How the Internet Works

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Contents

- World Wide Web, which is made of
- HTML and HTTP and communicates over
- TCP/IP, which uses
- Ethernet and other network media.
- Supported by routing and DNS

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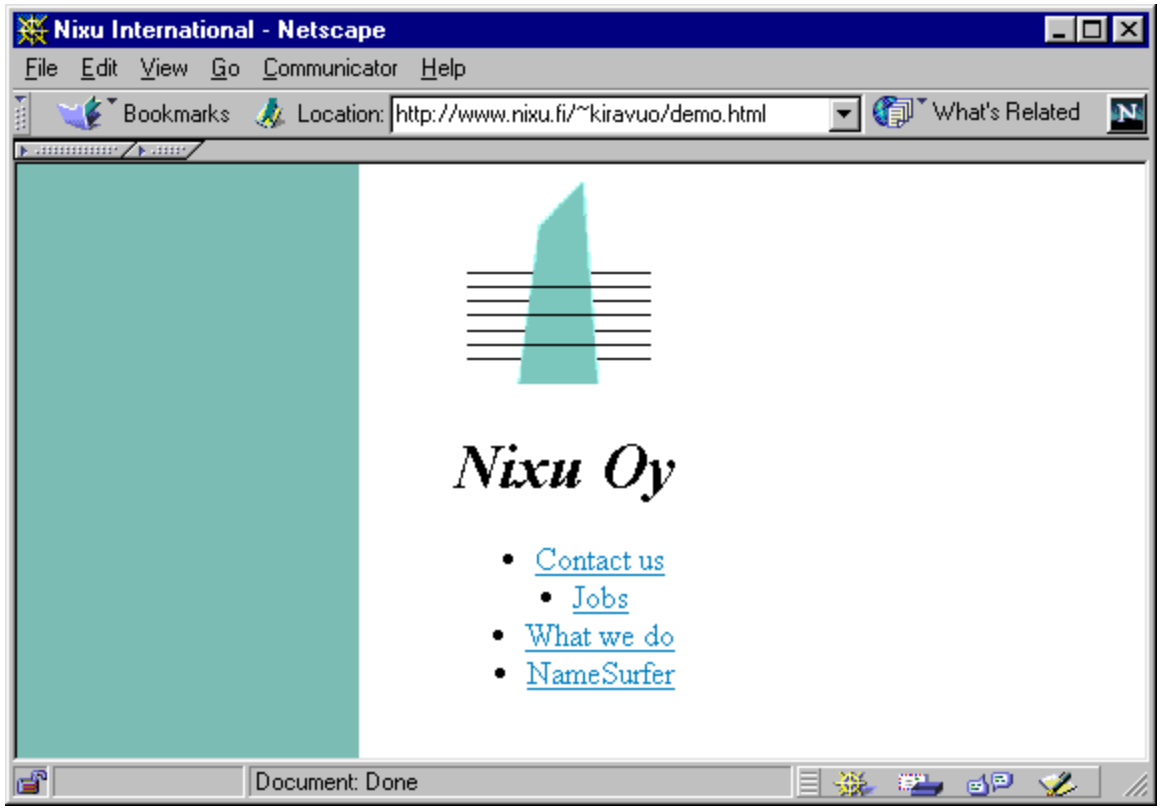
WWW Page



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HTML Code

```
<HTML>
  <HEAD>
    <TITLE>Nixu International</TITLE>
  </HEAD>
  <BODY background="/gfx/back1.gif">
    <CENTER>
      <IMG SRC="/gfx/logo.gif" ALT="Nixu Oy"><BR>
      <H1><I>Nixu Oy</I></H1>
      <UL>
        <LI><A HREF="/yhteysti.html">Contact us</A>
        <LI><A HREF="/avoimett/">Jobs</A>
        <LI><A HREF="/palvelut/">What we do</A>
        <LI><A HREF="http://www.namesurfer.com/">
              NameSurfer</A>
      </UL>
    </CENTER>
  </BODY> </HTML>
```

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World Wide Web

- Combines text, pictures and hyperlinks to a hypertext document
  – a hyperlink points to another document
- Can also contain moving pictures, active programs etc.
- Hypertext document is written in HTML language
  – HyperText Markup Language
  – based on SGML (Standard Generalized Markup Language)
  – describes the structure of a document
- WWW browser decides how to display the document based on the structure description in HTML

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URL

- Universal Resource Locator
- URL is an address to the current location of information

```
protocol://host[:server port]/path/file.html
protocol://host[:server port]/path/
```

- For example

```
http://www.hut.fi/
http://www.nixu.fi/~kiravuo/etiketti/index.html
news:sfnet.harrastus.retkeily
ftp://ftp.funet.fi/rfc/
```

- WWW browser uses the URL address to retrieve a document over the network

HTTP Session

- Connection to the HTTP server program in www.nixu.fi
  - equivalent to: **`telnet www.nixu.fi 80`**

```
GET /~kiravuo/demo.html HTTP/1.0
Connection: Keep-Alive
User-Agent: Mozilla/4.06 [en] (Win95; I)
Accept: image/gif, image/x-xbitmap, image/jpeg,
  image/pjpeg, image/png, */*
Accept-Charset: iso-8859-1,*,utf-8
...
HTTP/1.1 200 OK
Server: Apache/1.2.6
Last-Modified: Tue, 24 Nov 1998 06:35:48 GMT
Content-Length: 466
Keep-Alive: timeout=15, max=100
Connection: Keep-Alive
```

HTTP Session Cont.

```
Content-Type: text/html
...
<HTML>
  <HEAD>
    <TITLE>Nixu International</TITLE>
...
GET /gfx/back1.gif HTTP/1.0
Referer: http://www.nixu.fi/~kiravuo/demo.html
...
HTTP/1.1 200 OK
Content-Length: 902
Content-Type: image/gif
..GIF89a...
...
```

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HTTP Protocol

- HTTP is a simple protocol for file transfer over the network
- Client (browser) initiates the session by connecting to the server
  – Pull protocol, server does not transmit on its own
- Client issues the GET-command to retrieve a file from the server
- Additional information is also passed
  – Client type
  – Acceptable data formats
- Server sends information about the file and the contents of the file

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Connections

- HTML is a data format
- HTTP protocol transfers files over a reliable connection
  – No error checks or checksums in HTTP
- On the Internet we use TCP/IP for the reliable connection
  – TCP/IP provides a reliable byte-stream as a service to HTTP
- Browser uses HTTP to get the required HTML file specified by the URL

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Addresses

- Each host has a name
  – E.g. www.hut.fi
- The network uses numeric addresses
  – E.g. 130.233.224.28
- Translation is provided by the DNS (Domain Name Service)
- A host has also numbered ports, which are connected to server programs
  – Port addresses are standardized, eg port 80 for HTTP, port 25 for SMTP email

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TCP

- TCP = Transmission Control Protocol
- Defined in RFC-793
- Connection-oriented, reliable, byte-stream service
- Application data is broken into segments, which are sent as IP datagrams.
- Features:
  - Checksums, timeouts and flow control
  - Segment reassembly in correct order, discarding duplicate packets

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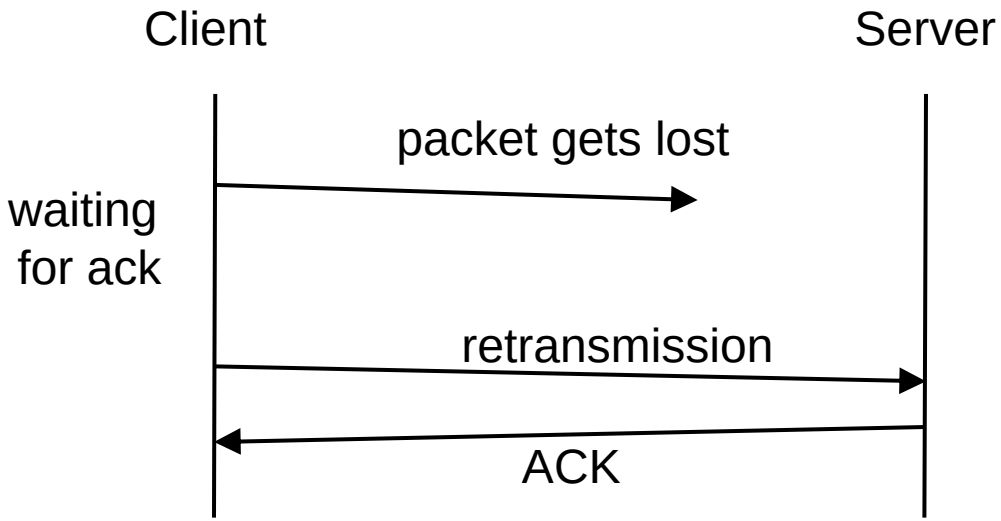
Reliable TCP Operation

- Receiver sends acknowledgment for each segment.



- If a packet gets lost, timeout will ensure it's retransmitted

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UDP

- UDP = User Datagram Protocol
- Defined in RFC-768
- Unreliable datagram-oriented transportation layer protocol
  – Offers little extra functionality besides port numbers
  – Light-weight, easy to implement
- Applications using UDP: DNS, Radius, NTP, SNMP

IP

- IP = The Internet Protocol
- Defined in RFC-791
- IP sends simple datagrams over network.
- It provides unreliable and connectionless delivery service.
  - Unreliable = no guarantees, best effort only
  - Connectionless = each packet is handled separately at the IP layer

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Ethernet

- Defined in IEEE 802.3
- One local area network (LAN) technology
  – Limited to short range connections (100 m - 1 km)
  – Different cabling options (coaxial cabling, twisted pair etc.)
- Has it’s own addresses
  – 6 bytes
  – Relevant only within one LAN

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Protocol Stacks

Internet (TCP/IP)	**OSI (Open Systems Interconnection)**
Application	Application
	Presentation
	Session
TCP, UDP	Transport
IP	Network
Data Link	Data Link
Physical	Physical

- The OSI model is mostly used as a reference
- The TCP/IP application layer combines the features of the three topmost OSI layers

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Actual Session Data

- Eavesdropping traffic is technically easy
  – Requires only an access to the physical media
- Here is a dump of the packets from the network
- A complete session would be a little bit longer

Data client -> Server

```
ETHER:  Destination = 8:0:20:74:f1:2c, Sun
ETHER:  Source      = 0:0:3b:80:e:93,
ETHER:  Ethertype = 0800 (IP)
IP:   Protocol = 6 (TCP)
IP:   Source address = 194.197.118.74,
  chili.nixu.fi
IP:   Dest. address = 194.197.118.20,
  jalopeno.nixu.fi
TCP:  Source port = 35620
TCP:  Destination port = 80 (HTTP)
TCP:  Sequence number = 760000273
TCP:  Acknowledgement number = 2370000258
HTTP:  "GET /~kiravuo/demo.html HTTP/1.0
        Connection: Keep-Alive
        User-Agent: Mozilla/4.06..."
```

Ack server -> Client

```
ETHER:  Destination = 0:0:3b:80:e:93,
ETHER:  Source      = 8:0:20:74:f1:2c, Sun
ETHER:  Ethertype = 0800 (IP)
IP:   Flags = 0x4 (do not fragment)
IP:   Protocol = 6 (TCP)
IP:   Source address = 194.197.118.20,
  jalopeno.nixu.fi
IP:   Dest. address = 194.197.118.74, chili.nixu.fi
TCP:  Source port = 80 (HTTP)
TCP:  Destination port = 35620
TCP:  Sequence number = 2370000258
TCP:  Acknowledgement number = 760000379
TCP:  Flags = 0x10 (ACK)
HTTP:  ""
```

Data server -> Client

```
ETHER:  Destination = 0:0:3b:80:e:93,
ETHER:  Source      = 8:0:20:74:f1:2c, Sun
ETHER:  Ethertype = 0800 (IP)
IP:   Protocol = 6 (TCP)
IP:   Source address = 194.197.118.20,
  jalopeno.nixu.fi
IP:   Dest. address = 194.197.118.74, chili.nixu.fi
TCP:  Source port = 80 (HTTP)
TCP:  Destination port = 35620
TCP:  Sequence number = 2370000299
TCP:  Acknowledgement number = 760000379
TCP:  Data offset = 20 bytes
TCP:  Flags = 0x10 (ACK)
HTTP:  "HTTP/1.1 200 OK
        Server: Apache/1.2.6
        Last-Modified: Tue, 2..."
```

Ack Client -> Server

```
ETHER:  Destination = 8:0:20:74:f1:2c, Sun
ETHER:  Source      = 0:0:3b:80:e:93,
ETHER:  Ethertype = 0800 (IP)
IP:   Protocol = 6 (TCP)
IP:   Source address = 194.197.118.74,
  chili.nixu.fi
IP:   Dest. address = 194.197.118.20,
  jalopeno.nixu.fi
TCP:  Source port = 35620
TCP:  Destination port = 80 (HTTP)
TCP:  Sequence number = 760000379
TCP:  Acknowledgement number = 2370000627
TCP:  Flags = 0x10 (ACK)
HTTP:  ""
```

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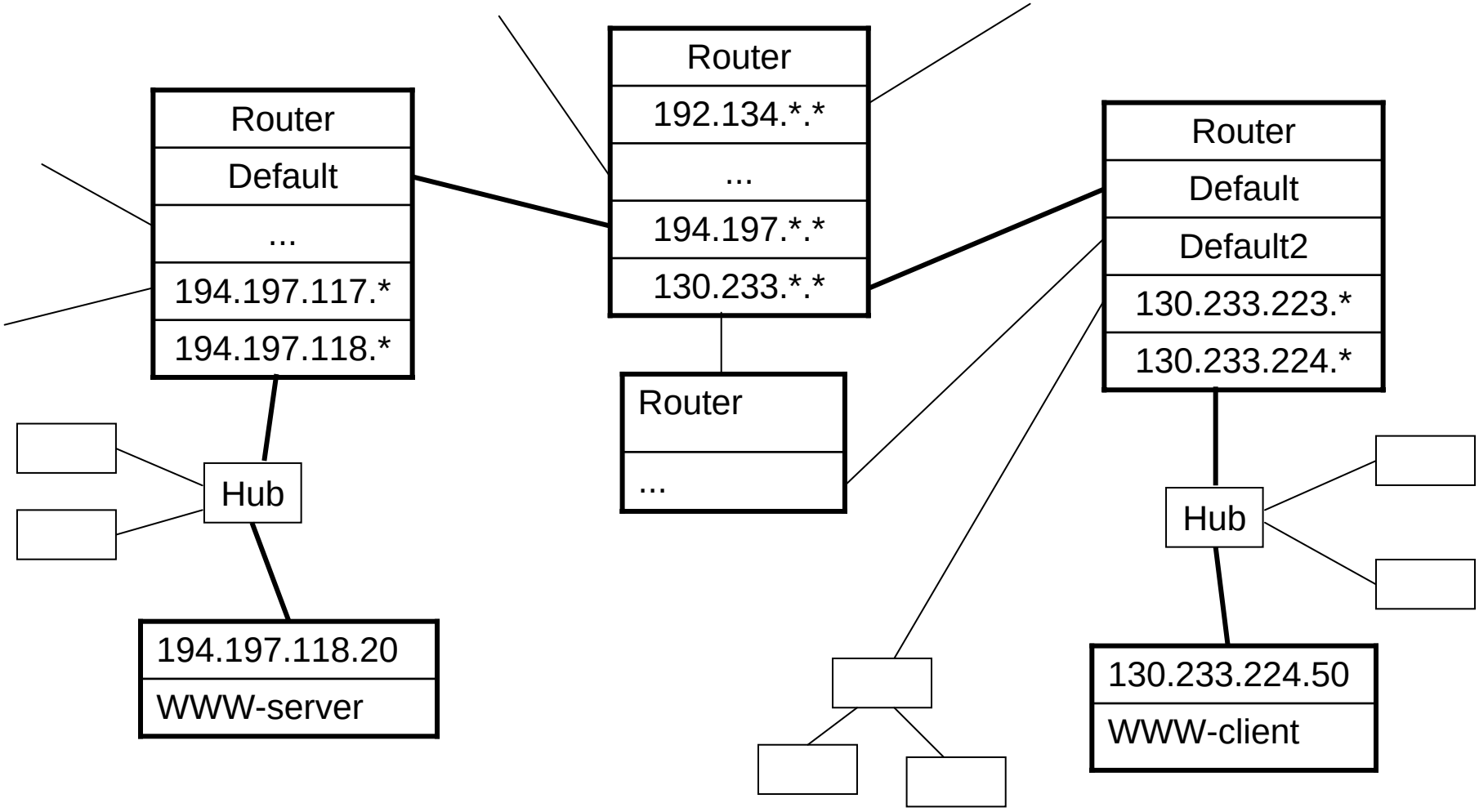
Routing

- LANs are connected by routers
- Each router has a table that tells which network address can be reached by which connection
- Backbone routers update their information automatically and can route around breaks in the network

Routing network



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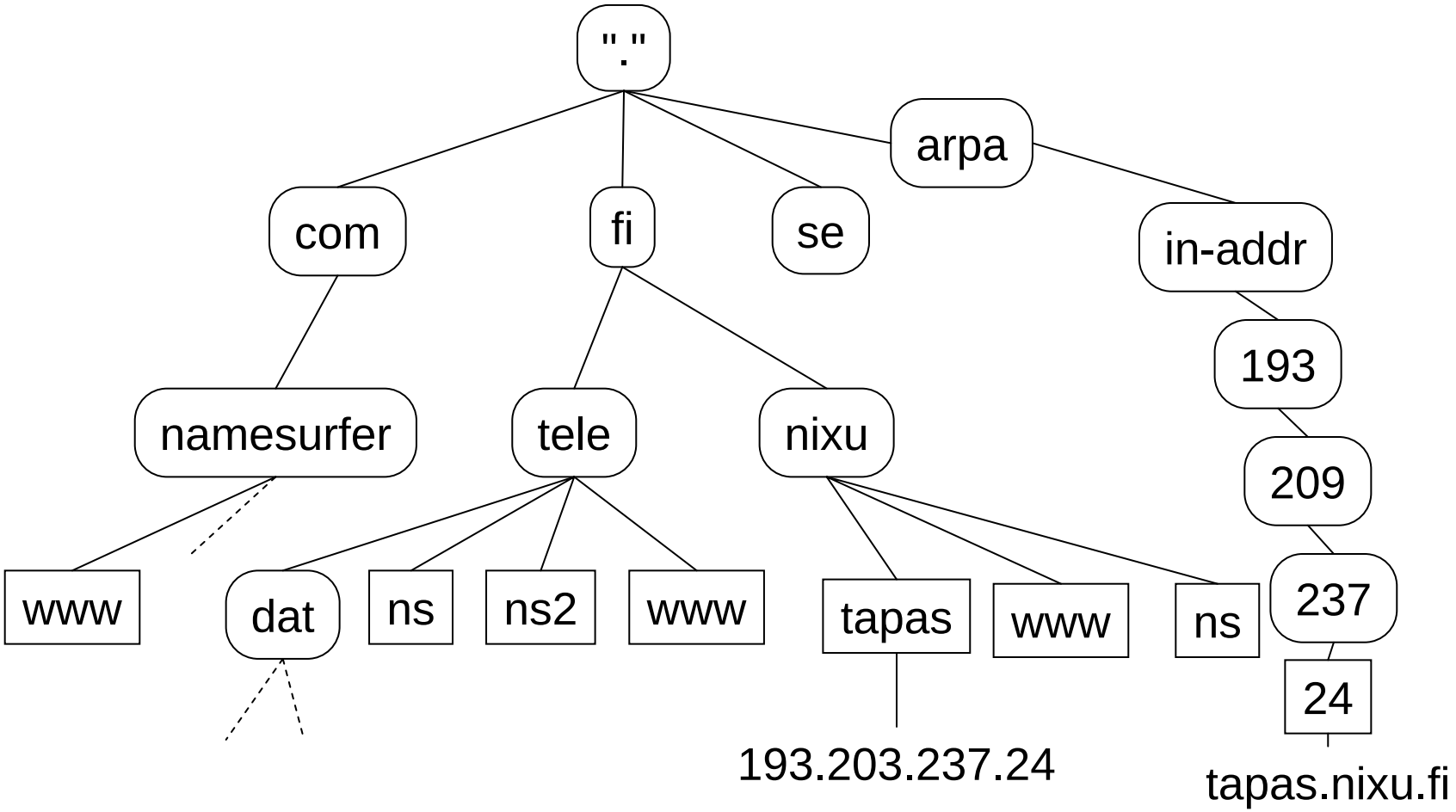
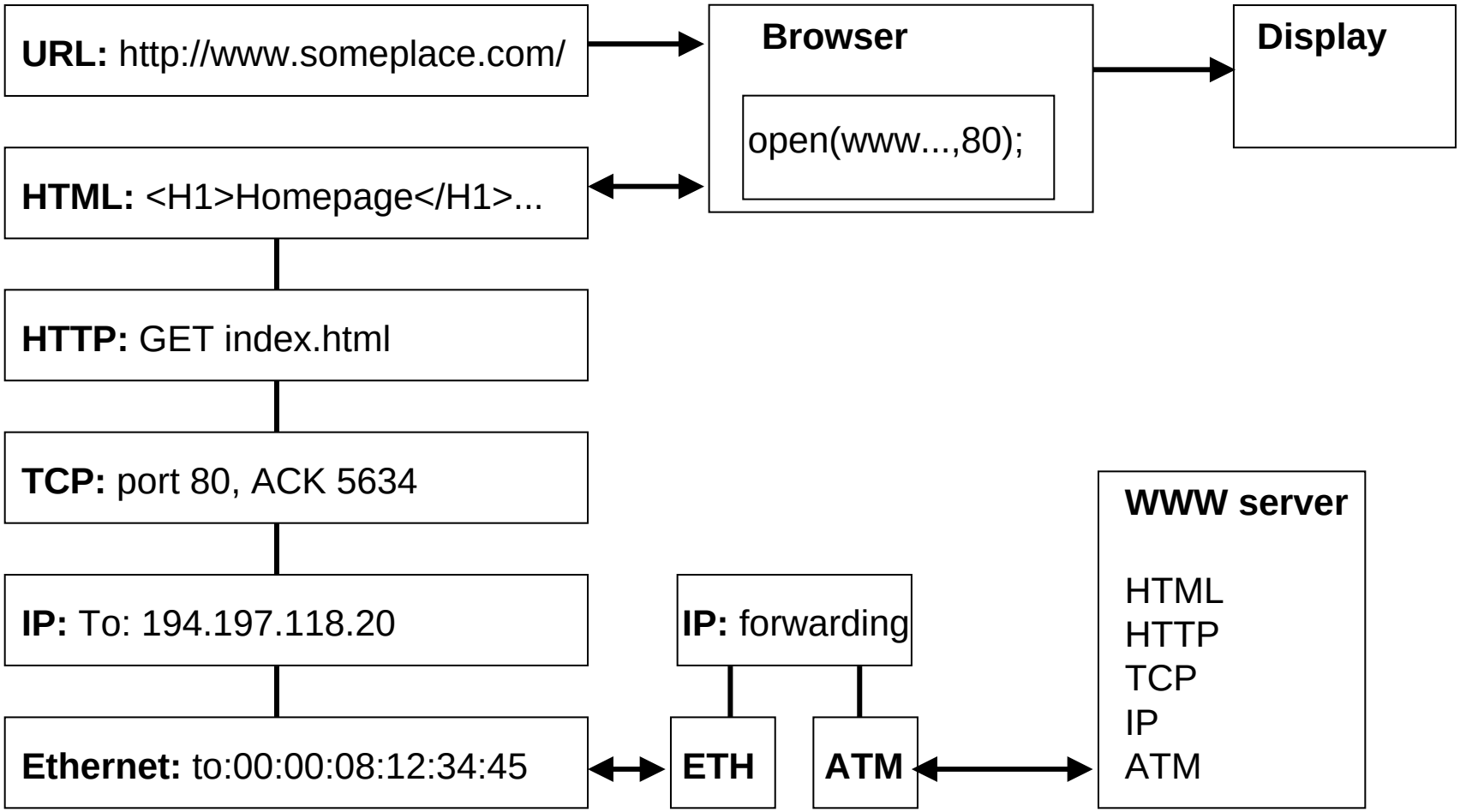
Domain Name System

- Distributed database with local caching
- Distributed administration (adding or deleting data)
- Services provided:
  - Hostname to IP address
  - IP address to hostname
  - Mail exchange records

Name Space Structure



Summary


URL: http://www.someplace.com/
Browser
Display
open(www...,80);
HTML: <H1>Homepage</H1>...
HTTP: GET index.html
TCP: port 80, ACK 5634
IP: To: 194.197.118.20
IP: forwarding
WWW server
HTML
HTTP
TCP
IP
ATM
Ethernet: to:00:00:08:12:34:45
ETH
ATM

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Conclusion

- Layered protocols are a flexible solution and enable one network to do many kinds of things
  – IP is the key protocol to which everything else attaches
- The TCP/IP family is not perfect and there are many known fundamental problems, however it works well enough for practical purposes