm enables fair-sharing between nodes that have different capabilities like connection bandwidth, processor power, and storage capacity.

To accomplish high-availability and robustness at the same time, heterogeneous networking is a rational approach. With the Youki-Kademlia we can integrate various devices like refrigerator, HDD video recorder and many more massive always-on devices into the DHT network. Integrated with greater devices like server computers, these devices may introduce a good amount of proximity and redundancy.

This research is described in detail in section "Achieving Heterogeneity and Fairness in Kademlia."

The research by Kenji Saito is on trust management. Kenji is trying to apply the i-WAT system to many applications including decentralized systems like Jabber (coupled with PGP identity), and web-based systems for WIDE project research community or for readers of a book.

Spontaneous contribution helps decentralized system to work correctly. And the research is a building block that could be applied by many decentralized systems like DHT, file sharing/caching, and sensor networks. The next step would be integrating between one or more DHT algorithms and barter transactions that i-WAT expects.

This research is described in detail in section "i-WAT: The Internet WAT System."

The research of Takaaki Ishida is unique. Takaaki's work realizes spatially sticky information between RF-transmitter devices using a very simple algorithm. A simulator is made to investigate how the algorithm works on random traffic patterns. His vision of applications includes ad-hoc advertisement and event notification in specific locations.

This research is described in detail in section "Design of Content Cruising System."

The research by Yusuke Doi enables peer groups managed on a DHT network to be used as the foundation of fine-grained node discovery. The work introduces a protocol to take intersection between sets managed on different nodes. It uses bloom filters effectively and reduces network traffic at risk of false positives.

With such an effective way to get intersection, a properly managed index of resources on DHT can be made into an effective resource discovery mecha-

nism. For example, intersection of peer groups (resource groups of peer nodes) gathered on peer's characteristic is fine-grained set of peers that have the characteristics.

This research is described in detail in section "Peer Group Rendezvous with DHT."

Another work jointly done by those members is about pointer on an inter-overlay network infrastructure. The pointer notation is called Uniform Rendezvous Pointer (in short, URP). The most significant difference between regular URL/URI and URP is that URP does not just identify a resource. Instead, URP is a notation how a client should try to search among overlays and how the result would be verified and treated. Because resources on some overlays like Freenet and Gnutella is unstable and has no identity, neither just an identifier nor locator would suffice in inter-overlays. URP would be an efficient glue between an i-WAT overlay network and other collaborative overlay networks.

This research is described in detail in section "Uniform Rendezvous Pointer."

3 Open Issues

To realize the communication model IDEON-wg proposes, we still have many open issues to be solved. To foresee the next steps of our research, we describe those issues here.

3.1 Measurement and Visualization

Measurement is always needed to keep a system well-formed and stable. For example, active DDoS should be detected quickly after the attack begun and blocked to prevent other normal traffic to fail. Visualization is also needed to make measurement understandable by human administrators.

But, measurement is always difficult for true distributed systems. IDEON expects all the systems have enough freeness. To ensure freeness, no central management point should be exist in the system.

Two evident examples are closely related with IDEON activity. One is DHT and the other is i-WAT. Those two are both true distributed, without authority nor checkpoint to pass.

A DHT system may have some shared seeding nodes. Like root servers of DNS, the system may mandate a node to contact some set of nodes before joining into the DHT network. With this seeding nodes, the system can take some sort of statistics and control. But this kind of checkpoint may put bottleneck on the system and most systems would take different approach. Possible approaches for DHT may be like random-sampling, automatic aggregation like aguri, and active event transmission over the overlays.

For i-WAT and other PGP-like systems, measurement is a more difficult issue. Communication model of those systems is truly ad-hoc peer-to-peer and no one other than the two communicating now can tell when and how the communication occurs. Difficulties may arise more if there is no daemonic node to process request except a user's jabber client (i-WAT case). In this case, there is no way to take measurement if the user is not on the net.

3.2 Multi Thin vs. Single Ultimate

We must investigate and select among the two evident architecture, multi thin (MT) overlay network and single ultimate (SU) overlay network. The goodness of MT overlay network is its extendability. For each new application and objectives, one can create its own overlay network that have tailored naming and routing system most suitable for the application.

At the same time, MT overlay introduces complexity. If there is no interconnection between each MT overlay that would be inconvinient. The resources on the overlay cannot be accessed from outside of the overlay. To overcome its restriction, one or some set of syndication mechanism would be needed.

Pros and cons of SU overlay network is just vice versa. SU overlay introduces widely-applicable naming and routing framework, thus most of application would be okay under the framework. But at the same time, a user who wants application beyonds the framework needs to modify the framework or to create a new and suitable framework for the application. One outstanding example of SU overlay network is Project JXTA (see `http://www.jxta.org/`).

3.3 Update and Transition Process

Architectures of overlay networks should include remote update functionarity. A overlay network is actually a coordination of programs on many nodes. This is totally distributed architecture thus update of the programs is not easy as update of server centric service. Moreover, transition from old network to new network would be a challenge like re-numbering of IP-network or transition from IPv4-only world to dual stacked world with IPv6.

(on later version more discussion would be here.)

4 Integration with (PG)^{3}A Working Group

(PG)^{3}A stands for *PGP/GnuPG Applications*, and the working group has been studying new trust mechanisms for distributed autonomous systems based on peer-to-peer authentications.

Since its activities are technically no longer bounded to usage of PGP, and the subject matter is closely related to many research topics in IDEON, the two working groups are going to be united to form a single group to pursue autonomy in distributed environments.

This section describes the past activities of (PG)^{3}A and the prospects of activities in IDEON in the future with respect to trust in distributed autonomous systems.

4.1 Brief History of (PG)^{3}A

(PG)^{3}A was established in October 2002. While its goal was deployment of PGP through development of PGP/GnuPG applications, its activities were focused on development of a new trust mechanism based on peer-to-peer authentication, using a sort of currency system to facilitate exchanges.

The following experiments have been conducted by (PG)^{3}A.

1. Evaluation of a free currency system as an application of PGP (WIDE Camp March 2003)

   i-WAT was introduced in this experiment. The objective was to evaluate the Jabber-based *i*-WAT system. Only seven participants could experience actual transactions, and the important finding was that even people with sufficient knowledge of PGP found the key exchange cumbersome. That led to the introduction of OMELETS below.

2. Verification of a cooperation mechanism using a free currency (WIDE Camp September 2003)

   OMELETS (Open, Modular and Extensible LETS[1]) was introduced in this experiment. A currency system called *WIDE Hour* was implemented as a web application using OMELETS. 166 WIDE members have been using WIDE Hour, and we are beginning to learn a lot about free currency exchange through the experiences.

4.2 Future of IDEON and Trust

Recent interests in *distributed algorithmic mechanism design* (DAMD) shows that researchers of distributed systems are beginning to pay more attention to incentives for cooperation and fairness of sharing resources.

DAMD is a unified efforts between economics (*mechanism design* part) and computer science (*distributed algorithmic* part). It is characterized by presence of strategies and payments. Participants of a distributed autonomous system behave selfishly, choosing strategies that would maximize the payments they receive. Abstraction of strategies and payments is one of the key issues of a DAMD design.

Since our interests are in autonomy, we are most interested when those strategies and payments are about barter relationships, connecting directly the parties of exchanges. The medium of such exchanges can be seen as a barter currency. One direction that IDEON can pursue is application of barter currencies to formation of distributed autonomous systems.

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[1] LETS (Local Exchange Trading System) is a form of community currency.