Hyperbolic vs. Link-State Routing in NDN

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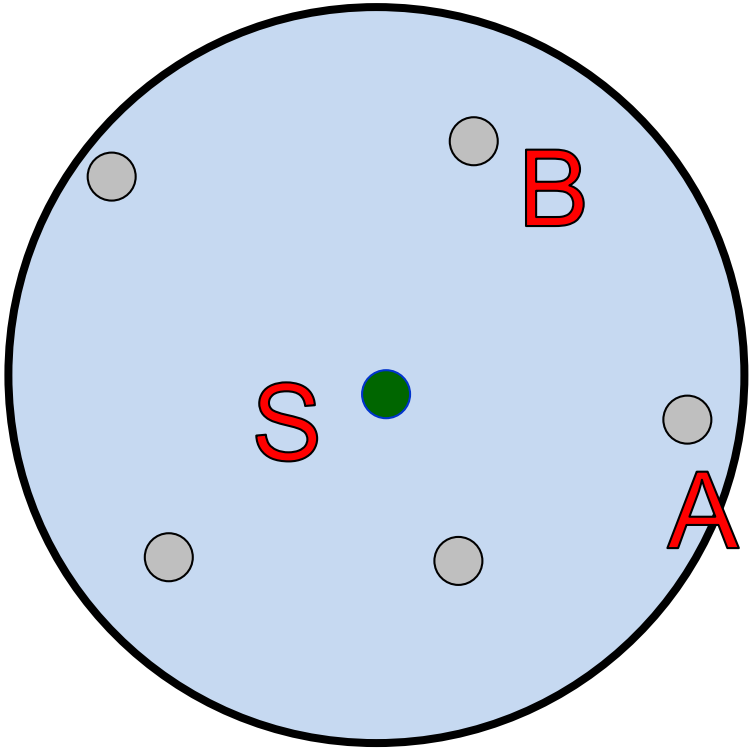
Routing Scalability in NDN

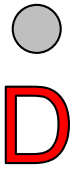
- Forwarding Information Base (FIB) in NDN could grow at an unmanageable rate
- Number of routing updates (overhead) to maintain consistent FIBs may also be costly
- NDN networks must scale in terms of name prefixes and routing protocol overhead

Hyperbolic Routing

Greedy geographic routing based on hyperbolic coordinates that encode network geometry



Destination	Next hops
D	{A, cost=10}, {B, cost=30}



To forward a packet:

- Find the neighbor closest to the destination
- Forward the packet to that neighbor

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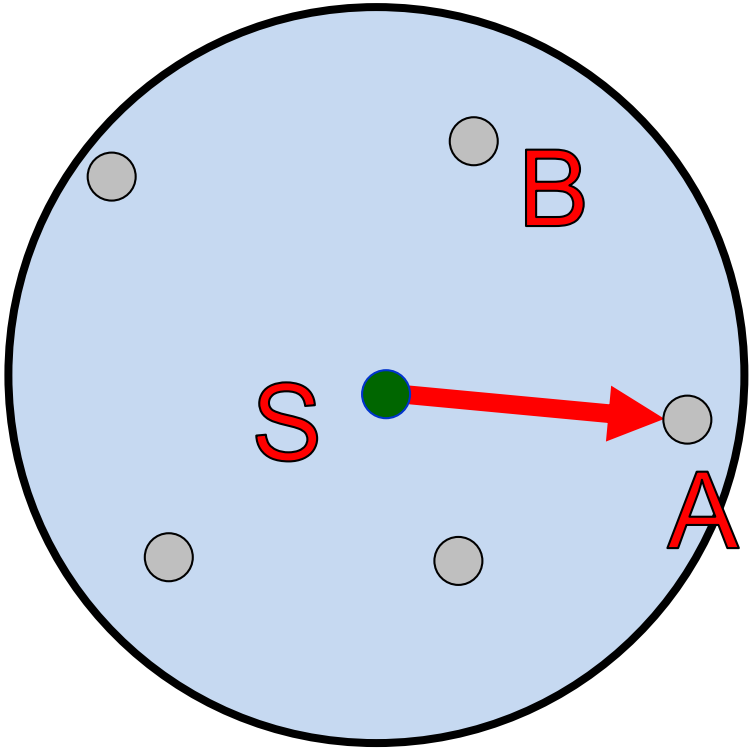

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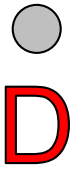

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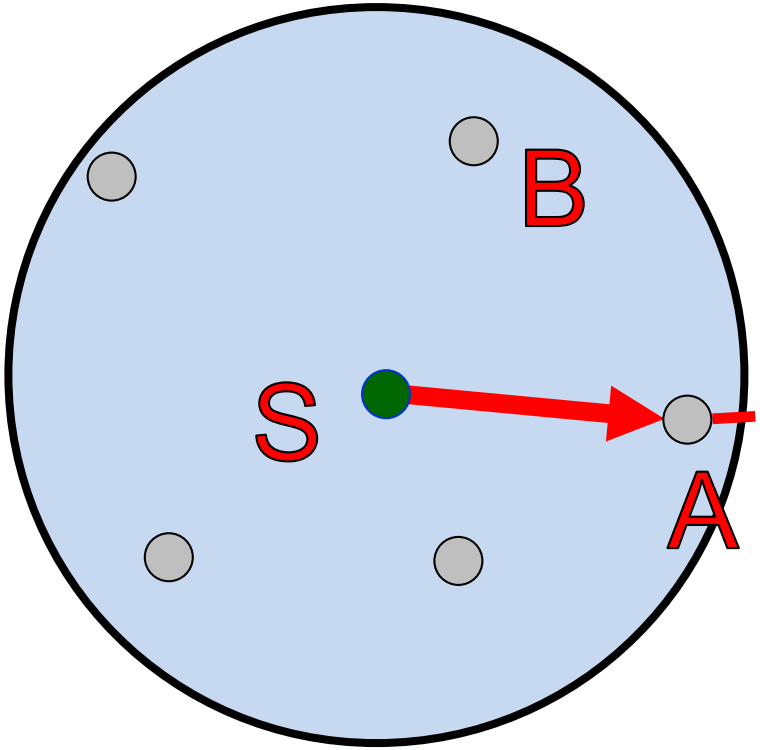

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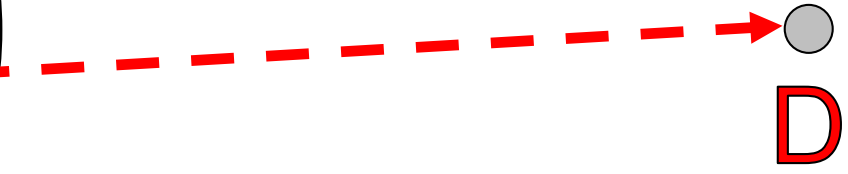

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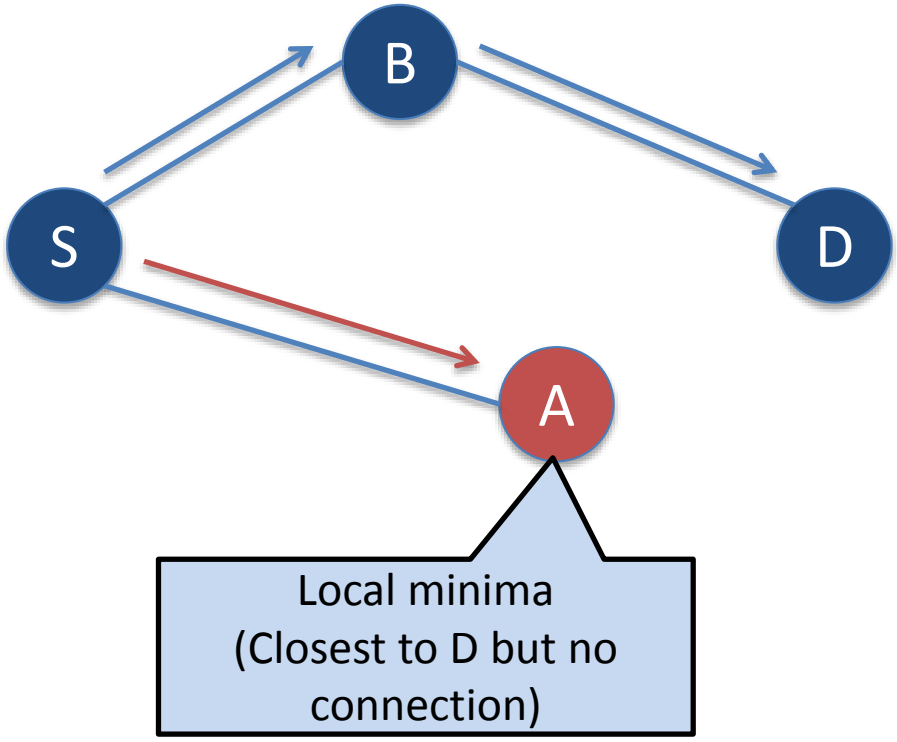
Why Hyperbolic Routing (HR)?

- In the ideal case, no FIB is needed
- Low communication cost

  Few routing updates, as coordinates rarely change
- Drawbacks?
  - Suboptimal paths
  - Local minima
  - Does not react to network dynamics
- **How to mitigate these drawbacks?**



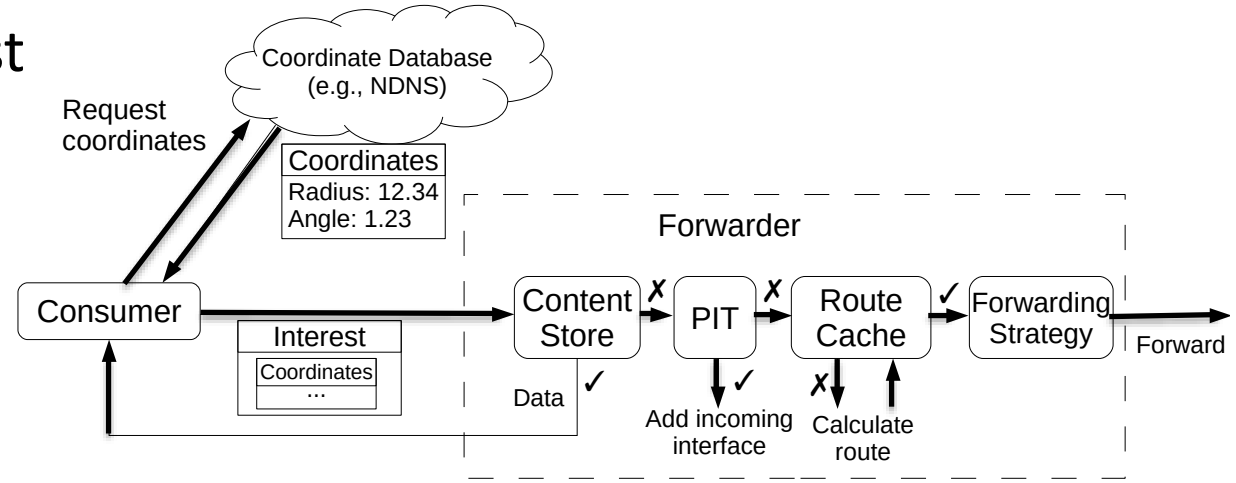
Forwarding Strategy

- Use Hyperbolic Routing's ranking as a hint, but probe alternative routes periodically

- Adaptive SRTT-Based Forwarding
  - Best SRTT-Based Forwarding
  - Probabilistic SRTT-Based Probing

HR Deployment in NDN

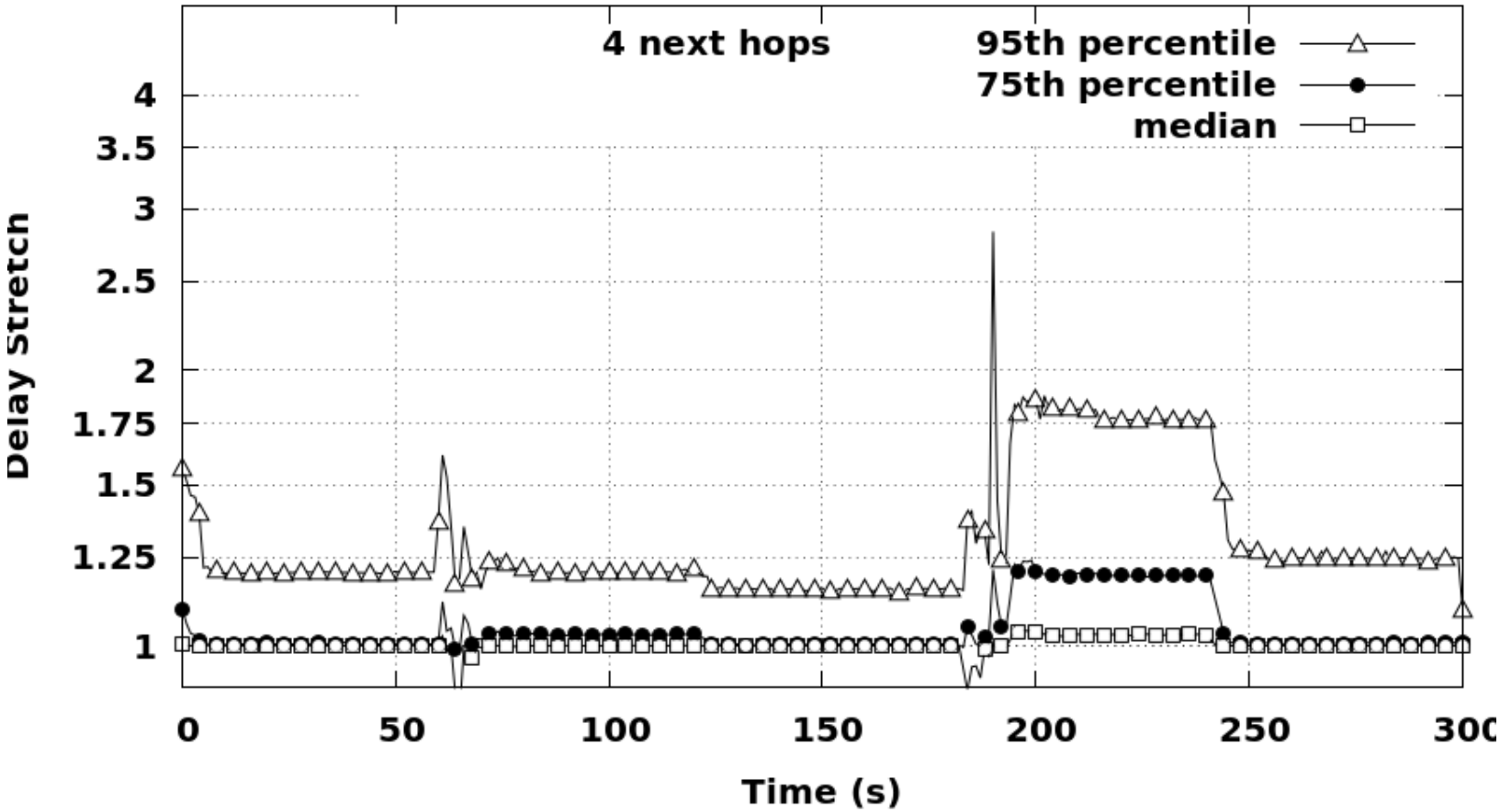
- Interest carries name and coordinates
- Forwarder picks next hop using neighbors' distances to coordinates
- Consumer can fetch coordinates from a distributed database (e.g. NDNS)
- **Note**: Name is first matched against CS, so still Data centric



Evaluation Goals

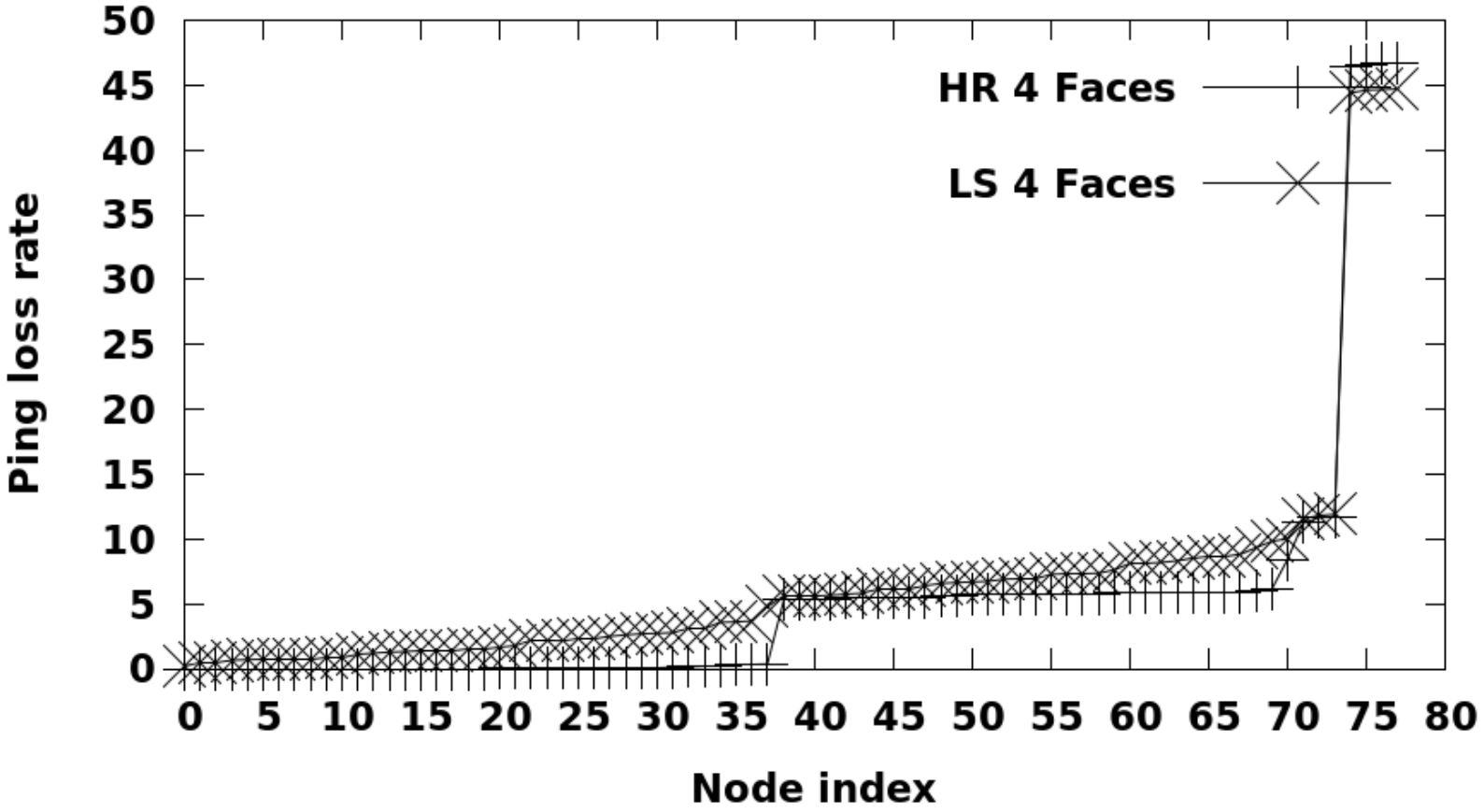
- We know HR has no FIB and updates, but:
  - Under HR, can forwarding strategy find optimal paths during failures and recoveries?
  - Is performance similar to link-state routing implemented by Named Data Link-State Routing (NLSR)?
  - Is probing overhead less than update overhead?
  - Does overhead scale as topology size increases?

Delay Stretch



Hyperbolic routing/ASF's delay stretch (over Link State Routing) has median close to 1 and 95th-percentile below 2.

Loss Rate


HR 4 Faces
LS 4 Faces
Ping loss rate
Node index
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80

Message Overhead

LS vs HR Per Node Overhead
Under MCN Failure

# Nodes	LS Overhead	HR Overhead
22	2.2 pps	0.28 pps
41	7.8 pps	0.28 pps
58	17.5 pps	0.36 pps
78	39.4 pps	0.47 pps