Naming Entities

- Names, identifiers, and addresses
- Name resolution
- Name space implementation

Naming

Essence

Names are used to denote entities in a distributed system. To operate on an entity, we need to access it at an access point. Access points are entities that are named by means of an address.

Note

A location-independent name for an entity E, is independent from the addresses of the access points offered by E.

Identifiers

Pure name

A name that has no meaning at all; it is just a random string. Pure names can be used for comparison only.

Identifier

A name having the following properties:

- P1: Each identifier refers to at most one entity
- P2: Each entity is referred to by at most one identifier
- P3: An identifier always refers to the same entity (prohibits reusing an identifier)

Observation

An identifier need not necessarily be a pure name, i.e., it may have content.

Flat naming

Problem

Given an essentially unstructured name (e.g., an identifier), how can we locate its associated access point?

- Simple solutions (broadcasting)
- Home-based approaches
- Distributed Hash Tables (structured P2P)
- Hierarchical location service

Simple solutions

Broadcasting

Broadcast the ID, requesting the entity to return its current address.

- Can never scale beyond local-area networks
- Requires all processes to listen to incoming location requests

Forwarding pointers

When an entity moves, it leaves behind a pointer to its next location

- Dereferencing can be made entirely transparent to clients by simply following the chain of pointers
- Update a client's reference when present location is found
- Geographical scalability problems (for which separate chain reduction mechanisms are needed):
  - Long chains are not fault tolerant
  - Increased network latency at dereferencing

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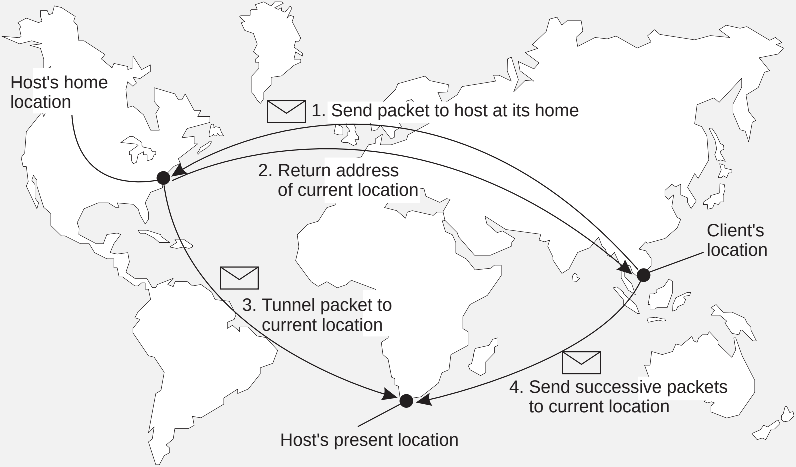
Home-based approaches

Single-tiered scheme

Let a home keep track of where the entity is:

- Entity's home address registered at a naming service
- The home registers the foreign address of the entity
- Client contacts the home first, and then continues with foreign location

Home-based approaches



Home-based approaches

Two-tiered scheme

Keep track of visiting entities:

- Check local visitor register first
- Fall back to home location if local lookup fails

Problems with home-based approaches

- Home address has to be supported for entity's lifetime
- Home address is fixed $\Rightarrow$ unnecessary burden when the entity permanently moves
- Poor geographical scalability (entity may be next to client)

Question

How can we solve the "permanent move" problem?

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Distributed Hash Tables (DHT)

Chord

Consider the organization of many nodes into a logical ring

- Each node is assigned a random *m*-bit identifier.
- Every entity is assigned a unique *m*-bit key.
- Entity with key k falls under jurisdiction of node with smallest $id \geq k$ (called its successor).

Nonsolution

Let node *id* keep track of $succ(id)$ and start linear search along the ring.

DHTs: Finger tables

Principle

- Each node p maintains a finger table $FT_p[]$ with at most m entries:

$$FT_p[i] = succ(p + 2^{i-1})$$

Note: $FT_p[i]$ points to the first node succeeding p by at least 2^{i-1}.

- To look up a key k, node p forwards the request to node with index j satisfying

$$q = FT_p[j] \leq k < FT_p[j+1]$$

- If $p < k < FT_p[1]$, the request is also forwarded to $FT_p[1]$

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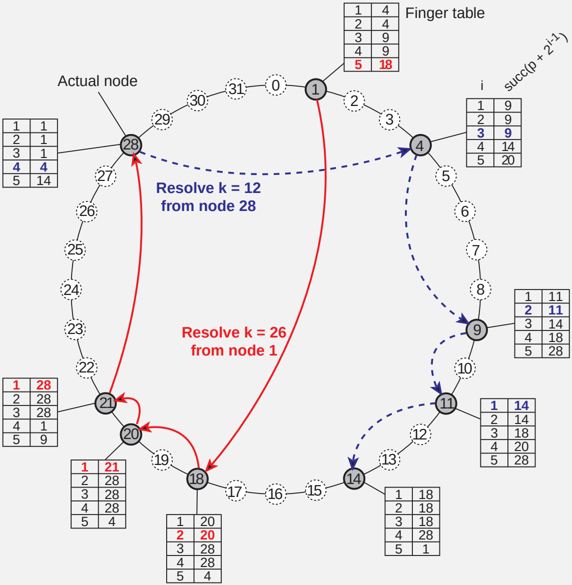

Exploiting network proximity

Problem

The logical organization of nodes in the overlay may lead to erratic message transfers in the underlying Internet: node k and node $succ(k+1)$ may be very far apart.

Topology-aware node assignment: When assigning an ID to a node, make sure that nodes close in the ID space are also close in the network. Can be very difficult.

Proximity routing: Maintain more than one possible successor, and forward to the closest.
Example: in Chord $FT_p[i]$ points to first node in $INT = [p+2^{i-1}, p+2^i-1]$. Node p can also store pointers to other nodes in INT.

Proximity neighbor selection: When there is a choice of selecting who your neighbor will be (not in Chord), pick the closest one.

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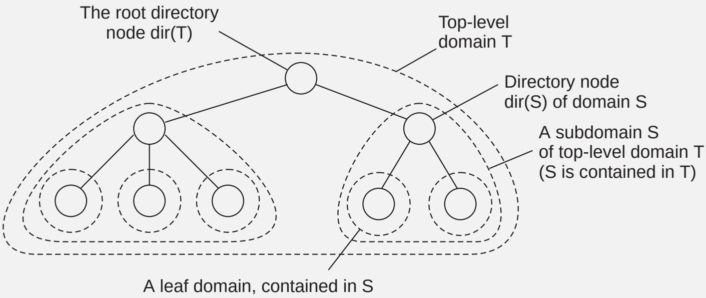
Hierarchical Location Services (HLS)

Basic idea

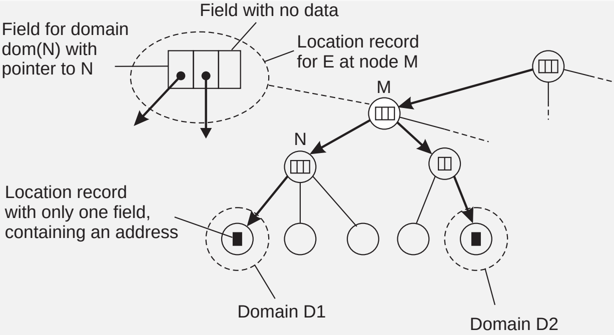
Build a large-scale search tree for which the underlying network is divided into hierarchical domains. Each domain is represented by a separate directory node.



HLS: Tree organization

Invariants

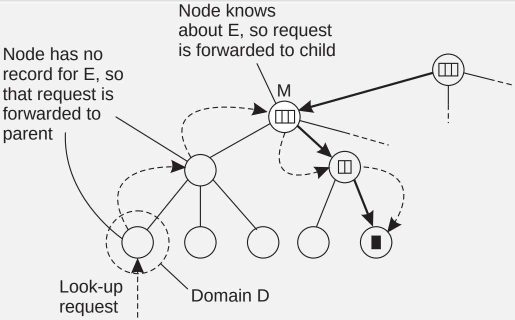
- Address of entity *E* is stored in a leaf or intermediate node
- Intermediate nodes contain a pointer to a child iff the subtree rooted at the child stores an address of the entity
- The root knows about all entities



HLS: Lookup operation

Basic principles

- Start lookup at local leaf node
- Node knows about $E \Rightarrow$ follow downward pointer, else go up
- Upward lookup always stops at root



HLS: Insert operation