Hypercubes – A Scalable and Ontology-Based Peer-to-Peer Infrastructure for Semantic Web Services

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Deterministic and Semantically Organized Network Topology

Hypercube network is decomposed into concept clusters, containing peers associated with a particular combination of ontology concepts supported by those peers. Concept clusters are sub-hypercubes of top hypercube. Addressing scheme: Ontology concept coordinates represent logical conjunction of supported concepts, storage coordinates allow for multiple peers per cluster.

- Shortest path routing on ontology coordinates
- Flooding optimal broadcast on storage coordinates to reach all peers in concept sub-hypercubes
- Restricted optimal broadcast on ontology coordinates and logic minimization to answer queries consisting of conjunctions and disjunctions of ontology concepts
- Scales to millions of peers while allowing for complex queries and providing search guarantees at optimal routing behavior.

Ontology-Based Network Shaping

1. Algorithm
   - Based on deterministic buffering scheme
   - Remaining nodes cover positions of departing nodes
   - Hypercube in node connections

2. Properties
   - Self-healing: Recovery from node failures
   - Deterministic and Semantically Organized Network Topology

3. Joining peer

4. Optimal broadcast on hypercube topology

5. Shortest path routing to any peer

6. Interesting topology properties
   - Logarithmic diameter – bounded search times
   - Vertex symmetry – load balancing over nodes
   - Fault tolerance – protection against attacks
   - Efficient search and broadcast algorithms

7. Addresses of concept clusters

8. Ontology-based Network Shaping

9. Evolution of current Gnutella-style (power-law) networks

10. Best fit for dynamic service networks

11. Scalable, real-time, immediate

12. Poor scalability to large number of nodes

13. Incomplete search without guarantees

14. Long search times

15. Vulnerable against malicious attacks

16. Concept coordinates

17. Storage coordinates

18. Concept coordinates and storage coordinates address sub-hypercubes. Concepts are defined with positive integers (e.g., Concept A is sub-hypercube (1, 0, 2)).

19. Addressing scheme: Ontology concept coordinates represent logical conjunction of supported concepts, storage coordinates allow for multiple peers per cluster.

20. Shortest path routing to any peer

21. Network Topology

22. Ontology-Based Construction

23. Based Routing

24. Distributed Topology Construction

25. Algorithm
   - Always implicitly maintain topology of next biggest hypercube in node connections
   - Remaining nodes cover positions of departing nodes based on deterministic buffering scheme
   - Arriving nodes are able to join via any peer in the network and take over position(s) in the hypercube.