Wired Geometric Routing

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Hourglass Project
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Overlay Networks Are Great

Fault-tolerant storage and lookup → DHTs: Chord, Pastry, CAN, ...

Reliable Internet routing → RON

Data dissemination, multicast → SplitStream, Bullet, Overcast

Locality-aware apps: web caching, gaming, ...

?
Locality-aware Web Cache

Route message toward web server’s location

Routes converge at cache points

Web Browser + Proxy

(-40,22)

(-50,4)

(-42,-10)

(-25,-17)

(-17,12)

(-22,-25)

(-15,-14)

(0,8)

Web Server

Cache
Wired Geometric Routing

• Given: each Internet host knows its location
  – Geographic location, e.g. longitude/latitude
  – Network coordinate using latency embedding

• Given: 2-d Euclidean multi-hop routing [Hassin ‘01]
  – Exploit “sense of direction”
  – Compared to wireless routing: no broadcast, long links OK
  – Scaled-Theta Routing: $\log(N)$ state and delay stretch

• Contributions
  – Practical implementation: $k^d$, RT/churn, closest node
  – Parameter tradeoffs / behavior on real network
  – Building block for e.g. locality-aware multicast, caching
Geometric Routing: To Overlay Node

- Route message to overlay node location \( X \)
  - Analogous to \( \text{route}(\text{key}, \text{msg}) \) in DHTs
  - But routing path has low latency between \( A \) and \( X \)
Geometric Routing: To Closest Node

- Route message to closest existing overlay node
  - Useful when location is external to overlay network
  - e.g. finding closest web crawler to web server X
Scaled Theta Routing

- Sectors
- Rings
- Zones
Scaled Theta Routing
Scaled Theta Routing
Network Coordinates on PlanetLab

- High embed accuracy w/few dimensions (3-5)
- Overlay node churn; maintenance
Practical Routing on Network Coordinates

• From theory to practice
  ✓ Non-omniscient routing table formation
    • Inspired by Pastry join protocol
  ✓ Generalized $k^d$ zone assignment
    • Hyperspherical coordinates: $d-1$ angles
  x Local minima in closest node lookups

• Evaluation
  – Parameter trade-offs: effect sectors and rings
  – Closest node on real network
  – Closest node with churn
Closest Node Lookups

- How does a node know it’s the closest node?
  - Closest node lookups mean **holes** in routing tables
  - **Greedy** strategy doesn’t work anymore

C is **not** in A’s routing table because $|AB| < |AC|

- Reduce probability of this by increasing number of sectors
  - At most one node off in practice
  - Use sensor net approach?
Evaluation: Closest Node

Closest coordinate vs. true closest node
- 4d+h embed of MIT King data set (1740 DNS Servers)
- Designate 10% as targets
- Assigned “perfect” routing tables (rings=8; base=4; sectors=6)
- Found closest coordinate (1/10000); thus: embed error dominates

Found node 20ms further than true closest
Conclusions + Open Questions

- First cut at efficient routing on NC substrate
  - Fundamental building block like DHTs
  - Geometric meaning for solving network problems

- Open Questions
  - Geographic coordinates?
  - Behaviours/optimizations different NC sets / graphs?
  - Quantify/analyze path convergence?
  - Fleshing out applications; not Meridian/OASIS competitor
  - Unify routing between wireless and wired networks??
Check out Pyxida:
A Network Coordinate Service for PlanetLab

http://pyxida.sourceforge.net

Thanks. Any Questions?

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