Revisiting Compact Routing

Presented by Kevin Fall

(kfall@cmu.edu)

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(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 <= 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 [Houthooft et al 2015] and GZR [SWL15]

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