HAIR: Hierarchical Architecture for Internet Routing

Re-Architecting the Internet – ReArch ’09

Wolfgang Mühlbauer
ETH Zürich / TU Berlin
wolfgang.muehlbauer@tik.ee.ethz.ch

Anja Feldmann
Deutsche Telekom
Labs / TU Berlin

Luca Cittadini
Università Roma Tre

Randy Bush
Internet Initiative Japan

Olaf Maennel
Loughborough University
Re-Architecting Internet Routing

- **Routing problems:**
  - routing table growth
  - high update rates
  - address shortage
  - mobility
  - multi-homing
  - traffic engineering
  - lack of security
  - ...

- **Clean-slate approach:** assume we could start from scratch
  - ideas may be incrementally applicable to current Internet

- **Our work:**
  - Hierarchical Architecture for Internet Routing (HAIR)
Outline

1. Related Work
2. Architecture
3. Evaluation
4. Conclusion
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Related Work

- **LISP**
  - addressing: separate
    - *locators* (RLOC)
    - *identifiers* (EID)
  - packet forwarding:
    - map EID to RLOC
    - tunnel packet through core based on RLOC
  - multihoming easier
  - routing table size ↓

- **shim6**
  - multihoming for IPv6-enabled sites
  - hosts control which locator is used

- HLP, HIT, and many others
Clean-Slate: Design Choices

- **Separation of locators/identifiers (LOC/ID split)?**
  - *no*: current Internet
  - *yes*: LISP

- **Flat/structured namespaces for LOCs and IDs?**
  - *flat*: Routing On Flat Labels (ROFL), SIGCOMM’06
  - *structured*: current Internet

- **Host- or network-based solution?**
  - *host-based*: Shim6, no state in the network
  - *network-based*: LISP, mapping done at tunnling router

...
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HAIR: Key Ideas

1. **Separation of locator/identifier** function of IP address
2. Use of **hierarchical** routing *and* mapping system
3. **Edge-based**: if possible transfer tasks to edge hosts, keep network simple
Why hierarchical?
- to provide scalability
  → graph theory

Leverage Internet hierarchy
e.g., 3 levels:
- core:
  large transit provider
- intermediate:
  small providers
- edge:
  access networks, LAN
HAIR: Packet Forwarding

- **Locator**: 3 parts
  - core exit point
  - intermediate exit point
  - identifier (ID)

- **Forwarding**:
  1. send packet to **core** (direct peerings supported)
  2. forward along “exit points”

- **Local routing scope** within hierarchy levels

![Diagram of HAIR: Hierarchical Architecture for Internet Routing](image-url)
**Design requirements**
- scale with number of hosts
- fast response times

**Hierarchical directories:**
- **local**: intermediates
- **global**: core

**Resolve mapping**
1. get pointer to local directory
2. get actual mappings

**Edge-based:**
- request sent by end host
- no action needed from e.g., core exit points
Dynamics

- **Link/router failure** inside core or intermediate:
  - find alternative route between all pairs of exit points
  - updates are localized in scope to core or intermediate

- **Failing or unreachable exit point:**
  - e.g., monitor reachability of exit points
  - update all affected locators in the mapping system

- **Change of locator:**
  - “intra-domain”: update local directory
  - “inter-domain”: update global directory, move locators
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Estimating the Benefits

- **Goal**: benefits if HAIR was deployed in today’s Internet?
  - how much can we scale the DFZ routing table?
  - core isolated from update churn originated by “edge”?

- **Data sources**
  - BGP updates and table dumps
  - classification of ASs according to business type e.g., transit provider, enterprise networks
  → Dhamdhere et al., IMC 2008
Estimating the Benefits – Results

- DFZ table size: reduction by more than a half
- Updates: majority of current updates from “edge”, see plot

Scalability since Internet mainly grows at the “edge”
Proof-of-Concept Implementation

- **Requirements:**
  - support existing applications
  - standard IP forwarding
  - user space
  - bootstrapping

- **Use existing software**
  - *IPv6*
  - *Click*
  - *Scapy*

- **Setup in testbed**
  - latency: *ping*
  - throughput *iperf*
  - mobility scenarios
Scalability
- routing AND mapping largely on a local scope
- HAIR captures growth of Internet at the edge

Multihoming, multipath, inbound traffic engineering:
- can be supported by mapping system

Migration path
- support legacy hosts via NAT-like boxes
Conclusion

Key ideas:
- separation of locator/identifier function of IP address
- use of hierarchical routing and mapping system
- edge-based: if possible transfer tasks to edge hosts, keep network simple

Current status:
- architecture specified
- proof-of-concept implementation demonstrates feasibility

Future work:
- mapping system
- security model and analysis
Thank you!
Conclusion

Key ideas:

- separation of locator/identifier function of IP address
- use of hierarchical routing and mapping system
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