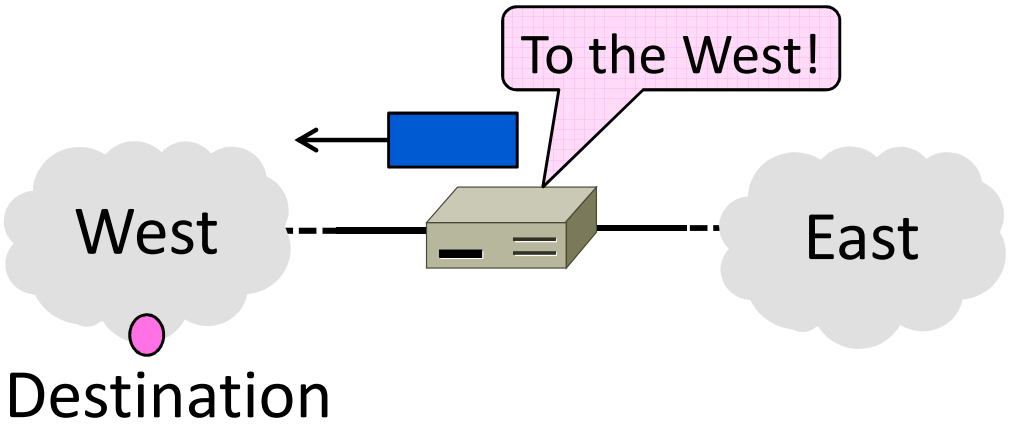
Introduction to Computer Networks

Hierarchical Routing (§5.2.6)

David Wetherall (djw@uw.edu)
Professor of Computer Science & Engineering
UNIVERSITY of WASHINGTON

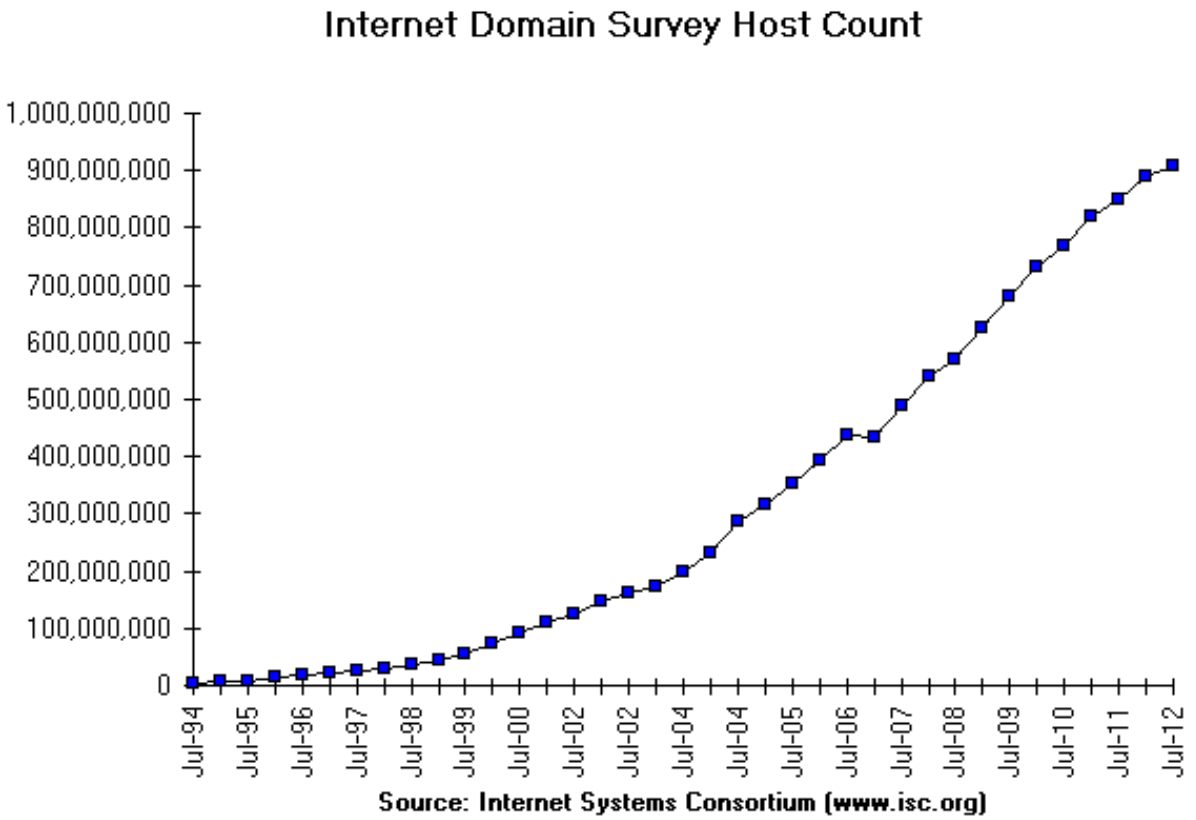
Topic

- How to scale routing with hierarchy in the form of regions
  - Route to regions, not individual nodes



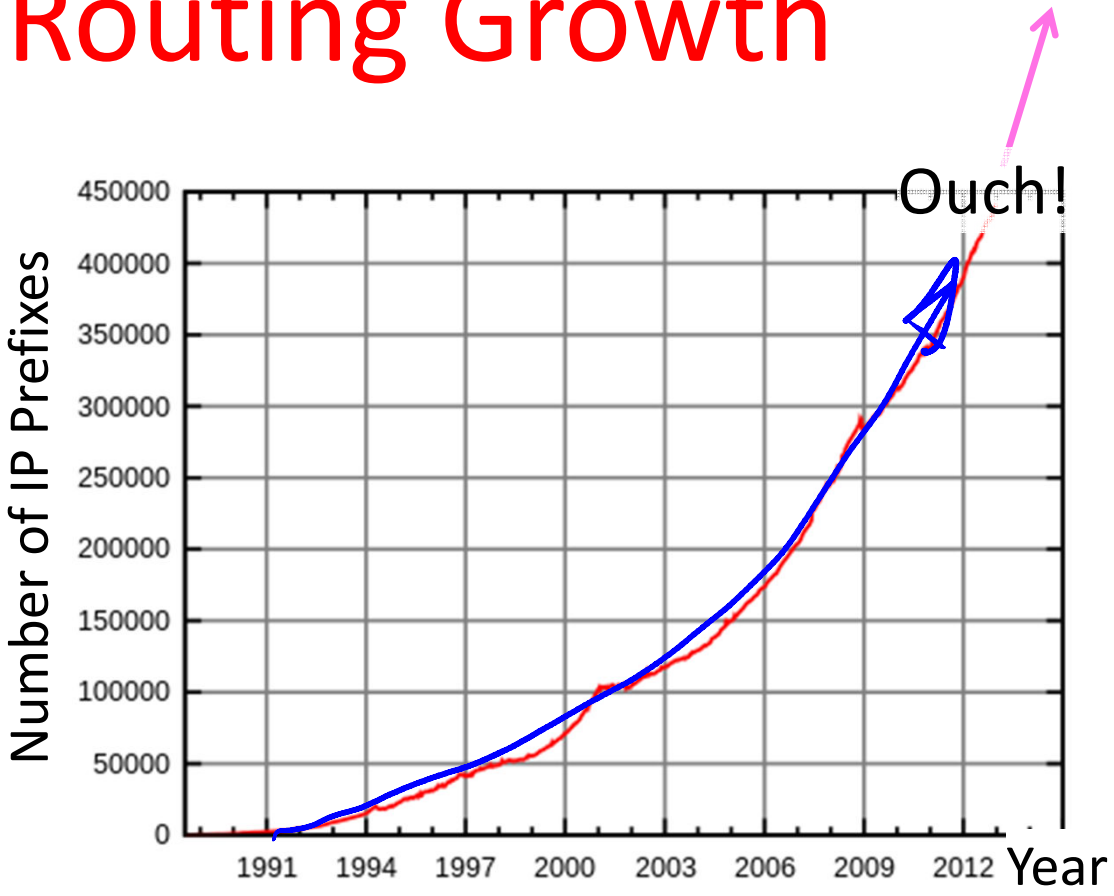
Internet Growth

- At least a billion Internet hosts and growing …



Internet Routing Growth

- Internet growth translates into routing table growth (even using prefixes) …



Source: By Mro (Own work), CC-BY-SA-3.0 , via Wikimedia Commons

Impact of Routing Growth

1. Forwarding tables grow
   - Larger router memories, may increase lookup time
2. Routing messages grow
   - Need to keeps all nodes informed of larger topology
3. Routing computation grows
   - Shortest path calculations grow faster than the size of the network

Techniques to Scale Routing

1. IP prefixes
   - Route to blocks of hosts

   } Last time

2. Network hierarchy
   - Route to network regions

   } This time

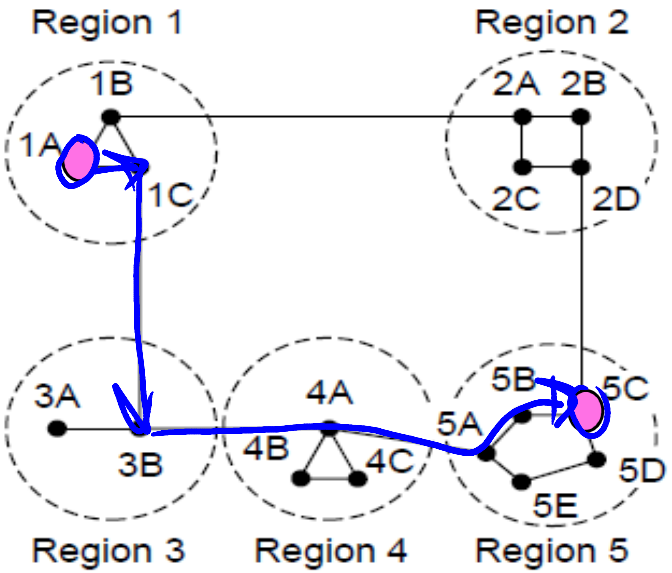
3. IP prefix aggregation
   - Combine, and split, prefixes

   } Next time

Hierarchical Routing

- Introduce a larger routing unit
  - IP prefix (hosts) ← from one host
  - Region, e.g., ISP network
- Route first to the region, then to the IP prefix within the region
  - Hide details within a region from outside of the region

Hierarchical Routing (2)



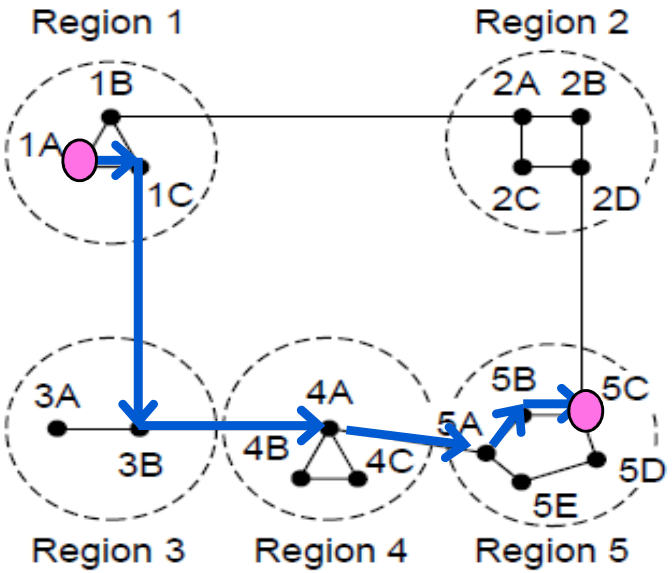
Full table for 1A

Dest.	Line	Hops
1A	–	–
1B	1B	1
1C	1C	1
2A	1B	2
2B	1B	3
2C	1B	3
2D	1B	4
3A	1C	3
3B	1C	2
4A	1C	3
4B	1C	4
4C	1C	4
5A	1C	4
5B	1C	5
5C	1B	5
5D	1C	6
5E	1C	5

Hierarchical table for 1A

Dest.	Line	Hops
1A	–	–
1B	1B	1
1C	1C	1
2	1B	2
3	1C	2
4	1C	3
5	1C	4

Hierarchical Routing (3)



Full table for 1A

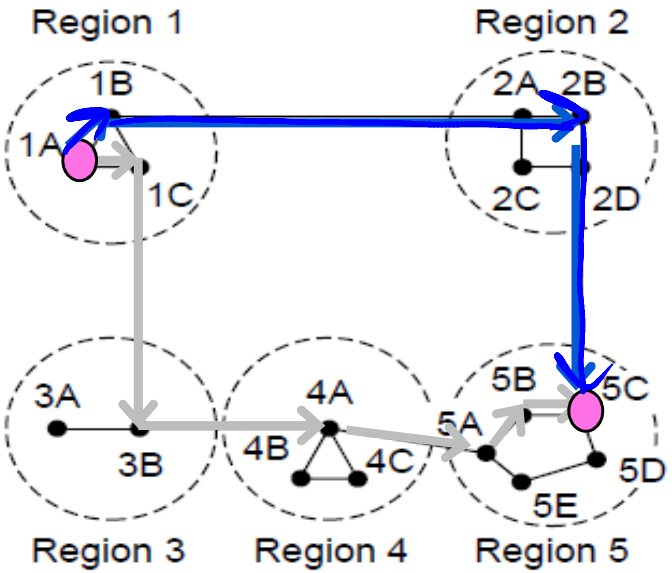
Dest.	Line	Hops
1A	–	–
1B	1B	1
1C	1C	1
2A	1B	2
2B	1B	3
2C	1B	3
2D	1B	4
3A	1C	3
3B	1C	2
4A	1C	3
4B	1C	4
4C	1C	4
5A	1C	4
5B	1C	5
5C	1B	5
5D	1C	6
5E	1C	5

Hierarchical table for 1A

Dest.	Line	Hops
1A	–	–
1B	1B	1
1C	1C	1
2	1B	2
3	1C	2
4	1C	3
5	1C	4

Hierarchical Routing (4)

- Penalty is longer paths



Full table for 1A

Dest.	Line	Hops
1A	–	–
1B	1B	1
1C	1C	1
2A	1B	2
2B	1B	3
2C	1B	3
2D	1B	4
3A	1C	3
3B	1C	2
4A	1C	3
4B	1C	4
4C	1C	4
5A	1C	4
5B	1C	5
5C	1B	5
5D	1C	6
5E	1C	5

Hierarchical table for 1A

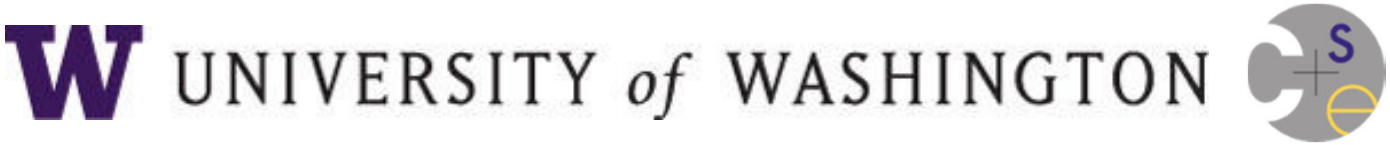
Dest.	Line	Hops
1A	–	–
1B	1B	1
1C	1C	1
2	1B	2
3	1C	2
4	1C	3
5	1C	4

1C is best route to region 5, except for destination 5C

Observations

- Outside a region, nodes have one route to all hosts within the region
  - This gives savings in table size, messages and computation
- However, each node may have a different route to an outside region
  - Routing decisions are still made by individual nodes; there is no single decision made by a region

END



© 2013 D. Wetherall

Slide material from: TANENBAUM, ANDREW S.; WETHERALL, DAVID J., COMPUTER NETWORKS, 5th Edition, © 2011. Electronically reproduced by permission of Pearson Education, Inc., Upper Saddle River, New Jersey