

## Naming in Distributed Systems

- Overview: Names, Identifiers, Addresses, Routes, Name Space, Name Resolution, ...
- Implementation of a Naming Service
- Case Studies: DNS, X.500
- Naming and Mobile Entities
- *Reading:*
  - *Coulouris: Distributed Systems, Addison Wesley, Chapter 9*
  - *Tanenbaum, van Steen: Distributed Systems, Prentice Hall, 2002, Chapter 4*

## Some Terminology: Entities, Names, Addresses

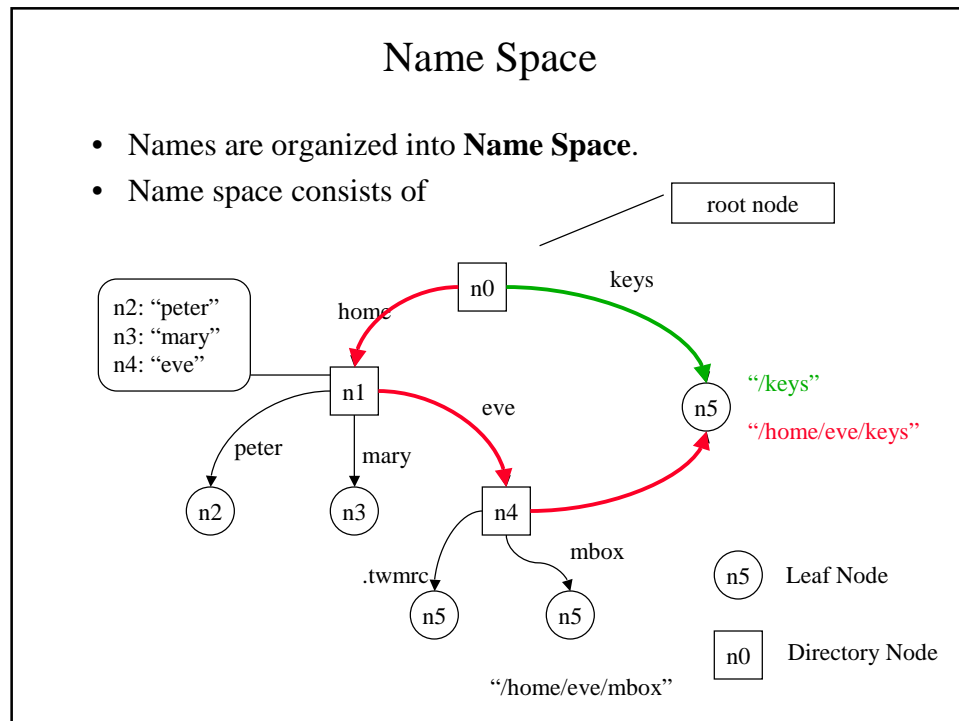
- An **Entity** in a distributed system can be pretty much anything.
- A **Name** is a string of bits used to refer to an entity.
- We operate on an entity through its **Access Point**.
- The **Address** is the name of the access point.

## Entities, Names, Addresses: Examples

- Example
  - Telephone as Access Point to a person.
  - The Telephone Number then becomes the address of the person.
  - Person can have several telephone numbers.
  - Entity can have several addresses.
- Another Example: Transport-Level Addresses
  - for servers this can be IP address and port number
- Entities may change access points over time
  - telephone numbers, e-mail addresses, IP addresses in mobile systems,  
...

## Identifiers are Special Names

- Can we use addresses of access points as regular name for the associated entity?
  - access points may change over time
  - entities may have several access points
- **Identifiers** uniquely identify an entity:
  - An identifier refers to at most one entity.
  - Each entity is referred to at most one identifier.
  - An identifier always refers to the same entity (never reused)
- Example:
  - SSN? Telephone Numbers?



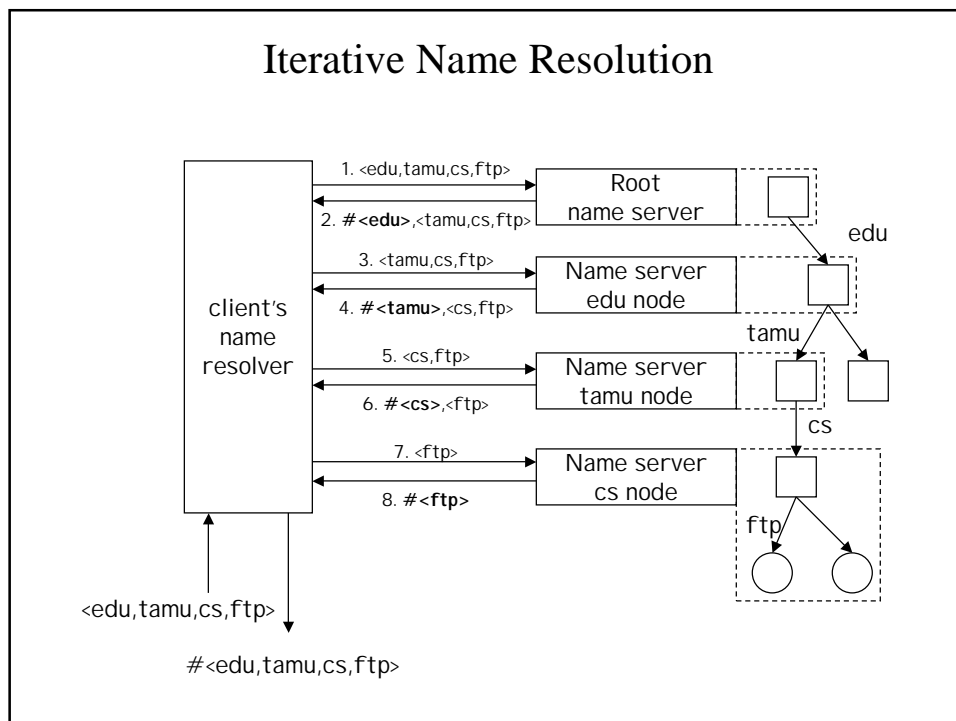
### Name Resolution

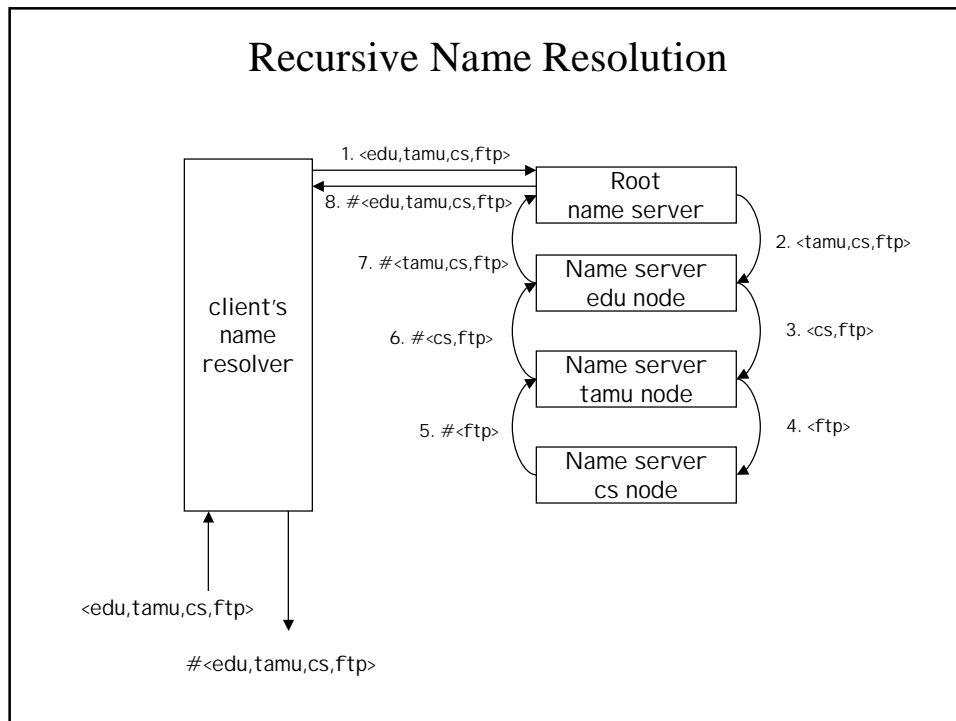
- Path name  
N:<label-1, label-2, ... , label-n>
- Absolute path name: first node in path name is root.
- Relative path name: first node can be any node.
- Global name vs. local name.
- Where to start name resolution? (“Closure”)
- Examples:
  - Location of inode of root directory.
  - Environment setting (e.g. HOME variable) to refer to home directory.

## Implementation of Name Resolution

- Simplified picture:
  - No replication of name servers
  - No client side caching
- Each client has access to local **name resolver**.
- Example: resolve  
*root:<edu,tamu,cs,ftp,netex,index.txt>*
- **Iterative Resolution vs. Recursive Resolution**

## Iterative Name Resolution





### Iterative vs. Recursive Name Resolution: Comparison

#### Iterative

- Stateless

#### Recursive

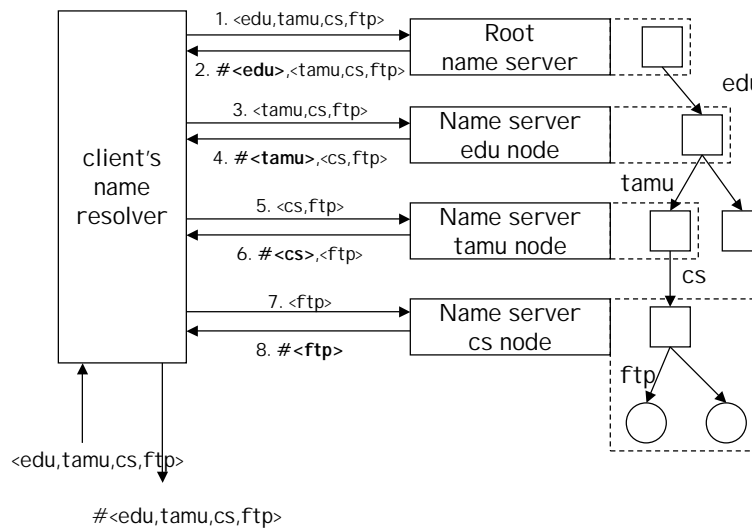
- Higher-level servers need to maintain state about resolutions. (!?)
- Caching is effective.
- Reduced communication costs.

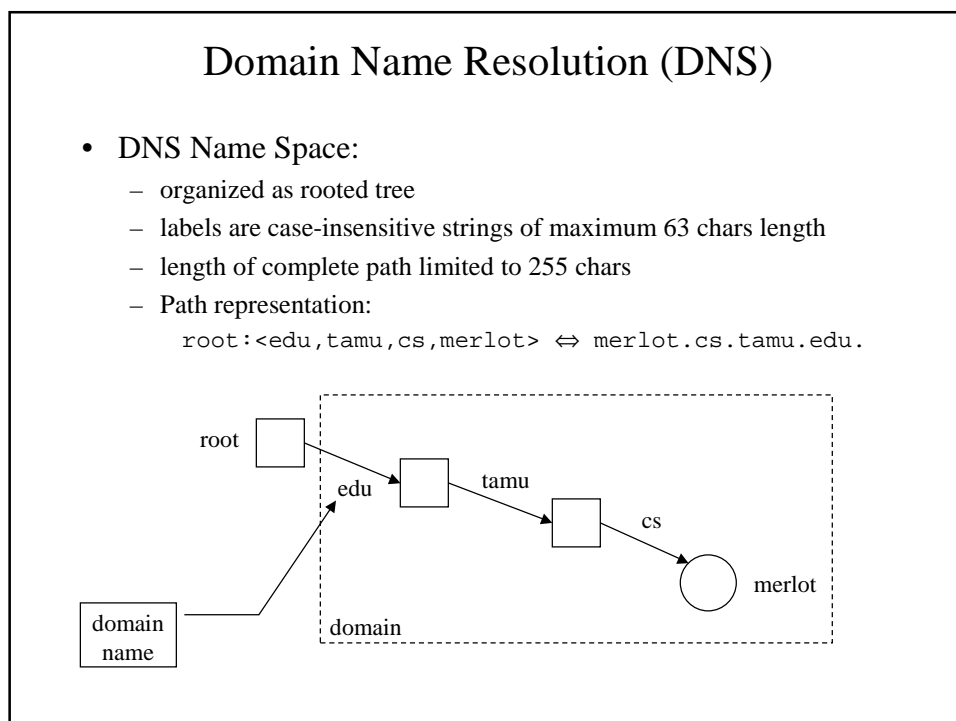
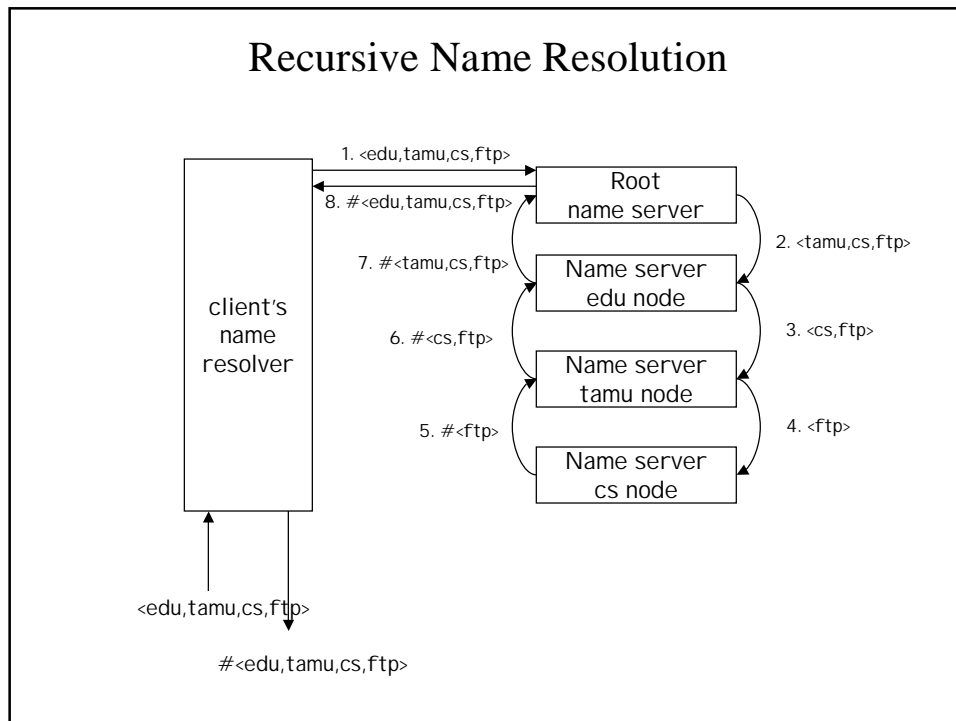
### Caching in Recursive Name Resolution

Server for node	Should resolve	Looks up	Passes to child	Receives and caches	Returns to requester
cs	<ftp>	#<ftp>	—	—	#<ftp>
vu	<cs,ftp>	#<cs>	<ftp>	#<ftp>	#<cs> #<cs, ftp>
nl	<vu,cs,ftp>	#<vu>	<cs,ftp>	#<cs> #<cs,ftp>	#<vu> #<vu,cs> #<vu,cs,ftp>
root	<nl,vu,cs,ftp>	#<nl>	<vu,cs,ftp>	#<vu> #<vu,cs> #<vu,cs,ftp>	#<nl> #<nl,vu> #<nl,vu,cs> #<nl,vu,cs,ftp>

Figure 4-10. Recursive name resolution of <nl, vu, cs, ftp>. Name servers cache intermediate results for subsequent lookups.

### Iterative Resolution and Locality





## Resource Records in DNS

Type of record	Associated entity	Description
SOA	Zone	Holds information on the represented zone
A	Host	Contains an IP address of the host this node represents
MX	Domain	Refers to a mail server to handle mail addressed to this node
SRV	Domain	Refers to a server handling a specific service
NS	Zone	Refers to a name server that implements the <b>represented zone</b>
CNAME	Node	Symbolic link with the primary name of the represented node
PTR	Host	Contains the canonical name of a host
HINFO	Host	Holds information on the host this node represents
TXT	Any kind	Contains any entity-specific information considered useful

**Figure 4-12.** The most important types of resource records forming the contents of nodes in the DNS name space.

## DNS Implementation

- Each zone is implemented by a (replicated) name server.
- Updates happen on primary name server, and secondary name server requests **zone transfers**.



## DNS Implementation (2)

Name	Record type	Record value
cs.vu.nl	SOA	star (1999121502,7200,3600,2419200,86400)
cs.vu.nl	NS	star.cs.vu.nl
cs.vu.nl	NS	top.cs.vu.nl
cs.vu.nl	NS	soio.cs.vu.nl
cs.vu.nl	TXT	"Vrije Universiteit - Math. & Comp. Sc."
cs.vu.nl	MX	1 zephyr.cs.vu.nl
cs.vu.nl	MX	2 tornado.cs.vu.nl
cs.vu.nl	MX	3 star.cs.vu.nl
star.cs.vu.nl	HINFO	Sun Unix
star.cs.vu.nl	MX	1 star.cs.vu.nl
star.cs.vu.nl	MX	10 zephyr.cs.vu.nl
star.cs.vu.nl	A	130.37.24.6
star.cs.vu.nl	A	192.31.231.42
zephyr.cs.vu.nl	HINFO	Sun Unix
zephyr.cs.vu.nl	MX	1 zephyr.cs.vu.nl
zephyr.cs.vu.nl	MX	2 tornado.cs.vu.nl
zephyr.cs.vu.nl	A	192.31.231.66
www.cs.vu.nl	CNAME	soling.cs.vu.nl
ftp.cs.vu.nl	CNAME	soling.cs.vu.nl
soling.cs.vu.nl	HINFO	Sun Unix
soling.cs.vu.nl	MX	1 soling.cs.vu.nl
soling.cs.vu.nl	MX	10 zephyr.cs.vu.nl
soling.cs.vu.nl	A	130.37.24.11
laser.cs.vu.nl	HINFO	PC MS-DOS
laser.cs.vu.nl	A	130.37.30.32
vucs-das.cs.vu.nl	PTR	0.26.37.130.in-addr.arpa
vucs-das.cs.vu.nl	A	130.37.26.0

Figure 4-13. An excerpt from the DNS database for the zone *cs.vu.nl*.

## DNS Implementation (3)

- How do other zones refer to the *cs.vu.nl* zone?
- Part of description of *vu.nl* domain, which contains *cs.vu.nl* domain:

Name	Record Type	Record Value
cs.vu.nl	NS	solo.cs.vu.nl
solo.cs.vu.nl	A	130.37.24.1