CSE 454

HTTP + Server Architecture

Previously

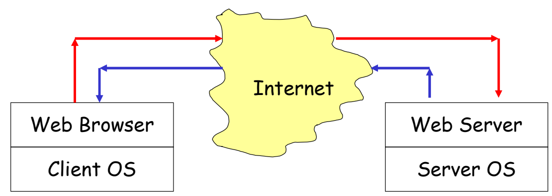
- **Introduction**
- **History**
- **Networking**
  - IP
  - TCP
  - DNS

Outline

- **HTTP Protocol**
- **Service Architecture & Scaling**

- **For next time**
  - Mailing list
  - Reading
    - HTTP Made easy
    - Responsibilities
    - Mercator

Connecting on the WWW



What happens when you click?

- **Suppose**
  - You are at www.yahoo.com/index.html
  - You click on www.grippy.org/mattmarg/
- **Browser uses DNS => IP addr for** www.grippy.org
- **Opens TCP connection to that address**
- **Sends HTTP request:**

```
Get /mattmarg/ HTTP/1.0
User-Agent: Mozilla/2.0 (Macintosh; I; PPC)
Accept: text/html; */*
Cookie: name = value
Referer: http://www.yahoo.com/index.html
Host: www.grippy.org
Expires: …
If-modified-since: ...
```

Request

Request Headers

HTTP Response

Status

```
HTTP/1.0 200 Found
Date: Mon, 10 Feb 1997 23:48:22 GMT
Server: Apache/1.1.1 HotWired/1.0
Content-type: text/html
Last-Modified: Tues, 11 Feb 1999 22:45:55 GMT
```

Response 1st header

Image/jpeg, ..

- **One click => several responses**

- **HTTP1.0: new TCP connection for each elt/page**
- **HTTP1.1:** KeepAlive **- several requests/connection**

Response Status Lines

- **1xx** **Informational**
- **2xx** **Success**
  - 200 Ok
- **3xx** **Redirection**
  - 302 Moved Temporarily
- **4xx** **Client Error**
  - 404 Not Found
- **5xx** **Server Error**

HTTP Methods

- **GET**
  - Bring back a page
- **HEAD**
  - Like GET but just return headers
- **POST**
  - Used to send data to server to be processed (e.g. CGI)
  - Different from GET:
    - A block of data is sent with the request, in the body, usually with extra headers like Content-Type: and Content-Length:
    - Request URL is not a resource to retrieve; it's a program to handle the data being sent
    - HTTP response is normally program output, not a static file.
- **PUT, DELETE, ...**

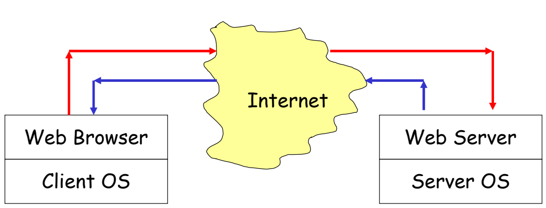
Cookies

- **Small piece of info**
  - Sent by server as part of response header
  - Stored on disk by browser; returned in request header
  - May have expiration date (deleted from disk)
- **Associated with a specific domain & directory**
  - Only given to site where originally made
  - Many sites have multiple cookies
  - Some have multiple cookies per page!
- **Most Data stored as** name=value **pairs**
- **See**
  - C:\Program Files\Netscape\Users\default\cookies.txt
  - C:\WINDOWS\Cookies

Logging Web Activity

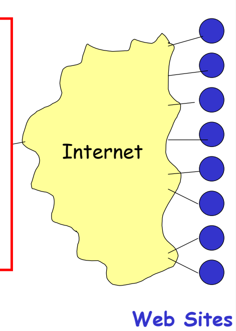
- **Most servers support "common logfile format" or "extended logfile format"**
- **Apache lets you customize format**
- **Every HTTP event is recorded**
  - Page requested
  - Remote host
  - Browser type
  - Referring page
  - Time of day
- **Applications of data-mining logfiles ??**

Connecting on the WWW

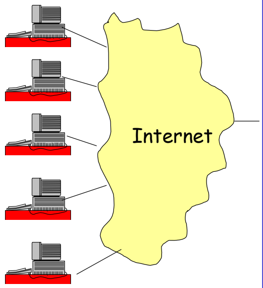


Client-Side View

Content rendering engine
Tags, positioning, movement
Scripting language interpreter
Document object model
Events
Programming language itself
Link to custom Java VM
Security access mechanisms
Plugin architecture + plugins



Server-Side View



Clients

Database-driven content
Lots of Users
Scalability
Load balancing
Often implemented with cluster of PCs
24x7 Reliability
Transparent upgrades

Trade-offs in Client/Server Arch.

- Compute on clients?
  - Complexity: Many different browsers
    - {Firefox, IE, Safari, …} × Version × OS
- Compute on servers?
  - Peak load, reliability, capital investment.
  + Access anywhere, anytime, any device
  + Groupware support (shared calendar, …)
  + Lower overall cost (utilization & debugging)
  + Simpler to update service

Dynamic Content

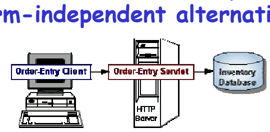
- We want to do more via an http request
  - E.g. we'd like to invoke code to run on the server.
- Initial solution: Common Gateway Interface (CGI) programs.
- Example: web page contains form that needs to be processed on server.

CGI Code

- CGI scripts can be in any language.
- A new process is started (and terminated) with each script invocation (overhead!).
- Improvement I:
  - Run some code on the client's machine
  - E.g., catch missing fields in the form.
- Improvement II:
  - Server APIs (but these are server-specific).

Java Servlets

- Servlets : applets that run on the server.
  - Java VM stays, servlets run as threads.
- Accept data from client + perform computation
- Platform-independent alternative to CGI.



- Can handle multiple requests concurrently
  - Synchronize requests - use for online conferencing
- Can forward requests to other servers
  - Use for load balancing

Java Server Pages (JSP) Active Server Pages (ASP)

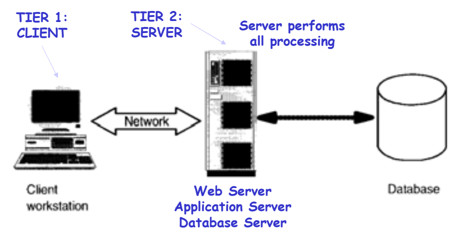
- Allows mixing static HTML w/ dynamically generated content.
- JSP is more convenient than servlets for the above purpose.

Tiered Architectures

1-tier = dumb terminal → smart server.
2-tier = client/server.
3-tier = client/application server/database.

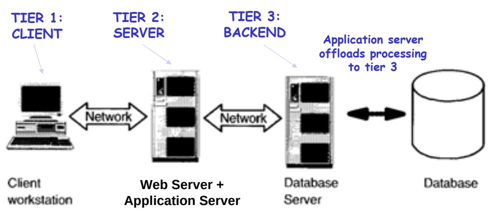
Why decompose the server?

Two-Tier Architecture



Server does too much work. Weak Modularity.

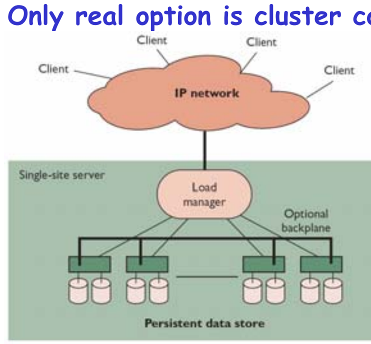
Three-Tier Architecture



Using 2 computers instead of 1 can result in a ***huge increase*** in simultaneous clients.
Depends on % of CPU time spent on database access.
While DB server waits on DB, Web server is busy!

Getting to 'Giant Scale'

- **Only real option is cluster computing**



Optional Backplane:

System-wide network for intra-server traffic:
Query redirect, coherence traffic for store, updates, …

Assumptions

- **Service provider has limited control**
  - Over clients, network
- **Queries drive system**
  - HTTP Get
  - FTP
  - RPC
- **Read Mostly**
  - Even at Amazon, browsing >> purchases

Cluster Computing

2001 Data

Service	Nodes	Queries	Node Types
AOL Web Cache	**>1000**	**10B/day**	**4 CPU DEC 4100s**
Inktomi Search Eng	**>1000**	**80M/day**	**2 CPU Sun wkstns**
Geocities	**>300**	**25M/day**	**PC-based**
Web email	**>5000**	**1B/day**	**Free BSD PCs**

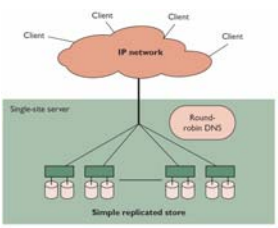
Cluster Computing: Benefits

- **Absolute Scalability**
  - Large % of earth population may use service!
- **Incremental Scalability**
  - Can add / replace nodes as needed
  - Nodes ~5x faster / 3 year depreciation time
  - Cap ex $$ *vs.* cost of rack space / air cond
- **Cost & Performance**
  - But no alternative for scale; hardware cost << ops
- **Independent Components**
  - Independent faults help reliability

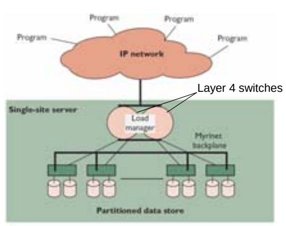
Load Management

- **Round-Robin DNS**
  - Problem: doesn't hide failed nodes
- **Layer 4 switch**
  - Understand TCP, port numbers
- **Layer 7 (application layer) switch**
  - Understand HTTP; Parse URLs at wire speed!
  - Use in pairs (automatic failover)
- **Custom front-ends**
  - Service-specific layer 7 routers in software
- **Smart client end-to-end**
  - Hard for WWW in general. Used in DNS, Cell roaming

Case Studies



Simple Web Farm



Search Engine Cluster

Inktomi (2001) Supports programs (not users)
Persistent data is partitioned across servers:
⇑ capacity, but ⇓ data loss if server fails

High Availability

- **Essential Objective**
- **Phone network, railways, water system**
- **Challenges**
  - Component failures
  - **Constantly evolving features**
  - **Unpredictable growth**

Typical Cluster

- **Extreme symmetry**
- **Internal disks**
- **No monitors**
- **No visible cables**
- **No people!**

- **Offsite management**
- **Contracts limit**
  - ∆ Power
  - ∆ Temperature

Availability Metrics

- **Traditionally: Uptime**
  - Uptime = (MTBF – MTTR)/MTBF
- **Phone system ~ "Four or Five Nines"**
  - Four nines means 99.99% reliability
  - I.e. less than 60 sec downtime / week
- **How improve uptime?**
  - Measuring "MTBF = 1 week" requires > 1 week
  - Measuring MTTR much easier
  - New features reduce MTBF, but not MTTR
  - ***Focus on MTTR***; just best effort on MTBF

Yield

- **Queries completed / queries offered**
  - Numerically similar to uptime, but
  - Better match to user experience
  - (Peak times are much more important)

Harvest

- **Data available / complete data**
  - Fraction of services available
    - E.g. Percentage of index queried for Google
    - Ebay seller profiles down, but rest of site ok

Architecture

- **What do faults impact? Yield? Harvest?**
- **Replicated systems**
  Faults → reduced capacity (hence, yield @ high util
- **Partitioned systems**
  Faults → reduced harvest
  Capacity (queries / sec) unchanged

- **DQ Principle $\exists$ physical bottleneck**
  Data/Query × Queries/Sec = Constant

Using DQ Values

- **Measurable, Tunable**
- **Absolute Value Irrelevant**
  - Relative value / changes = predictable!

- **Methodology**
  1. Define DQ value for service
  2. Target workload & load generator
  3. Measure for hardware × software × DB size
     Linearity: small cluster (4 nodes) predict perf for 100
  4. **Plan**: capacity/traffic; faults; replic/part;

Graceful Degradation

- **Too expensive to avoid saturation**
- **Peak/average ratio**
  - 1.6x - 6x or more
  - Ticketmaster: 10x capacity for Phantom Menace
    - Not enough…
- **Dependent faults (temperature, power)**
  - Overall DQ drops ***way*** down

- **Cutting harvest by 2 doubles capacity…**

Admission Control (AC) Techniques

- **Cost-Based AC**
  - Denying an expensive query allows 2 cheap ones
  - Inktomi
- **Priority-Based (Value-Based) AC**
  - Stock trades *vs.* quotes
  - Datek
- **Reduced Data Freshness**

Managing Evolution

- **Traditional Wisdom**
  - "High availability = minimal change"
- **Internet: continuous growth, ⇑ features**
  - Imperfect software (memory leaks, intermit bugs
- **Acceptable quality**
  - Target MTBF; low MTTR; no cascading failures
  - Maintenance & upgrades = controlled failures