Exploring Alternative Internet Architectures

HAIR: Hierarchical Architecture for Internet Routing
Approach

Key ideas
- Separation of locator/identifier function of IP address
  => separation of routing and location mapping
- **Hierarchy** for routing and location mapping

Two components
- Routing system based on locator
- Mapping system to map an identifier to a locator
Hierarchical routing

- Network is organized in multiple levels
- Levels are separated by separators
- Routers only know the details about their level
Hierarchical routing: Internet

- Where do we have small separators?
- Internet structure
  - Core
    - Set of interconnected autonomous systems (ASs)
    - Tier-1, tier-2 ASs, ...
    - Transit ASs
- AS core
  - ~5000 ASs
- AS edge
  - ~30000 AS
- **AS core**
  - ~5000 ASs
- **AS edge**
  - ~3000 AS

Potential large separator

Potential small separator

Core

Enterprise Network

ISP1

ISP2

ISP3

Transit AS 1

Transit AS 2

Access Provider

Stub AS
Hierarchical routing: Internet

- Where do we have small separators?
- Internet structure
  - Core
    - Set of interconnected autonomous systems (ASs)
    - Tier-1, tier-2 ASs, ...
    - Transit ASs
  - Intermediate
    - Stub ASs, e.g., metropolitan area networks
    - Enterprise networks
    - Content distribution networks
  - Edge
    - Local area networks
Hierarchical routing: Internet

- **Separator size**
  - Core → Intermediate
    - Stub ASs, e.g., metropolitan area networks: < 10 links
    - Enterprise networks: < 10 links
    - Content distribution networks: < 1000 links
  - Intermediate → Edge
    - Local area networks: < 10 links

- **Terminology**
  - Core / WAN
  - Intermediate / MAN
  - Edge / LAN
  - Separator / Attachment point (AP)
Hierarchical network

- Example: Three levels of hierarchy
  - Routing via intermediate points – the separators
    => specify attachment points
  - WAN APs: WAP
    - Provider access links
  - MAN APs: MAP
    - Firewalls
Sending a packet

- Routing via intermediate access points
  - Mapping service: resolve identifier to locator
  - 3 locator parts: WAP|MAP|ID
Routing scalability

- **Core**
  - Routing based on WAPs
  - Stable business relationships
  - Almost no churn
  - Aggregatable addresses
  - Common routing protocol (e.g., BGP)

- **Intermediate (smaller ISPs/enterprises)**
  - Routing based on MAPs
  - Separate addresses and routing
  - Local changes → local impact

- **Edge (e.g., Ethernet LAN)**
  - Standard L2 switching
Mapping system

- **Design requirements**
  - Scales with number of hosts
  - Fast response times
  - Easy to update

- **Approach**
  - Clients are responsible
  - Hierarchical design
    - Global DHT or DNS like system
      - For each identifier: pointer to MMS
      - WANs contribute resources
    - MAN mapping service (MMS)
      - Stores locators for attached nodes
      - Provided by MAN(s)
Mapping identifiers to locators

- Steps
  - Client queries
    - Global DHT
    - MMS
  - To avoid lookups
    - Use caching
    - Include source locators in packet
    - ...
  - Global DHT/MMS
    - Can store multiple alternatives
  - Failure recovery
    - Via multiple alternatives
Discussion (1)

 Scalability
  - Hierarchical routing AND mapping system
  - Updates are localized => low update rates
  - No manual configuration

 Mobility: local visibility of changes
  - Intra-MAN mobility: frequent
    - Updates restricted to MMS
  - Inter-MAN mobility: less frequent
    - Update global DHT (fast)
    - Move locators to new MMS
Discussion (2)

• Multihoming
  ▪ Inherent support: APs exposed to routing system

• Multipath
  ▪ Use multiple locators in parallel

• Inbound traffic engineering
  ▪ Per-host basis
  ▪ MANs/MMS have control

• Migration path
  ▪ To support legacy hosts
Migration via NATs/Firewalls: Sending

- Firewalls/NAT act as MAPs
- Legacy packet arrives from LAN
  - Treat dst address as dst ID
  - Resolves locator for ID
  - Add source locator to packet header
  - Encapsulate original packet and sends it
Migration: Receiving

- WAP strips encapsulation
- MAP/NAT strips the second layer
  - May get the mapping for the source locator
- Packet is routed onward
What’s different here

- Routing hierarchy based on structure of the Internet
  - Smaller table sizes
  - Lower update rates
- Mapping service is hierarchical
  - With local control and responsibility
- Hosts are responsible for obtaining mapping
- Incremental deployment possible
Lessons learned

- Main goals
  - Scalability
  - Support for multi-homing, TE, mobility, etc.
  - Smooth migration, support for legacy hosts

- Key ideas
  - Separation of locator/identifier function of IP address
  - Hierarchical routing and location mapping scheme

- Two components
  - Routing system based on locator
  - Mapping system to map an identifier to a locator