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

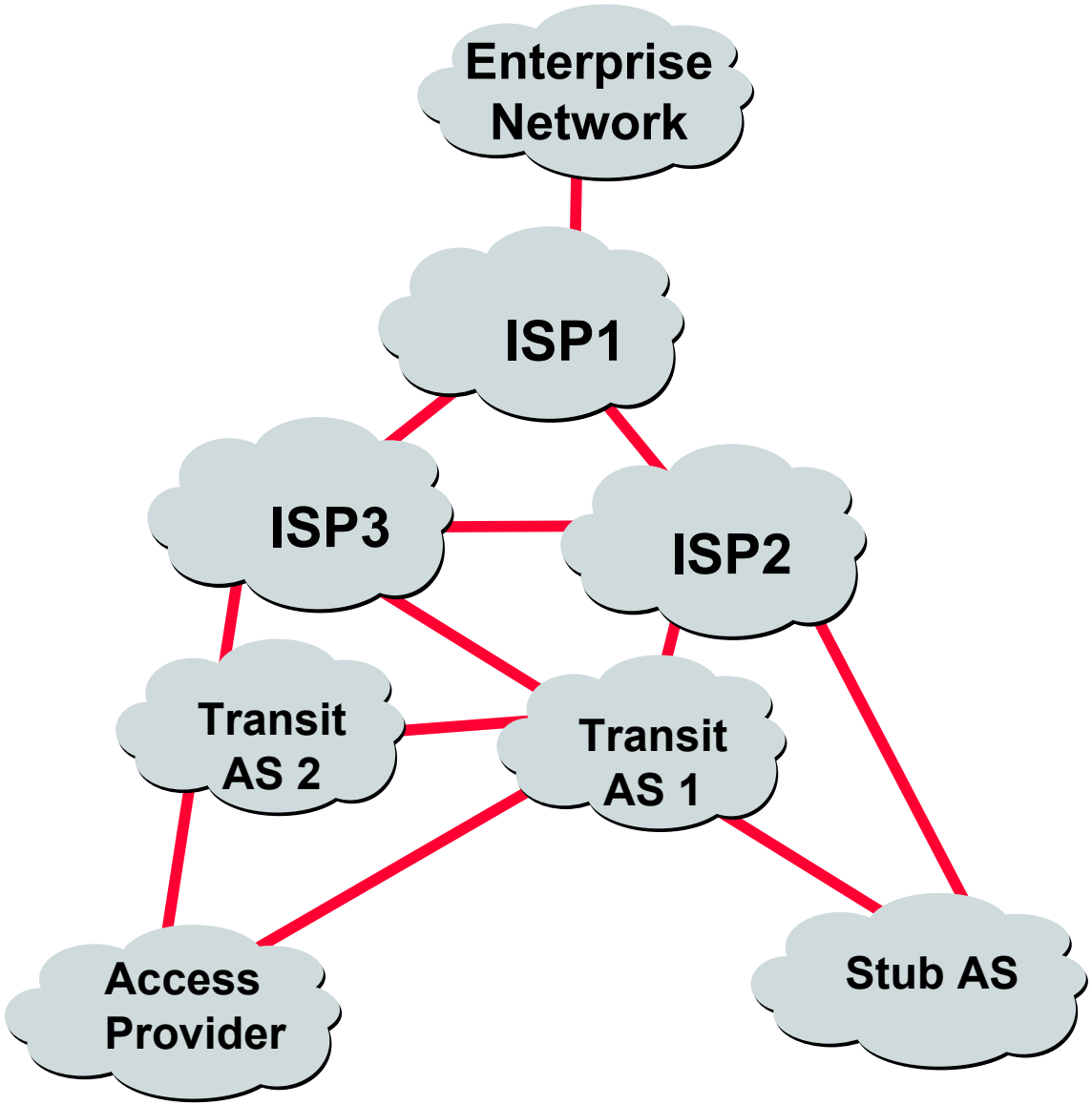
- Two components
  - Routing system based on locator
  - Mapping system to map an identifier to a locator

Hierarchical routing

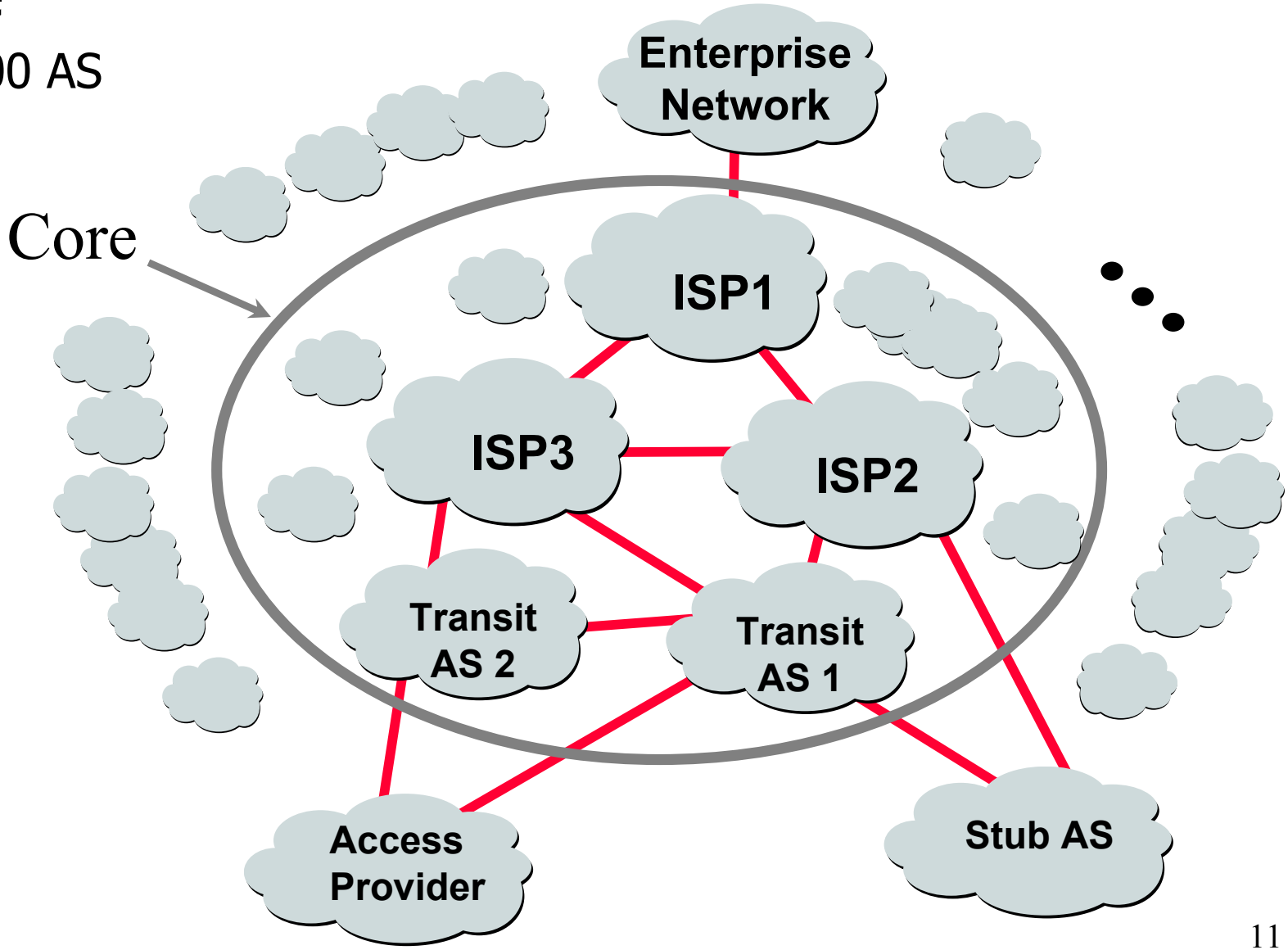
- Network is organized in multiple levels
- Levels are separated by separators
- Routers only know the details about their level

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


Enterprise Network
ISP1
ISP3
ISP2
Transit AS 2
Transit AS 1
Access Provider
Stub AS

- AS core
  - ~5000 ASs
- AS edge
  - ~30000 AS



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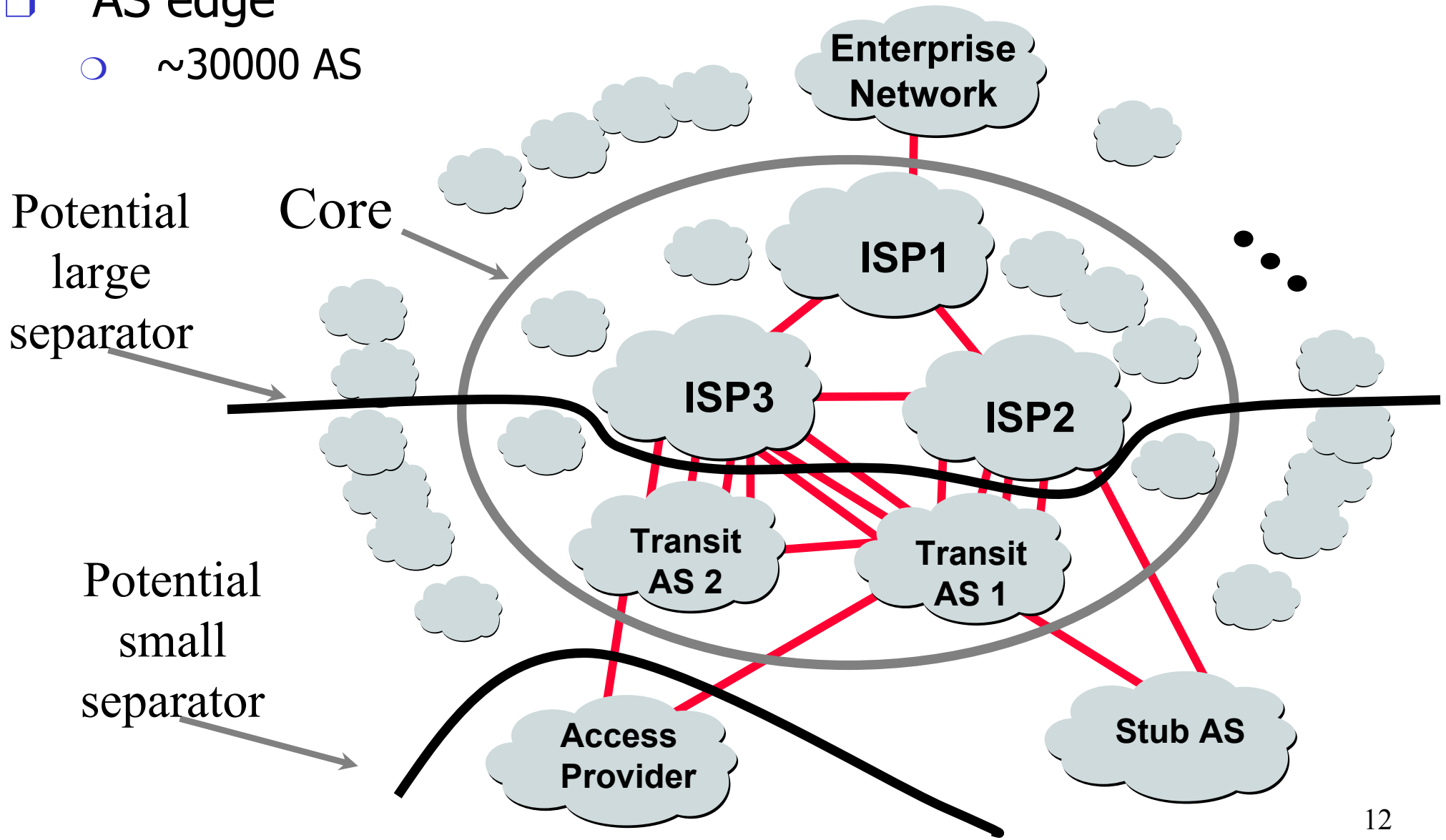


Hierarchical routing: Internet

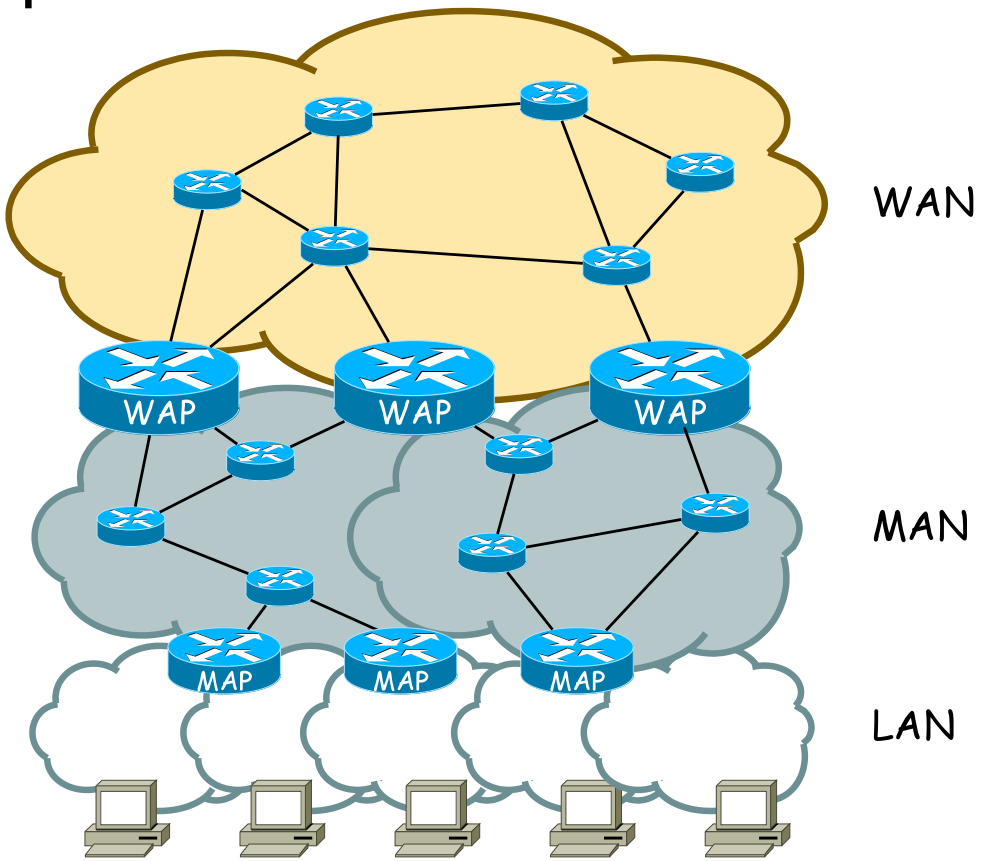
- Where do we have small separators?
- Internet structure
  - Core
    - Set of interconnected autonomous systems (ASs)
    - Tier-1, tier-2 ASs, …
    - Transit ASs
  - Intermediate
    - Stub ASs, e.g., metropolitan area networks
    - Enterprise networks
    - Content distribution networks
  - Edge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

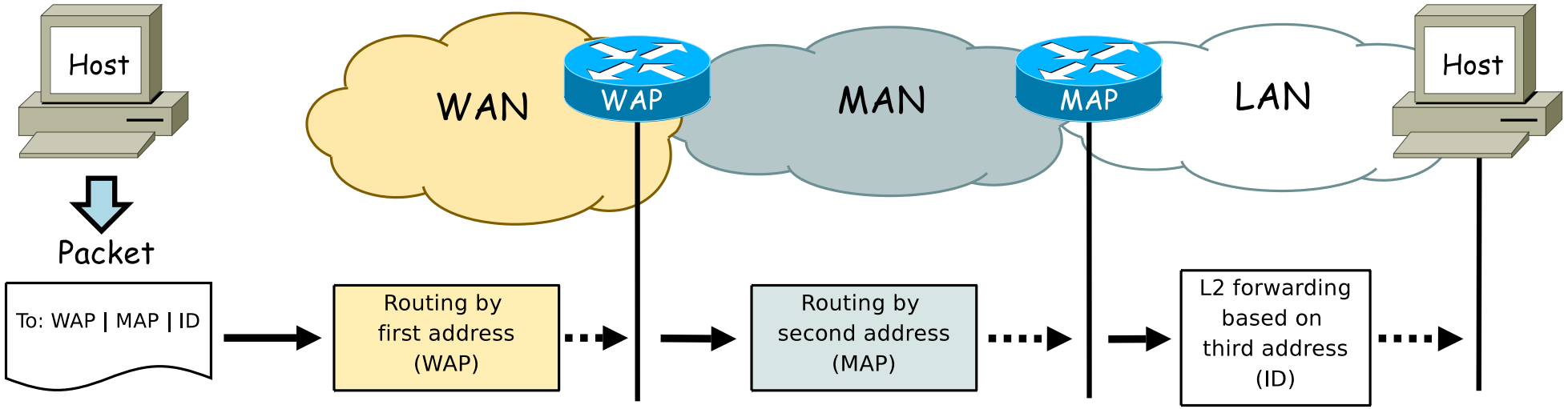
Hierarchical network

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

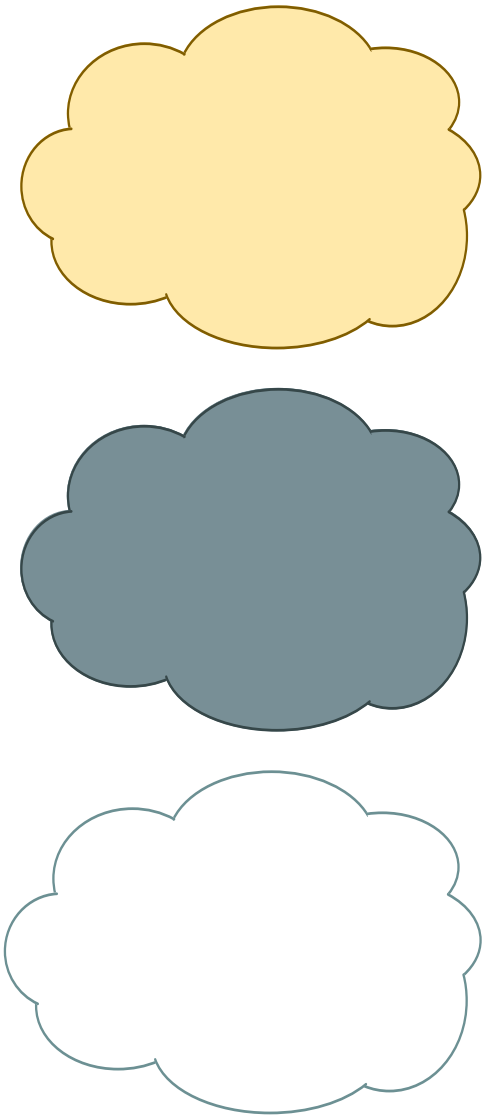


Sending a packet

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



Routing scalability

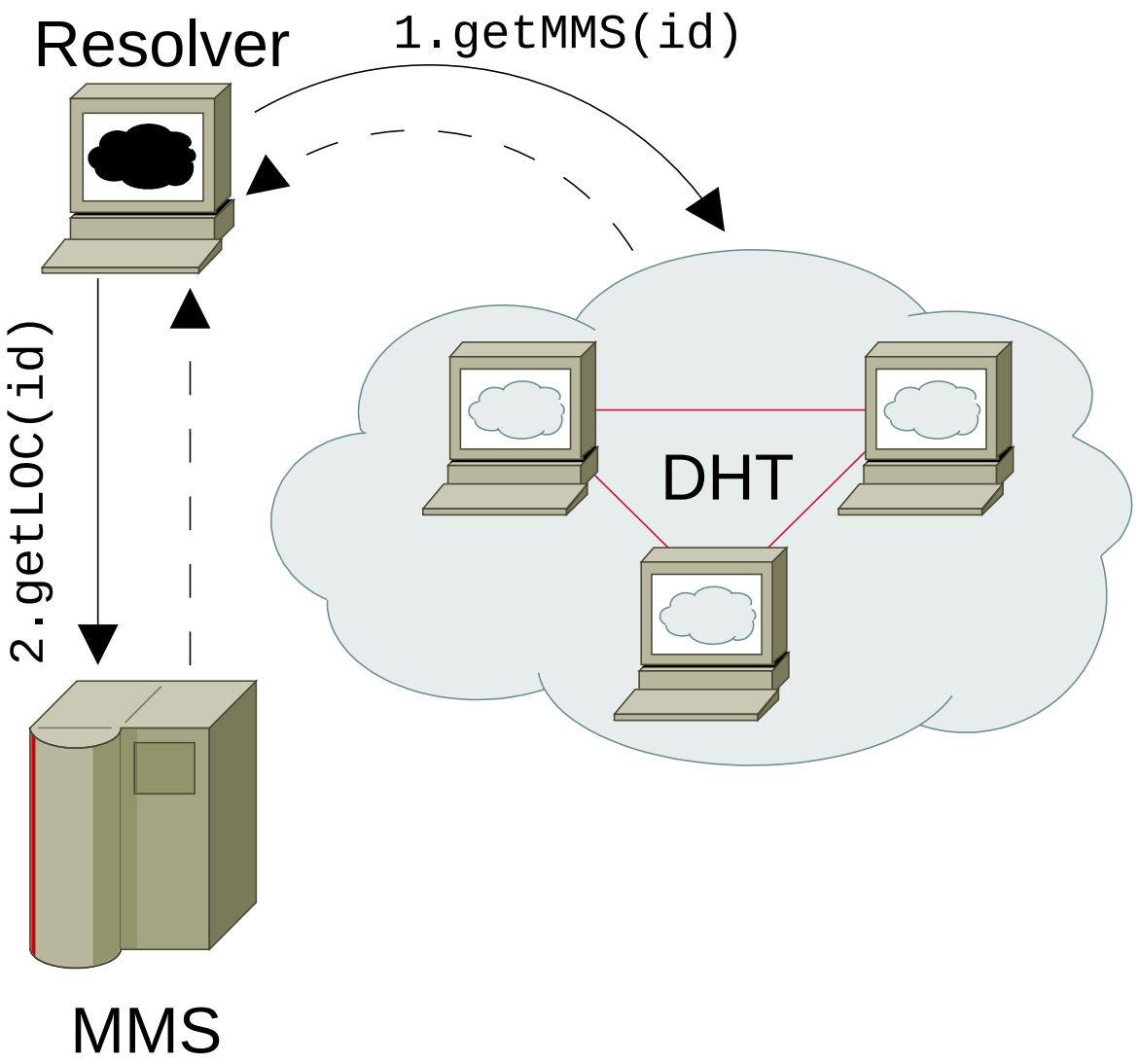


- Core
  - Routing based on WAPs
  - Stable business relationships
  - Almost no churn
  - Aggregatable addresses
  - Common routing protocol (e.g., BGP)
- Intermediate (smaller ISPs/enterprises)
  - Routing based on MAPs
  - Separate addresses and routing
  - Local changes → local impact
- Edge (e.g., 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

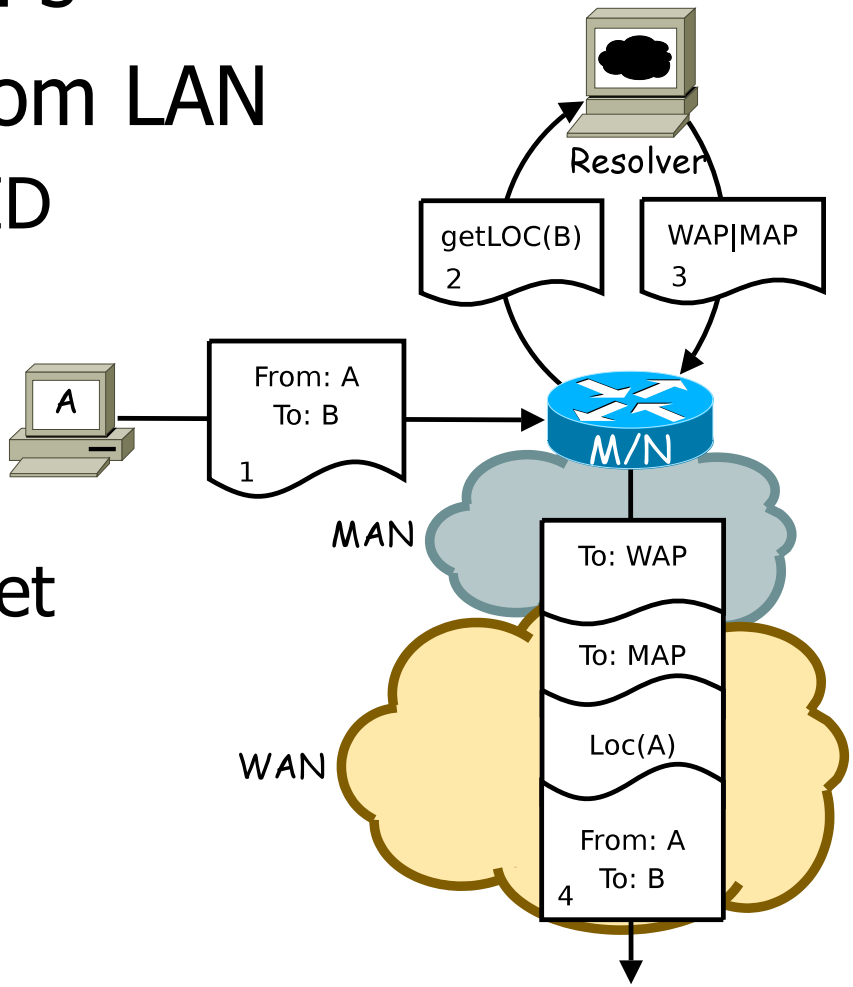
- Mobility: local visibility of changes
  - Intra-MAN mobility: frequent
    - Updates restricted to MMS
  - Inter-MAN mobility: less frequent
    - Update global DHT (fast)
    - Move locators to new MMS

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

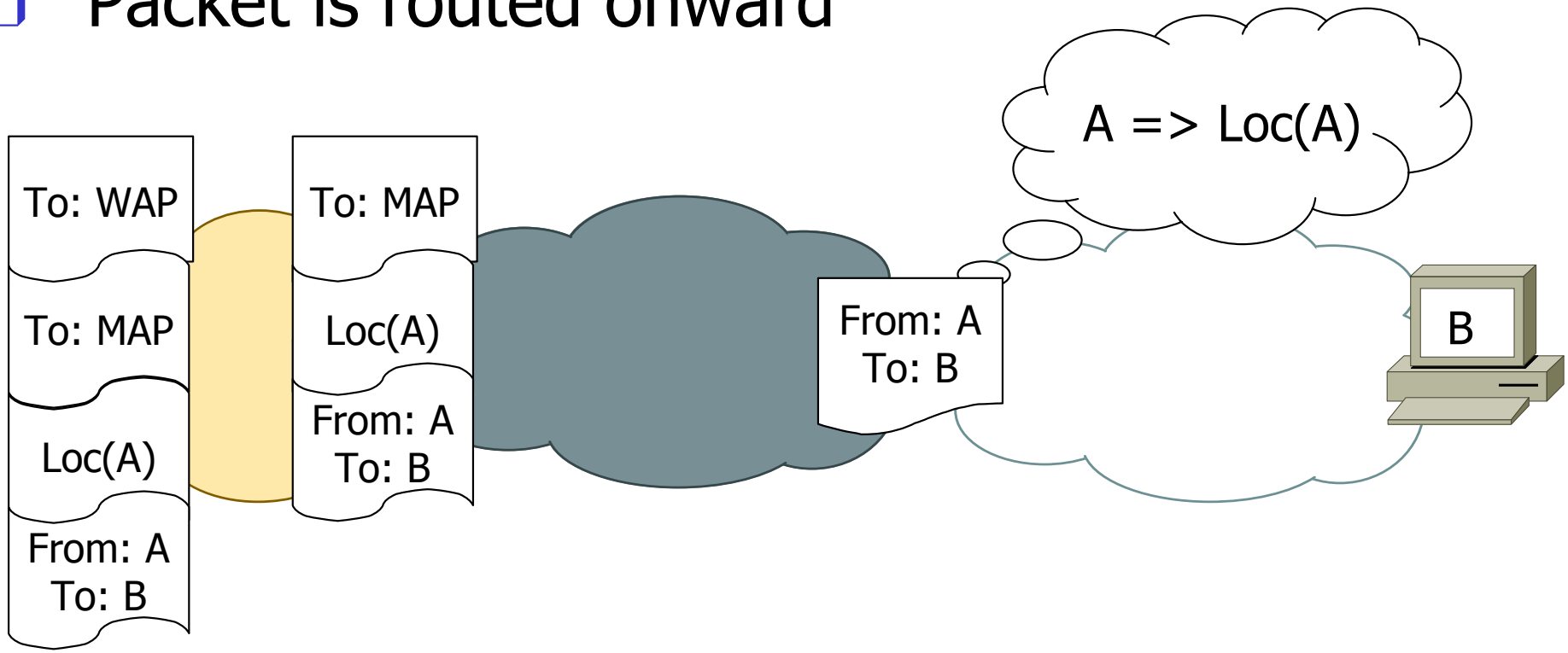
Migration via NATs/Firewalls: Sending

- 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 locater