The Domain Name System

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Overview

- Introduction
- History
- Name space structure
- Technical details
- Administrative details
- Political details
- Futures
- Summary

Introduction

- For the Internet to operate, certain globally unique identifiers must exist
  - Protocol numbers, port numbers, addresses, names, etc.
- Administration of these identifiers is done by the Internet Assigned Numbers Authority (IANA)
  - The IANA delegates the administration of some of these resources to other entities
  - Names are by far the most contentious

Names vs. Addresses

- In the Internet, an address provides information on how to reach a particular place
  - Usually hierarchical in nature
    - Cherry Hills Ogikubo #301, 4-6-6 Ogikubo Suginami-ku, Tokyo, Japan
    - +1-808-329-6085
    - 202.12.28.129
- Names identify an object once its location is known
  - Any hierarchy is administrative only
    - David R. Conrad
    - Tokyo
    - isc.org
- People use names, machines use addresses

The Domain Name System

- A system which permits humans to use names and machines to use addresses
- Scalable
  - Over 90 million entries in the global DNS now
- Consistent
  - You get the same answer where ever you ask
- Resilient
  - Specifically designed to avoid single points of failure
- Without the DNS, the Internet would not be usable

DNS in a Nutshell

- DNS is a distributed database
  - Data is maintained locally, but available globally
- DNS uses
  - replication to achieve robustness
  - caching to achieve adequate performance
- DNS is composed of
  - a namespace
    - the database’s structure
  - name servers
    - store data from specific segments of the database Answer questions from...
  - resolvers
    - translate applications’ requests for data into DNS queries
    - Interpret name server’s responses

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In the Beginning...

- There was the ARPANET’s *`HOSTS.TXT`* file
  - *`HOSTS.TXT`* mapped every ARPANET host’s name to its IP address
  - Format of an entry looked like:
    - HOST:<address>:<name,aliases>:<hardware>:<os>:<list of services>
    - e.g.,: HOST : 10.2.0.52 : USC-ISIF,ISIF : DEC-1090T : TOPS20 :TCP/TELNET,TCP/SMTP,TCP/FTP,TCP/FINGER,UDP/TFTP :
  - With this simple format, mapping from name to address (“forward mapping”) and from address to name (“reverse mapping”) is easy
    - On Unix systems, the HOSTS.TXT file was converted to /etc/hosts format

Life with `HOSTS.TXT`

- Easily implemented and understood
- Everybody (in theory) had the same version of the file
- The file was maintained by the SRI Network Information Center (the "NIC")
  - All file edits done by hand
- Network administrators sent updates via the net
  - Initially via electronic mail
  - Later via FTP
- The NIC released updated versions of the file twice a week

The Network Explodes

- Around 1980, the ARPANET consisted of hundreds of hosts
- The ARPANET changed networking protocols from NCP to TCP/IP
  - NCP required hardware (IMPs)
  - TCP/IP was implemented in software
    - And thanks to the U.S. government, the software was essentially free
- LANs became popular
  - And engineers figured out how to use ARPANET hosts as “routers” so that any host on the same LAN could use the ARPANET

The Problems with *HOSTS.TXT*

- Consistency
  - The network changed more quickly than the file was updated
- Name collisions
  - No two hosts could have the same name
    - “Good” names quickly exhausted
  - There was no good method to prevent duplicate names
    - Human intervention was required
- Traffic and load
  - The traffic generated by downloading the file became significant
    - Download time sometimes longer than update period
- The model didn't scale well

Solving the Problem

- ARPANET powers-that-were launched an investigation into replacement for HOSTS.TXT
- Goals:
  - To solve the problems inherent in a monolithic host table system
  - Have a consistent naming structure
  - Create a generic solution that can be used for multiple purposes

The New Naming System

- Requirements:
  - Decentralized administration
    - With data updated locally, but available globally
  - A hierarchical name space
    - To guarantee unique names
  - Massive scalability
- Assumptions:
  - Database size will be proportional to the number of users, not hosts
  - Names are long term persistent

The Advent of DNS

- Paul Mockapetris, then of USC's Information Sciences Institute, designed the architecture of the new system, called the *Domain Name System,* or *DNS*
- The initial DNS RFCs were released in 1984:
  - RFC 882, “Domain Names - Concepts and Facilities”
  - RFC 883, “Domain Names - Implementation and Specification”
- The transition plan was initially released in November, 1983, transition to be completed by May, 1984

The DNS RFCs

- RFCs 882 and 883 were superseded by:
  - RFC 1032, “Domain Administrators Guide”
  - RFC 1033, “Domain Administrators Operations Guide”
  - RFC 1034, “Domain Names -- Concepts and Facilities”
  - RFC 1035, “Domain Names -- Implementation and Specification”
- Additional RFCs specified
  - New “resource record” types
  - DNS operational considerations
  - DNS policies
- DNS continues to evolve to meet the changing demands of the Internet

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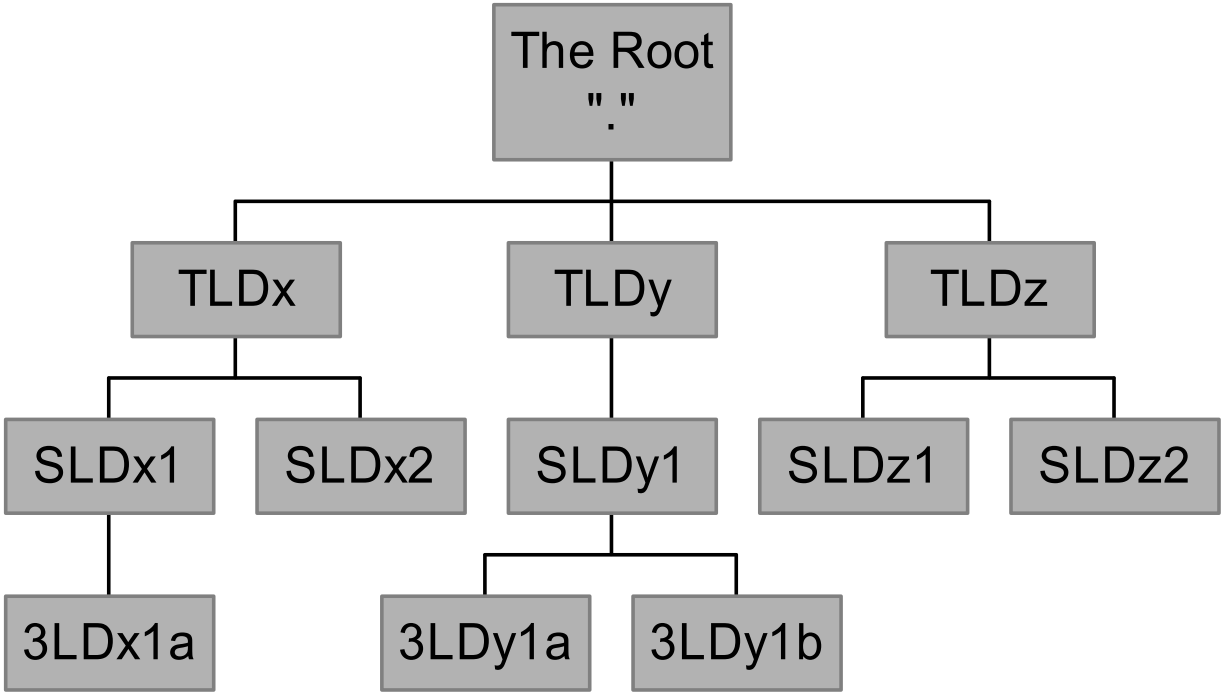
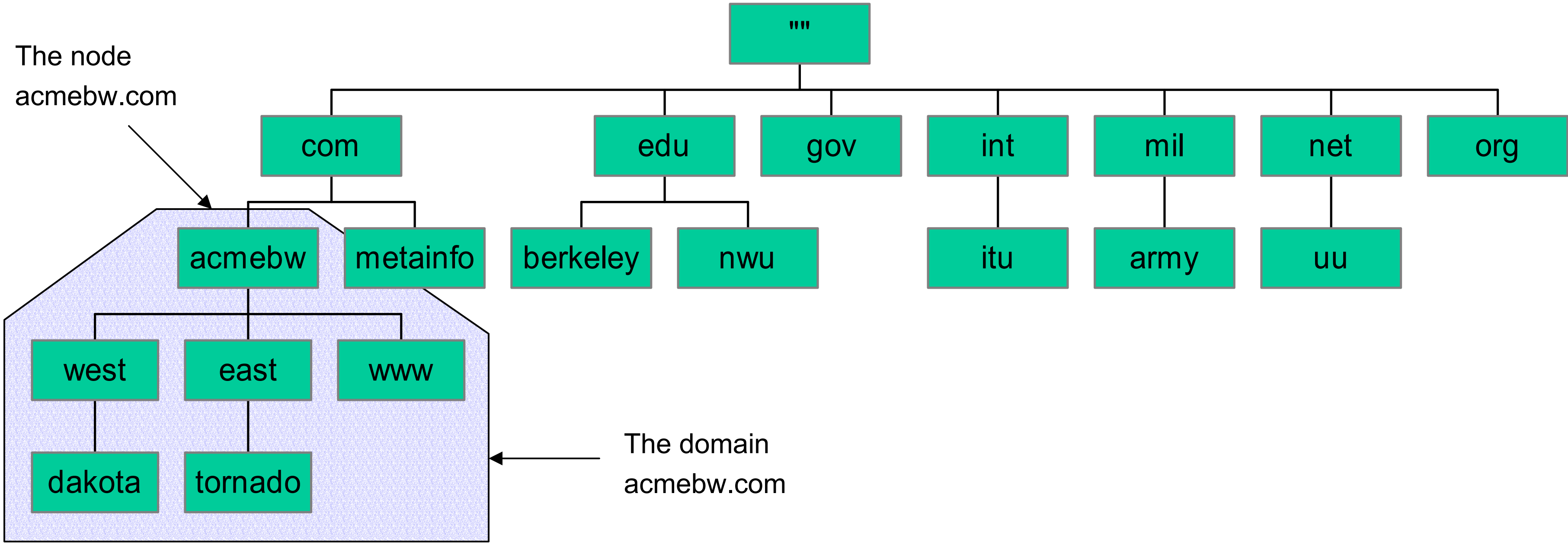
The Name Space

- The *name space* is the structure of the DNS database
- It’s an inverted tree of nodes with the **root** at the top
- Each node has a **label**
- The root node has a null label, written as “.”



Domains

- A *domain* is a node in the name space and all its descendants
  - That is, a subtree of the name space
- A domain's domain name is the same as the name of the node at the root (top) of the subtree



The node acmebw.com

The domain acmebw.com

Subdomains

- One domain is a *subdomain* of another if its root node is a descendant of the other’s root node
- More simply, one domain is a subdomain of another if its domain name ends in the other’s domain name
  - So *sales.acmebw.com* is a subdomain of *acmebw.com*
    - Also of .*com*, but that isn’t usually stated
  - *acmebw.com* is a subdomain of *com*

The Levels

- Above the top is the root.
- Beneath the root are the “Top Level Domains”
  - e.g., .COM, .JP, .INT, etc.
- Beneath the Top Level Domains are “Second Level Domains”
  - e.g., Nominum.COM, AD.JP, ITU.INT
- Beneath the Second Level Domains are “Third Level Domains”
  - e.g., www.Nominum.COM, IIJ.AD.JP, www.ITU.INT
- And so on...

The Root

- The DNS provides a coherent, consistent namespace via a **singly** rooted hierarchical tree structure
  - This root holds the definition of all top level domains that are guaranteed to be unique in that DNS tree
- THERE CAN ONLY BE ONE!
  - Violation of this rule results in inconsistencies in the namespace
    - That is, a name can translate to different addresses depending on where you ask the question
- Due to protocol limitations there are 13 nameservers that serve the root zone
  - a-m.root-server.net
    - a.root-server.net is the primary
- The root nameservers are provided in a configuration file
  - Control of this file is becoming an issue

TLD Structure

- In 1983 (RFC 881), the idea was to have TLDs correspond to network service providers
  - e.g., .ARPA, .DDN, .CSNET, etc.
    - Bad idea -- if your network changes, your email address changes
- By October, 1984 (RFC 920), the concept of functional domains (e.g., .GOV for Government, .COM for commercial, .EDU for education, etc.) was established
  - "The motivation is to provide an organization name that is free of undesirable semantics."
- RFC 920 also provided for
  - Country domains
  - "Multiorganizations"
    - large, composed of other (particularly international) organizations
- The RFC 920 TLD structure remained stable until 1997 or so
  - More on this later...

The .ARPA Hack

- The DNS provides obvious and elegant name to address mapping
- The reverse (address to name) is a bit less elegant
  - Create a domain out of the dotted quad IP address
  - Reverse the ordering to allow for proper delegation
  - Create a “special” domain to hold the delegations
- For Example:
  - 5.10.8.128.in-addr.arpa → umd5.umd.edu
- Originally, a IN-ADDR top level domain was used
  - This was felt inappropriate, so in-addr was moved under .ARPA
- This technique has some problems when dealing with non 8-bit aligned IP address blocks

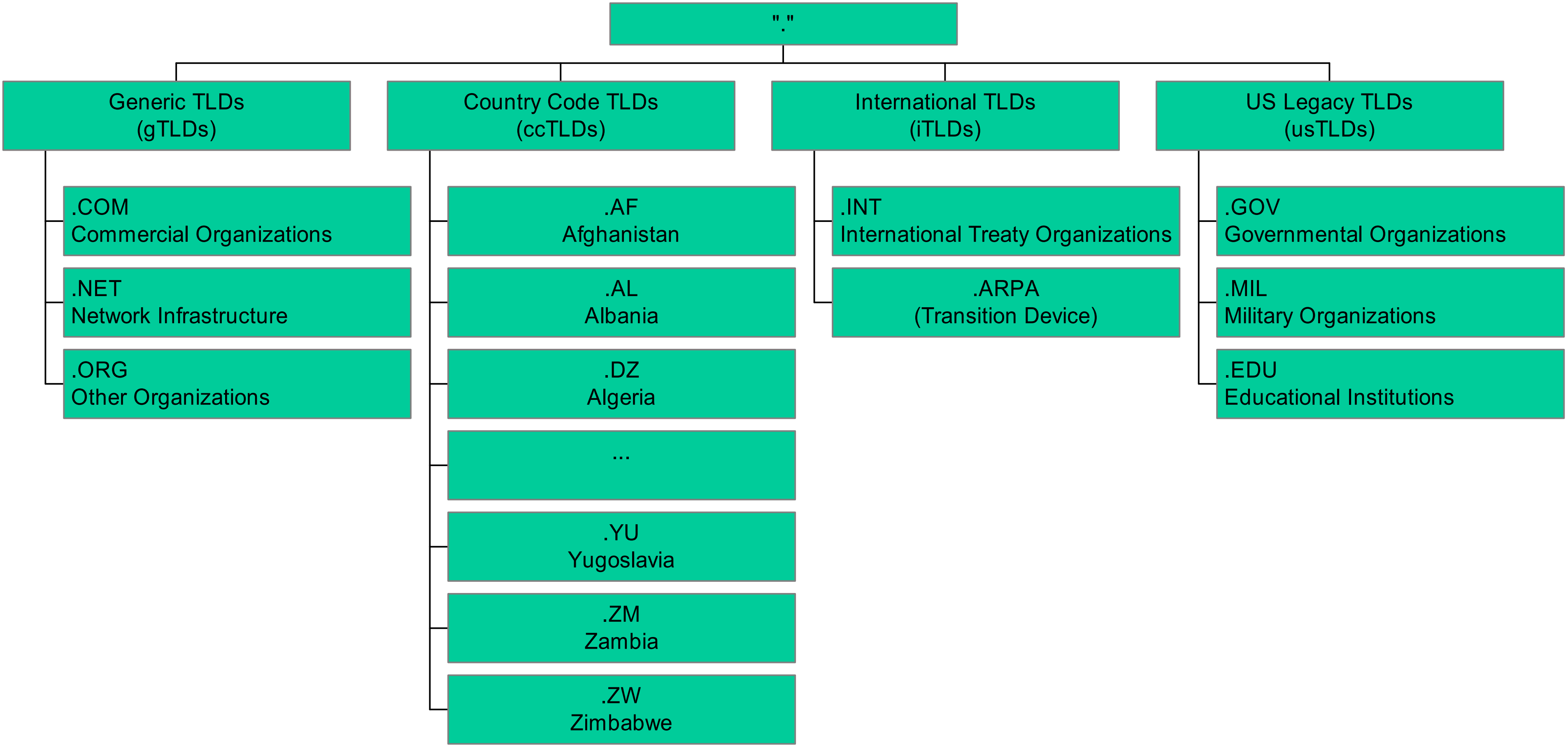
Country Domains

- With RFC 920, the concept of domains delegated on the basis of nations was recognized
- Conveniently, ISO has a list of "official" country code abbreviations
- The IANA likes using lists others define
  - Can always blame someone else…
- The ISO 3166 list is officially available from:
  - `http://www.din.de/gremien/nas/nabd/iso3166ma/codlstp1.html`
- The IANA also uses International Postal Codes for country domains
- In either case, the IANA has no control over what is in those lists

Country Domains (cont'd)

- How each country top-level domain is organized is up to the country
  - Some, like Australia's *au,* follow the functional definitions
    - *com.au, edu.au,* etc.
  - Others, like Great Britain's *uk* and Japan's *jp,* divide the domain functionally but use their own abbreviations
    - *ac.uk, co.uk, ne.jp, ad.jp,* etc.
  - A few, like the United State's *us,* are largely geographical
    - *co.us, md.us,* etc.
  - Canada uses organizational scope
    - *bnr.ca* has national scope, *risq.qc.ca* has Quebec scope
  - Some are flat, that is, no hierarchy
    - *nlnet.nl*, *univ-st-etienne.fr*
- Considered a question of national sovereignty

Current TLDs



"."

Generic TLDs
(gTLDs)

.COM
Commercial Organizations

.NET
Network Infrastructure

.ORG
Other Organizations

Country Code TLDs
(ccTLDs)

.AF
Afghanistan

.AL
Albania

.DZ
Algeria

...

.YU
Yugoslavia

.ZM
Zambia

.ZW
Zimbabwe

International TLDs
(iTLDs)

.INT
International Treaty Organizations

.ARPA
(Transition Device)

US Legacy TLDs
(usTLDs)

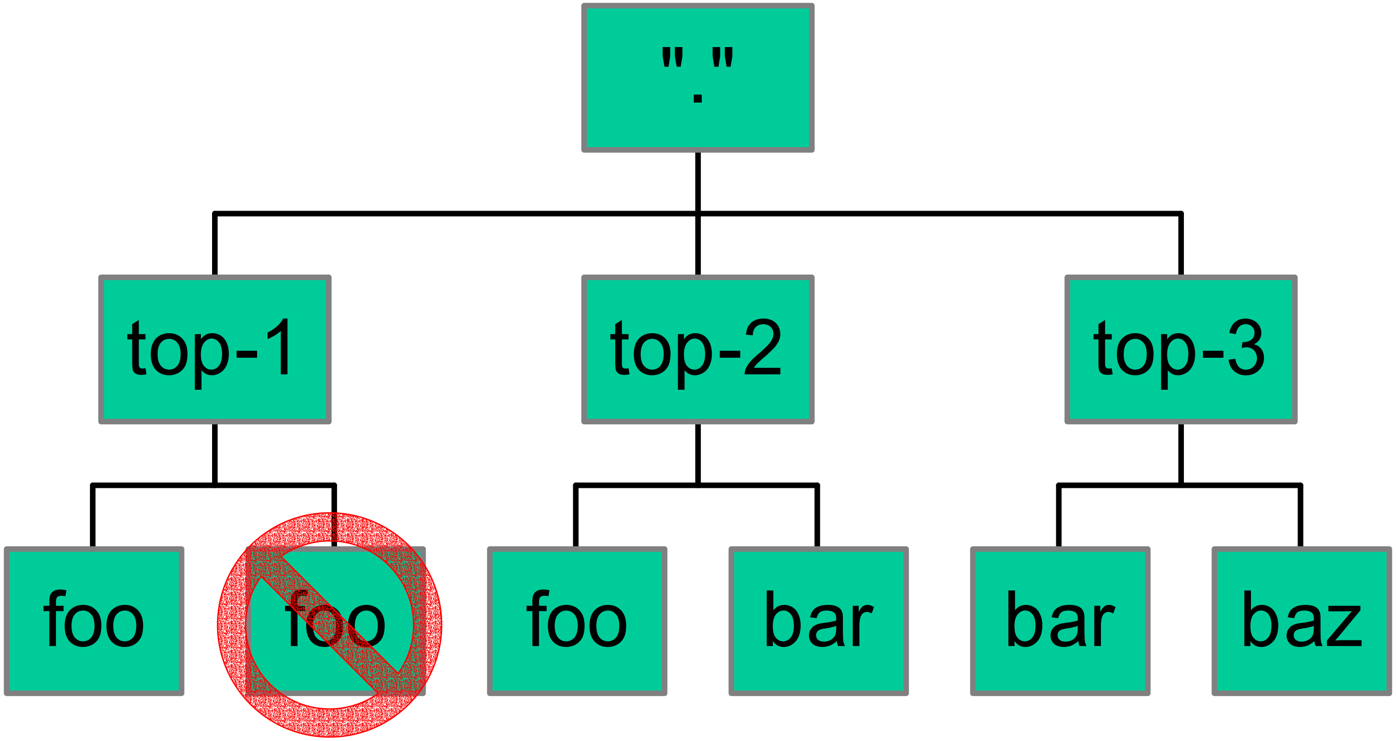
.GOV
Governmental Organizations

.MIL
Military Organizations

.EDU
Educational Institutions

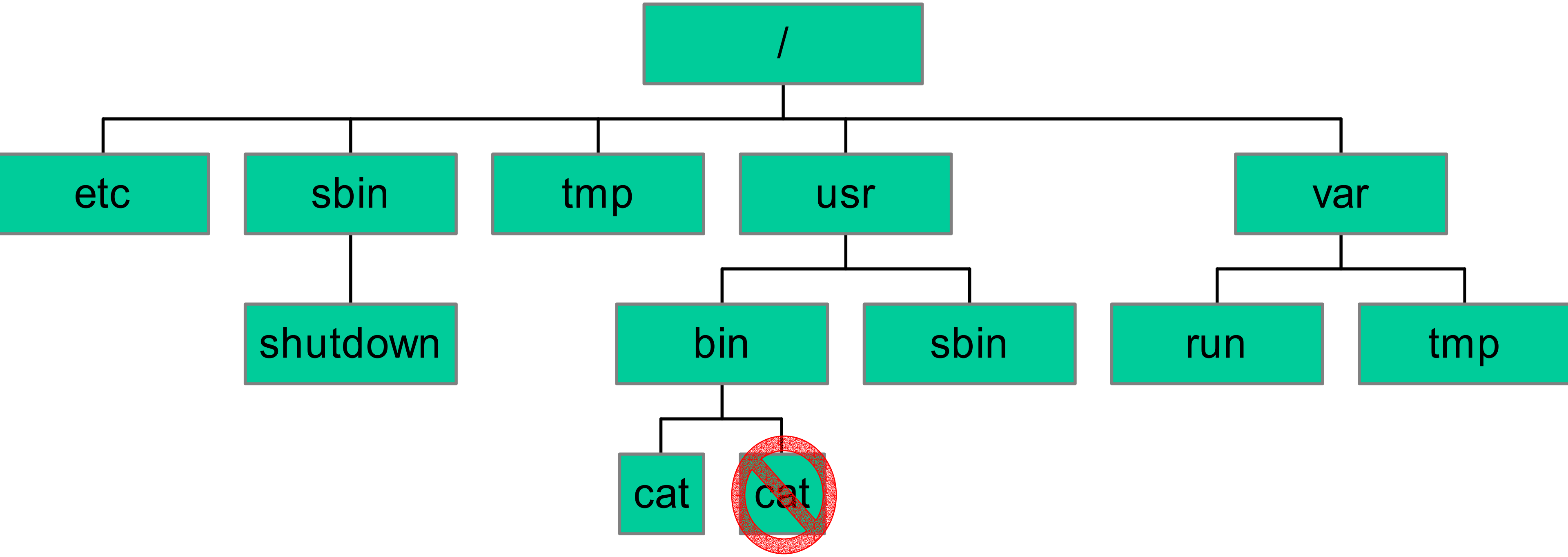
Restrictions on Labels

- The null label is reserved for the root node
  - The terminal “.” can be left off
- Labels cannot exceed 63 characters
  - Legal characters on the Internet are alpha-numeric and dash
- Sibling nodes must have unique labels



An Analogy

- The structure of the name space is similar to the many computer file systems, e.g., Unix:



Domain Names

- A *domain name* is the sequence of labels from a node to the root, separated by ".''s
  - Each label limited to 63 characters
  - Each name limited to 255 characters
  - Maximum of 127 labels per name
- A node's domain name identifies its position in the name space
  - Read from right (least specific) to left (most specific)
    - Similar to postal addresses in the US
      - <building> <street> <city> <state>
  - Much as a pathname uniquely identifies a file or directory in a filesystem

But What About <insert your script here>?

- RFC 952 (circa 1985) defines the Internet Host Table format (HOSTS.TXT)
  - The characters allowed in **host names** were defined as

    ```
    <name> ::= <let>[*[<let-or-digit-
    or-hyphen>]<let-or-digit>]
    ```
- RFC 1123 (circa 1989) relaxed legal host names to start with a number or a letter
  - RFC 1123 is the “Host Requirements” RFC
    - A standard
- Many (legacy) applications assume only RFC 1123 hostnames exist

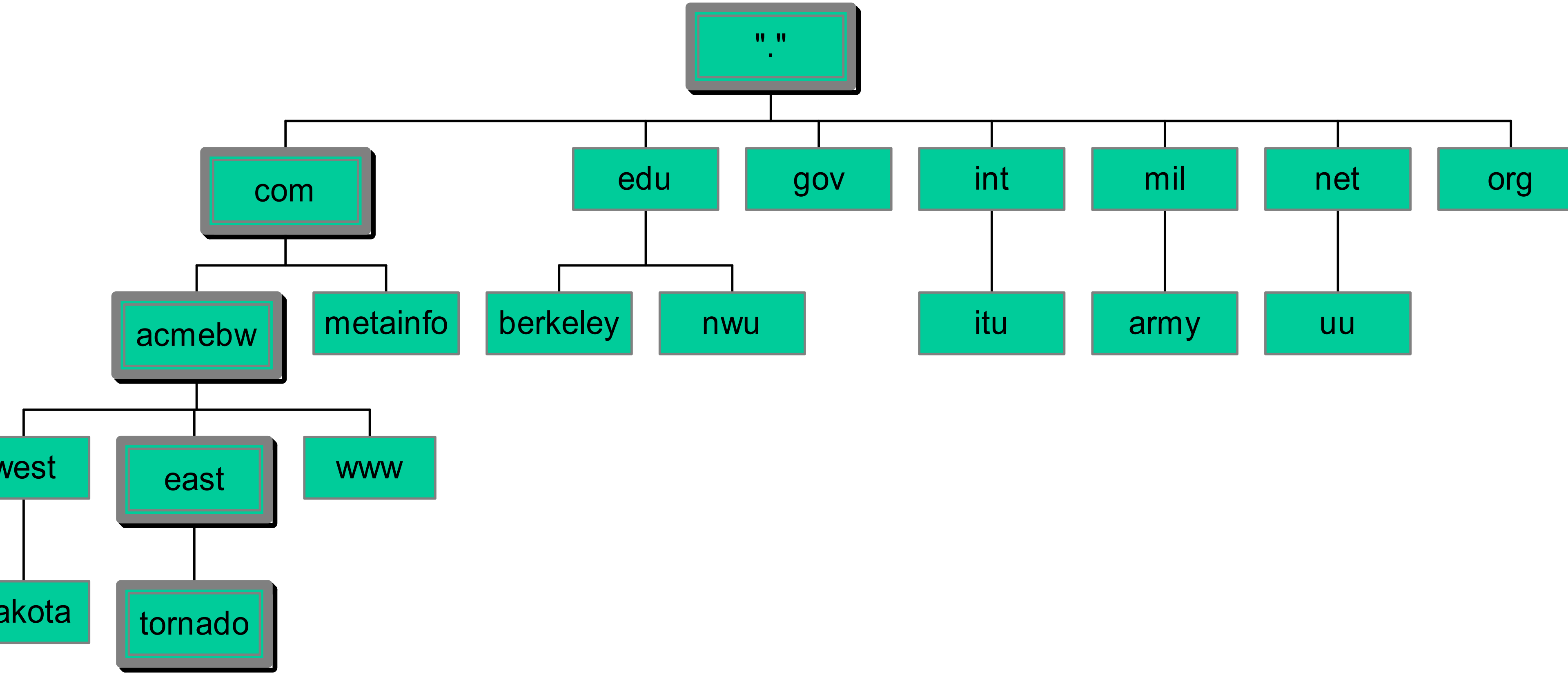
Multi-lingual Domain Names

- RFC 1123 restrictions were enforced in BIND’s resolver around 1996
  - Bad guys were putting shell meta-characters into the reverse mapping names, e.g.:
    - 129.28.12.202.in-addr.arpa →`rm -fr /*`.com
- Around 1998, people started asking why they can’t have their own script in the DNS
  - Microsoft releases Win98 which permits internationalized characters in domain names
- IETF deeply concerned
  - Legacy systems have trouble with “unusual” characters

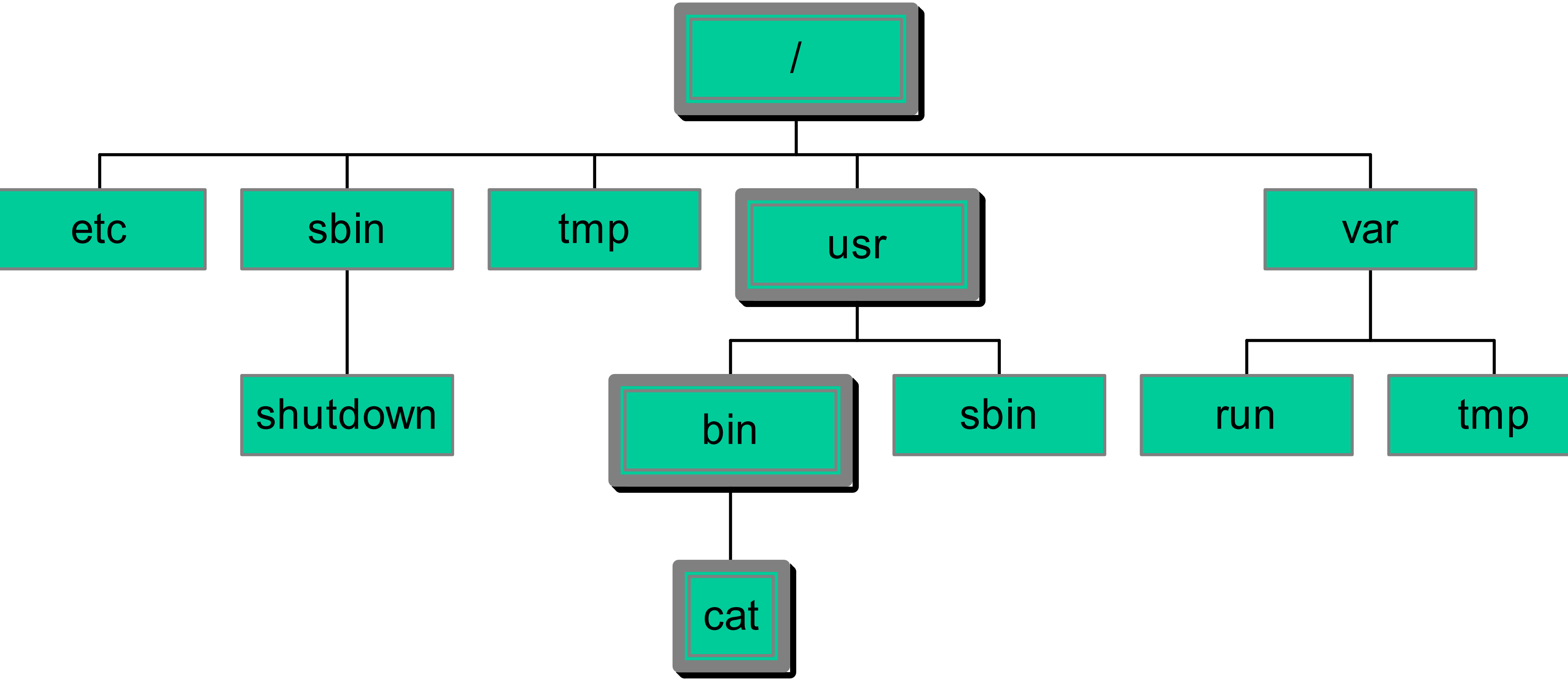
Multi-lingual Domain Names

- Today, there are at least 13 companies providing multi-lingual domain name systems
  - Most do not interoperate with each other
- The IETF has chartered the Internationalized Domain Name (IDN) working group
  - Slated to produce a specification for allowing more than [A-Za-z0-9\-] in domain names
    - Most likely by using new DNS features to transmit UTF-8 if the server can understand UTF-8, falling back to a “hostname character set” encoding if the server can’t

The Domain Name
tornado.east.acmebw.com.



A UNIX Analogy: The File /usr/bin/cat



Fully-Qualified Domain Names

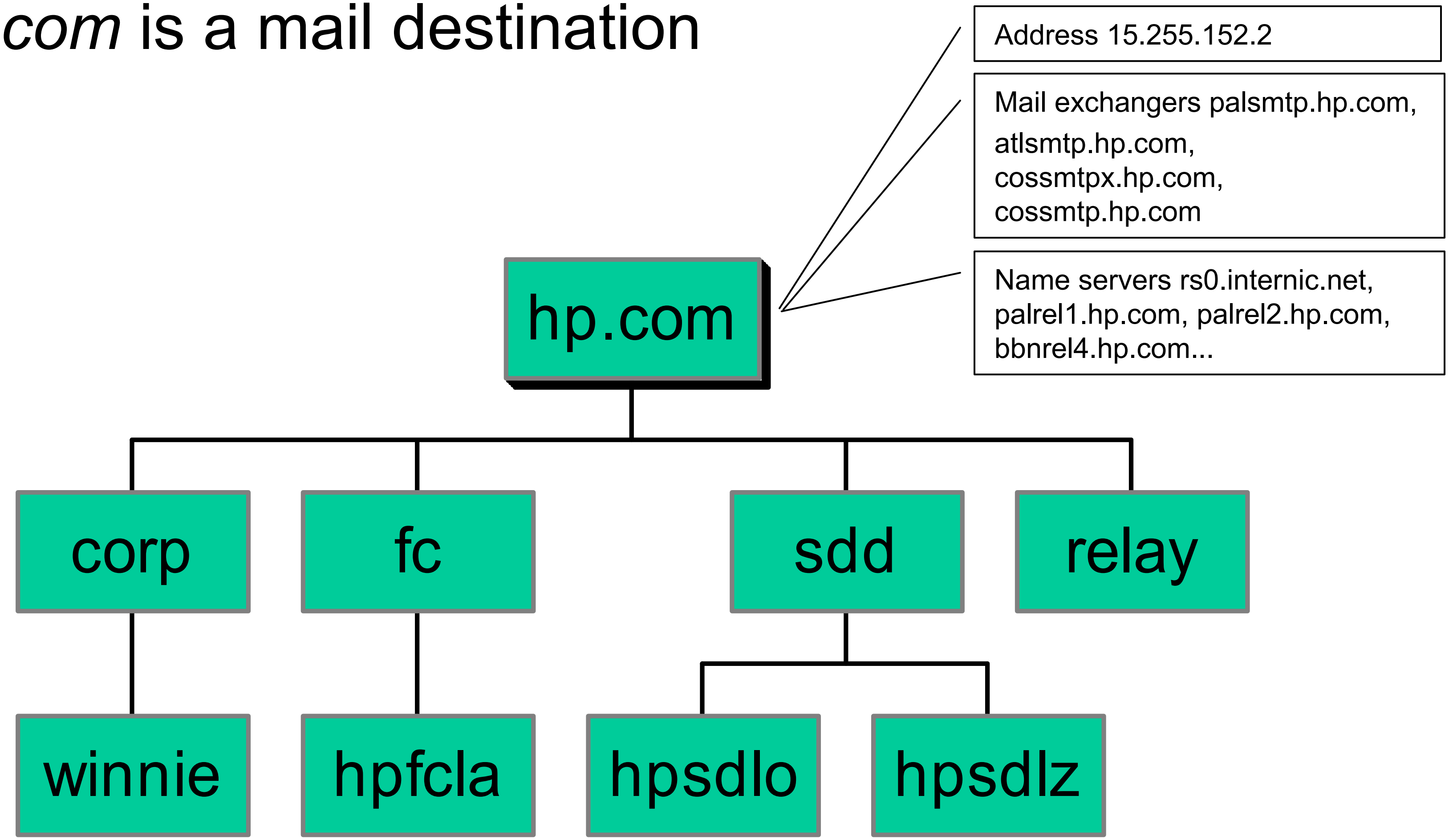
- A *fully-qualified domain name* (abbreviated “FQDN”) ends in a top-level domain name or a dot
  - A trailing dot (“.”) is actually the final separator between the top-level domain and the root’s null label
  - This is like absolute pathnames, which start with "/”
- Domain names without a trailing "." are not necessarily interpreted relative to the root domain
  - Just as pathnames without a leading "/" are usually interpreted relative to the current directory
- In many cases, non-absolute domain names have a domain “path” appended to them
  - Can be a security risk

Where Did the Hosts Go?

- Everywhere!
- The nodes in the name space act as indices into the distributed database
  - Some nodes represent hosts
    - These are indexes to addresses
  - Some nodes represent mail destinations
    - These are indexes to mail routing information
  - Some nodes represent an entire domain
    - These are indexes to lists of name servers
  - Some nodes are aliases for other nodes
  - A single node can represent a combination of hosts, mail destinations and domains

hp.com Domain, Host and Mail Destination

- *hp.com* is a domain (there are nodes below it)
- *hp.com* is a host in Palo Alto, California
- *hp.com* is a mail destination



Address 15.255.152.2

Mail exchangers palsmtp.hp.com, atlsmtp.hp.com, cossmtpx.hp.com, cossmtp.hp.com

Name servers rs0.internic.net, palrel1.hp.com, palrel2.hp.com, bbnrel4.hp.com...

Delegation

- Administrators often create subdomains to distribute management of the domain
  - An administrator can delegate responsibility for managing a subdomain to someone else
  - The parent domain retains pointers to the sources of data for the delegated subdomain
- This sub-delegation provides for administrative scaling
  - Delegation is a good thing

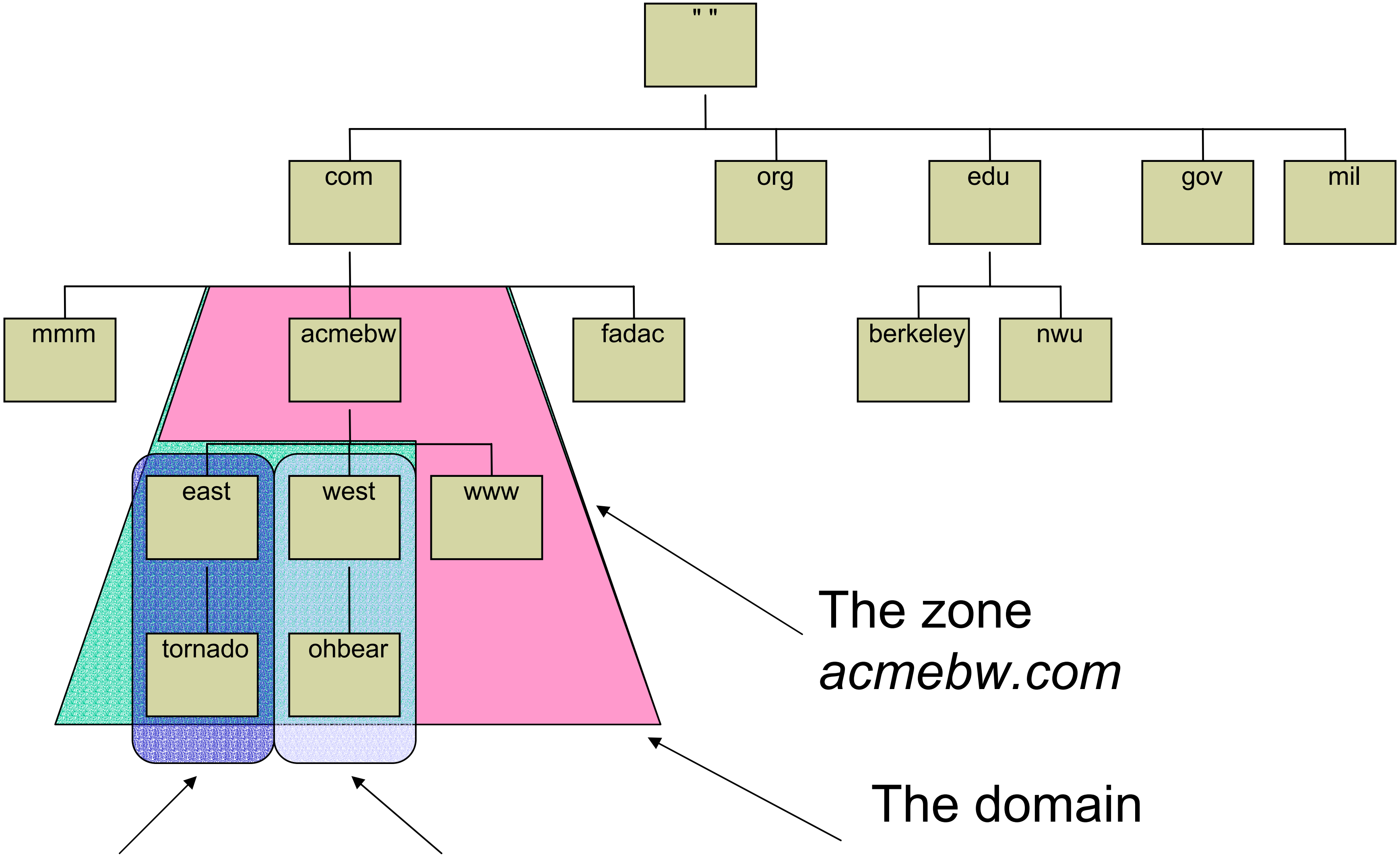
Delegation Creates Zones

- Each time an administrator delegates a subdomain to someone else, this creates a new unit of administration
  - The subdomain and its parent domain can be administered independently
  - These units are called *zones*
  - The boundary between zones is a point of delegation in the name space

What’s in a Zone?

- Like a domain, a zone is named after its root node
- Unlike a domain, a zone contains only descendants of the zone’s root nodes that aren’t in a delegated subdomain
  - Nodes below the delegation point are in another zone

The Domain acmebw.com Divided into Zones



The zone *acmebw.com*

The domain *acmebw.com*

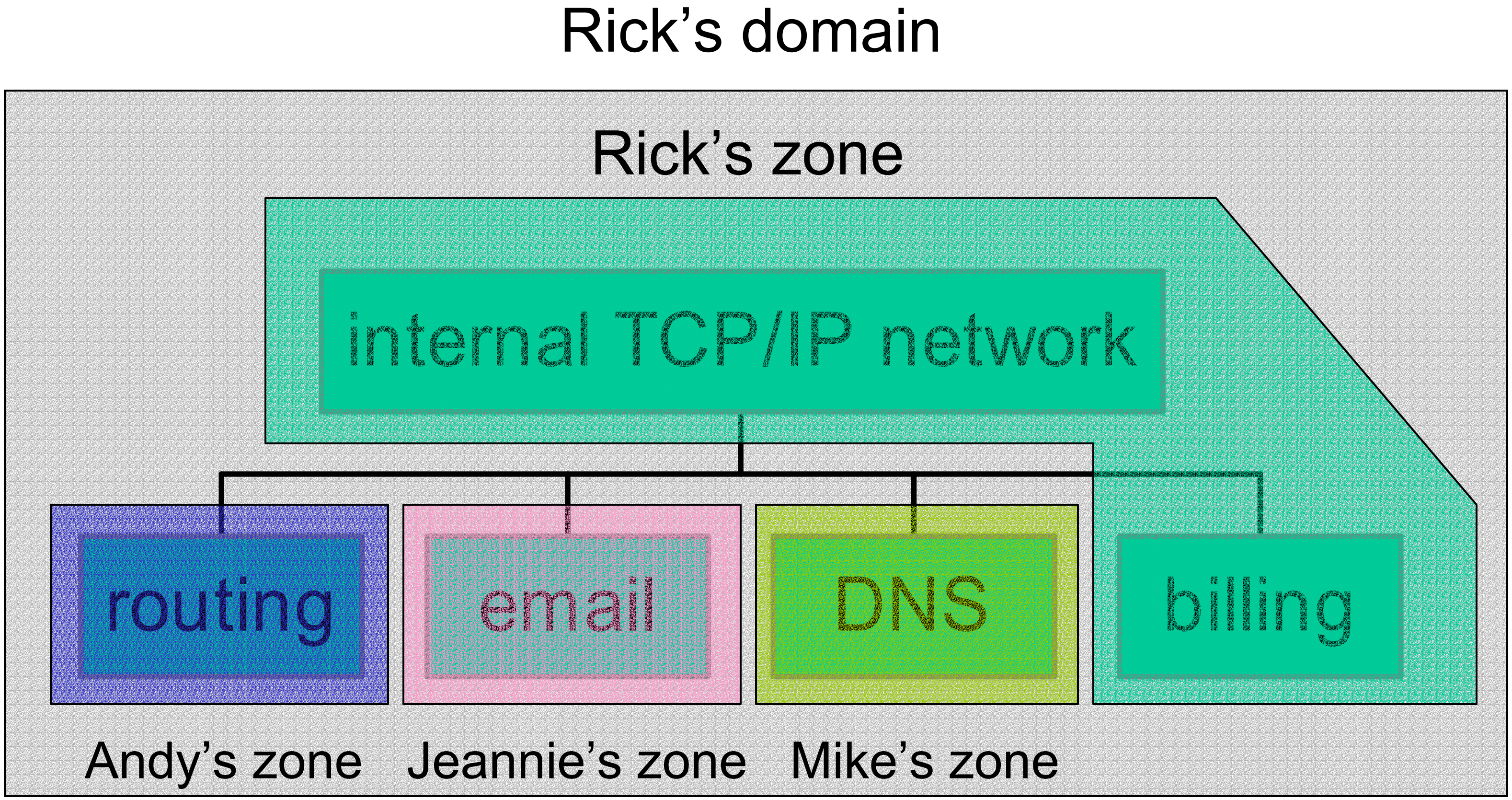
The zone *east.acmebw.com*

The zone *west.acmebw.com*

A Delegation Example

- Think of delegation in a managerial setting
  - A manager, Rick, has overall responsibility for managing his company’s internal TCP/IP network
  - However, he can’t do everything himself; he delegates responsibility for some tasks to his employees
    - He delegates routing to Andy
    - He delegates email to Jeannie
    - He delegates DNS to Mike
    - But he keeps billing for himself

The "Internal" TCP/IP Network Domain Divided into Zones



Rick's domain

Rick's zone

internal TCP/IP network

routing

email

DNS

billing

Andy's zone

Jeannie's zone

Mike's zone

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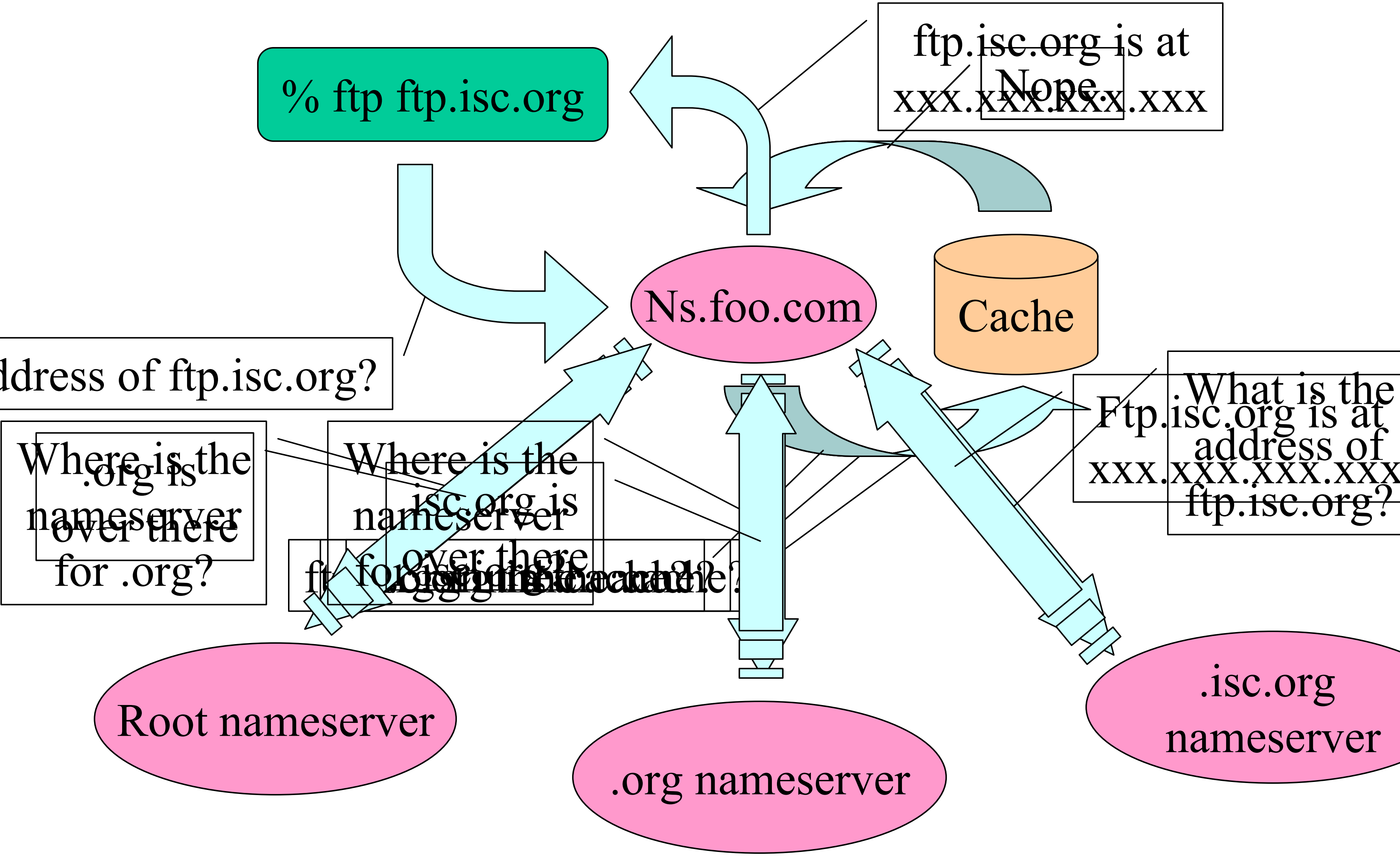
The DNS Architecture

- The Domain Name System has a client-server architecture
  - *Resolvers* are the client half
    - Always linked into an application program
      - Users execute the program, resolution requests are created and sent to servers, e.g.:
        - netscape http://www.isc.org
      - will result in the resolver requesting the IP address(es) of www.isc.org
    - Some configuration of the resolver possible
      - Nameservers to query, timeouts, number of retries
      - On Unix, found in /etc/resolv.conf
  - *Name servers* are the server half
    - Long running server process (always active)
    - Best run on a dedicated machine
    - Resource requirements depends on many factors

Resolvers

- Resolvers are responsible for
  - *Translating* an application's request for information about a domain name into a DNS query,
  - *Sending* the query to a name server,
  - *Retransmitting* the query, if necessary,
  - *Falling back* to another name server or name service, if necessary,
  - *Translating* a name server's DNS response into a reply to the application
  - *Notifying* the application of name lookup failure (time out, authoritative non-existence, server failure, etc.)
- The operation of the resolver is almost always transparent
  - Usually a library call within an application

Name Resolution Example



% ftp ftp.isc.org

ftp.isc.org is at xxx.xxx.xxx.xxx

Nope.

Ns.foo.com

Cache

ddress of ftp.isc.org?

Where is the nameserver for .org?

.org is over there

Where is the nameserver

isc.org is over there

[illegible]

What is the address of ftp.isc.org?

Ftp.isc.org is at xxx.xxx.xxx.xxx

Root nameserver

.org nameserver

.isc.org nameserver

Name Servers

- Name servers are responsible for
  - *Storing* information about the name space,
    - Including additions, deletions, and changes
  - *Answering* queries from resolvers and other name servers,
  - *Querying* other name servers for information about the name space they don’t already know, and
  - *Caching* information they learn about the name space from other name servers

Name Server Architecture

- You can think of a name server as part
  - *database server,* answering queries about the parts of the name space it knows about,
  - *agent,* helping resolvers and other name servers find data that other name servers know about, and
  - *cache,* temporarily storing data it learns from other name servers.

Name Server Data

- Name servers store information about the name space in units of zones
  - The name servers that load a complete zone are said to “have authority for” or “be authoritative for” the zone
- Usually, more than one name server is authoritative for the same zone
  - This ensures redundancy and spreads the loads
- Also, a single name server may be authoritative for many zones

Data in the Name Space

- Each domain name in the name space points to one or more *resource records,* or *RRs* for short
- Each resource record has a class and a type associated with it
  - The class specifies what kind of network (e.g., TCP/IP) the record describes
  - The type specifies what type of data (e.g., address) the record stores

Resource Records

- Resource records have as many as five fields, some of which are optional:
  - *Owner:* the domain name of the node to which the record is attached
  - *Time to live (TTL):* how long to keep the record in a cache
  - *Class:* the kind of network this record describes
  - *Type:* an indication of the function of this record
  - *RDATA:* record-specific data
    - The RDATA can be further subdivided into type-specific fields

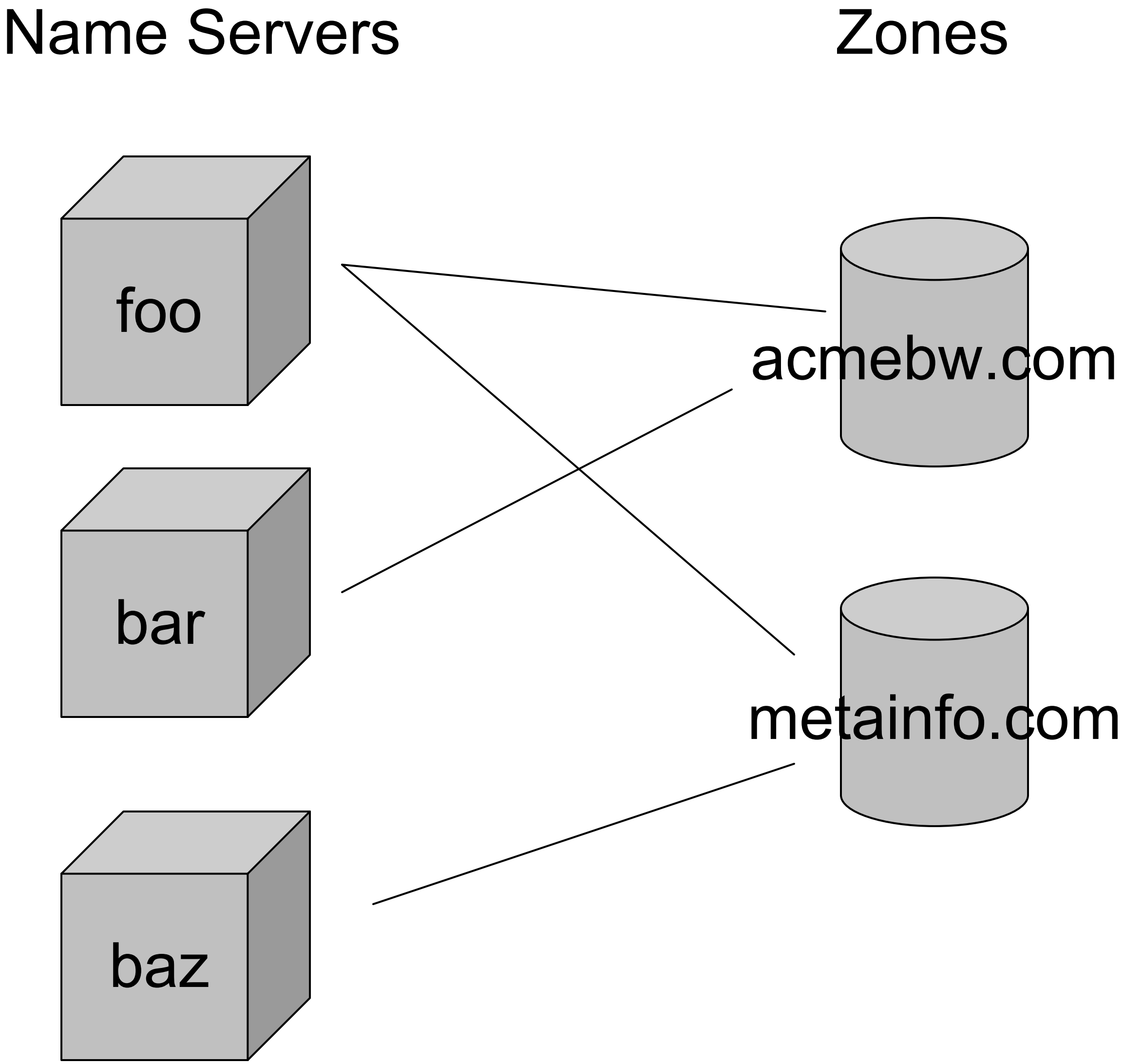
Record Classes

- By far the most common class of data is the Internet class, abbreviated *IN*
  - This specifies, for example, that the addresses stored are IP addresses
- Other classes include
  - *Hesiod,* for MIT's Hesiod network protocols,
  - *CHAOSNET,* for the (largely historical) CHAOSNET protocols (also out of MIT)

Zone Data Files

- Resource records are collected into “RR Sets”
  - The collection of all RRs with the same owner
- All RR Sets associated with a zone are kept in “*zone database files*”, also called database files or db files
- Zone database files are usually named after the zone whose records they contain
  - On UNIX, usually db.zone, e.g., db.acme or db.acme.com
  - On NT with the Microsoft DNS Server, usually zone.dns, e.g., acmebw.com.dns

Name Servers and Zones

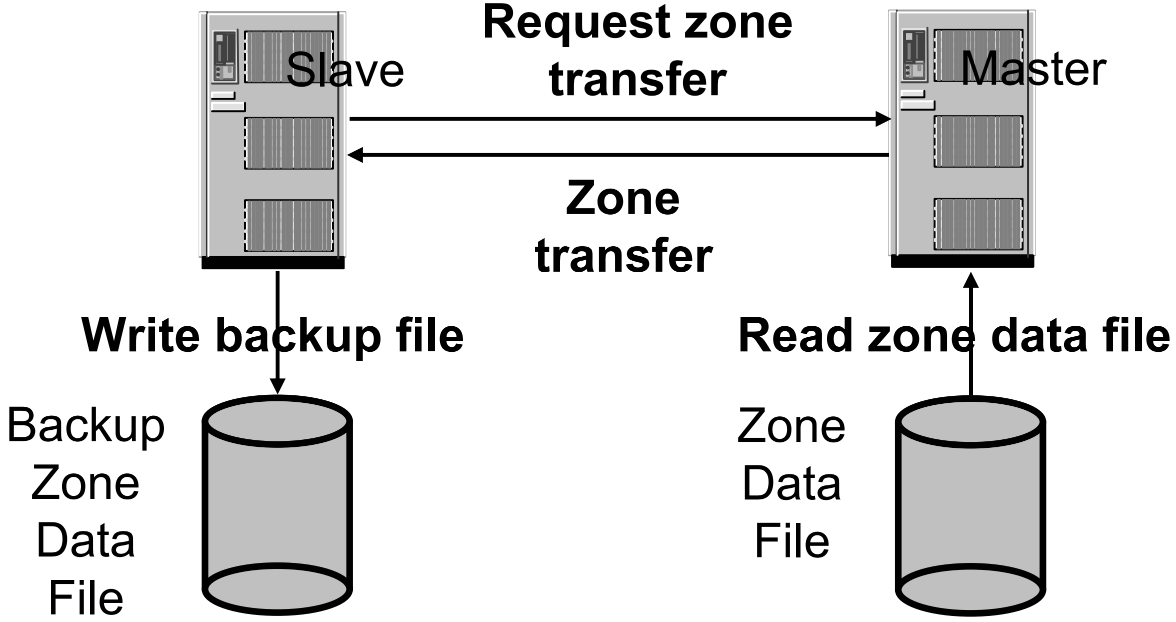


Types of Name Servers

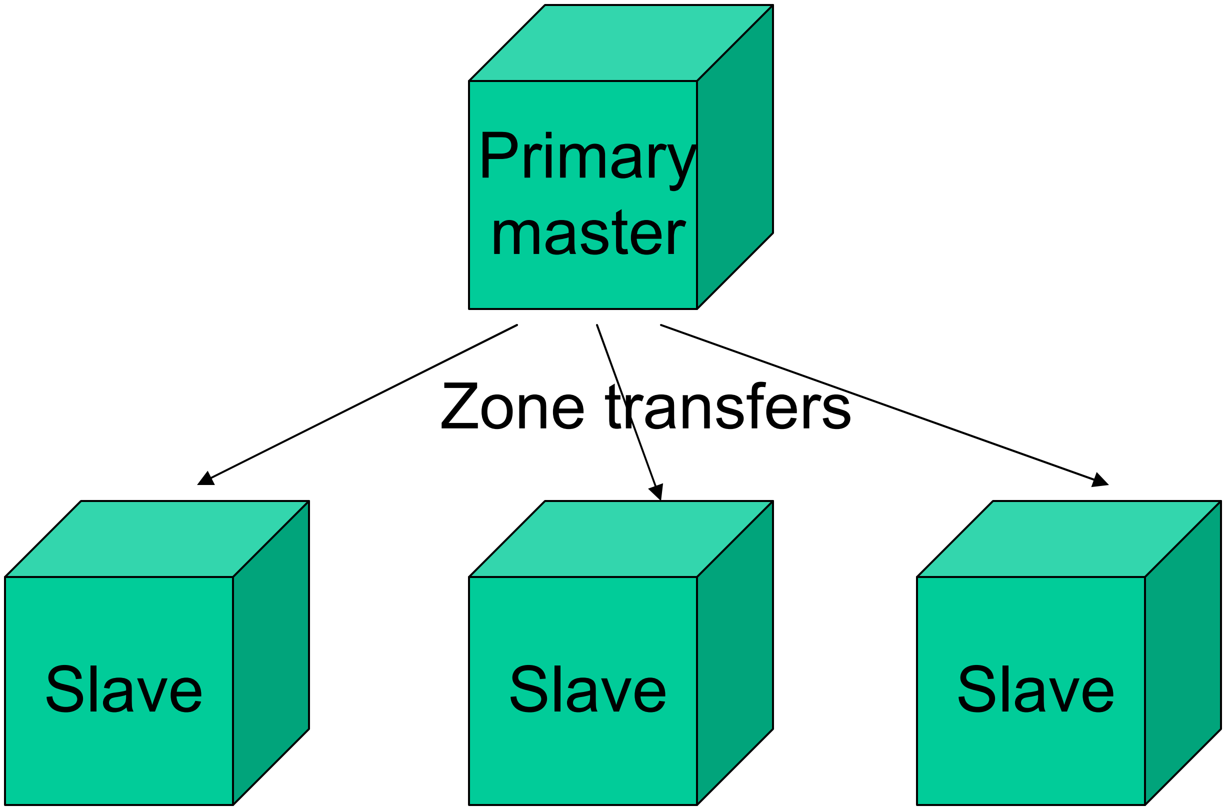
- The *primary master* name server for a zone loads the zone’s data from a file on disk
- A *slave* name server for a zone loads the zone’s data from another authoritative name server (often the primary master)
  - The equivalent BIND 4 term for slave was “secondary master”
  - The server the slave gets its zone data from is called its *master* server
- A single name server can be the primary master for some zones and a slave for other zones
  - The relationship is defined zone-by-zone

Zone Transfers

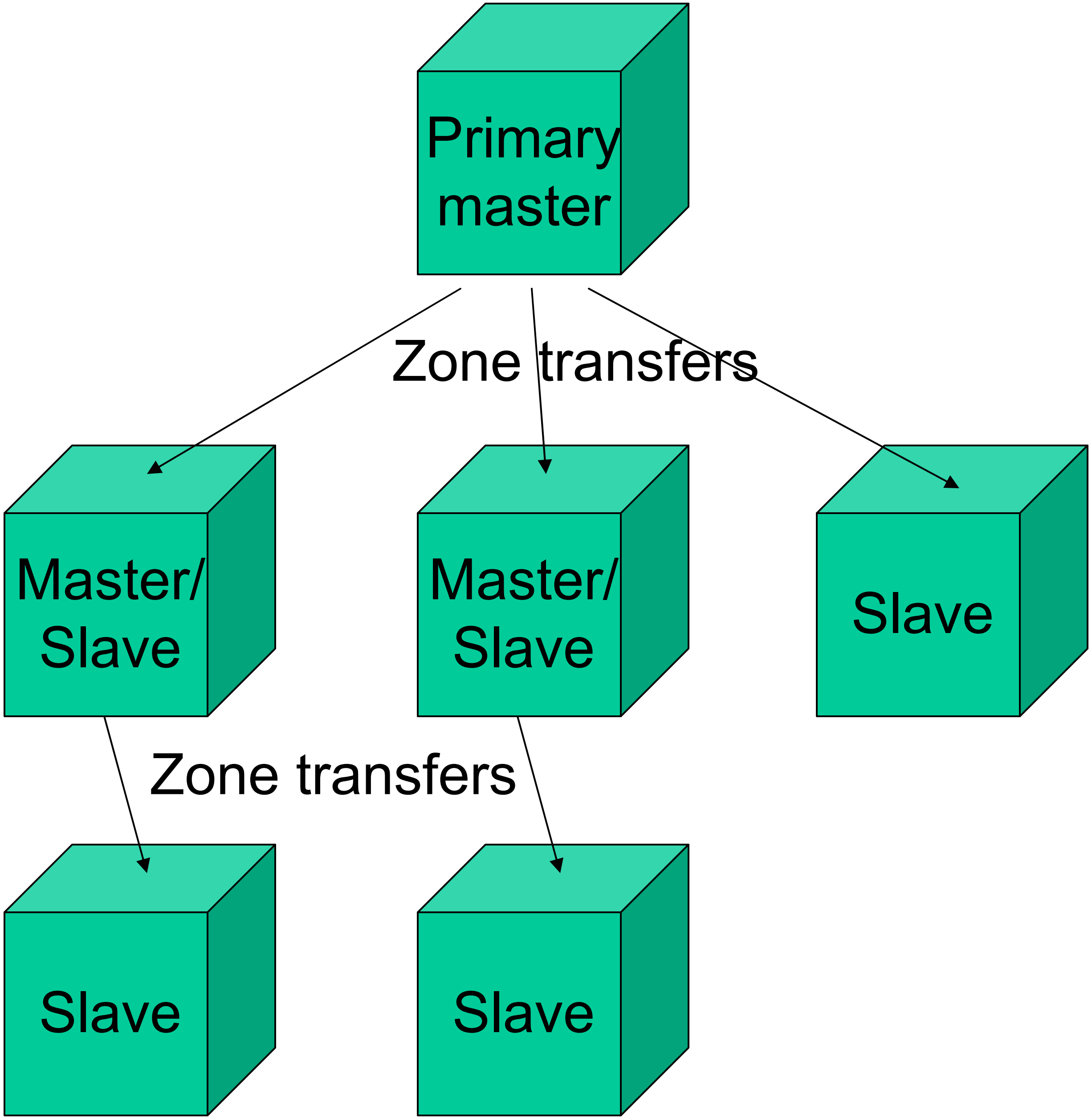
- Slave servers retrieve zone data from other authoritative name servers using a *zone transfer*
- The zone transfer is initiated by the slave
  - By initiating a TCP connection to the master name server



A Simple Primary Master/Slave Configuration



A Two-Tier Primary Master/Slave Configuration



For the Technically Inclined

- ISC provides an “Open Source” reference implementation of the DNS known as BIND
  - Current versions:
    - 4.9.7
    - 8.2.2-P5 (8.2.3 due out soon)
    - 9.0.0 (due out soon)
  - Available from http://www.isc.org/bind.html
- Other freely available DNS implementations
  - DJBDNS, see http://cr.yp.to/djbdns
  - DENTS, see http://www.dents.org
- Commercial DNS implementations available from:
  - Nominum (:-)), Microsoft, Cisco, Lucent, Checkpoint, and many others

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Administration of the DNS

- Management of a small scale zones is relatively easy
  - Won’t be addressed here
  - See “DNS & BIND, 3rd Edition” by Paul Albitz & Cricket Liu, O’Reilly & Assoc.
- Management of large scale (country sized) zones is a bit more of an issue
  - Services you should provide
  - Traps to watch out for

What Does it Mean to Provide a Country TLD Service

- RFC 920 first documented the concept of country code domains
  - Rumor is ccTLDs were an afterthought
    - Original idea was to have, e.g., all the world's military organizations under .MIL
- RFC 920 was issued in 1984
  - No ccTLD administrators yet existed
  - The IANA initially delegated the ccTLD to anyone who asked
  - Soon, the policy was revised to require the administrative contact in-country
  - The IANA imposed no requirements on how the TLD was to be administered

Providing ccTLD Services

- With international proliferation of the Internet came increased demand for domains from ccTLD
  - The IANA allocated ccTLDs to:
    - Universities
    - Commercial entities
    - Individuals
- Until around 1995 or so, governments ignored the Internet
  - The world was moving to OSI
    - Or so they thought…

Providing ccTLD Services (cont’d)

- As the Internet became more popular/important, national Network Information Centers began to sprout up
  - Entities interested in a domain from a particular ccTLD contacted these national NICs
  - In some cases national NICs provided services equivalent to InterNIC
  - In other cases, the national NIC didn’t
- There is no requirement (to date) to provide any services other than name allocation
  - And to insure duplicate names aren’t allocated

Useful Services (cont’d)

- Domain name allocation
  - Avoidance of duplicates
- Nameserver operation for the domain
  - Secondary for sub-domains of the domain
- Domain name registration
  - Making the registration database available
- Providing training and information on Internet related issues
- Providing a forum for Internet development within a country

Recommendations for a NIC

- Technical competence
  - Always a good thing
- Good connectivity
  - Required if you'll be running the nameserver primary
- No discrimination
  - Or rather, equal discrimination
    - Fair and equitable policies for all applicants
- Documented policies
  - Including the appeals process

Obtaining the Delegation of a ccTLD

- As of now, only KP (N. Korea) and EH (W. Sahara) are not delegated
- However, increasingly ccTLDs are being transferred between organizations within a country
- To obtain the delegation, you will need:
  - Support of the majority of the local Internet community
    - Or, be a governmental agency if the delegation is not already made to a governmental organization
      - "The desires of the government of the country with regard to delegation of a ccTLD are taken very seriously"
  - Well connected nameservers
    - Albeit, not necessarily in-country
  - Demonstrated technical competence
  - Agreement to comply with RFC 1591

Support of the Local Internet Community

- Everybody should work together
  - Re-delegation will not occur if there is more than one supported contender for the domain name
- No strong objection should exist against the proposed NIC
  - If a strong objection exists, requestor(s) will be told to work it out and come back when they have
- If mistrust exists, TLD may not be re-delegated until a consensus is reached

Well Connected Nameservers

- Required to provide nameservice for the allocated subdomains to the rest of the Internet
- Secondary servers required at other locations
  - Definitely on different networks
  - Preferably in widely geographically dispersed locations
  - Provided free of charge by RIPE-NCC, APNIC, and others
- Bandwidth to nameserver need not be large
  - But must be stable

Proof of Technical Competence

- NIC’s nameservers control all domains under it
- Unstable service could result in loss of reachability for all domain owners
  - Unless people have memorized IP addresses
- Database and administrative services must be provided appropriately
  - Backups of critical databases
  - 24x7 systems support pretty much expected
  - 24x7 user support would be nice
    - But extremely rare
- The IANA won’t give a test
  - But will pull a delegation if badness happens

RFC 1591 Compliance

- RFC 881 (revised several times, 1591 being the last) set forth the basic principles of name delegation:
  - Technical and administrative contacts must exist and must act as the manager for the domain
  - The designated managers are trustees and serve the community the domain represents
  - The manager must be equitable to all groups
  - Significantly interested parties must all agree that the manager is the appropriate body to administer the domain
  - The manager must do a good job
  - Any transfer of responsibility must be coordinated
- NIC operators will have to indicate compliance with these requirements

Application for a ccTLD

Obtain the template found at

- http://www.iana.org/cctld-template.txt

Fill it in

- It is amazingly similar to the InterNIC domain request template

Send the filled in template to iana@iana.org

Wait…

The IANA will

- Verify the information on the form
- Verify the appropriateness of the request
- Update the InterNIC database appropriate

or

- Send mail back explaining why they won’t be processing the request

Operational Requirements

- It is very important to have well formulated and **published** policies
  - Fair and equitable to potential customers
  - Not discriminatory
- It is even more important that the policies are adhered to
- It is helpful to have the policies translated to English and available on the Web
  - People prefer copying to re-inventing the wheel
  - Allows for similar policies over the Internet

Policies (Overview)

- Policies should be defined for the following areas:
  - Structure of the namespace
  - Eligibility for domains under the TLD
  - TLD and subdomain ownership
  - Allocation model
  - Charging and billing
  - Domain name disputes
  - User participation
  - Documentation
  - Appeals process

Structuring the Namespace

- Generally it’s possible to just assign any domain under the TLD
  - Flat namespace
- Not generally a good idea
  - Doesn’t scale well
  - Can lead to confusion
  - May result in administrative nightmares later
- Structured namespaces are generally better thought of
- Restructuring an existing namespace must provide for a period of transition!

Structuring the Namespace (cont'd)

- If a hierarchical namespace is chosen
  - NIC chooses the SLDs
    - Customers obtain 3LDs
- It is very important to document the circumstances under which a new SLD will be created
  - Community input is generally a good thing
- Policies for determining which SLD should be used should be objectively verifiable
  - e.g., a business license for commercial domains, organization charter for non-profit domains, etc.

Eligibility

- Who is allowed to apply for a domain under the TLD?
  - Only registered entities?
  - Only local businesses, organizations, etc?
  - Anyone in the world?
- What is the policy for multiple domain names by a single organization?
  - If restricted, what is the unit of organization?
    - Subsidiaries? Branches? Offices?

Application Procedures

- Should be explicit and easily understood
- Should be available online
  - WWW, FTP, e-mail
  - Nice to have automated forms with ticketing systems to track requests
- Quality of service parameters should be documented
  - Turnaround time, etc.
- Additional documentation requirement should be spelled out prior to application
  - Minimize the number of query/response cycles

Ownership

- Who owns the delegated domain?
  - The NIC?
  - The organization requesting the domain?
  - The end user of the domain?
- Which rights to the domain are conferred?
  - Full rights?
  - Only the use of the domain for actual activities?
    - As opposed to resale?
- What constitutes (il)legal use of a the domain name?

Allocation of Domains

- Model:
  - Outright sale?
  - Rent/Lease for a period of time?
  - Membership model?
    - E.g., use of the domain name only allowed while owner is a member of the NIC?
- Renewal period?
  - How often
    - Once-and-for-all?
    - Yearly?
- Transfer of domain names
- When can a delegation be revoked?
- When will a domain be re-delegated?
  - What is the NIC’s hold time

Charging and Billing

- NICs will incur substantive costs
  - How much will depend on the level and quantity of services provided
- Fees may be charged for NIC services
  - Strongly recommended
    - Only way to insure long term viability
- What is the fee structure?
- How will money be accepted?
  - Credit cards, checks, cash?
  - If foreign ownership allowed, how is currency exchange handled?
- Policy for partial-term names?

Fee Structure

- Flat or differentiated?
  - First domain cheap, next more expensive?
  - Type of organization (non-profit vs. commercial, etc.) determines fee?
- Fee period
  - One time?
  - Periodic?
    - What period? Yearly, monthly, etc.
- Maintenance fees separated from allocation fees?

Profits

- If fees are charged, they should at least cover costs
- Domain names are now seen as a valuable resource
  - People will question right of the NIC to make money off that resource
- If no competition is allowed, non-profit status might reduce flamage
  - Alternatively, profits can be reinvested into the Internet community
  - Alternatively, people can be told to get a life

Dispute Resolution Policy

- Domain names can conflict with trademarks
- Disputes **will** arise:
  - Domain names must be unique
  - Trademarks need not be
- NICs have been sued in the past
- If a lawsuit is filed, costs will be incurred
  - Expect this and plan for it in budgets
- If a lawsuit is lost, operation of the NIC can be imperiled
  - It would be nice if the NIC is recognized as non-sue-able by the government

Avoid Being Sued

- Not equal to avoiding disputes
- Require customer to stipulate non-infringement
  - Make it their responsibility
- Require indemnification
- Insure delegation does not confer any legal right to the *name* that corresponds to the domain
- Evaluate whether to check for infringements carefully
  - Don’t become an “editor” of content

Dispute Policy

- Clearly define where customers claim infringement
  - If at all possible, not at the NIC
- Define how parties involved will participate in the resolution of the dispute
- Indicate how disputes will be handled
  - Whether the domain will be put “on hold”
    - Whether it will be usable in that state or not
- The NIC should try **really** hard to avoid adjudicating disputes
  - That’s what court systems are for

Overview

- Introduction
- History
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- Administrative details
- Political details
- Futures
- Summary

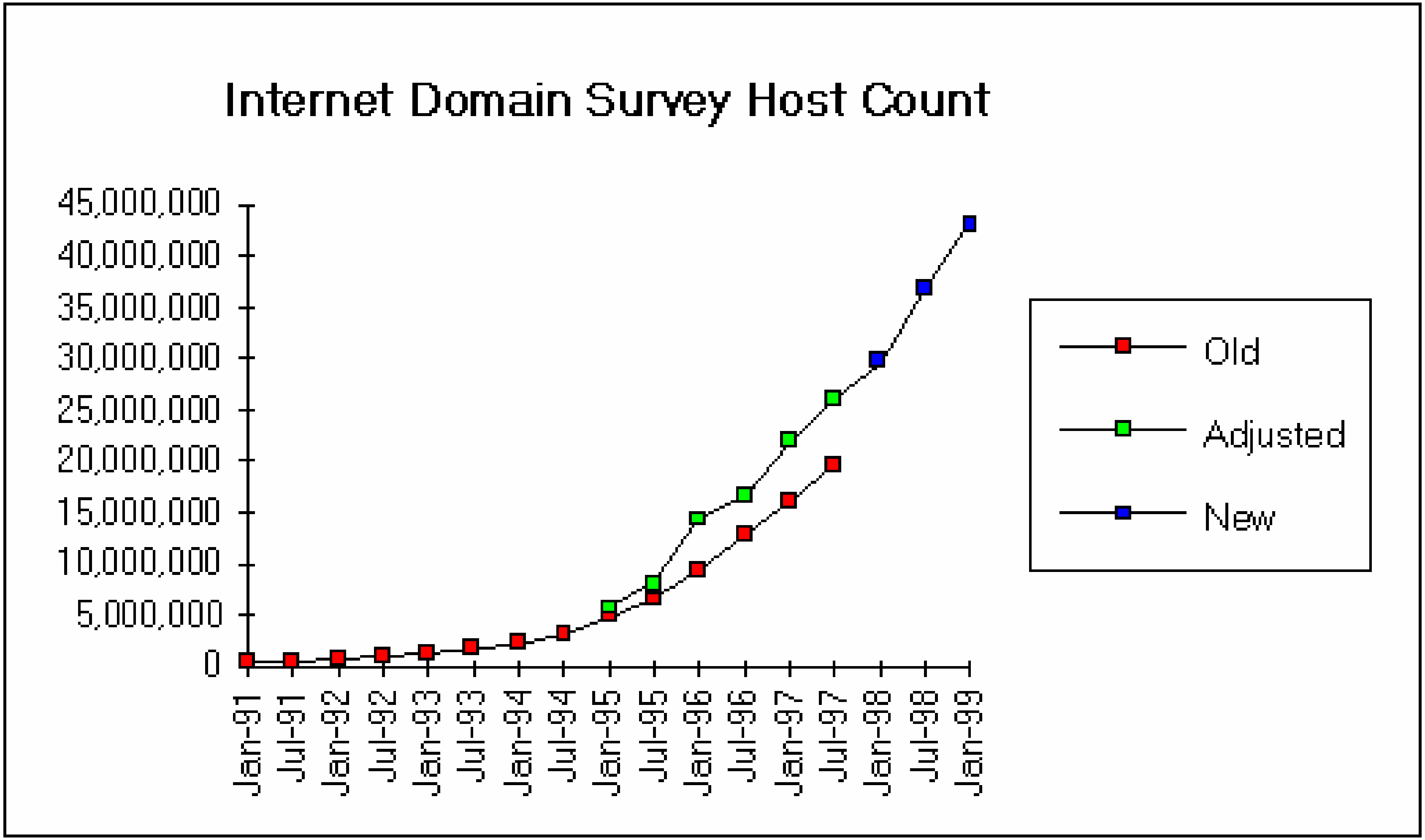
DNS Politics -- Background

- In 1992, the National Science Foundation re-bid the Network Information Center function
  - The new NIC would be called "InterNIC"
    - Composed of 3 parts
      - Registration services
      - Database services
      - Information services
  - Network Solutions won registration services
  - AT&T won database services
  - General Atomics won Information services
- Transfer from SRI-NIC didn't go smoothly
  - But after a while, everything worked pretty well…

Mid-Term Review

- In 1995, NSF commissioned a mid-term review for the InterNIC project
  - General Atomics failed
    - Dropped from the InterNIC cooperative agreement
  - AT&T passed, but just barely
    - Told to do more
  - NSI passed with flying colors
    - But it was noticed NSI was struggling under a significant load
    - Increasingly, NSI was being threatened with lawsuits
    - Domain Name Speculators were becoming an issue

Domain Name Growth



From Network Wizards
http://www.nw.com/zone/hosts.gif

Steps are Taken

- In November, 1995, NSF approves NSI’s request to apply a user fee for the allocation of domain names in the .COM zone
  - NSF always intended InterNIC registration services to be self-supporting
    - Funds for RS decreased over time
  - NSI’s load related difficulties resulted in NSF paying more money to NSI
- NSF approved a US $50/year domain name registration fee
  - 30% to go to an NSF administered “Internet Infrastructure Fund”

Used Food → Fan

- Many (very vocal) people were outraged
  - “NSI is a government mandated monopoly!”
  - “No competition!”
  - “Infrastructure Fund is a tax!”
- NSI’s dispute resolution policy further enrages the masses
  - NSI policy favors trademark holders
- NSI makes a **lot** of money
  - c. 1996, NSI had registered about 2 million domains
- Significant “discussion” ensues

Addressing Concerns

- Early 1996: The YMBK Proposal
  - create small number of new exclusively held TLDs
  - high entrance fee payable to ISOC
- Mid 1996: AlterNIC
  - "Who needs InterNIC anyway?"
  - Point root nameservers elsewhere
- Mid 1996: Open Root Server Coalition
  - Multiple sets of root nameservers
    - Coordinated using out-of-band mechanisms
- May, 1996: Postel Proposal
  - Revised YMBK proposal
    - lower fees, clarified requirements

IAHC

- In Sept. 1996, Postel throws the problem to ISOC
- ISOC formed the “International Ad Hoc Committee”
  - Composed of people nominated by various “stakeholders”
    - IANA, IAB, WIPO, ITU, INTA, ISOC
- in Dec. 1996, IAHC came up with a proposal to create 7 new TLDs
  - .firm, .store, .web, .arts, .rec, .info, .nom
- Key feature: TLDs are a public trust
  - all gTLDs must be shared
  - Creation of the gTLD-Memorandum of Understanding
    - Only signatories to the MoU have input into policies

Counter-proposals

- Shared names were (are) a contentious issue
- Counter-proposals focused on creating new non-shared TLDs
  - NSI (not surprisingly) provided one of these proposals
- IAHC proposal modified in response to the counter-proposals
  - Still no consensus
- Multi-root proposals appealing (decentralizes the DNS), but fundamentally flawed
  - The DNS just doesn’t work that way

Resulting Key Concepts

- Competition is the goal
  - How to get there is the question
- Separation of Registration Functions
  - Registry -- entity operating the database containing registration information
  - Registrar -- entity submitting add/delete/change requests to the registry
  - Registrant -- entity requesting the registrar perform add/delete/changes to a domain name registration
- For example:
  - NSI historically has acted as both registry and registrar for .COM, .NET, and .ORG

U. S. Government Steps In

- Jan 30, 1998, US Government issues the “Green Paper”
  - Draft policy document
  - Unilaterally asserts US Government can decide Internet Governance policy
- Proposes
  - to create a new non-profit entity to take over IANA functions
    - Very specific definitions of how it would be created, who would be on the board
  - competition at the registrar level, non-shared registries
  - creation of up to 5 new gTLDs
  - registries should take steps to avoid trademark infringement
  - Internet Infrastructure fund administered by NSF
- Response
  - No significant complaints about US Gov’t assertions of control
  - Much unhappiness about the level of detail
    - Many felt the Green Paper much too “top down”

The White Paper

- Jun 5, 1998, US Government issues the “White Paper”
  - A Statement of Policy
- Revision of the Green Paper, taking into account input received during the comment period
  - Dodges all the hard problems
    - Describes Board of non-profit, but no indication of how to select the board
    - Non-profit to establish criteria for new TLDs, but no hint of what those criteria should be
    - Competitive vs. non-competitive registries left for further study
    - Ask WIPO to propose solution to trademark issues
  - However, this is what people thought they wanted
    - Non-profit should decide as much as possible

ICANN

- Internet Corporation for Assigned Names and Numbers
  - “Newco” (the non-profit) described in the White Paper
- Formed in Oct., 1998
- Composed of
  - Board of
    - 19 directors
    - 9 at-large directors elected by supporting organizations
    - 1 president/CEO (ex officio board member)
  - A secretariat
  - 3 Supporting Organizations
    - Address Supporting Organization
    - Domain Name Supporting Organization
    - Protocol Supporting Organization

DNSO

- The DNSO “will advise the ICANN Board with respect to policy issues relating to the Domain Name System”
- Composed of
  - A Names Council
  - A General Assembly
  - Various Constituency Groups representing specific interests
    - Currently 7 are defined
      - 6 have been formed
    - Constituencies recognized by the ICANN board

DNSO Names Council

- Consists of 3 representatives from each constituency
- Responsible for the consensus building for DNS policies
- Policies can be proposed by the GA or the any one of the Constituencies
- Decisions are made by 2/3's consensus
- NC members nominated by the GA
  - Simple majority of NC members confirms appointment

DNSO Constituencies

- Constituencies are self-organized
  - Recognized by the ICANN board by a majority vote
- Initial Constituencies are:
  - ccTLD registries
  - commercial and business entities
  - gTLD registries
    - Currently only NSI
  - ISP and connectivity providers
  - non-commercial domain name holders
    - The contentious one
  - registrars
  - trademark, other intellectual property and anti-counterfeiting interests

Fun With ICANN

- Many complaints about closed-ness
  - Some decisions made with no indication as to how the decision was reached
  - Closed meetings in which policy decisions were made
- Concerns about how the interim board was chosen
  - By whom? Under what conditions?
- Unhappiness with the decisions made
  - The current board is “interim”
- However…
  - No other game in town
  - ICANN recognized by US Dept. of Commerce as “newco”

More Fun With ICANN

- Governmental Advisory Committee (GAC)
  - Closed committee consisting of governmental appointees
    - Provides input to ICANN
  - Some are concerned about how binding that input is
    - Argument is that it is the GAC that gives ICANN its legitimacy
  - GAC as ejected some designated representatives from meetings
    - Individuals were not governmental employees
      - Worked for US based DNS registrar handling the country’s TLD

Even More Fun with ICANN

- Non-commercial Domain Name Holders Constituency
  - Having significant trouble self-organizing
    - ISOC in one camp, ACM in the other
  - Key issues:
    - Exclusion of individuals in other constituencies
    - Definition of “non-commercial”

Individual Constituency

- Proposal has been made for an 8th constituency
  - Created to “provide representation in the DNSO for all Domain Name Owners, who do not wish to be classified as non-commercial, nor wish to be represented by the Business constituency.”
  - Mission is “to be a voice for the Individual DN owners in the DNSO, to work for their interests and to provide representation for them on the Names Council”
- Proposal sent to the ICANN interim board at the Berlin Meeting (May, ‘99)

What Does it All Mean?

- The Domain Name System is fundamentally broken
  - DNS solves a technical problem in a technical way
    - Social/political issues were ignored
  - TCP/IP is designed to be decentralized
  - The DNS requires centralization
    - The root
- This centralization has attracted those interested in controlling the Internet
  - Really amazing amounts of political machinations going on
- ICANN’s increasingly Byzantine structure is a result of those machinations
  - Don’t expect it to get better anytime soon...

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Futures (Technical)

- The DNS protocol suite continues to evolve
  - Future improvements will include
    - stronger DNS security
      - DNS could be the basis for a PKI
    - support for IPv6
      - Should that be necessary
    - Integration with directory service protocols
      - LDAP, in particular
- DNS is being used for things far outside the original scope
  - When all you have is a hammer, everything looks like a nail

Futures (Administrative)

- Policies and procedures for TLD administration will change
  - Continued migration of TLD administration to governmental bodies
  - Clearer definition of operational requirements
  - More/clearer policies and procedures will be required of the TLD administrators
- ccTLDs have strong advantages in the intellectual properties arena
  - There is a non-controversial place to sue
  - Possible migration (duplication) of current non-ccTLD names into the ccTLD spaces

Futures (Political)

- ICANN will stabilize
  - Really is no other game in town…
- Continued political jockeying
  - Becoming a player in the Internet has become a political prize
- Domain Names are seen as big money potentials
  - Many people want their cut
  - Arbitrary fees in the gTLD space will likely push people to the stability of the ccTLDs

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Summary

- The Domain Name System provides human-friendly identifiers for Internet users to reference the sites they want to get to
- The DNS is a distributed, global name lookup system composed of
  - A namespace in which all names reside
  - Resolvers which are the clients in name lookups
  - Servers which respond to queries from clients
- The Namespace is hierarchical with a **single** root
  - Required for consistency
  - Provides a handle for the politicians

Summary (cont'd)

- After length "discussion" administration of the DNS has been vested in ICANN
  - As delegated by the US Government
- ICANN still being formed
  - Interim board is making policies
  - Domain Name constituencies being established
  - Battle lines being drawn

"What's in a name? That which we call a rose by any other name smells as sweet."

William Shakespeare
Romeo and Juliet

Where to Get More Information

- http://www.rfc-editor.org/rfcsearch.html
  - RFC 1032, 1033, 1034, 1035, 1591
- http://www.isc.org/bind.html
- “DNS and BIND, 3rd Edition”, Cricket Liu and Paul Albitz, O’Reilly & Associates
- http://www.iana.org/domain-names.html
- http://www.icann.org
- http://www.dnso.org
- http://www.ntia.doc.gov/ntiahome/domainname/domainhome.htm
- http://www.networksolutions.com