EE 122 Final Note Sheet

Domain Name System (DNS)

Internet Names & Addresses

- Machine Addresses: e.g., 169.229.131.101
  - reouter-usable labels for machines
  - conforms to network structure (the ”where”)
- Machine Names: e.g., instr.eecs.berkeley.edu
  - human-usable labels for machines
  - conforms to organizational structure (”the who”)
- The Domain Name System (DNS) is how we map from one to the other.

Goals of DNS

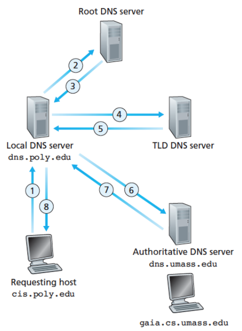
- No naming conflicts (uniqueness)
- Scalable (many names and frequent updates)
- Distributed, autonomous administration
  - Ability to update my own machines names
  - Don’t have to track all updates
- Highly available
- Lookups are fast

DNS Hierarchy

Made up of three intertwined hierarchies

- Hierarchical namespace, as opposed to the original flat namespace.
- Hierarchically administered, as opposed to centralized
- (Distributed) Hierarchy of servers, as opposed to centralized storage.

Domain Resolution



- Recursive query, asks the server to get you the answer.
- Iterative quere, asks the server to give you the next server to check.

DNS Records

DNS info is stored as resource records (RRs)

- Address: name = hostname, value = IP Address
- Name Server: name = domain, value = name of dns server for domain
- Canonical NAME: name = hostname, value = canonical name
- Mail eXchanger: name = domain in email address, value = canonical name of mail server

DNS Protocol

Client-Server interaction is on UDP Port 53

DNS Caching

- DNS servers cache responses to queries
- Responses include a TTL field and the server deletes the cached entry after the TTL expires
- Negative Caching: misspellings like cnn.comm take a long time to fail the first time. Some servers implement a cache of mistakes, but it is optional and not widely implemented.

Hyper Text Transfer Protocol (HTTP)

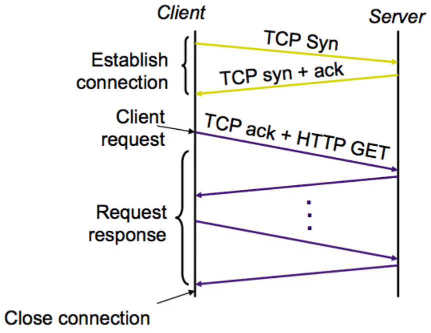
Uniform Record Locator (URL)

Web content is named using URLs, URLs use DNS hostnames

HTTProtocol

- Stateless
  - Each request-response is treated independently, servers do not retain state
  - Good: This improves server-side scalability, failure handling
  - Bad: Some application need persistent state (ex, shopping carts, user profiles, ect.)
- HTTP runs over TCP on port 80
- Synchronous request/reply protocol

Steps in an HTTP Request/Response



Client-to-Server Communication

- HTTP Request Message
  - Request line: method, resource, and protocol version
  - Request headers: provid information or modify request
  - Body: optional data (ex, ”POST” data to the server)
- HTTP Response Message
  - Status line: Protocol version, status code, status phrase
  - Response headers: provide information
  - Body: optional data

HTTP Performance

Most web pages have multiple objects. Naively, this would be one tcp connection per (possibly small) object.

- Concurrent Requests and Responses
  - Uses multiple connects in parallel
  - Doesn’t necessarily maintain the order of responses.
- Persistent Connections
  - Maintain TCP connection across multiple requests. (including transfers from the current page.) Either the cliet or the server can tear down the connection.
  - This avoids overhead of connection set-up and tear-down, creates a more accurate RTT estimate, allows TCP congestion window to increase. (Thereby being able to use previously discovered bandwidth.)
  - default in HTTP/1.1
- Pipelined Requests
  - Batch requests and responses to reduce the number of packets
  - Multiple requests can be contained in one TCP segment
- Getting n Large Objects

Connection Style	latency	bandwidth
One-at-a-time	2n RTT	nF/B
M concurrent	[n/m] RTT	[n/m] F/B
Persistent	(n+1) RTT	nF/B
Pipelined	2 RTT	nF/B
Pipelined/Persistent	2 RTT then RTT later	nF/B

- Caching
  - Adds the modifier, ”If-modified-since”, os if the resource hasn’t changed, it simply returns ”not modified”
  - The response header has field, ”Expires” that tells it how long it is safe to cache and ”No-cache” which will ignore caches and always get the resource.
  - Client Caching: on your computer.

- Forward Proxies: Done by ISPs to reduce network traffic and lower latency
- Reverse Proxies: Done close to the server to reduce server load. Usually done by the content provider.

- Replication
  - Replicates popular web sites across multiple machines. This spreads load on servers, places content closer to clients, and helps when content isn't cacheable. To account for locationality, DNS returns different addresses based on client's geo location, server load, ect.

Physical Layer

Properties of a Desired Link

- Fast (High Rate)
- Reliable: Very low probability of undetected error

Inside the Link Layer

- MAC - Medium Access Control: manages many different connections talking simultaneously. (How to share limited space)
  - Time Division Multiplexing - taking turns in the Time Domain
  - Frequency Division Multiplexing - takes turns in Frequency Domain
  - Spacial Division Multiplexing - Chooses a particular direction to listen to signals (cell phones)
  - Aloha Protocol - If you have data to transmit, send it. 2/3rds of bandwidth is lost, but it turns out to be bettern than making everyone wait for a turn to send data.
- PHY - "Physical Layer", gets bits from point A to point B. This operates on 3 levels,
  - Bits - dealing with individual bits of data
Bits are packaged into frames, with codes for error detection and correction
  - Signals - operates on the signal level (Discrete Time Sampling)
Modulation, translates the bits into analog values and vice versa
Codes, Hash functions used to verify frames, add redundancy (Reid Soloman)
  - Hardware - Antennas/ Laser Diodes
Timers/Clocks, Mixing/Demixing, Amplification, Filtering, Antennas

Raw Resource(s) in Wireless

In Wireless (802.11n)

- W, Bandwidth (MHz) typically 20MHz for wifi
- k, Number of antennas
- Signal to Noise Ratio (SNR)
- Acheivable Bits/second = $k * W \log_2(1 + SNR)$

Random Access MAC Protocols

ALOHA, slotted ALOHA, CSMA

- When a node has a packet to send, it transmits at full channel data rate, there is no priorities given. If two or more nodes happen to transmit at the same time (collision), the data is lost.
- The Random Access MAC protocols specify how to detect collisions and recover from them.

Carrier Sense Multiple Access (CSMA)

Basically Clear Channel Assessment, if the channel sensed idle, transmit entire frame otherwise delay transmission. Because of propagation delays, this doesn't eliminate all collisions.

CSMA/CD (Collision Detection)

This protocol when a collision is detected, it aborts the transmission thereby removing time that was wasted seding a packet that would be useless. CD has limited use in high latency environments and is difficult in wireless scenarios

Key Ideas of Random Access

- Carrier Sense: before sending check to see if anyone else is.
- Collision detection: if someone else starts talking at the same time, stop
- Collision avoidance: Explicit ACK from receiver signals lack of collision and impending communication
- Randomness: if you can't send, wait a random amount of time before trying again

Wireless

Properties of Wireless

- Broadcast: colisions happen, limited range (no global collisions.)
- Can't receive while broadcasting, can't detect collisions
- Complex signal deterioration (no defined radio range)

Wireless Protocols (RTS/CTS)

CSMA/CA Collision Avoidance

- RTS (Request to Send) frame is sent out containing the length of the transmission and the destination.
- CTS (Clear to Send) frame is sent back if it is ok. Then the sender can transmit it's data
- If there is no CTS, the sender assumes a collision

Ethernet

Self Learning in Ethernet

Approach

- Flod first packet to node you are trying to reach
- Avoids loop by restricting flooding to spanning tree
- Flooding allows packet to reach destination
- In the process switches learn how to reach source of flood

Building the Spanning Tree

- Shortest paths to (or from) a node form a tree

Naming accross the Layers

- Application layer: URLs and Domain Names
- Network Layer: IP addresses
- Link Layer: MAC addresses

When a host is born, all it knows is its MAC address. It needs to discover it's IP address and the remote host's IP

Dynamic Host Configuration Protocol (DHCP)

DHCP is used to discover a host's own IP address, netmask, IP addresses for DNS name servers, and IP addresses for the first-hop routers.

1. One or more local DHCP servers maintain the required information.
2. Client broadcasts a DHCP discovery message.
3. One or more DHCP servers respond witha DHCP "offer" message
4. Client broadcasts a DHCP request message
5. Selected DHCP server response with an ACK

Done over port 67

Address Resolution Protocol (ARP)

- Every host maintains an ARP table (list of IP address -¿ MAC address pairs)
- When sending a packet the host consults the table
- If the IP address is not in the table,
the sender broadcasts "Who has IP address 1.2.3.4?"
the receiver response: "MAC address 58-58-88-FA-20-B0"
The response goes into the host's table.

How to we get Google (Starting with a cold start)?

1. Self Discovery: You use DHCP to discover bootstrap parameters. (Your IP address, your DNS server's IP, Router's IP Address, . . .)
2. You need to find the MAC address of your Router, ARP
3. Get google's IP: create a dns query to my local server's IP address. Directed using the router's MAC.
4. Get google's webpage from its server

Data Centers

Componentization of Data Centers

- "North-South Traffic", traffic between external clients and the data center.
- "East-West Traffic", traffic between machines in the data center. (ex Map Reduce) Traffic may shift on small timescales.