Compact Routing Schemes
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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
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

- Bounded increase in path length!
Centers

Pick a set of ‘centers’ $A$

These images are from Zwick’s slides

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**: $v \in \text{cluster}_A(u)$
  Route directly since shortest path is stored at $v$

- **Case**: $v \notin \text{cluster}_A(u)$
  Route through $\text{cent}_A(v)$ - shortest path to $\text{cent}_A(v)$, from there to $v$
Picking Centers

```
algorithm center(G, s)

A ← Ø ; W ← V ;
while W ≠ Ø do
{
    A ← A ∪ sample(W, s) ;
    C(w) ← {v ∈ V | δ(w, v) < δ(A, v)}, for every w ∈ V;
    W ← { w ∈ V | |C(w)| > 4n/s } ;
}
return A ;
```
Stretch-3 Proof

If $v \in \text{cluster}_A(u)$, stretch = 1; Otherwise the following theorem holds

**Theorem**

$$\delta(u, \text{cent}_A(v)) + \delta(\text{cent}_A(v), v) \leq 3 \times \delta(u, v)$$
Stretch-3 Proof

If \( v \in \text{cluster}_A(u) \), stretch = 1; Otherwise the following theorem holds

Theorem:

\[
\delta(u, \text{cent}_A(v)) + \delta(\text{cent}_A(v), v) \leq 3 \times \delta(u, v)
\]

- Triangle inequality - \( \delta(u, \text{cent}_A(v)) \leq \delta(u, v) + \delta(v, \text{cent}_A(v)) \)
Stretch-3 Proof

If $v \in \text{cluster}_A(u)$, stretch = 1; Otherwise the following theorem holds

**Theorem**

$$\delta(u, \text{cent}_A(v)) + \delta(\text{cent}_A(v), v) \leq 3 \times \delta(u, v)$$

- Triangle inequality - $\delta(u, \text{cent}_A(v)) \leq \delta(u, v) + \delta(v, \text{cent}_A(v))$

- Symmetry - $\delta(v, \text{cent}_A(v)) = \delta(\text{cent}_A(v), v)$
If $v \in \text{cluster}_A(u)$, stretch = 1; Otherwise the following theorem holds

**Theorem**

$$\delta(u, \text{cent}_A(v)) + \delta(\text{cent}_A(v), v) \leq 3 \times \delta(u, v)$$

- Triangle inequality - $\delta(u, \text{cent}_A(v)) \leq \delta(u, v) + \delta(v, \text{cent}_A(v))$
- Symmetry - $\delta(v, \text{cent}_A(v)) = \delta(\text{cent}_A(v), v)$
- Since $v \notin \text{cluster}_A(u)$, $\delta(\text{cent}_A(v), v) \leq \delta(u, v)$
Node v’s label contains \((v, \text{cent}_A(v), \text{port} (\text{cent}_A(v), v))\)

This label is carried in every message to v

Use hash table at every node w, containing \((v, \text{port}(w, v))\) \(\forall v \in A \cup \text{cluster}_A(w)\)
Routing Decision Time and Header Size

- Node $v$’s label contains $(v, \text{cent}_A(v), \text{port}(\text{cent}_A(v), v))$

- This label is carried in every message to $v$

- Use hash table at every node $w$, containing $(v, \text{port}(w, v)) \ \forall v \in A \cup \text{cluster}_A(w)$

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

"I'LL BE BACK"