On the Discovery of Brokers in Distributed Messaging Infrastructures

Authors

Shrideep Pallickara, Harshawardhan Gadgil, Geoffrey Fox
Community Grids Lab
Indiana University

Presented by

Harshawardhan Gadgil
hgadgil@cs.indiana.edu

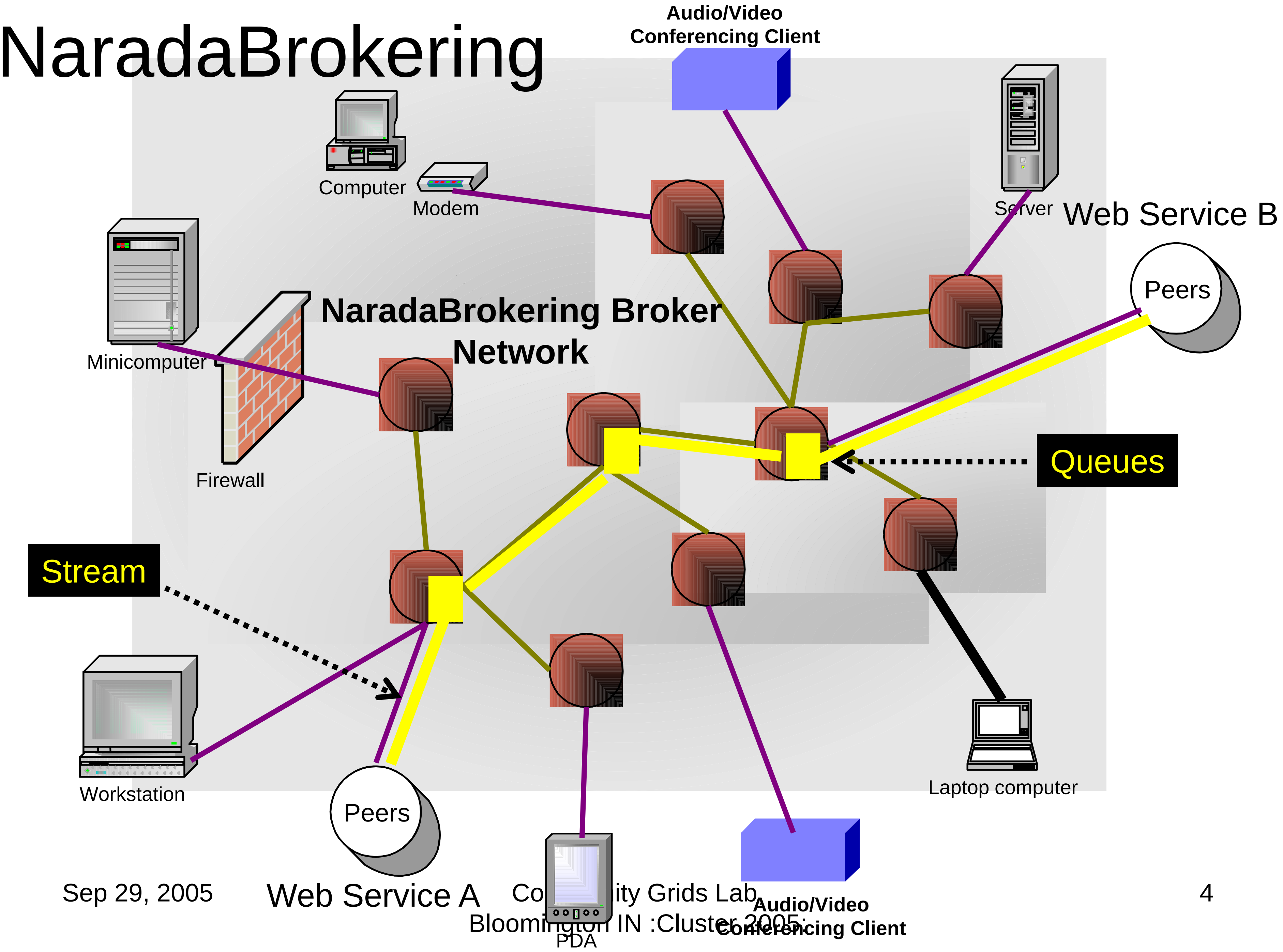
Talk Outline

- Overview of Distributed Messaging Architecture (NaradaBrokering)
- Motivation / Requirements
- Related Work & Our approach
- Some results
- Discussion of results

NaradaBrokering

- Distributed messaging middleware based on a network of cooperating broker nodes
  - Cluster based architecture allows system to scale in size
- Originally designed to provide uniform software multicast to support real-time collaboration linked to publish-subscribe for asynchronous systems.
- Project Website: **`http://www.naradabrokering.org`**

NaradaBrokering



NaradaBrokering Broker Network

NaradaBrokering Core Features

- Multiple protocol transport support
  - Transport protocols supported include TCP, Parallel TCP streams, UDP, Multicast, SSL, HTTP and HTTPS.
  - Communications through authenticating proxies/firewalls & NATs. Network QoS based Routing
  - Allows Highest performance transport
- Subscription Formats
  - Subscription can be Strings, Integers, **XPath** queries, **Regular Expressions**, **SQL** and tag=value pairs.
- Reliable Delivery
  - **Robust** and **exactly-once delivery** in presence of failures
- Ordered Delivery
  - **Producer Order** and **Total Order** over a message type. **Time Ordered** delivery using Grid-wide **NTP based absolute time**
- Recovery & Replay
  - **Recovery from failures** and disconnects. **Replay** of events/messages at any time. **Buffering** services.

NaradaBrokering Core Features

- Security
  - **Message-level** **WS-Security** compatible **security**
- Message Payload Options
  - **Compression** and **Decompression** of payloads
  - **Fragmentation** and **Coalescing** of payloads
- Message Compliance
  - Java Message Service (**JMS**) 1.0.2b compliant
  - Support for routing P2P **JXTA** interactions.
- Grid Feature Support
  - NaradaBrokering enhanced **Grid-FTP**. Bridge to **Globus** **GT3**.
- Web Service Support
  - Implementations of **WS-ReliableMessaging**, **WS-Reliability** **and** **WS-Eventing.**

Discovering Brokers

- Motivation
  - Peer-to-peer systems are very dynamic
  - Middleware manages scalability and availability to maximum extent ! HOWEVER...
  - Client's responsibility to discover the most appropriate broker that would maximize the its ability to leverage the services provided
  - Accessing the same broker over and over (statically configured) may lead to poor bandwidth utilizations and performance degradation

Desiderata

- The Discovery process must work on current state of broker network
  - Thus newly added brokers would be automatically and quickly assimilated
- Discovery process must be independent of failures within the brokering system
- Should result in better utilization of network and networked resources
  - Find the nearest (network distance) broker from the set of available brokers

Existing approaches

- IDMaps
  - Uses specialized nodes (tracers) that maintain the topology map of the network

    Shortest distance between A and B

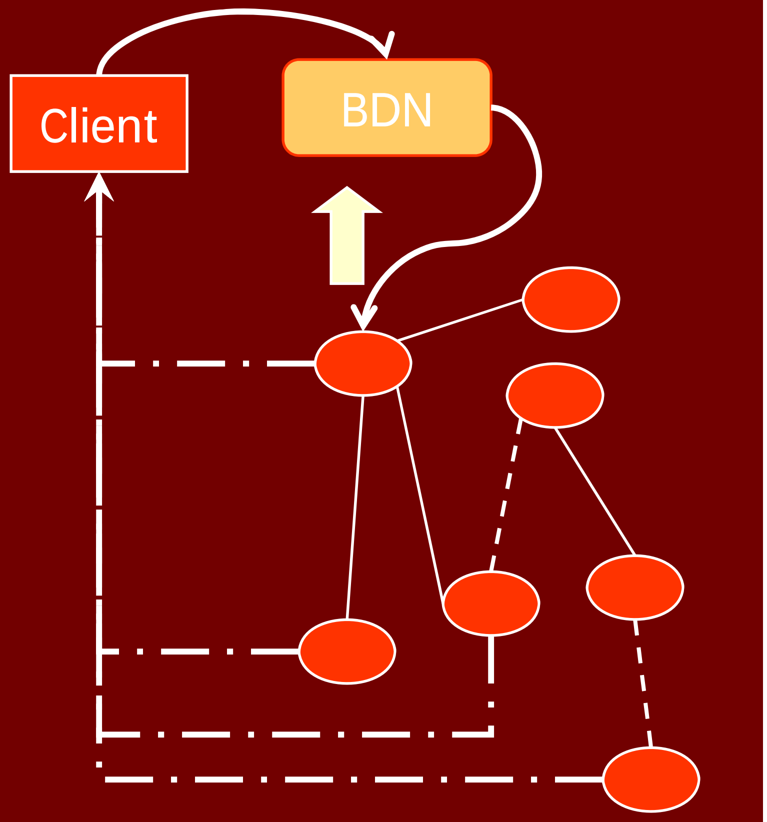
    $= D_{\boldsymbol{A-T1}} + D_{\boldsymbol{B-T2}} + SD_{\boldsymbol{T1-T2}}$
  - More the number of traces, better the accuracy of prediction. However requires internet-wide deployment of tracers
- JXTA uses rendezvous peers to match peers with matching constraints.
  - Requires knowledge of existence of these peers and means to connect to them

Existing approaches (contd.)

- Tiers approach uses hierarchical grouping of peers to improve scalability of the system
- Distributed Binning and Beaconing requires deployment of landmark entities to serve as reference points for proximity tests
- Global Network Positioning uses a distance function over a set of coordinates that characterize the position of the entity in the network to compute the nearest distance
  - The approach presented in this paper uses only UDP Ping to compute average Round-Trip time to calculate proximity

Our approach

- Broker Discovery Node (BDN)
  - Registry of existing brokers
  - Forwards **`BrokerDiscoveryRequest`** to registered brokers
  - As soon as a discovery request arrives, it is propagated to all connected brokers over a special topic
- Brokers matching requested criteria respond using UDP
  - Why UDP ? Unreliable, hence response OR lack of one is a good measure of availability of broker



Our approach

- Avoiding Flooding:
  - Each discovery request has a UUID. Broker keeps track of (say) 1000 UUIDs. If a request comes with a UUID already seen, then request is dropped and not propagated.
- The client constructs a Broker Target Set from a set of weighed metrics
  - Number of links, Total / Available memory, Response time
  - NOTE: Broker Target Set is very small (usually should be 3 – 5 OR less)
- The client then re-pings each broker from the target set to determine the nearest broker (OR uses some other criteria to determine the broker to connect to).

Advantages of our approach

- Not all brokers in the brokering network need to be registered with the BDN
  - In fact if only one broker is registered, it suffices.
  - What happens if broker network is partitioned ?
    - See next point...
- If BDN fails (OR there is a Broker network partition), discovery request may be propagated using multicast (if network configuration allows it)
- No deployment of special entities required for proximity analysis

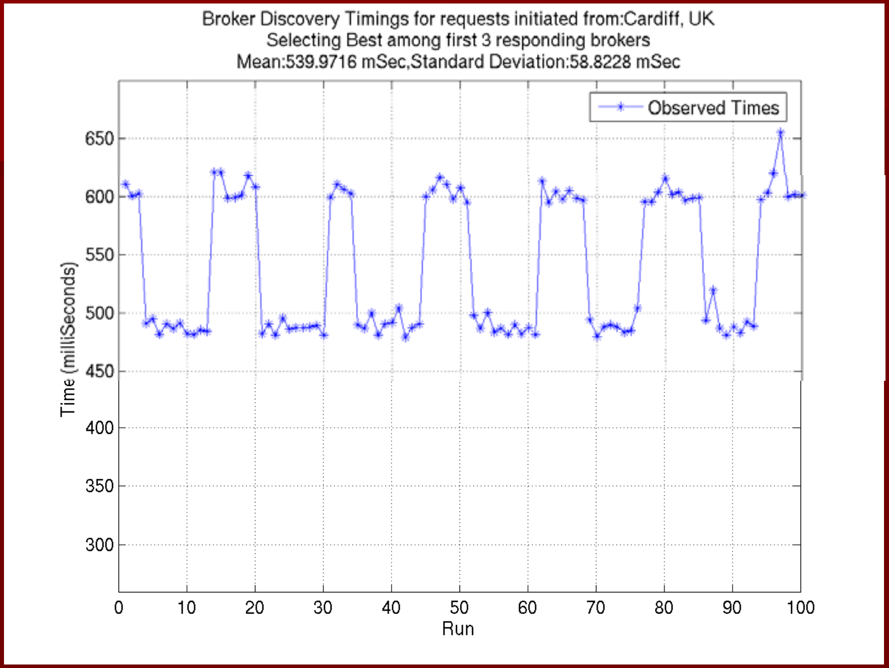
Advantages of our approach

- New brokers in the system are automatically incorporated to the discovery process
  - Since Broker Discovery response includes usage metrics, newly added brokers would be preferentially selected
- Private BDNs can be easily setup
- Approach ensures that the client connects to the nearest available broker if the client presents the right credentials

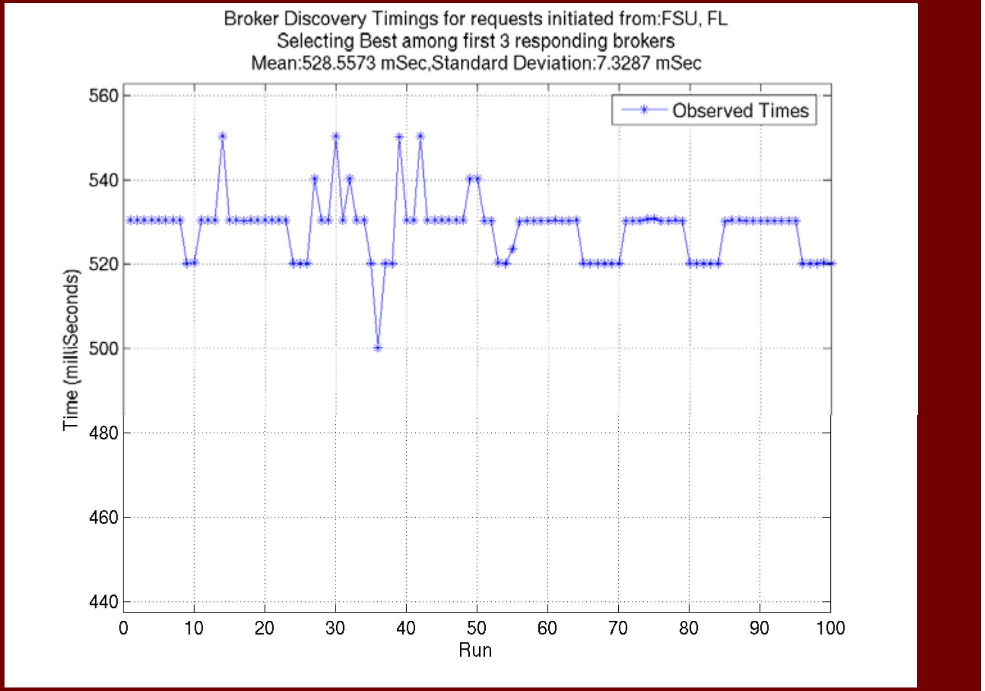
Some Results

- Distributed brokers in FSU (Tallahassee), NCSA, UMN (Twin cities), Cardiff (UK) and IU / IUPUI (Indianapolis)
  - High resolution timing (microsecond)
- Different topologies
  - Unconnected (None of the brokers connected to each other, All registered with BDN)
  - Linear (One broker registers itself with BDN, rest connected to this broker in a linear fashion)
  - Star (One broker registers itself with BDN, all others connected to this broker directly)
- Refer paper for complete set of results

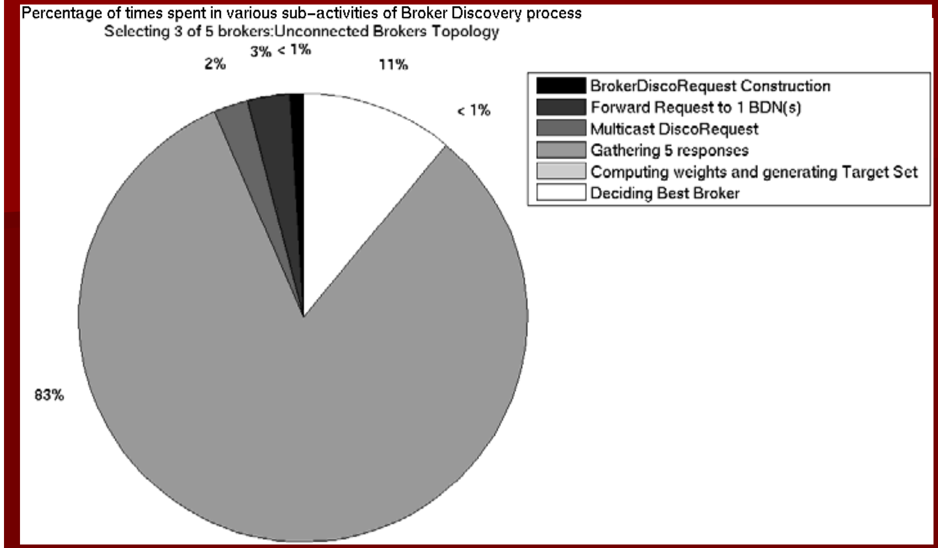
Results

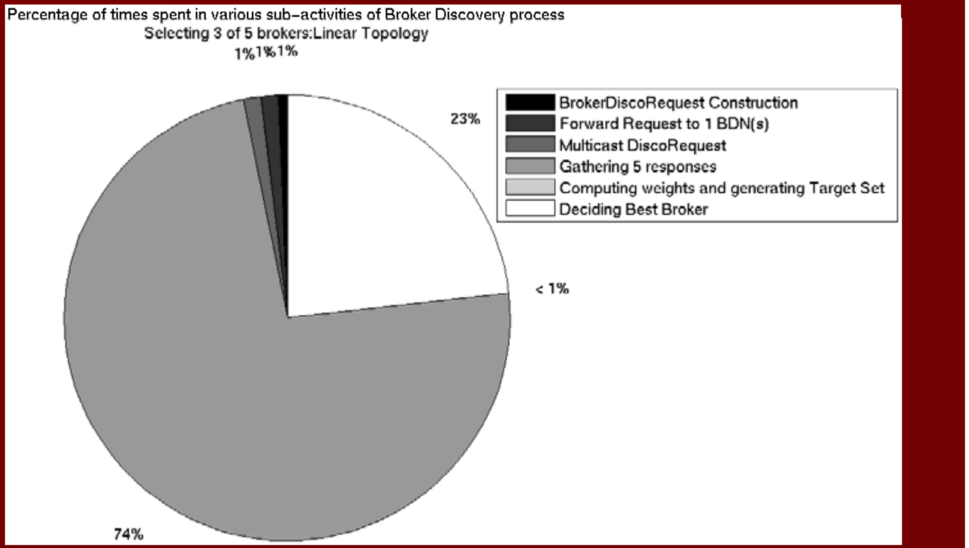


- Shown (Graphs for Discovery times when discovery is initiated from Cardiff, UK and FSU, FL)
- Average time to discover nearest broker
  - Approximately 350 – 550 mSec

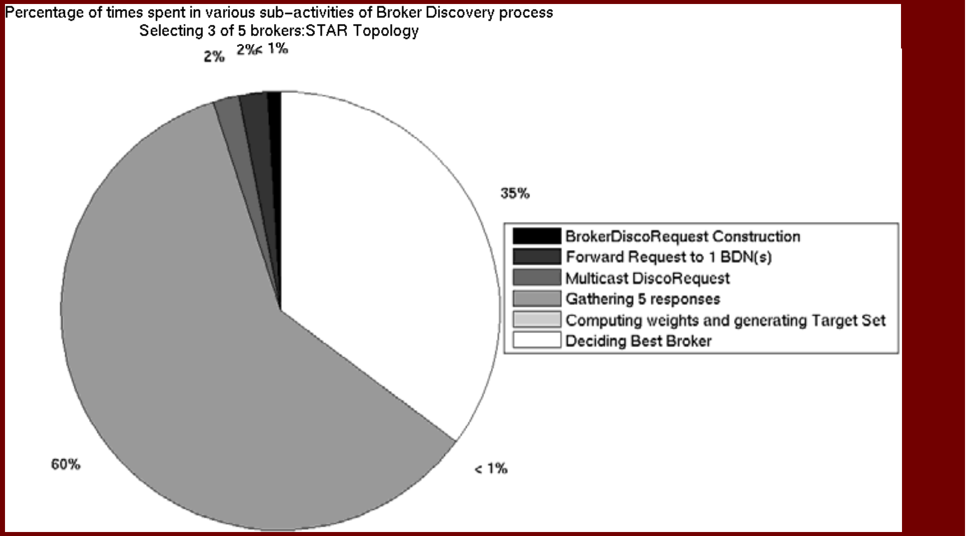


Results (contd.)


Percentage of times spent in various sub–activities of Broker Discovery process
Selecting 3 of 5 brokers:Unconnected Brokers Topology


Percentage of times spent in various sub–activities of Broker Discovery process
Selecting 3 of 5 brokers:Linear Topology

- Maximum time spent (60% – 80%) in gathering initial response to construct the BrokerTargetSet
  - Note this depends on how fast the discovery request propagates through the network which is dependent on the broker topology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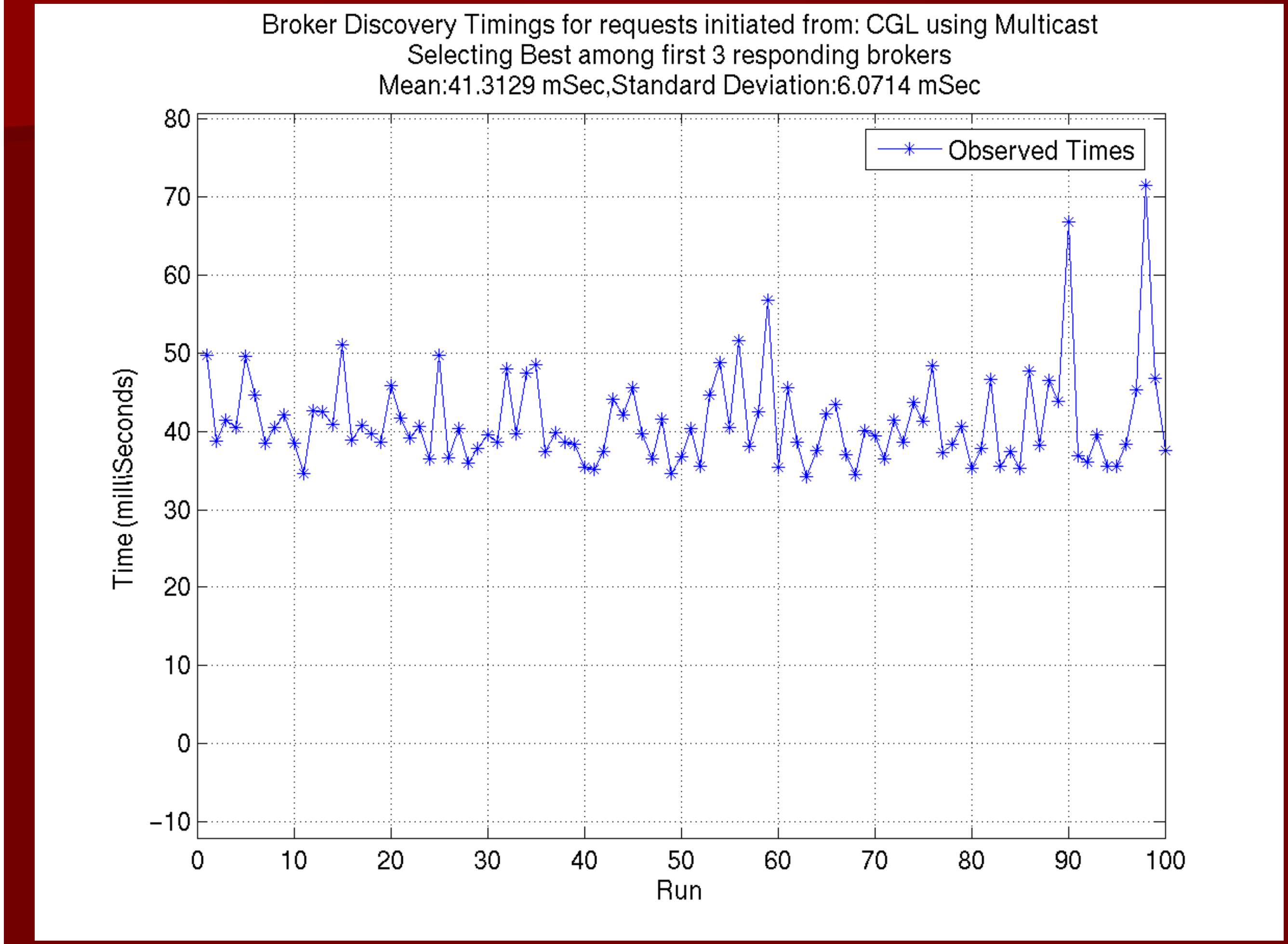
Results (contd.)



- Multicast whenever available (usually in local networks only) takes approximately abt. 40 mSec to find the nearest broker

Discussion

- Discovery process depends mainly on the network bandwidth.
- Maximum time spent in waiting for initial responses from brokers.
- Higher timeout
  - More time spent in overall discovery
  - BUT, more results gathered, possibly more accurate target set construction
  - NOTE: IF only few brokers exist OR only few brokers decide to respond then unnecessary waste of time
- Lower timeout
  - Less time spent in overall discovery
  - BUT, One risks gathering lesser number of responses from brokers
- Multicast works under the assumption that at-least 1 broker is reachable at the configured **`address:port`**

Discussion (contd.)

- Current scheme may be augmented with Security by encrypting Discovery Request/Response
- Requests from authorized clients only would be honored
- Not yet implemented but we tested to find the cost associated with such a scheme
  - Approx 6 mSec to validate a client certificate
  - Approx 25 mSec to Encrypt / Decrypt a Broker Discovery Request

Conclusion...

- Presented an architecture for discovering existing brokers
- Presented results in WAN (Wide area network) settings
- Security and private BDNs can easily be incorporated in our scheme

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Questions / Comments

- Any Questions / Comments ?

THANKS

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