Quality in P2P networks using principles from geometry

Competence Center NGNI

Michael Kleis, Thomas Hirsch

{kleis,hirsch}@fokus.fraunhofer.de

Fraunhofer Institute for Open Communication Systems

Overview

- Challenges in P2P Networks
- Geometric models and P2P Networks
- Mapping Functions
- Service Specific Metrics
- Service/Network aware optimisation of P2P Network Topology
- Pathological Cases and Problems
- Future Work

P2P/Overlay Networks

Challenges:

- P2P Network Topology:
  - Quality/Performance.
  - Scalability, distributed algorithms for management.
  - Routing (requests/data) should be “simple” and efficient.
  - Avoid partitioning of P2P Network (nodes join/leave dynamic).
- Quality, Service/Network aware optimisation of P2P Network:
  - Definition of service specific metrics for optimisation (e.g. “loss”, “delay”, “jitter” and/or “server load” in case of streaming).
  - Keep system performing over time.
  - Avoid “much” measurement overhead.

Geometric Topologies for P2P Networks

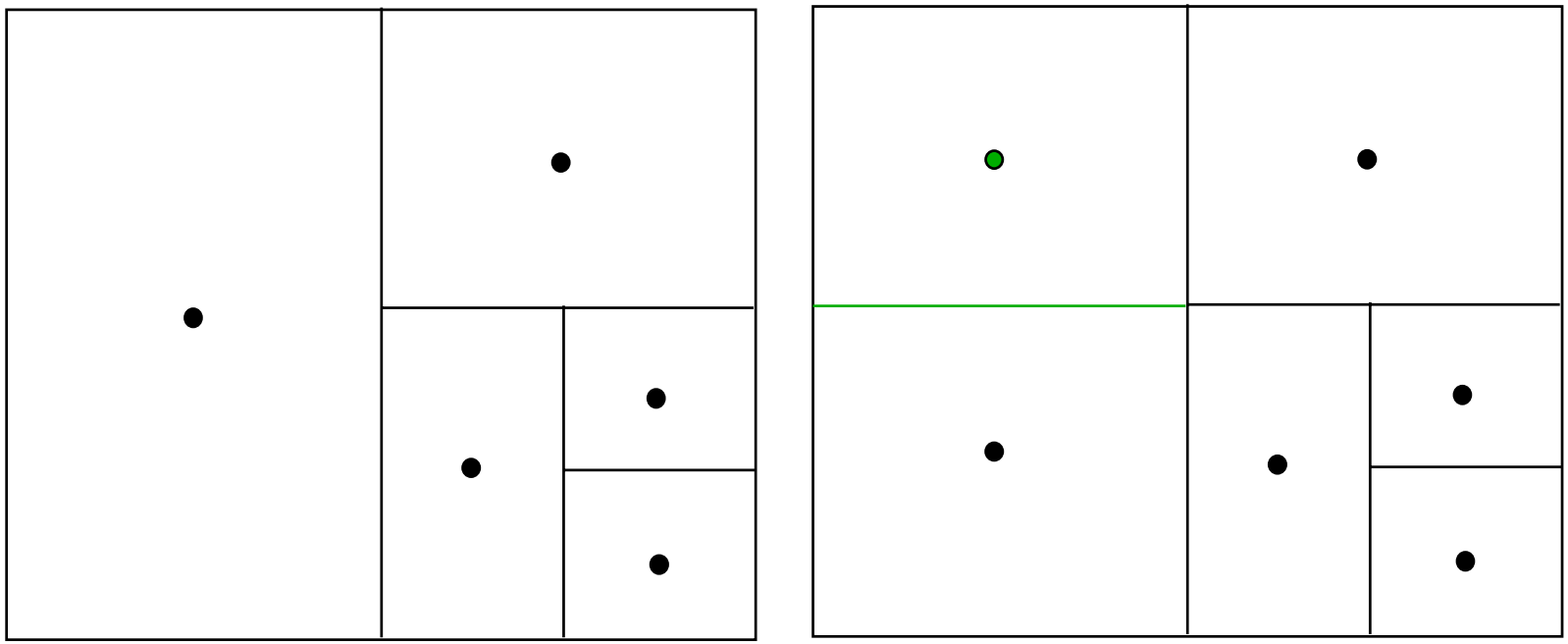
Advantages:

- Rich repository from Geometry available (CAN, Delaunay Triangulation, Voronoi Diagrams, HyperCubes).
- Routing can be based on “structure” (e.g. Compass Routing and Delaunay Triangulations).
- Proximity detection “easy” (e.g. Voronoi Diagrams).

Challenges:

- Mapping function for assigning “meaningful” geometric coordinates to a node needed.
- Mapping Trade-off: Scalability vs. Accuracy.
- How to keep the coordinate of a node meaningful over time ?

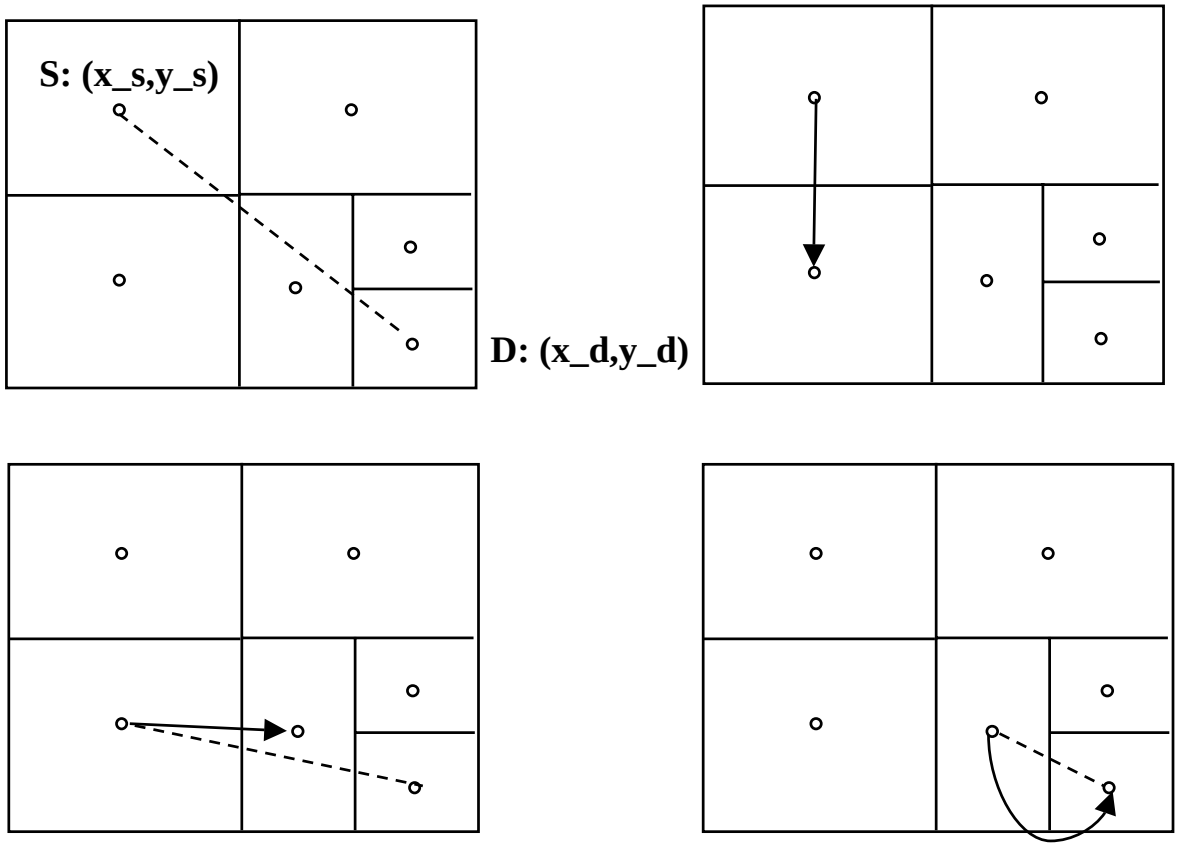
Geometric Topologies: Content Addressable Network (CAN)



Sylvia Ratnasamy, Paul Francis, Mark Handley, Richard Karp, Scott Shenker

„A Scalable Content-Addressable Network“, Proceedings ACM SIGCOMM 2001

Compass Routing in CANs



Geometric Topologies: Voronoi Diagrams/Delaunay Triangulations

Voronoi Diagrams for organisation of Nodes in Overlay/P2P Network:

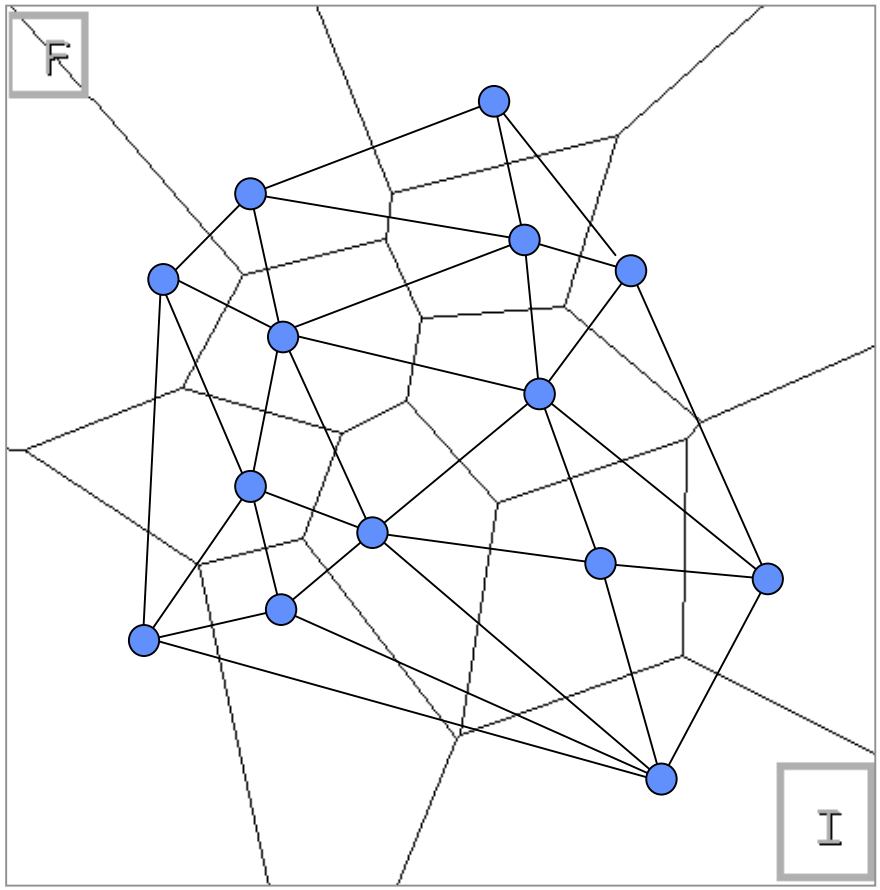
Routing: “Compass Routing”.

Broadcast: “Reverse Path Forwarding”.

Proximity detection: “easy” (Voronoi Diagram represents solution of “post office problem”).

Resilience: Neighbour relationship represents Delaunay Triangulation.

Distributed algorithms for management and recovery of node failures possible.



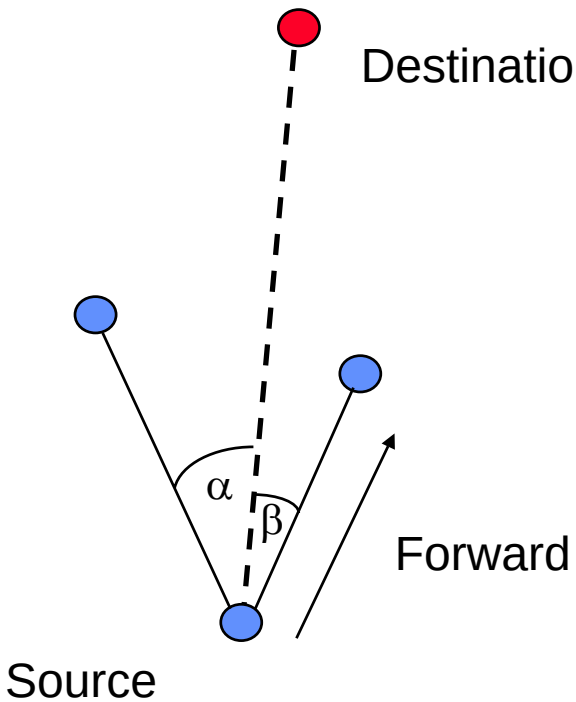
Jörg Liebeherr, Michael Nahas, Weiheng Si,

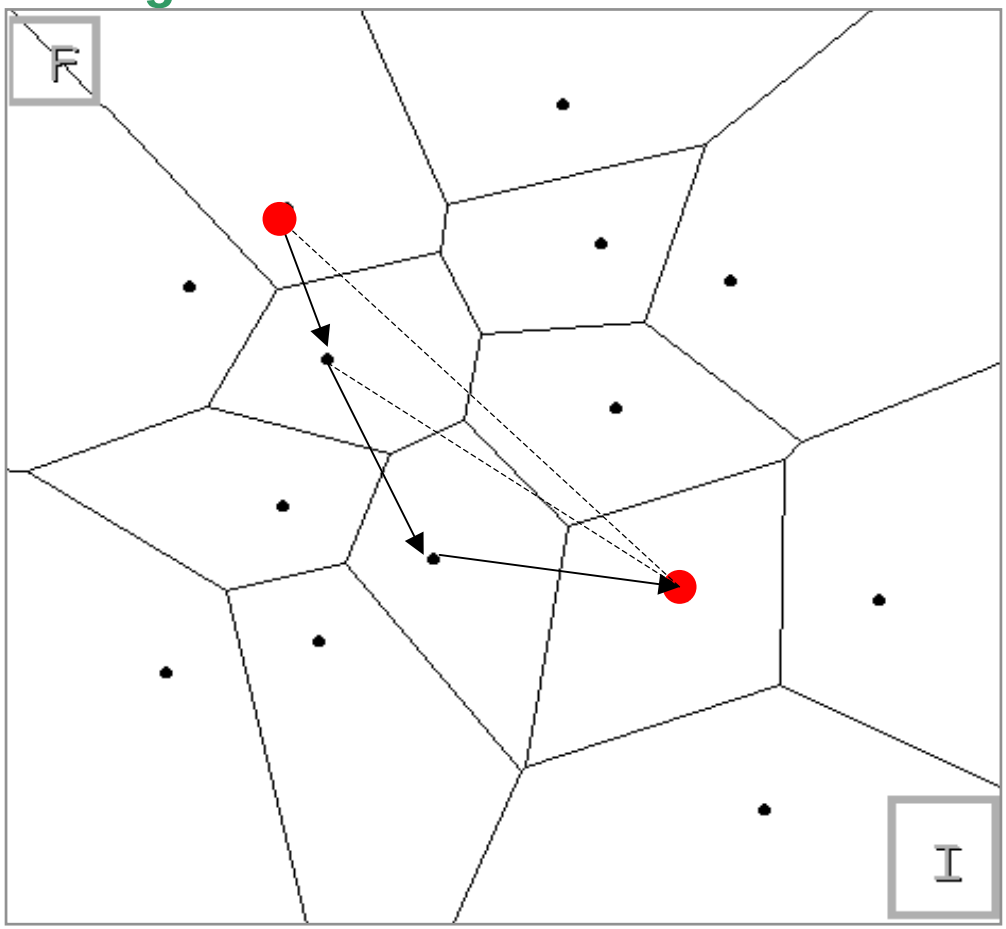
Application -Layer Multicasting with Delaunay Triangulation Overlays (2001)

`http://citeseer.nj.nec.com/liebeherr01applicationlayer.html`

Delaunay Triangulation/Voronoi Diagrams

Compass Routing:





Mapping Functions: GNP

Global Network Positioning (GNP) (by T.S. Eugene Ng and Hui Zhang)

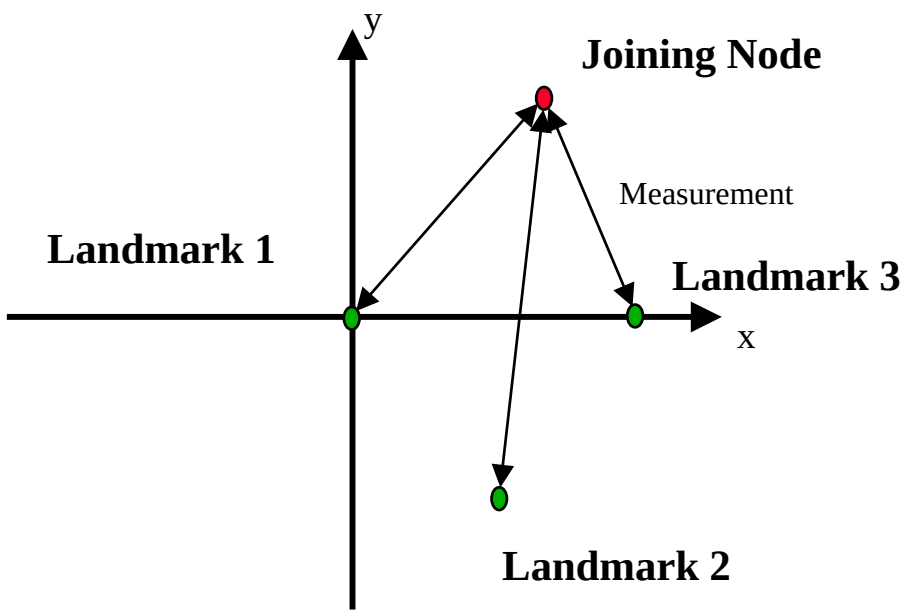
Landmarks and GPS principle for calculation of coordinates.

Heuristic used: Triangle inequality is valid in networks.

Number of landmarks can be constant (i.e. constant measurement complexity)

Service/Network aware optimisation:

- Measurement used by landmarks has to reflect service requirements.
- Nodes that have equal properties regarding the service specific metric are „near“ in the geometric representation.



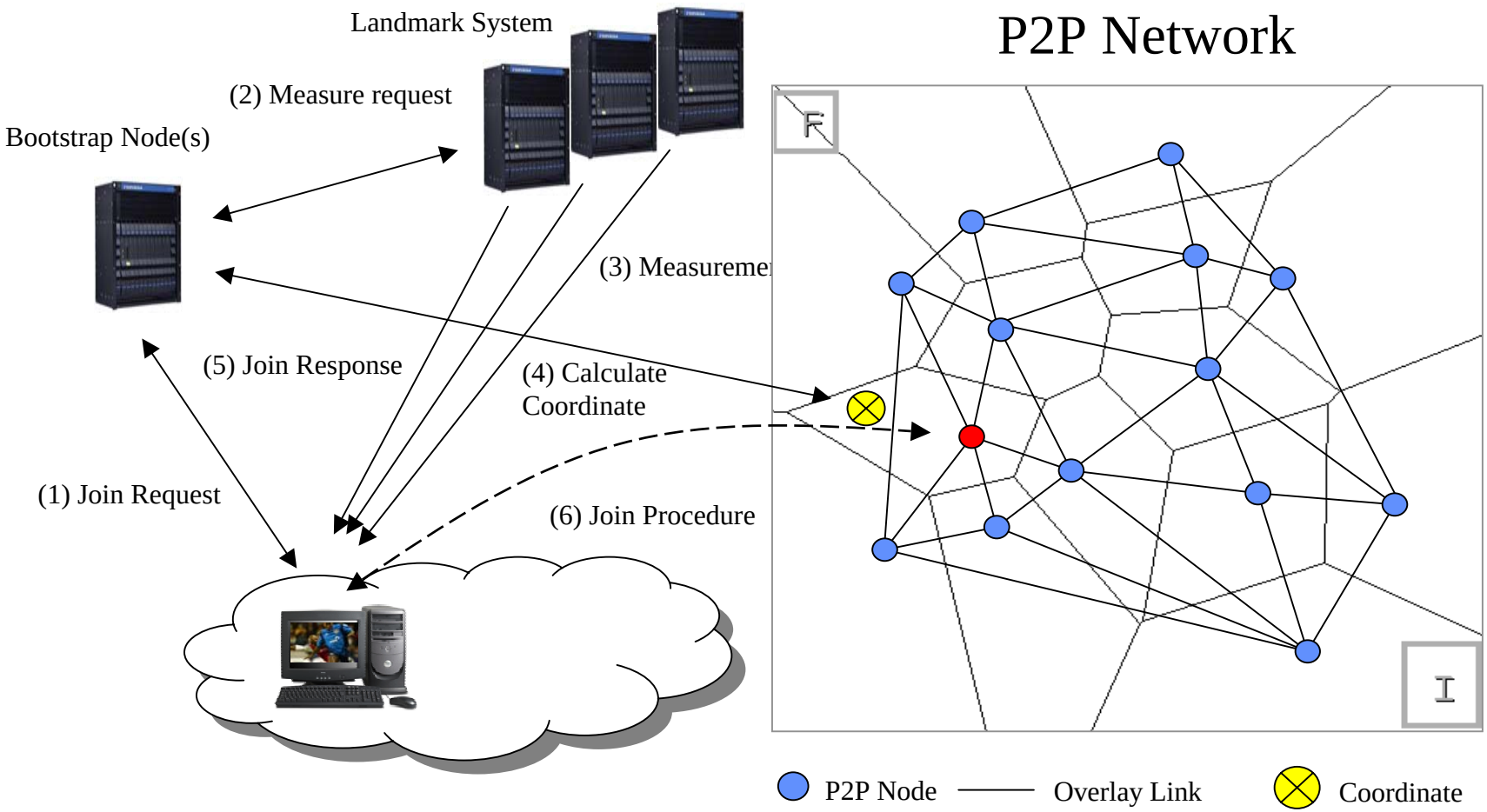
Mapping Functions: IDMaps

- Target: Nearest Mirror selection Problem.
  - Internet-wide infrastructure to collect distance information.
  - Distance metrics: hop count, round-trip time, minimum bandwidth.
  - Provides: long-term approximate distances, distance estimation between any two points on the Internet.
  - Does not provide: end-to-end application level performance, available bandwidth or current delay, characteristics of any “specific path”.
- IDMaps:
  - Tracer Infrastructure.
  - All hosts in an Address Prefix region are considered to be equidistant from the rest of the Internet.
  - Tracers measure distance between themselves and to APs -> Distance Map.

Service Specific Metrics and Quality in P2P Networks

- Aim: Use Geometric Topology and mapping function to optimise P2P/Overlay Network for Service Requirements.
- Interconnect nodes that are “near” in the geometric representation of the Network.
- Measurement used by mapping function for canonical optimisation:
  - Bandwidth: Packet Pair Method, Active Measurement.
  - Delay: Round Trip Time.
  - Loss: Hop Count (heuristic).
  - Application specific Metrics (load of system etc.).
- In the case of multiple requirements:
  - Every node may have multiple “identities” in the P2P Network.

Service Aware Optimisation of P2P Network using Proximity Detection

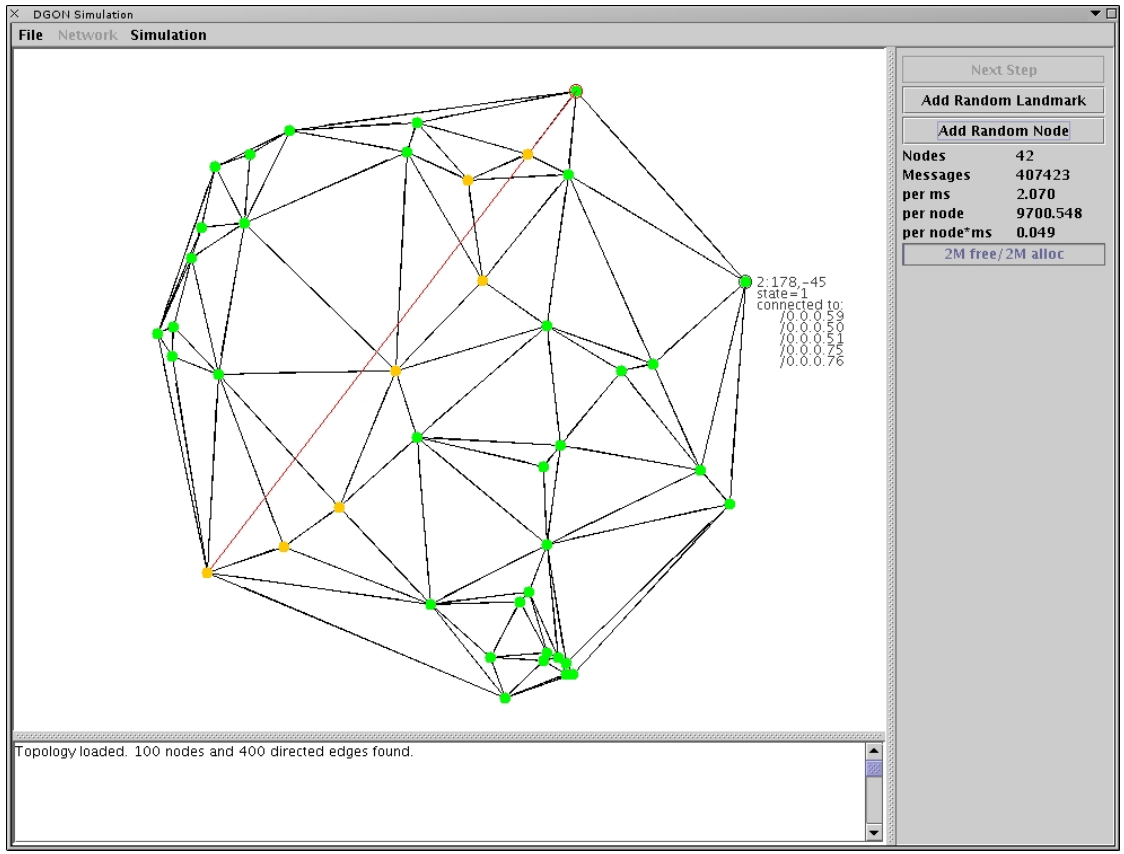


Pathological Cases and Problems

- Placement of landmarks is critical to the quality of resulting P2P/Overlay Network.
- Measurement used for placement is just a snapshot of the situation in the Network -> replacement strategy needed.
- Replacement changes node coordinate -> update of directory service or name service needed.
- Organisation of nodes in hierarchical (multi layer) topologies:
  - Leader election algorithms for choosing “local” Leader.
  - “local” Leader serves as router for long-distance communication.
- Security !

Current Simulation Environment (DGON)

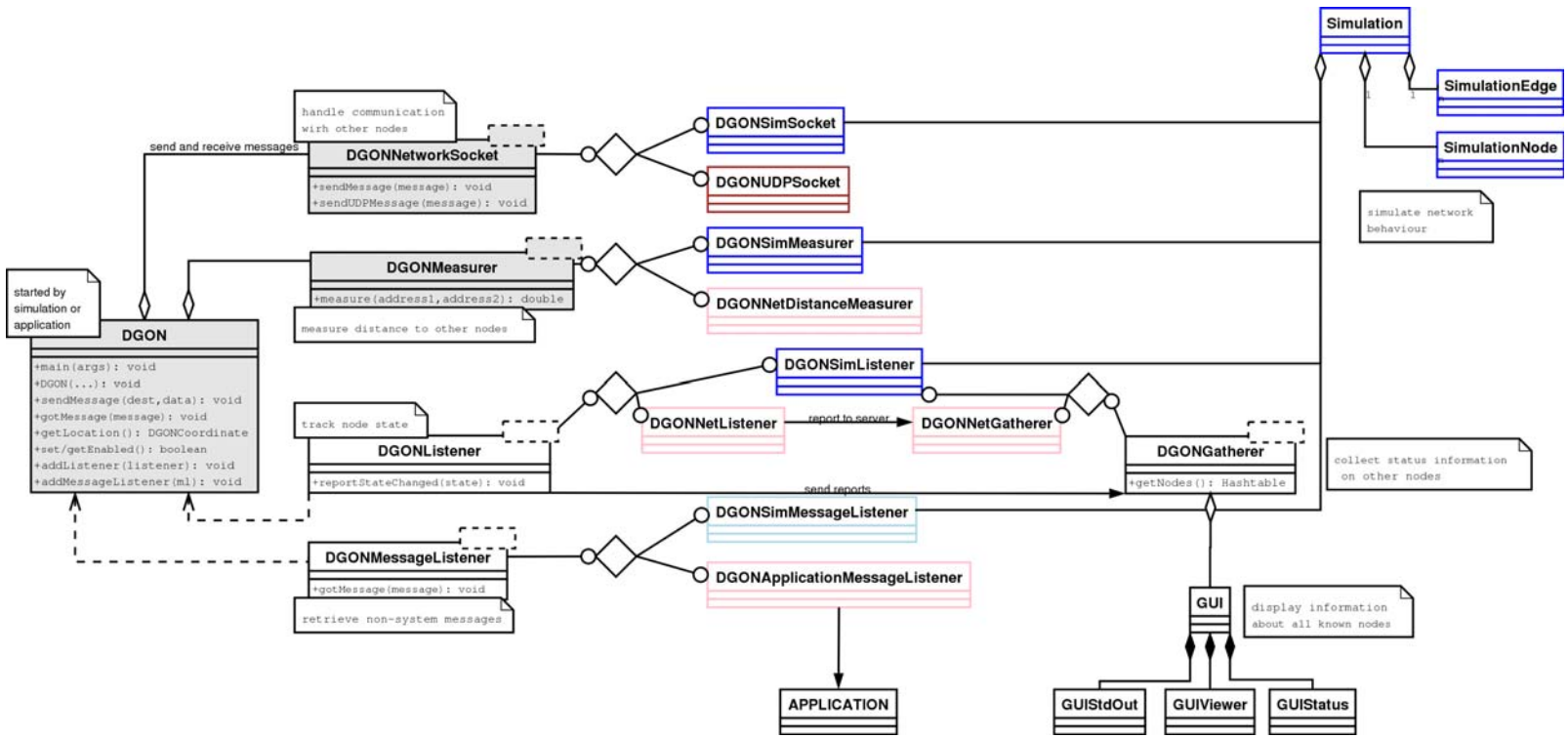
- Written in java.
- Imports Network Topologies generated by BRITE
- Implements FARA.
- GNP used for placement.
- Triangulation/Voronoi Diagram based.
- Compass Routing.
- Dimensions > 2 possible.
- Fully distributed.



Clark, D., Braden, R., Falk, A., and Pingali, V., **"FARA: Reorganizing the Addressing Architecture".** ACM SIGCOMM 2003 FDNA Workshop, Karlsruhe, August 2003.

BRITE: http://www.cs.bu.edu/brite/index.html

Current Simulation Environment



Overlay/P2P Networks for information distribution

Application-layer Multicast for distribution services on top of content delivery networks - CDN, or P2P systems.

Advantages:

- Error control (ARQ, FEC) and congestion control can be based on unicast solutions (e.g. in the case of streaming).
- Broadcast/Multicast services possible without IP Multicast infrastructure.
- Streaming content can be tailored to client / user (transcoding, targeted advertising etc.)

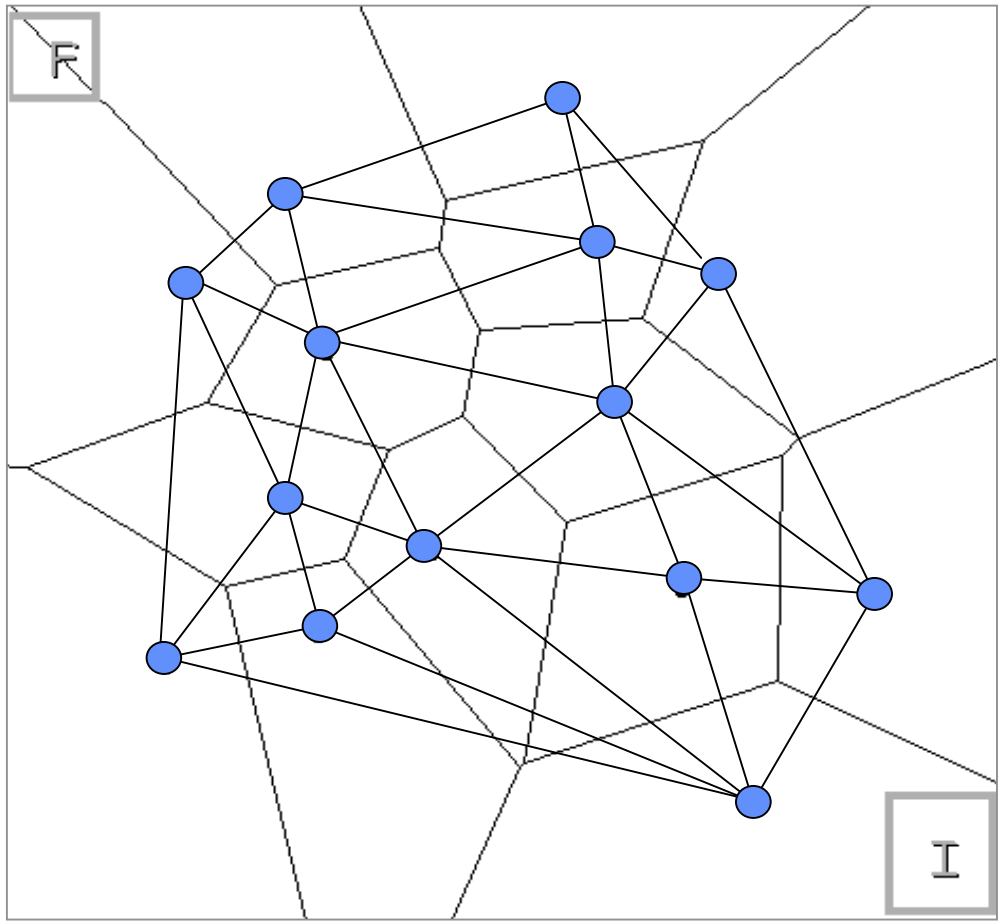
Disadvantages:

- Reduced efficiency compared to IP-Multicast (redundant traffic on physical links).

Application Layer Multicast

Possible Platform for:

- Broadcast of streaming data.
- Event notification.
- Policy distribution.
- Online gaming.



Future Work

- Keep the P2P/Overlay Network performing over time.
- Include FARA addressing and hierarchical approach.
- More simulation and measurements !
- Implementation of prototype.

Thank you for your Attention !

Questions ?