Compact Routing Schemes

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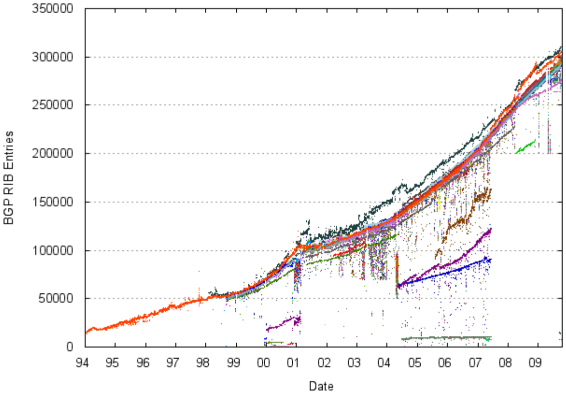
CS 598

Oct. 20, 2009

The Extremes

- Complete $\Omega(n)$ size route tables (Image Credits: Geoff Houston @ potaroo.net)



- Source routing with $\Omega(n)$ packet headers

A Mid-way Approach

- $\tilde{O}(\sqrt{n})$ routing tables at nodes
- $(1 + o(1)) \log_2 n$ -bit node headers
- Constant time routing decisions at nodes

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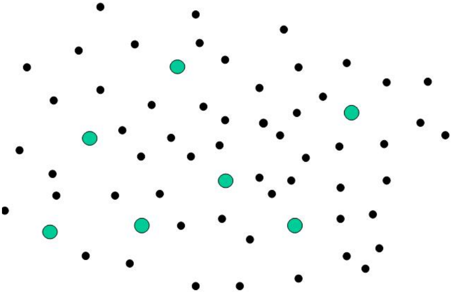
- $\tilde{O}(\sqrt{n})$ routing tables at nodes
- $(1 + o(1)) \log_2 n$ -bit node headers
- Constant time routing decisions at nodes

- Bounded increase in path length!

Centers

Pick a set of 'centers' A

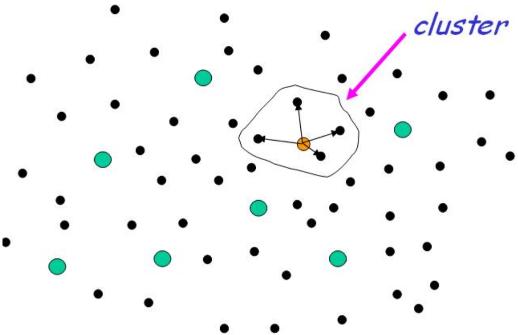


These images are from *Zwick's slides*

$\text{cent}_A(v)$ is the center closest to v

Clusters

$$C_A(w) = \{ v \in V \mid \delta(w,v) < \delta(A,v) \}$$

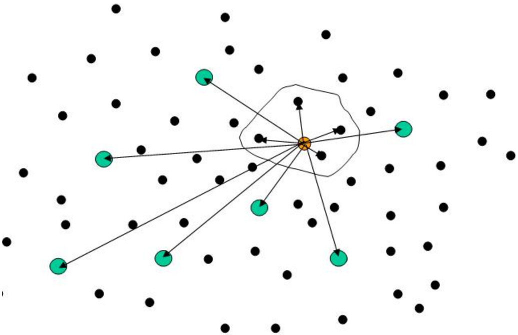


cluster$_A$(w) is the set of nodes closer to w than to any center

State at a Node

Every node v stores

- Shortest paths to all centers
- Shortest paths to all nodes in cluster$_A$(v)



Routing Method

For routing a message from u to v

- Case: $v \in cluster_A(u)$
  Route directly since shortest path is stored at v

- Case: $v \notin cluster_A(u)$
  Route through $cent_A(v)$ - shortest path to $cent_A(v)$, from there to v

Picking Centers

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algorithm center(G, s)
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$A \leftarrow \emptyset$; $W \leftarrow V$;

while $W \neq \emptyset$ do

{

$A \leftarrow A \cup \textbf{sample}(W, s)$;

$C(w) \leftarrow \{v \in V \mid \delta(w, v) < \delta(A, v)\}$, for every $w \in V$;

$W \leftarrow \{ w \in V \mid |C(w)| > 4n/s \}$;

}

return A ;

Stretch-3 Proof

If v $\in$ cluster_A(u), stretch $=$ 1; Otherwise the following theorem holds

Theorem

$\delta(u, cent_A(v)) + \delta(cent_A(v), v) \leq 3 * \delta(u, v)$

Stretch-3 Proof

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Theorem

*δ(u, cent$_A$(v)) $+$ δ(cent$_A$(v), v) $\leq$ 3 * δ(u, v)*

- Triangle inequality - δ(u, cent$_A$(v)) $\leq$ δ(u, v) $+$ δ(v, cent$_A$(v))

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- Triangle inequality - δ(u, cent$_A$(v)) $\leq$ δ(u, v) $+$ δ(v, cent$_A$(v))
- Symmetry - δ(v, cent$_A$(v)) $=$ δ(cent$_A$(v), v)

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Theorem

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- Triangle inequality - $\delta(\text{u, cent}_A(\text{v})) \leq \delta(\text{u, v}) + \delta(\text{v, cent}_A(\text{v}))$
- Symmetry - $\delta(\text{v, cent}_A(\text{v})) = \delta(\text{cent}_A(\text{v}), \text{v})$
- Since v $\notin$ cluster_A(u), $\delta(\text{cent}_A(\text{v}), \text{v}) \leq \delta(\text{u, v})$

Routing Decision Time and Header Size

- Node v's label contains (v, cent_A(v), port(cent_A(v), v))
- This label is carried in every message to v
- Use hash table at every node w, containing (v, port(w, v)) $\forall$v $\in$ A $\cup$ cluster_A(w)

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- Header size reduction depends on clever ordering and labeling of nodes and ports

Tree Routing, Handshaking and All That Jazz ...

- Stretch 2k - 1 requires O($n^{1/k}$) state at routers
- This involves use of more ‘loose’ structure than the global centers - tree covers!
  - Each router is included in a bounded number of trees
  - Each pair is connected by a stretch 2k - 1 path in at least one tree
  - Tree routing algorithms are then used on this tree cover
- Handshaking: exchange of information after which the stretch 2k - 1 path becomes known

Discussion?

- How practical are the header size reduction methods?
- What issues must be addressed before this can be deployed?
- What changes with mobility of nodes?

Thank You!