

Revisiting Compact Routing

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Based on work by/with several others, especially Dmitri Krioukov

Compact Routing

- A *routing scheme* is an algorithm to establish a set of paths in a graph and forwarding data (headers+tables)
 - Path stretch is $p(u,v)/d(u,v)$ where $p(u,v)$ is cost and $d(u,v)$ is minimum cost
 - A scheme's stretch is $\max(\text{path stretches})$; stretch 1 requires $O(n \log n)$ size
 - So, a fundamental tradeoff exists between stretch and size (tables+headers)
 - A scheme is *compact* if it has tables $< O(n)$, bounded stretch, $O(\log n)$ headers
- Universal CR can have table size $(\sqrt{n} * \log^2 n)$ with stretch ≤ 3 [TZ01]
 - Actually, slightly better than that [Chechik13]
 - Also holds with name independent labels (!) [AGMNT08]
 - And seems to keep most paths near their minimums on Internet AS graphs (!)
 - Graphs with power-law node degree distribution, strong clustering, “small-world” property
 - Stretch seems to be near the optimal (avg 1.1), avg table size 50 (up to 2200) [KFY04]
 - Indeed, *additive stretch* describes CR schemes on scale-free type graphs [BC04]
 - Remains attractive even with historical AS graph evolution [SP12]

So What?

- CR is theoretically attractive, especially for Internet-like graphs
 - Next theory challenge: a scheme (?) with tables $O(n^{1/k})$ with stretch $\leq 2k$
 - Using such schemes for dynamic (edge deleting) graphs at least linear [AGR89]
- Hierarchical routing on Internet-style AS graph is basically hopeless
 - Eg. Locator/ID split doesn't really help in reducing RT size fundamentally
 - Because both topology-dependent label tables *and* dictionary updates are needed
- But can a CR protocol be developed for Internet use?
 - Similar to our early-mid 2000's questions, 'infinitely scalable' looks iffy [KFCB07]
 - Communication cost and policy (and maybe processing delay) remain challenges
 - Communication cost for scale-free (and all) graphs routing at least $O(n)$ [KP08]
 - Note: see Stephen Strowes PhD thesis (Glasgow, 2012) which considers this too
- There is one other line of work to consider...

Routing with Greedy Embeddings [PR05]

- Compact routing literature provides strong bounds on size/stretch
 - By considering the topology of the routing graph and its node labels
- Another approach to routing is based on distance in a metric space
 - (M,d) with set M and distance function $d(u,v)$ obeys triangle inequality, etc.
 - Greedy routing (e.g., geo) entails hopping to a “closer to destination” node
 - In a space where node locations are labeled and neighbor distance is computable⁴
 - But this doesn't always work due to “dead ends” (see GPSR and face routing)
- It is possible to embed a topology and greedy route in some spaces
 - Such that reachability in the topology graph is *fully* maintained in the space
 - Not generally possible in Euclidean space, but *is so* in Hyperbolic [K07]
 - More to say, but see, for example: PIE protocol [HWT11; updated in 2013]
 - And even more recently, Forrest Routing [Houthoof et al 2015] and GZR [SWL15]

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