# Introduction to LAN/WAN

## Application Layer (Part III)

# Application Layer Topics

- Domain Name System (DNS) (7.1)
- Electronic Mail (E-mail) (7.2)
- World Wide Web (7.3) ←
  - Performance Enhancements
  - Wireless Web

# Web Performance Enhancements

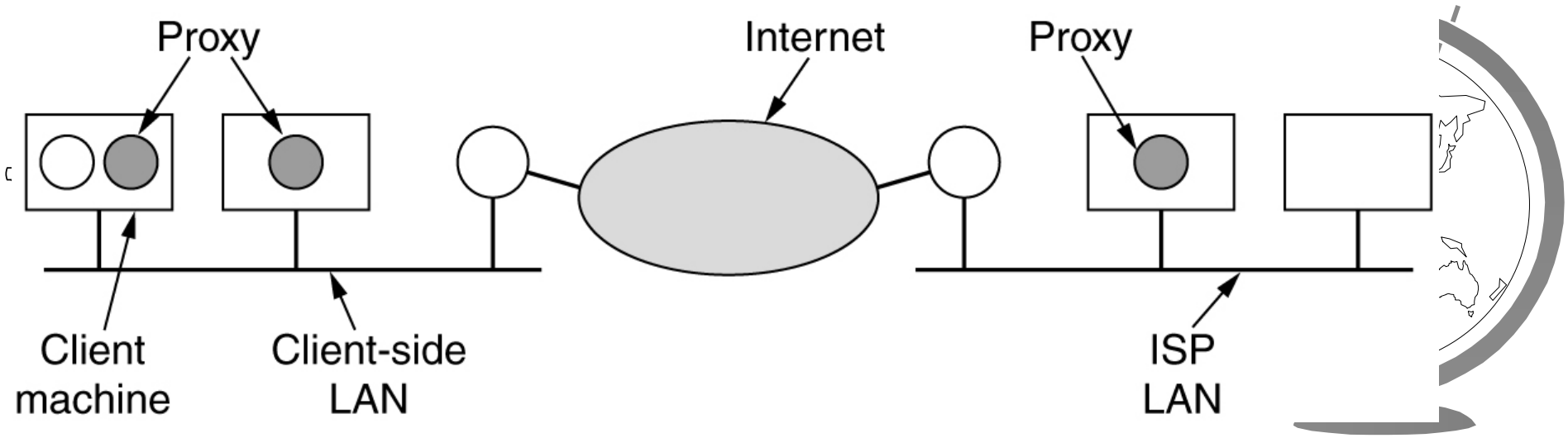
- Web increasingly popular
- Performance becoming a big issue
- 3 main ways to improve WWW performance:
  - Caching
  - Server replication
  - Content Delivery Networks (CDNs)
- Caching: save requested pages in case requested again
- Technique effective for busy websites
- Process called *proxy* caches pages

# Web Caching

- Browser checks *cache* for web page first
- If page is in cache, page returned quicker
- If page not in proxy's cache, then
  - Proxy fetches page from web server
  - Adds page to cache for next request
  - Returns page to client
- Two key questions for caching:
  - Who should do caching?
  - How long should pages be cached

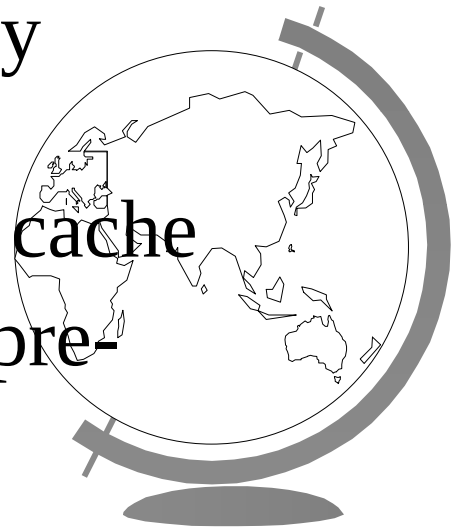
# Who should cache?

- 3 possible cache locations
  - Cache on client's PC
  - On dedicated proxy machine on company's LAN
  - On proxy at ISP
- *Hierarchical caching*: combine all 3



# How long to cache pages?

- Two approaches:
  - Cache based on *last modified* time: e.g. page last modified 1 hr ago, proxy caches for 1 hr
  - RFC 2616: cache management:
    - Proxy checks with server sends last modified date to see if page has been modified
    - If not modified, server sends back short message
    - If modified, server sends back page
- Dynamic pages (PHP, etc), different query parameters every time,  never cached
- Server instructs all proxies on path not to cache
- *Proactive caching*: linked pages, images pre-fetched

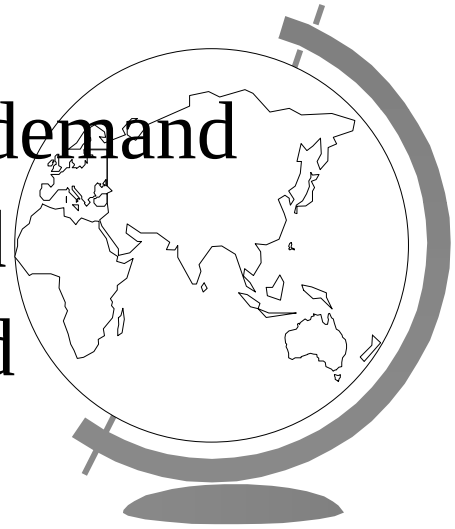


# Server Replication

- Replication: server-side technique to improve performance
- *Mirroring:* Popular websites replicate content at multiple, widely-separated locations
- Example: Company maintains separate sites for regional sites
- Main website contains few images and links for regional sites
- User initially starts on main website, re-directed to regional website

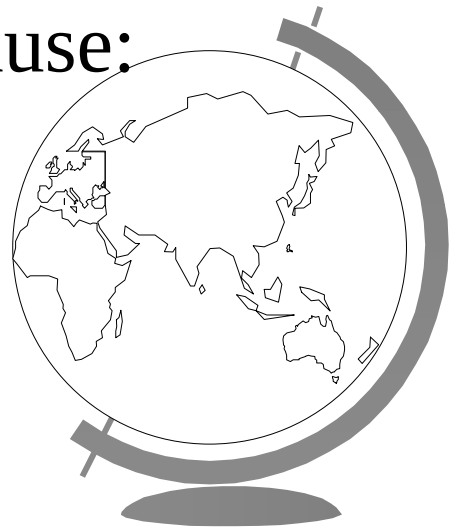
# Flash Crowds

- Previously low-traffic website may suddenly experience overwhelming traffic
- Example: Florida sec of state website during 2000 US presidential election
- Website became top 5 visited website
- Solution: FL sec of state signs deal with web hosting company
- Web hosting company creates clones on demand
- Shuts down clone when no longer needed
- FL sec of state pays for actual traffic used



# Content Delivery Networks (CDNs)

- CDN Companies (e.g Akamai) own servers round the world
- Paid by content providers (e.g yahoo) to place content closer to user
- CDN servers typically located on ISPs LAN
- CDN pays ISPs
- ISPs agree to collocate CDN servers because:
  - More money
  - ISPs clients get quicker response time

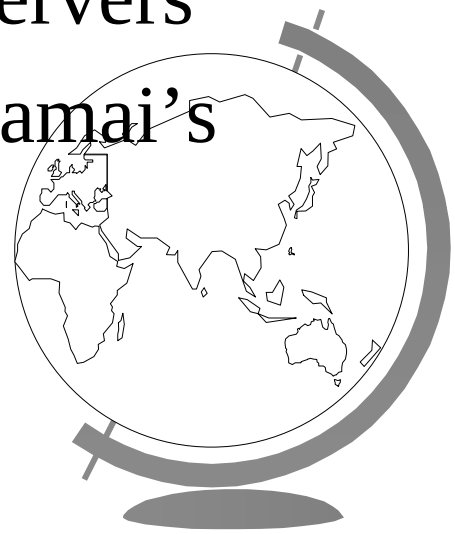


# CDNs

- Must be possible to re-direct client's page request to closer CDN server
- Example: client in London should be able to get yahoo's pages from server in London *not* from Yahoo's office in San Francisco
- Redirection must be possible without modifying DNS entry of page
- Next: How Akamai's CDN works…

# How CDNs work

- Yahoo gives Akamai its content
- Akamai runs yahoo's pages through pre-processor, replaces URLs with modified versions
- Yahoo's pages has many small HTML pages, linking huge image, video files
- HTML pages are fetched from Yahoo's servers
- Large image, video files fetched from Akamai's servers



# Pre-processed Web pages

```
<html>
<head> <title> Furry Video </title> </head>
<body>
<h1> Furry Video's Product List </h1>
<p> Click below for free samples. </p>

<a href="bears.mpg"> Bears Today </a> <br>
<a href="bunnies.mpg"> Funny Bunnies </a> <br>
<a href="mice.mpg"> Nice Mice </a> <br>
</body>
</html>
```

(a)

```
<html>
<head> <title> Furry Video </title> </head>
<body>
<h1> Furry Video's Product List </h1>
<p> Click below for free samples. </p>

<a href="http://cdn-server.com/furryvideo/bears.mpg"> Bears Today </a> <br>
<a href="http://cdn-server.com/furryvideo/bunnies.mpg"> Funny Bunnies </a> <br>
<a href="http://cdn-server.com/furryvideo/mice.mpg"> Nice Mice </a> <br>
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```
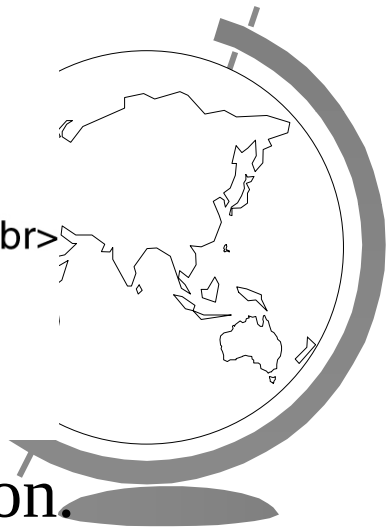
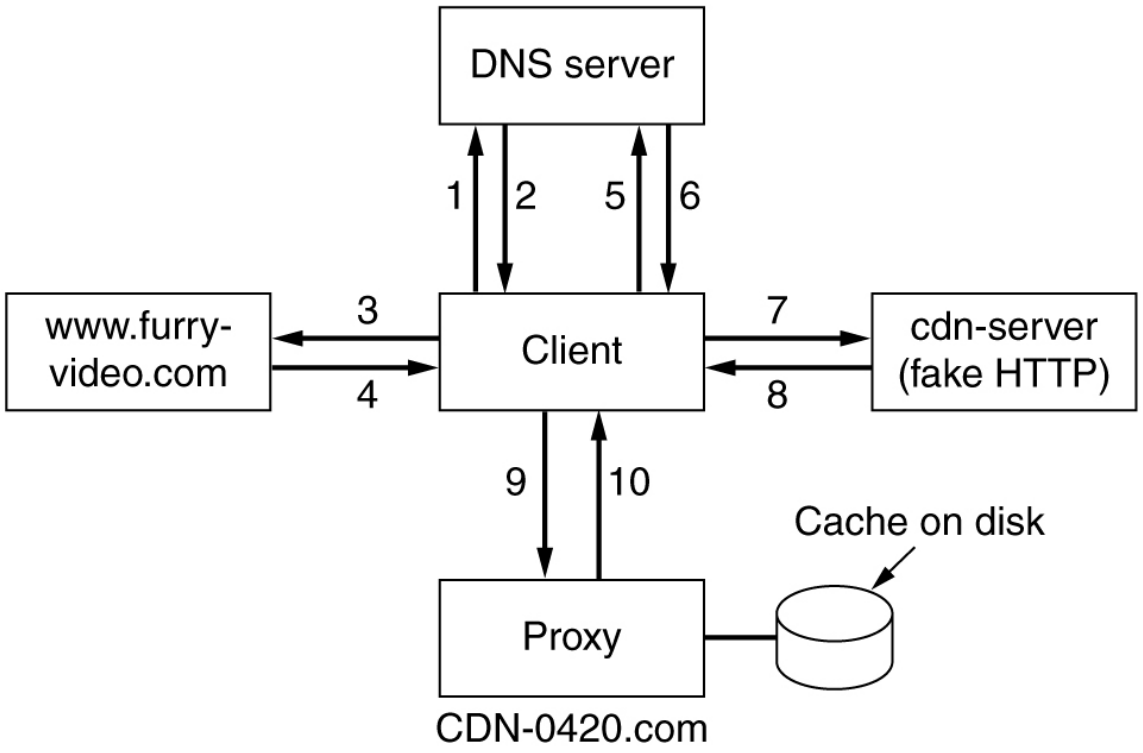

(b)



(a) Original Web page. (b) Same page after transformation.

# CDNs Process

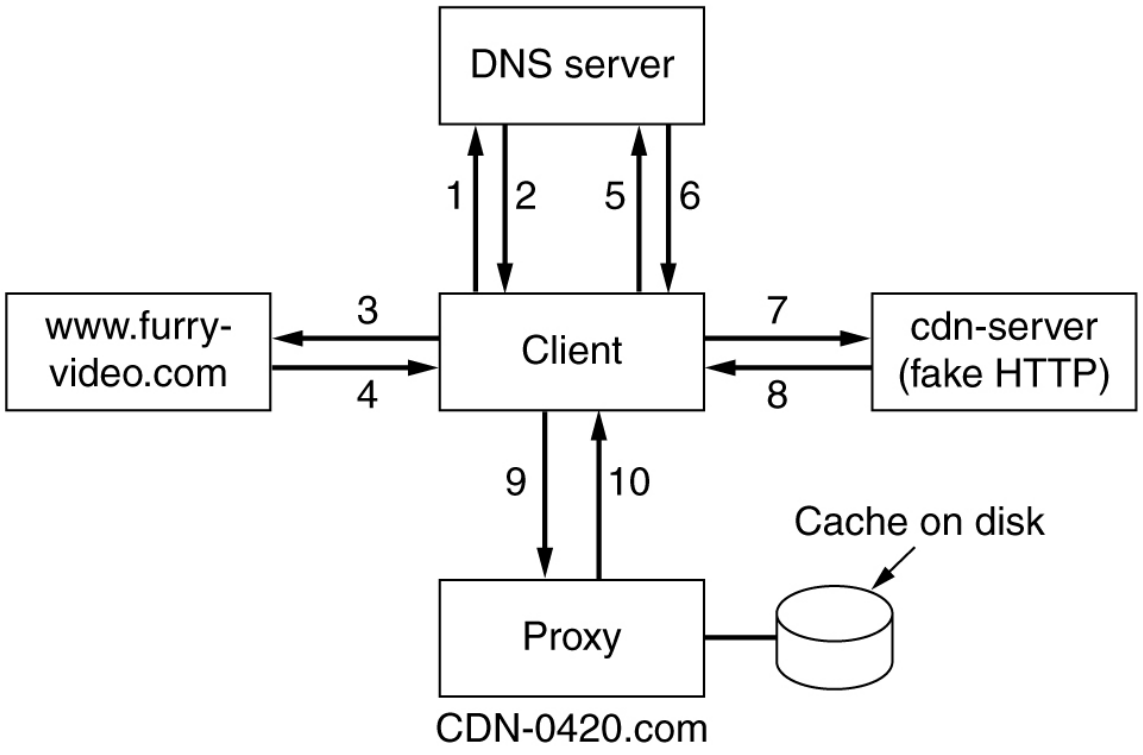
- User types in www.furryvideo.com
- See process below
- Key: cdn-server is *fake*, returns closest Akamai server
- Closest is tough.. geographically? topology? Least busy?




1. Look up www.furryvideo.com
2. Furry's IP address returned
3. Request HTML page from Furry
4. HTML page returned
5. After click, look up cdn-server.com
6. IP address of cdn-server returned
7. Ask cdn-server for bears.mpg
8. Client told to redirect to CDN-0420.com
9. Request bears.mpg
10. Cached file bears.mpg returned

# CDNs Process

- Step 8: *cdn-server.com* sends back response with status code 301 and *Location* header for nearest server
- Step 9: Client requests mpeg files from closest server
- Important: CDN-0420.com is location-dependent!

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# Wireless Web

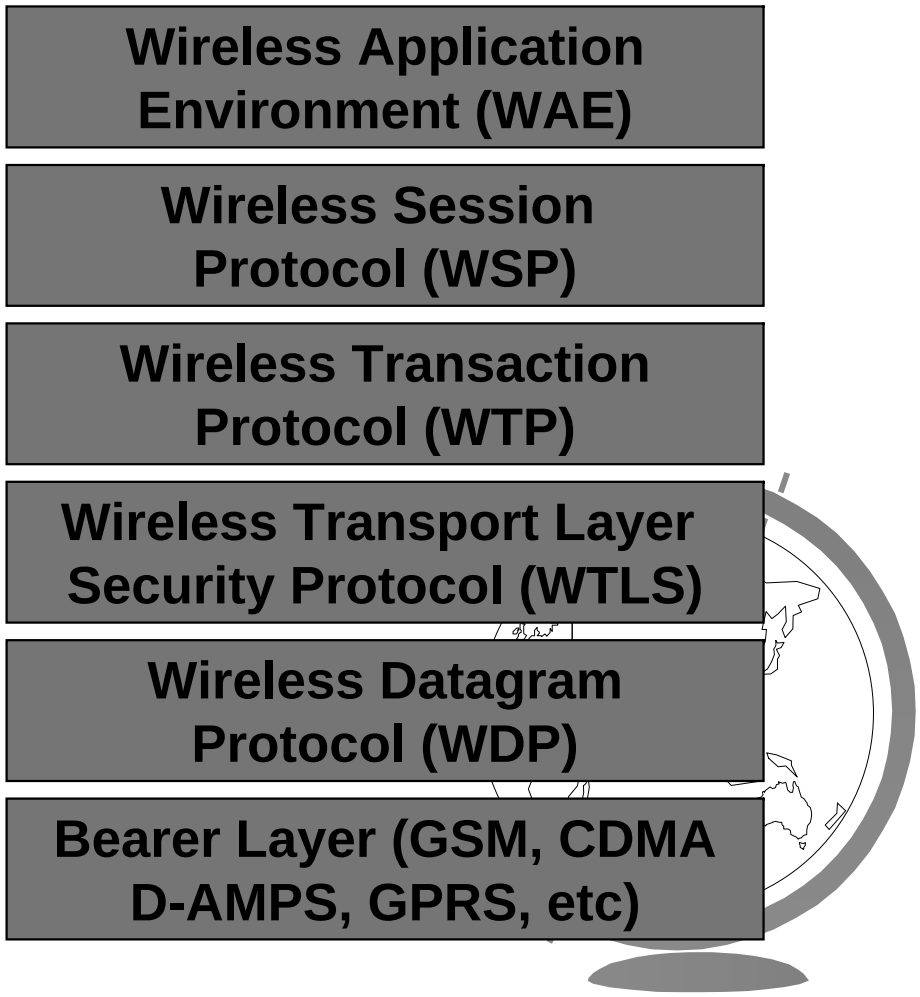
- Today's web model
  - You click on a page, HTML page and linked elements (images, are retrieved)
  - Page is retrieved in network packets (packet switched)
  - Success of web made people want to access it wirelessly
- Wireless Application Protocol (WAP) 1.0
  - Application protocol stack for wireless web
  - Standard proposed by consortium which included Nokia, Ericsson, Motorola, and Phone.com (previously Unwired planet)
  - WAP device may be mobile phone, PDA, notebook, etc.
  - WAP optimized for mobile device (low CPU, memory, screen), low-bandwidth wireless links

# WAP 1.0

- WAP 1.0
  - Brute force approach
    - Make phone call to web gateway
    - Send URL to gateway
    - If available, gateway returns page
  - Issues:
    - Connection-oriented (circuit-switched, per-minute billing), charged while reading web page
    - WAP pages written in Wireless Markup Language (WML) (major drawback: No HTML)
    - WML is XML-based
    - Sometimes a WAP filter (server) can automatically convert HTML pages to WML
  - Result: failed, but laid groundwork for iMode and WAP 2.0

# WAP Protocol Stack

- Six layers (including actual wireless network)
- WDP is datagram protocol, similar to UDP
- WTLS is security layer,
- subset of Secure Socket
- Layer by Netscape
- WTP is similar to TCP,
- concerned with requests
- responses
- WSP is similar to HTTP/1.1
- WAE is microbrowser



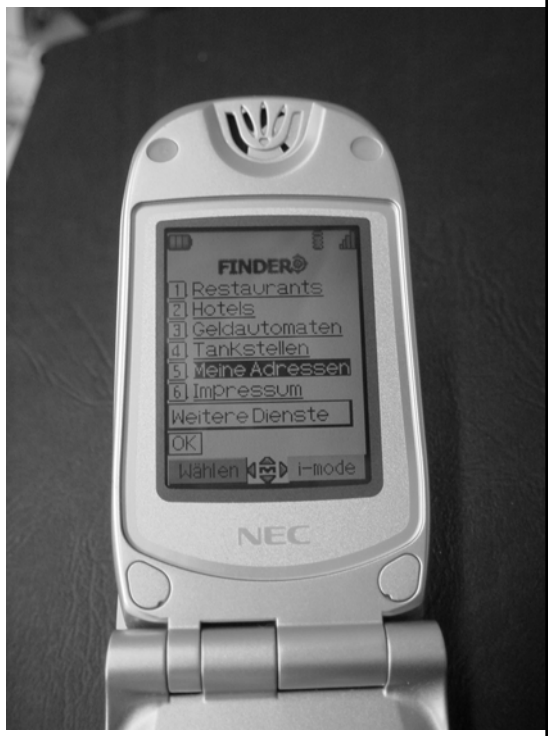
# I-Mode

- Sometimes in telecom, single organization or person beats consortium E.g. Jon Postel developed RFCs for TCP, SMTP, etc
- In parallel to WAP effort, Japanese woman Mari Matsunaga created different approach called I-Mode (Information Mode)
- Mari convinced Japanese telco monopoly, NTT DoCoMo to deploy service
- I-Mode deployed in Feb. 1999
- I-Mode subscription exploded!!
- 35 million Japanese subscribers in 3 years, access to 40,000 I-Mode pages
- Major financial success!
- Interesting case study: features, why it succeeded?

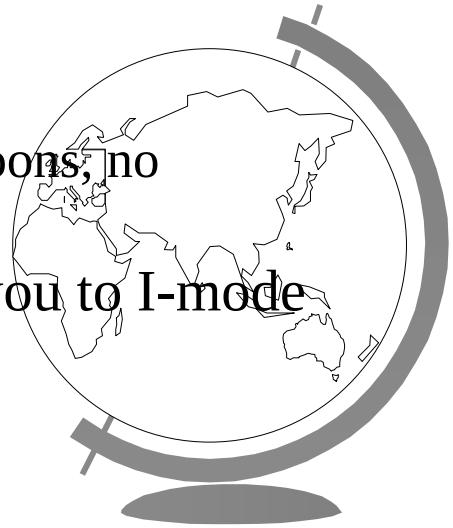
# I-Mode

- To make I-Mode work, 3 new components:
  - New transmission system (partnership with Fujitsu)
  - New handset (partnered with NEC, Matsushita)
  - New web page language (cHTML)
- Transmission system:
  - 2 separate networks:
  - Voice mode:
    - old 2G digital phone network, PDC
    - (circuit-switched),
    - billed per connected minute
  - I-Mode:
    - New packet-switched network for I-Mode, always on
    - Internet connection, users unaware of this!
    - No connection charge, billed per packet sent
    - Uses CDMA, 128-byte packets at 9600 bps
  - Both networks cannot be used simultaneously

# I-Mode




- I-Mode handsets:
  - Enhanced features with CPU power of PC in 1995
  - small screen
  - IP-capable communications
- Handset specifications
  - 100 MHz CPU
  - Memory: Several MB flash memory, 1MB RAM
  - Dimensions: smaller than pack of cigarettes, 70 grams
  - Screen:
    - Resolution: min. 72 x 94 pixels, 120 x 160 high end
    - Color: 256 colors initially, good for line drawings, cartoons, no photographs. New: 65,000 colors
  - Navigation: no mouse, use arrow keys, “i” key takes you to I-mode services menu

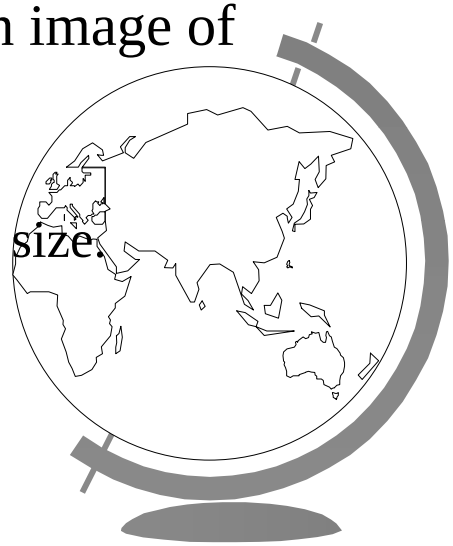


# I-Mode

- I-Mode handsets:
  - When user hits “i” key on handset, user presented with list of Categories: email, news, weather, sports, etc (a portal)
  - over 1000 “services” in about 20 categories
  - Lots of services targetted at teenagers, young people
  - Each service is I-Mode website run by independent company
  - May type in service URL directly also
  - Users subscribe to services ($1-$2 per service)
  - > 1,000,000 subscriber makes service official
  - Official services billed through phone bill
  - 1500 official services, 39,000 unofficial circa 2001

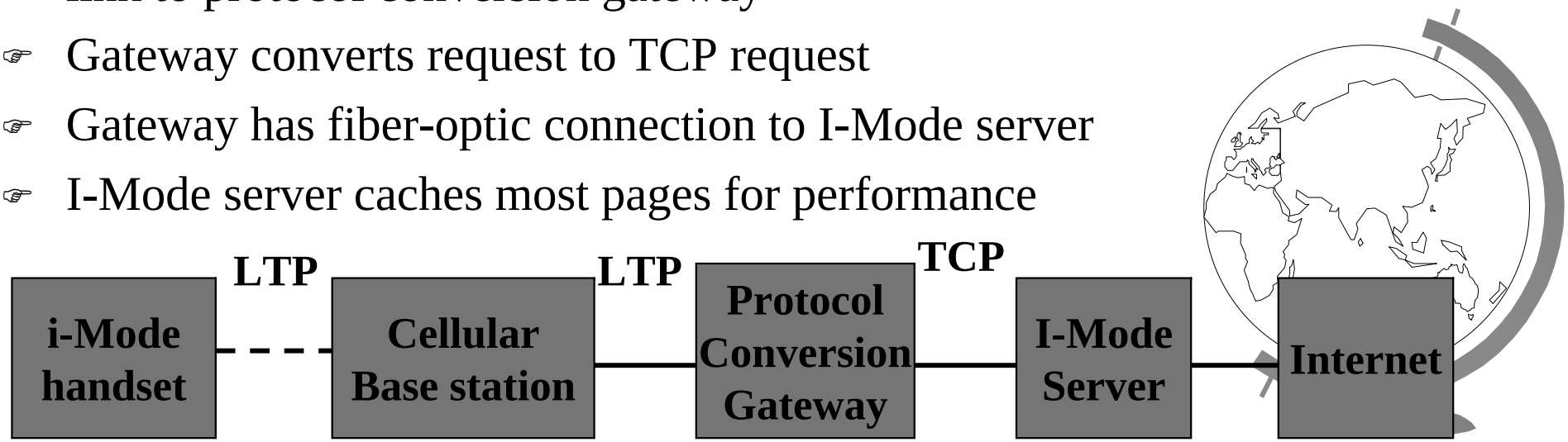
# I-Mode

- I-Mode handsets:
  - Most popular application is email: limit of 500 bytes (SMS on GSM limit is 160 bytes)
  - I-Mode phone number doubles as email address (e.g. 0345671234@docomo.co.jp)
  - Rich in graphics content, Japanese have high visual sensibility
  - Invented new cute pictograms like smileys called **emoji**
  - US company, Funmail has patented text-to-graphics. E.g. word Hawaii in email may be converted to animated cartoon image of *"beach with swaying palm trees"*
  - Funmail is multi-platform technology:
    - cell phones receive animations scaled for power, screen size.
    - Desktops receive full-blown animation



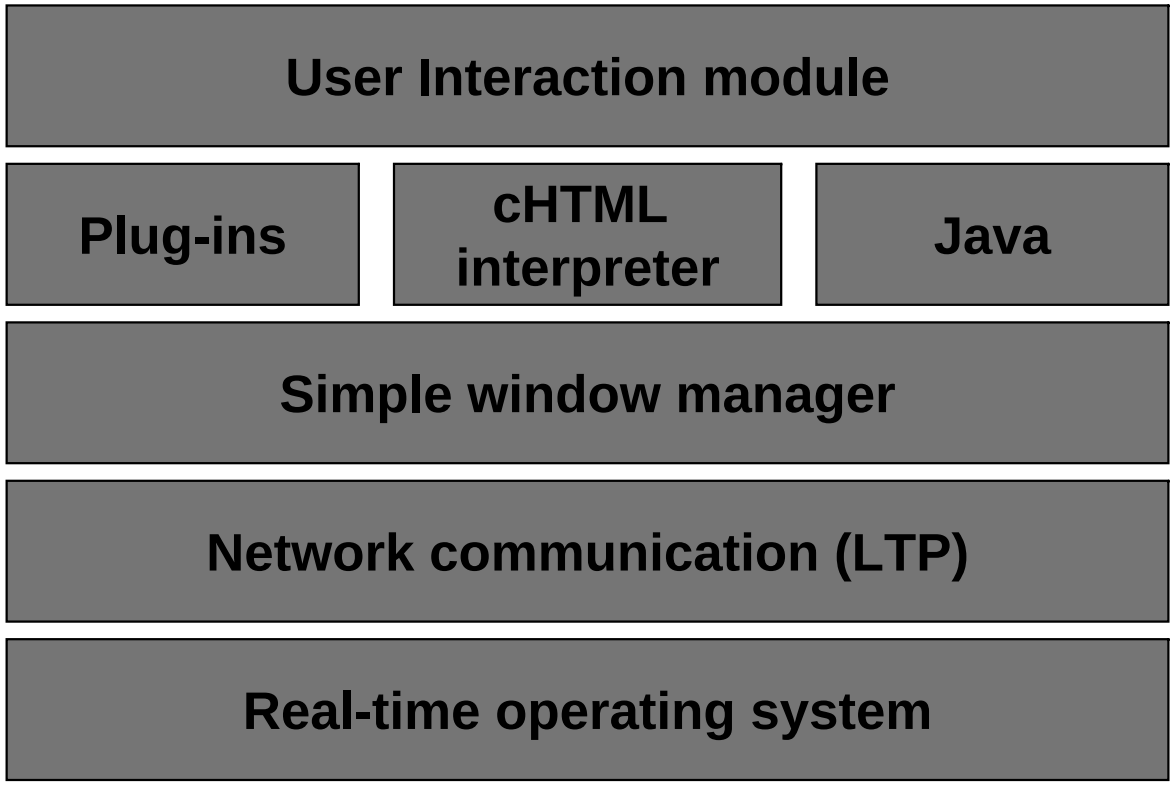
# I-Mode

- I-Mode is massive success in Japan because:
  - Few people own PCs
  - Local phone access is expensive
  - Lots of time spent commuting
- Different circumstances for US and Europe
- I-Mode structure and operation:
- Handsets speak Lightweight Transport Protocol (LTP) over wireless link to protocol conversion gateway
- Gateway converts request to TCP request
- Gateway has fiber-optic connection to I-Mode server
- I-Mode server caches most pages for performance



# I-Mode

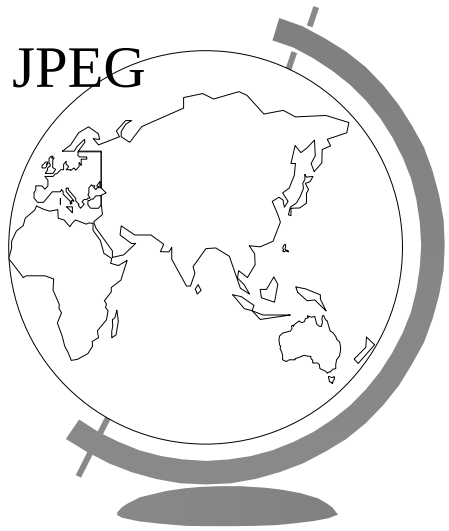
- I-Mode protocol stack:




- I-Mode pages programmed in cHTML
- Java functionality based on J2ME (Java 2 Platform Micro Edition) based on the Kilobyte Virtual Machine (KVM)
- Maximum of 5 applets can be stored at a time

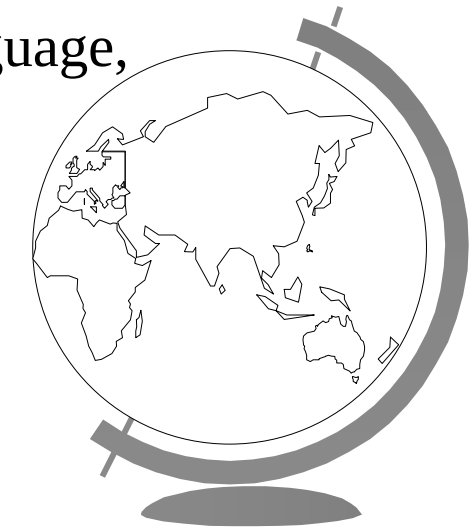
# I-Mode

- cHTML
  - Developed by Access, embedded software maker
  - based on HTTP 1.0, with omissions and extensions
  - Most HTML tags allowed. E.g. <body>, <ul>, <br>, etc
  - New tag to dial phone number, phoneto
  - E.g. phoneto on a restaurant's page lets you dial number
  - HTML-based: can view I-Mode pages on regular browser
- I-Mode Browser:
  - Limited
  - Allows plug-ins and helper applications e.g. JVM
  - No Javascript support, frames, background colors/images, JPEG (takes too long)
- I-Mode Server-side:
  - Full-blown computer, all bells and whistles
  - Supports CGI, Perl, PHP, JSP, ASP, most web standards



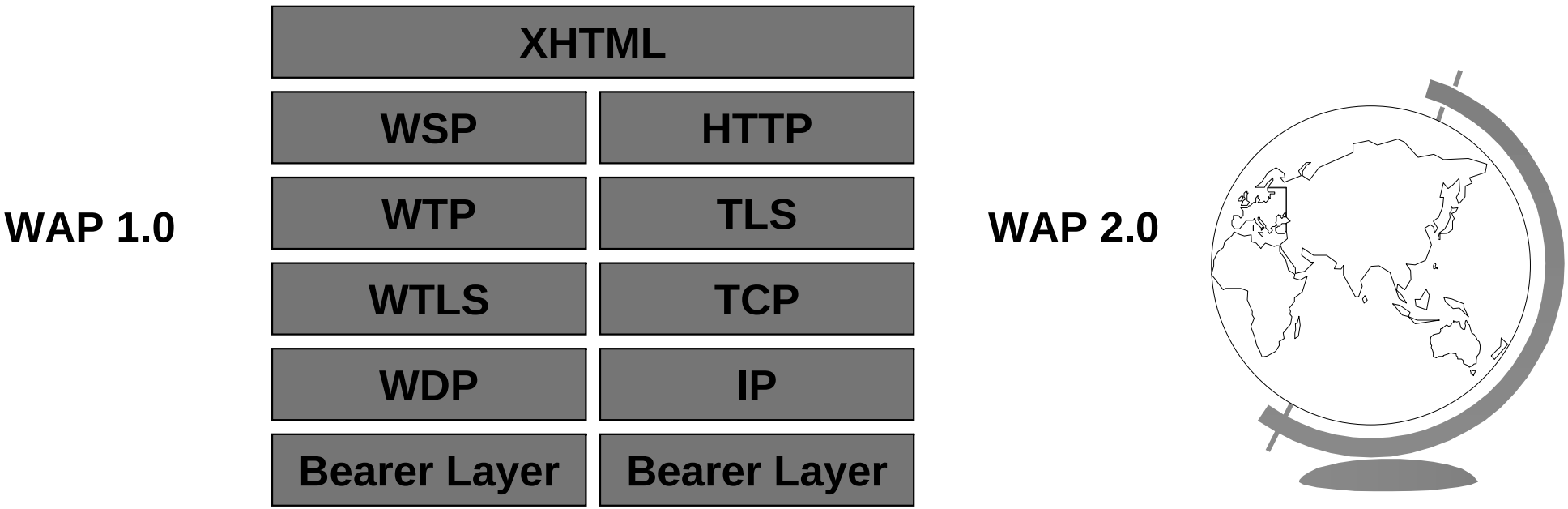
# WAP 2.0

- Goal: fix WAP 1.0 shortcomings
- Features:
  - Push model as well as pull
  - Integrated telephony (voice and data) into applications
  - Multimedia messaging
  - Include 264 pictograms (emoji)
  - Interface to storage device (e.g. flash memory)
  - Support for browser plug-ins (also new scripting language, WMLScript)



# WAP 2.0

- New protocol stack based on TCP and HTTP/1.1
- Modified TCP (compatible with original)
  - Fixed 64KB window
  - No slow start
  - Maximum 1500-byte packet
  - Slightly different transmission algorithm
- WAP 2.0 supports new and old (WAP 1.0) protocol stack



# WAP 2.0

- WAP 2.0 supports XHTML basic
- NTT DoCoMo has agreed to support XHTML so that pages will be widely compatible
- Hopefully, this will end format wars
- XHTML targetted at low end devices (mobile phones, TVs, PDAs, vending machines, pagers, watches, etc)
- Thus, no style sheets, scripts or frames
- WAP 2.0 speed 384 kbps
- WAP threat:
  - 802.11b (11Mbps) and 802.11g (54Mbps) can download regular web pages, becoming available in coffee shops
  - People will prefer 802.11 where available
- Hybrid solution: dual mode devices that use 802.11 where available and WAP otherwise