GENI Backbone: Research

GENI Backbone Working Group

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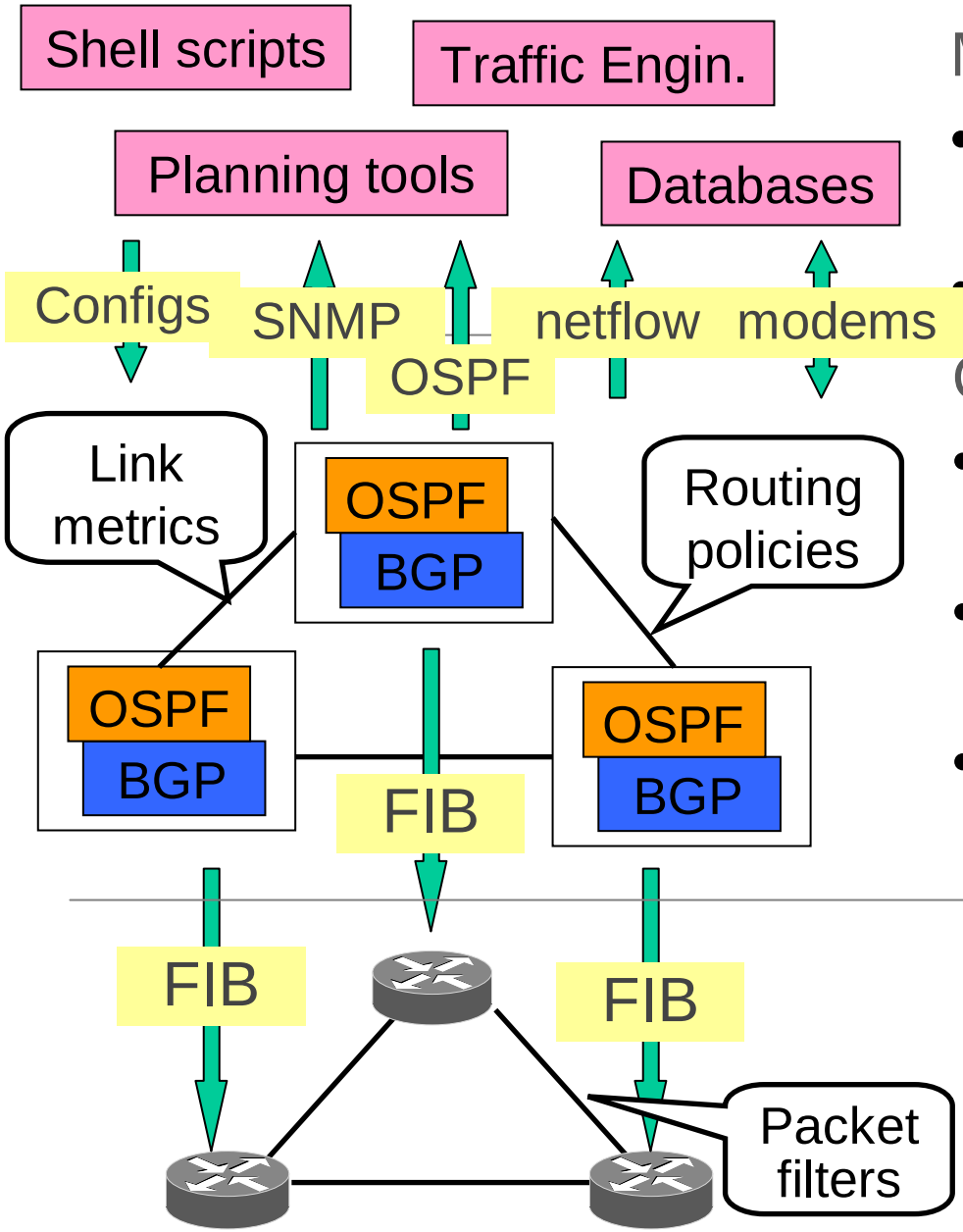
Backbone Research on GENI

- Many experiments view backbone as resource
  - High-bandwidth best-effort connectivity
  - … between GENI sites, and also the Internet
  - Or, guaranteed bandwidth between edge sites
- Other experiments "program" the backbone
  - New addressing and forwarding schemes
  - New routing and signaling protocols
  - New control and management architectures
- A few examples from my own interests…
  - Refactoring control and management
  - Virtualization as a final architecture

Refactoring Control and Management

NSF NeTS-NBD project on 4D with Hui Zhang and Ty Znati; HSARPA project on incrementally deployable security for interdomain routing with Joan Feigenbaum

Today: Inside a Single Network



Management Plane

- Figure out what is happening in network
- Decide how to change it

Control Plane

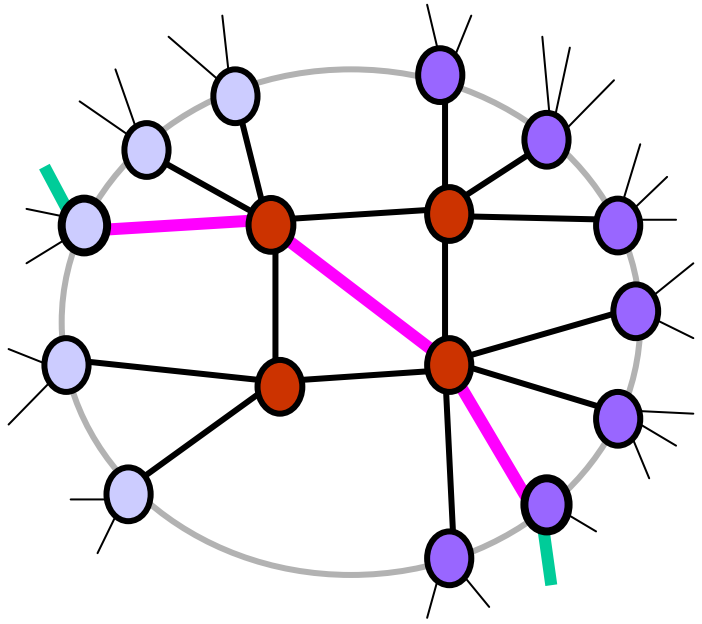
- Multiple routing processes on each router
- Each router with different configuration program
- Many control knobs: link weights, access lists, policy

Data Plane

- Packet handling by routers
- Forwarding, filtering, queuing

What Does the Network Operator Want?

- Network-wide views
  - Network topology (e.g., routers, links)
  - Mapping to lower-level equipment
  - Traffic matrix
- Network-level objectives
  - Load balancing
  - Survivability
  - Reachability
  - Security
- Direct control
  - Explicit configuration of data-plane mechanisms



4D Architecture

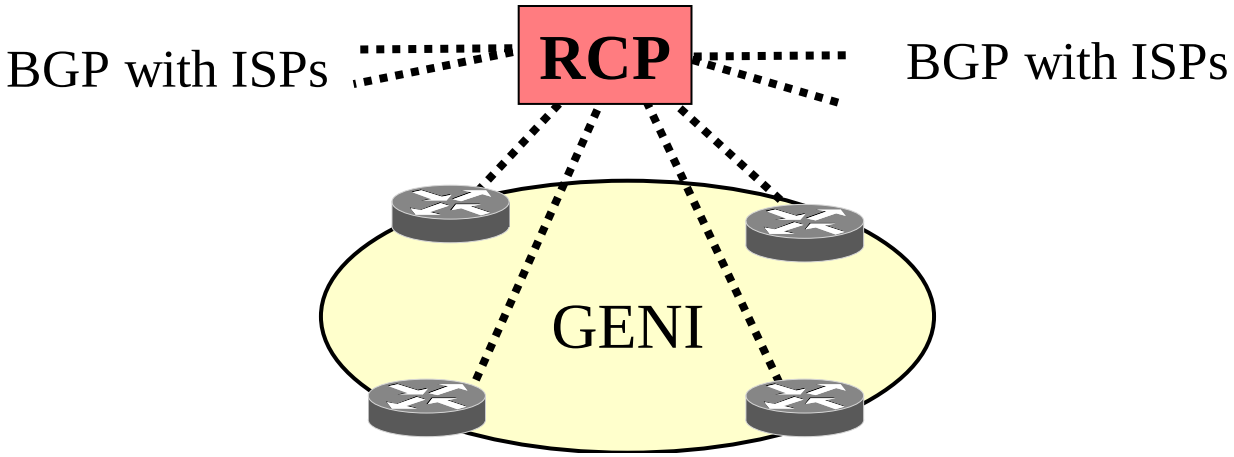
- Decision plane: replaces today's management plane
  - Operates on *network-wide* view and objectives
  - *Directly* controls the behavior of the data plane
- Dissemination plane: replaces router configuration
  - Communication between components and decision plane
- Discovery plane: replaces today's control plane
  - Responsible for providing the network-wide view
  - Topology discovery, traffic measurement, etc.
- Data plane: much like today's data plane
  - Queues, filters, and forwards data packets
  - Accepts *direct instruction* from the decision plane

Advantages of the New Approach

- Lower management complexity
  - Complete, network-wide view
  - Direct control over the routers
  - Single specification of policies and objectives
- Simpler routers
  - Much less control-plane software
  - Much less configuration state
- Enabling innovation
  - New algorithms for selecting paths within an AS
  - New approaches to inter-AS routing

RCP: 4D System for Interdomain Routing

- Routing Control Platform (RCP)
  - Refactoring of control and management planes
  - Computes forwarding tables in separate servers
  - Initial version already deployed in AT&T backbone
- Building a prototype of RCP in XORP
  - Starting to evaluate the prototype in VINI



Example Research Questions

- Scalability of the RCP
  - Is it fast and reliable enough?
- Can it improve routing security?
  - Detect and avoid anomalous routes
  - Support multipath routing and forwarding
  - Incrementally deploy secure control plane
- Does it reduce complexity?
  - Simpler, more flexible policy specification
  - Modularity to enable third-party software
- Better data and dissemination planes
  - What would we do if we could start over?

Virtualization as a Final Architecture

NeTS-FIND project "Concurrent Architectures are Better than One"
with Nick Feamster and Lixin Gao

It's Hard to be a Routing Protocol These Days

- Many, many design goals
  - Global reachability
  - Fast convergence
  - Efficient use of resources
  - Low protocol overhead
  - Secure control plane
  - Flexible routing policies

- Perhaps we cannot satisfy all of these goals
  - Perhaps we should not even try
  - Perhaps we should have customized protocols

Example: Security vs. Reachability

	Online Banking	Web Surfing
Properties	Security, even at the expense of reachability	Reachability more important than security
Routing	Secure control plane for participating parties	Insecure control plane for all parties
Addressing	Self-certifying address associated with person	Ephemeral address related to the topology

Example: Convergence vs. Scalability

	Voice over IP Gateway	Remaining Traffic
Properties	Fast convergence for a few prefixes	Scalability to 200K prefixes
Dissemination	Flooding	Hierarchical
Routing Protocol	OSPF or IS-IS	Internal BGP with route reflectors

Supporting Customized Protocols

- Virtualization
  - Multiple logical routers on a single platform
  - Resource isolation in CPU, FIBs, and bandwidth
- Programmability
  - General-purpose CPUs for the control plane
  - Network processors and FPGAs for data plane
  - Third-party software for routing and forwarding
- Economic refactoring
  - Infrastructure provider: manage routers and links
  - Service provider: offer end-to-end services

Example Research Questions

- Good to run multiple architectures in parallel?
  - Does this make things simpler, or more complex?
  - Can we quantify the performance gains?
- Economic refactoring
  - Do the two roles (infrastructure and service providers) make economic sense?
  - Does it lead to a more efficient solution?
- Virtualization substrate
  - Discovering resources and instantiating slices
  - Marketplace for buying/selling virtual components