EULER

Experimental UpdateLess Evolutive Routing

http://www.euler-fire-project.eu/

Main objective

Investigate new **routing** paradigms so as to design, develop and validate **experimentally** a distributed and dynamic routing scheme for the **Internet**. The resulting routing scheme intends to address the fundamental limits of current stretch-1 shortest-path routing in terms of routing table **scalability** but also in terms of **topology** and **policy dynamics** (perform efficiently under dynamic network conditions).

The range of routing paradigms that the project investigates covers a spectrum ranging from dynamic **compact routing** to **greedy routing** and its variants, e.g., **updateful** and **updateless**.

Routing system architecture

Formally described by

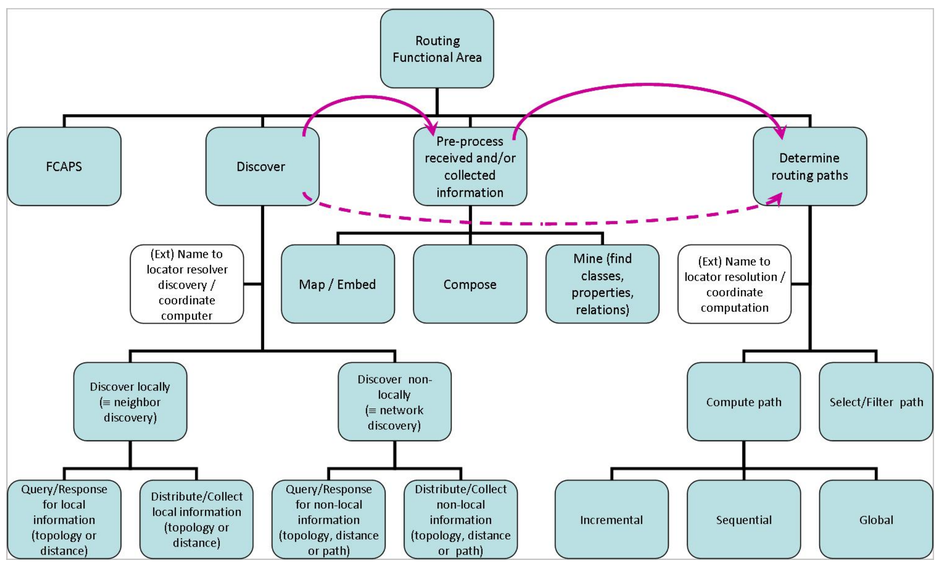
- Function and Procedural model
- Information and Data model
- State and State Machine model

Why routing system architecture driven approach?

- Common baseline –enabler
- Common "language" to prevent misinterpretation among different dimensions involved in designing routing system
- Structuring and cohesive role
- In computer communication context, leads to modular software development (and prevents duplicates)
- Driver for forward looking and for broad perspective
- Without such framework adding or removing functionality leads to further complexity (see IP control plane design today)

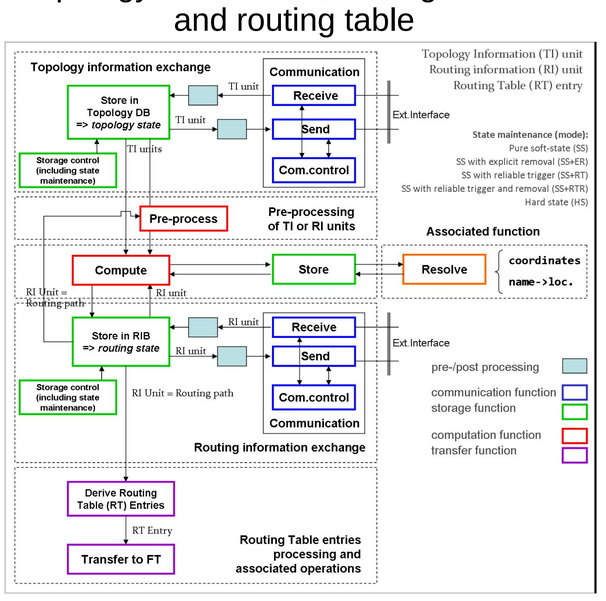
Hierarchical decomposition

of functional routing area



Block diagram

for topology information, routing information and routing table



Graph-based topology modeling and analysis

Construct by means of generative models the network topology as a graph that statistically verifies certain properties (known a priori to best characterize the topology).

Main challenge: model the evolution and the dynamics of the topology in order to derive properties usable for routing purposes.

Topology models

- Erdös Rényi
- Power law
- Configuration model
- Positive feedback preference
- Recursive matrix

Properties for **Compact routing**

- Chordality
- Doubling dimension
- Growth
- Treewidth

Properties for **Greedy routing**

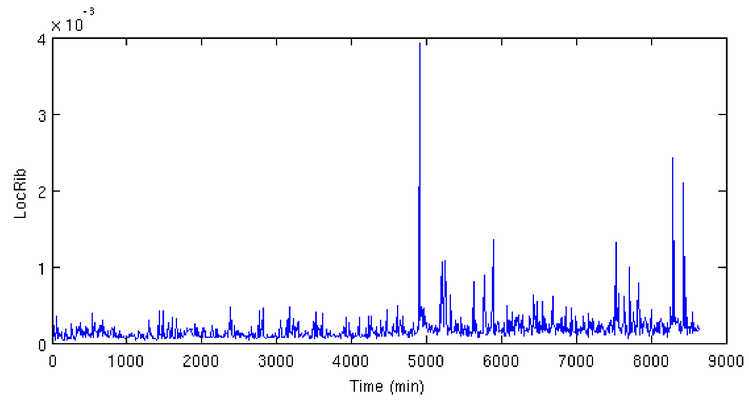
- Node degree distribution
- Joint node degree
- Clustering
- Centrality
- Hyperbolicity

Measurement-based topology modeling and analysis

Considers the network as a dynamic and evolving system known only through 'observables'.

Main challenge: model the network's characteristics using information derived from measurement (observation) measured at various time instants.

Example of **stability analysis** for selected routes of real BGP data



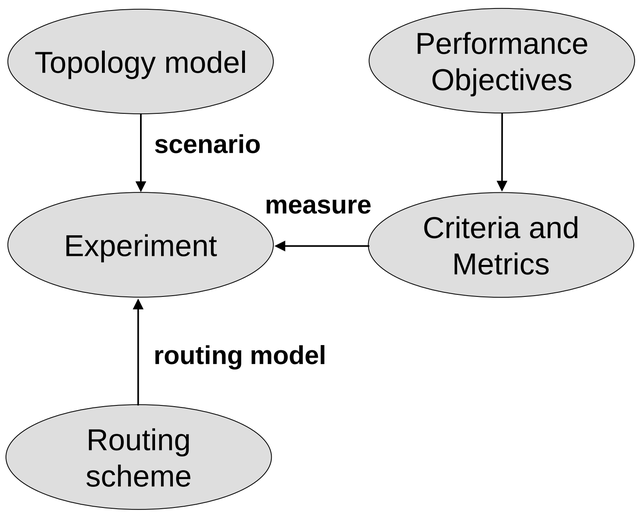
On average the Loc_RIB contains a few, 60-120, unstable routes (out of 318k)
During the 3rd day (5k minutes), 2 spikes indicate large changes in stability

Routing schemes and experimentation

To ensure **repeatable** and **reproducible** results common topology and traffic dynamics scenarios are considered. To ensure **verifiable**, and **reliable** results, a common set of functional and performance **objectives**, criteria and **metrics** are defined to be experimented on controlled tools (simulator, and emulator).

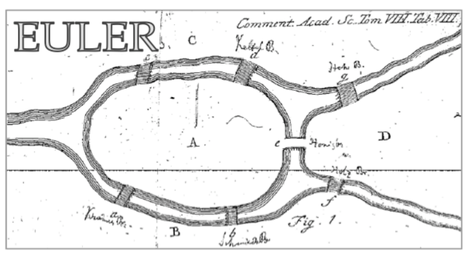
Objectives

- **Scalability**: number of routing table entries in the order of 10^9 (BGP supports today about 3.5 10^6)
- **Complexity**: both in time and space should grow sub-linearly with the routing protocol input size
- **Quality**: minimize the path length, and number of steps to reach a consistent and stable routing state
- **Adaptivity**: capacity to timely response when internal or external events occur (e.g., topology, and policy dynamics).
- **Availability**: maximize number of protectable routing paths while minimizing the recovery resources and stretch of protecting paths



Metrics

- **Stretch**: routing path length vs. min.path length for same (s,d) pair
- **Storage**: number and size of the (local) routing table entries
- **Complexity**: number of execution steps and resources needed to compute routing paths
- **Communication cost**: number, size and rate of routing updates
- **Convergence**: time to reach a stable state upon instability event
- **Fault-tolerance (coverage and time)**: number of reparable routing paths and time required to repair them
- **Forwarding table storage and delay**: number and size of forwarding entries and time to select outgoing interface
- **Throughput**, **delay**, and **packet loss** per routing path



Project information

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