Architectural Issues for Identifiers and Locators

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Outline

- Terminology
- Core Problems
  - Routing scalability
  - Mobility (host and site)
  - Multihoming (host and site)
  - Location Privacy
- What can be changed?
- Design space questions

Starting from basics

- Users deal with *names*, not addresses (esp. in IPv6)
  - Humans need “friendly” identifiers that can be remembered and typed
  - Name = who (informally) you are
- Routing deals with *locators* (e.g., IP addresses)
  - Locator = where you are
- Security deals with *identities* that can be used as principals
  - Identity = who you are (really!)
  - May or may not be tightly bound to a name or locator (e.g., CGA)

Routing Scalability Basics

- Today we use hierarchical aggregation, which is broken by:
  - **Provider Independent (PI) addressing:** Sites want to be able to change providers without renumbering, to have a sense of "ownership" of their address space, to ease site multihoming.
  - **Site Multihoming:** Even if PI addressing is not used, multihoming injects more-specific routes from one provider to another which the entire global routing table must then carry.
  - **Traffic Engineering:** Providers inject more-specific routes to influence the behavior of the routing system, in order to control various traffic patterns
- All of these challenges are due to local operational state propagated globally

Mobility Basics

- If routing had no scaling and convergence time limitations, mobility could be handled by routing
  - Just use dynamically updated host routes
- If name resolution had no scaling and convergence time limitations, mobility could be handled by name resolution
  - Just use dynamically updated name records

Host Mobility 1: Accept new connections immediately after a move

Q: So what’s the problem?

A: Mainly design limitations of current solutions:

- Inability of name resolution (DNS) to deal with rapid changes
  - Some DNS servers don’t respect small TTLs
- Addresses are cached by applications and services
  - Applications don’t respect TTLs either

Host Mobility 2: Preserve established connections

- Locators change over time
- There can also be periods of complete disconnectivity
  - Travel between work and home (long)
  - Ride in an elevator (medium)
  - Just walk past a cement pillar (short)
- To deal with disconnectivity, some layer must do a reconnect transparent to the user
- There is benefit to applications handling disconnectivity themselves
- Even if application does reconnects, reconnect time is still long enough that dealing with mobility below the application is still necessary for real-time interactive apps

Site Mobility: Ease Renumbering

- Renumbering pains depend on how many places addresses are configured:
  - Routers
  - Hosts
  - DNS servers
  - DHCP servers
  - Firewall
  - Remote monitoring systems
  - Intrusion detection systems
  - Load balancers
  - Management tools/databases
  - Etc.
- Whether renumbering is any easier or not depends how many of above have to change

Multihoming: Support redundancy, load sharing, etc (RFC3582)

- Named entities exist on machines with a set of locators
- Efficient load sharing & redundancy needs a locator set to be communicated somehow
  - One end chooses which locators are communicated
  - Other end chooses among locators learned
- Problems:
  - Various applications and protocols (TCP, SIP, etc.) today only communicate one address
  - They also don’t re-bind during connections

Location Privacy

- Ability to hide topology details from outsiders
- Locator is visible to remote endpoint unless:
  - A translator is in between, or
  - End wanting privacy tunnels to/from something in between
  - Both separate identifier seen by remote endpoint from locator used by local routing

What can we change? (1/2)

- “Managed” systems are easier
  - “managed” = frequently/automatically upgraded software/patches
- “Unmanaged” systems are hard
  - “unmanaged” = someone rarely (if ever) looks at it and patches aren’t automatic

Common Cases:	Managed	Unmanaged
Hosts	**Homes**	**Corporate**, Embedded, Legacy
Routers	**Corporate**	**Homes**

What can we change? (2/2)

- Applications:
  - Can’t change all of them
  - But can affect new applications
    - Note that many applications are moving up to higher-layer APIs anyway, so a host change may be sufficient for them
- Management & Security systems:
  - These are often the last/hardest to change
  - Most of them assume upper-layer identifier == locator
    - Separation makes it harder for intermediate system to peek in and look at the identifier
  - Unlike apps, you have to work with all of them before you can deploy in a corporation
  - Implies either blocked on changing them, or else must have identifier == locator within a corporate network

Incentive Structure

- Best if *only* requires changes by entities actually feeling pain, e.g.
  - Service Provider (Routers): routing scalability
  - End-user (Hosts): mobility, host multihoming
- Often **only one entity** experiences the pain, and so is incented to change
  - Best if provides actual benefits when only that entity is changed

Design Questions

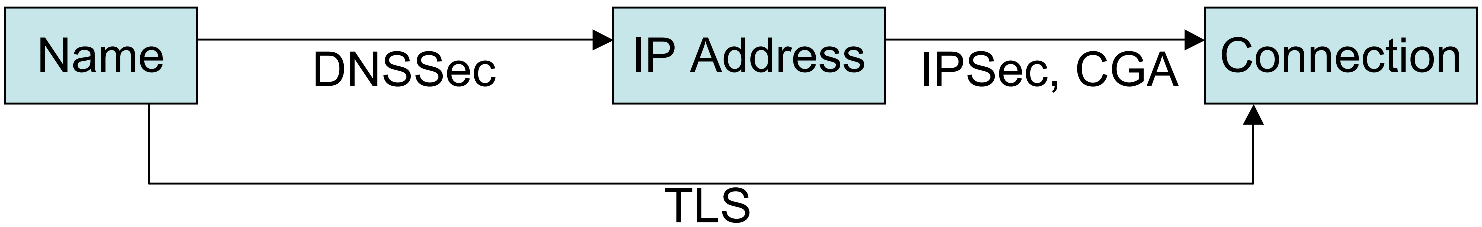
- What properties should an *identifier* have?
  - Take as given (per BOF description):
    - Works with legacy applications
    - Works with legacy destinations
    - Supports referrals
  - Open questions:
    1. How is mapping secured?
    2. How do you map?
    3. Is identifier routable or not?
    4. Explicit in data packet or not?

Support referrals

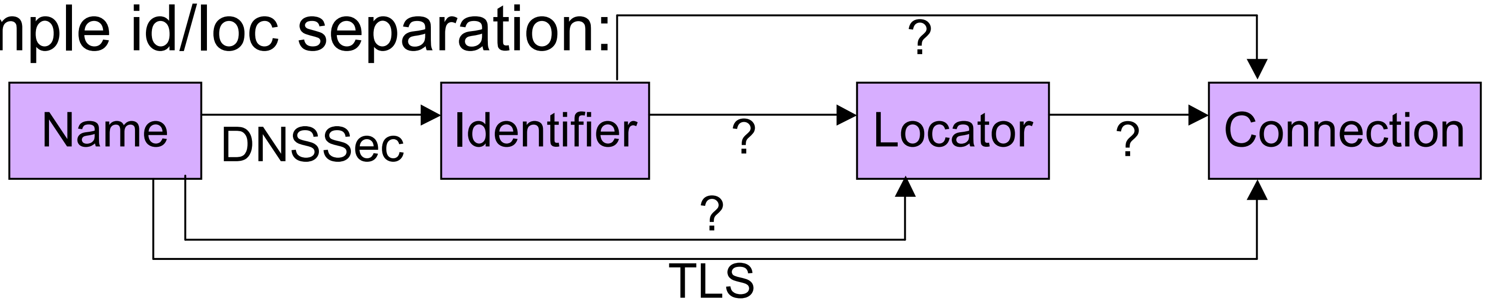
- One application/user/service wants to refer/redirect you to another one
  - Would like the new identifier to be authenticatable
    - I.e., want chain of trust from identifier to connection
  - Why not just use a name? (example: HTTP redirect URL contains hostname)
  - Inefficiency of subsequent name-to-locator mapping step
    - But refer/redirect could provide a locator hint
  - Further complicated by current design/deployment limitations:
    - Many protocols are defined to refer/redirect to IP address
    - Some apps might only cache addresses
    - Not all applications/users/services have a name

1. How is mapping secured? (1/3)

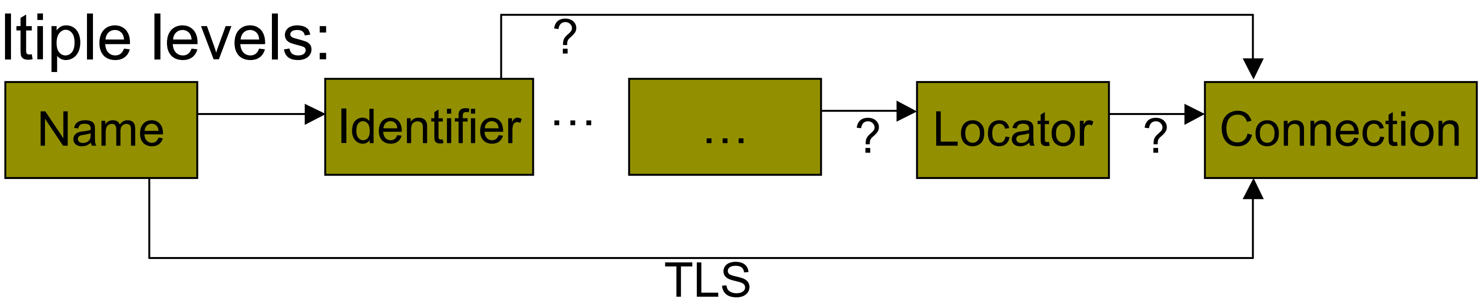
Currently defined (examples):



Simple id/loc separation:



Multiple levels:



Security Basics

- Need a chain of trust from a user-friendly name to a connection
  - DNSsec alone is not sufficient if the locator can be spoofed
  - Self-signed CGAs alone are not sufficient if the name-to-locator mapping can be spoofed
  - If names are authenticated directly (e.g., TLS/DTLS) then any spoofing attacks are reduced to DoS

- Need a chain of trust from whatever an application starts from, to a connection
  - Not all applications act on behalf of humans (e.g., server apps)
  - Either application always needs to start from a name, or also need chains of trust from whatever other type of identifier is in use

How is mapping secured? (3/3)

- Identifier algorithmically derived from identity?
  - Chain of trust goes from identifier to connection
- Identifier/locator mapping is signed by some trusted identity?
  - Chain of trust goes from identifier to locator, and relies on something else for locator-to-connection
- Return routability check only?

2. Mapping name to identifier

- If name == identifier, this is a no-op
- Otherwise:
  – Need to work with existing name resolution mechanisms (DNS, SIP, etc.)
  – Need to deal with security
  – Can there be multiple identifiers?
    - Some names map to multiple hosts (www.example.com)

Mapping identifier to locators (1/3)

- What?
  - Need to deal with dynamically changing locators
  - Need to deal with multiple locators
  - Need to deal with security

Mapping identifier to locators (2/3)

Where?

- Vertical locus:
  - Application
  - Session Layer
  - Transport Layer
    - Do the above 3 work for *all* applications?
  - Network Layer
  - Below IP
    - Does it work for *all* link types?
- Horizontal locus:
  - Within host
  - Out in the network somewhere
    - Doesn't work if the host attaches to different networks
    - Farther out centralizes burden

Mapping identifier to locator (3/3)

- When?

  A priori:

    - How much data has to be learned a priori?

  On demand:

  – Name resolution time

    - But not all apps resolve names (server apps, referrals, etc.)

  – At time of first packet

    - **Forced to buffer/drop packets**
    - How avoid circular dependency between routing and lookup?

  – When do you get changes to the mapping?

Implications on Mapping Function (nod Ross Callon)

- If in a router:
  - On-demand forwarding plane update implies demands on the router control plane
    - May be ok if rare enough, but not if too frequent
    - Imagine multiple 100G interfaces sending packets “every so often” to a general purpose CPU
  - Will some routers have mapping tables that are just as or more large and dynamic as today’s FIBs?

3. Is identifier routable or not?

- Non-routable
  - May need **both** “ends” to change (deployability impact)
  - May have to drop/queue pending lookup (app impact)
- “Routable” (in some topology)
  - May increase routing state (“router” impact)

4. Explicit in data packet or not?

- Is id->locator mapping explicit in every data packet, or implicit (only communicated in signaling plane)?
- Do we provide the ability for intermediate systems to see the identifier or not?

- Explicit (e.g., tunneling):
  - Identifier can be seen in packet by intermediate systems that change to look for it
  - Causes increase in packet size, more fragmentation

- Implicit (e.g., index or translation):
  - Identifier not findable in data packets
  - Asymmetric paths mean intermediate systems may not have mapping state

Summary

- Need to align ease of deployment and incentives
- There are plenty of interesting problems, but incentives are in different places
- There might not be one solution, but rather complementary ones
  - Different problem -> incentive -> location of change
  - E.g., routing scalability in provider-managed routers vs host mobility in hosts