(Stuff You Should Know About…)

Web-based Clinical Information Systems

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Agenda

- Building blocks of the Web: Web addresses, HTTP, Cookies, HTML, browser differences
- Page design comments
- Introducing XML
- XML and HL7
- Security and encryption
- Structure of Web-based clinical systems
  - > Pitt: MARS and Special Vision

Application: Public Information and Marketing

- University of Pittsburgh Cancer Center
- Texas Cancer Registry
- NCI SEER Program
- OncoNavigator (Registries)

Application: Data Delivery

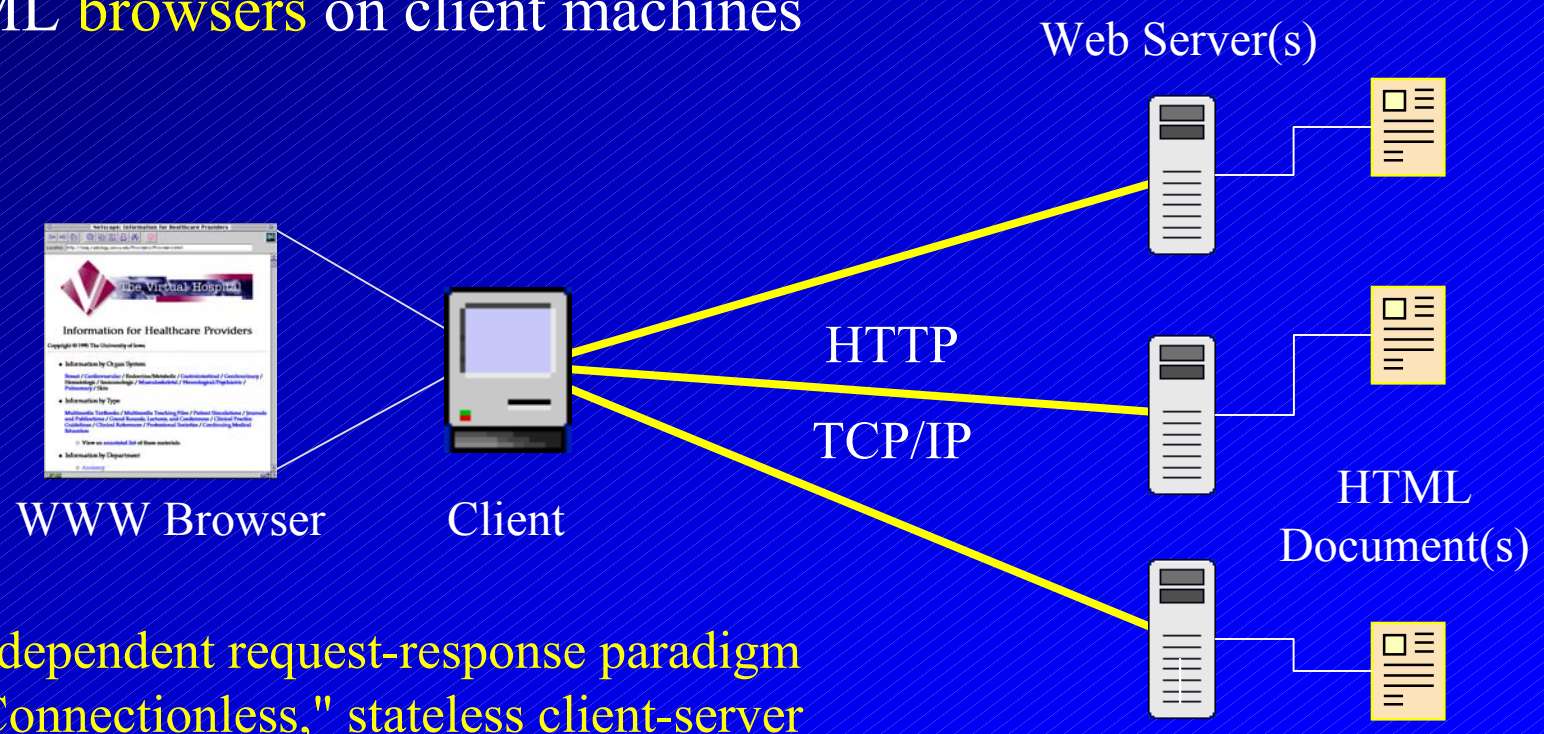
- NCI SEER Program
  - Overview
  - Incidence statistics
  - Graphical output
- Cancer Surveillance Online
  - Overview
  - Incidence by province
- NAACCR
  - CiNA
  - Data selection and specification
  - Graphical output
- Delivery of pre-set reports and data files for analysis

Application: Data Abstraction

- Belgian Thyroid Cancer Registry
  - > Task Selection
  - > Forms Index

Building Blocks of the World Wide Web

- A global network of servers that communicate via HTTP
- Transmit documents encoded in HTML
- HTML browsers on client machines



Independent request-response paradigm
"Connectionless," stateless client-server

Uniform Resource Locators (URL/URI)

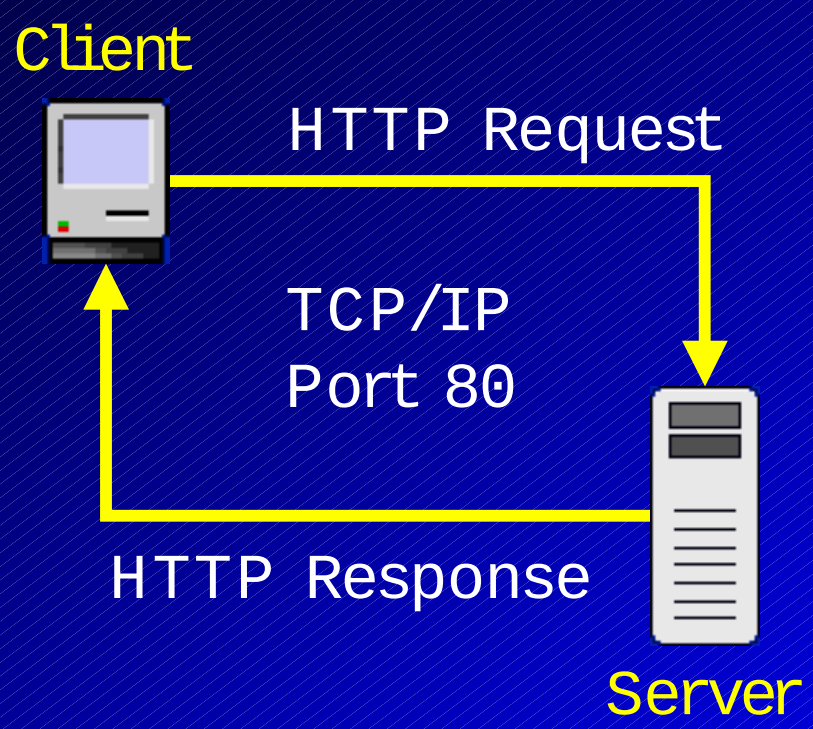
A standard nomenclature for Internet addresses

http://path.upmc.edu/divisions/informatics.html
http://path.upmc.edu/divisions/index.html
ftp://path.upmc.edu/resources/cases/caseList.doc

Protocol — server — directory(ies) — document

gopher://
telnet://
mailto:
file:///

Hypertext Transport Protocol (HTTP)



Request

```
GET url HTTP/1.0        [POST, PUT]
Accept: text/plain
Accept: text/html
User-Agent: Mozilla/4.0
Cookie: cookie data, if any
blank line
```

Response

```
HTTP/1.0 200 Document follows
Date: Mon, 09 Oct 1995 17:59:15 GMT
Server: NCSA/1.4.2
Content-type: text/html
Last-modified: Sun, 08 Oct 1995 17:49:26 GMT
Content-length: 1772
 blank line
<HTML>
... the document...
</HTML>
```

HTTP 1.0: response automatically closes connection

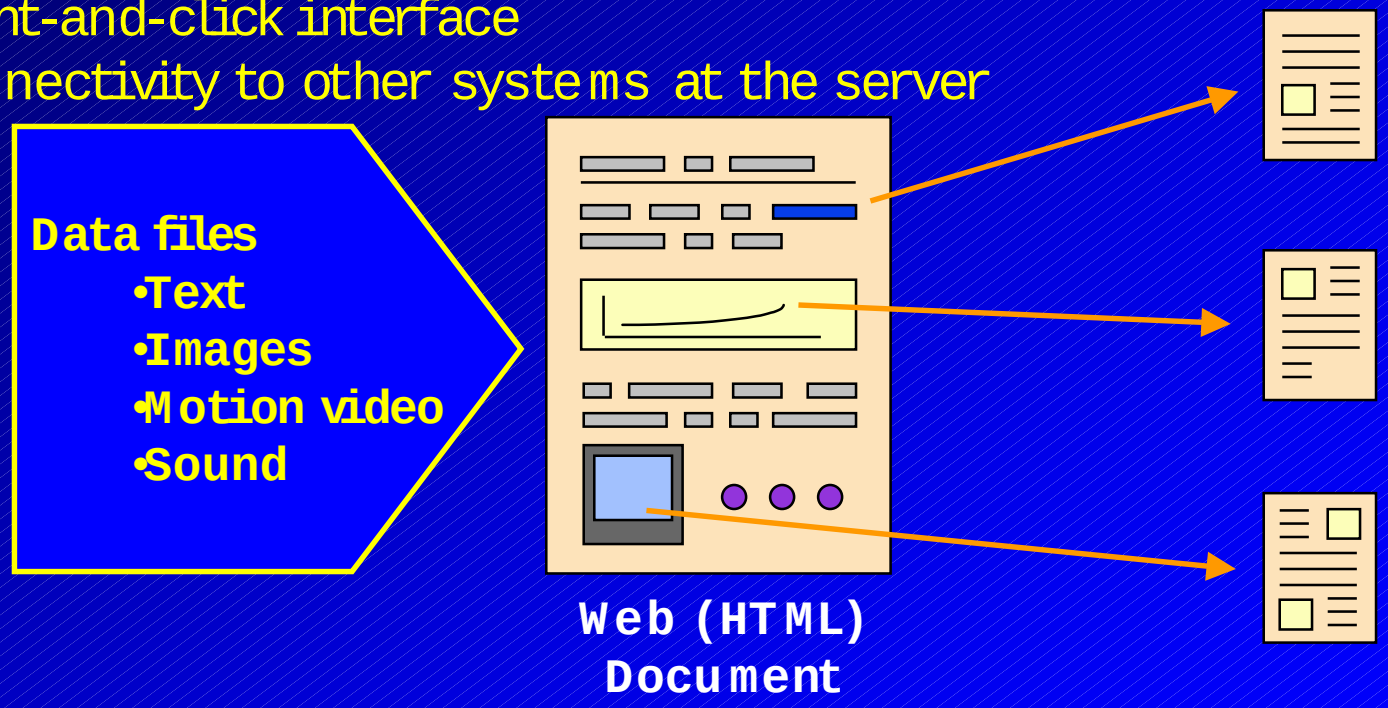
HTTP 1.1: connection stays open until explicitly closed

Maintaining State on the Web Server

- Simulates sessions on a connectionless server
- Pass state data back to the user's browser after each connection
- "Cookies:" a standard way to store and retrieve state data as text strings within the user's browser
- Allows the user to maintain a history of interaction with the server
- Cookies can be stored between user sessions, but may then be lost or accessed by non-authorized users

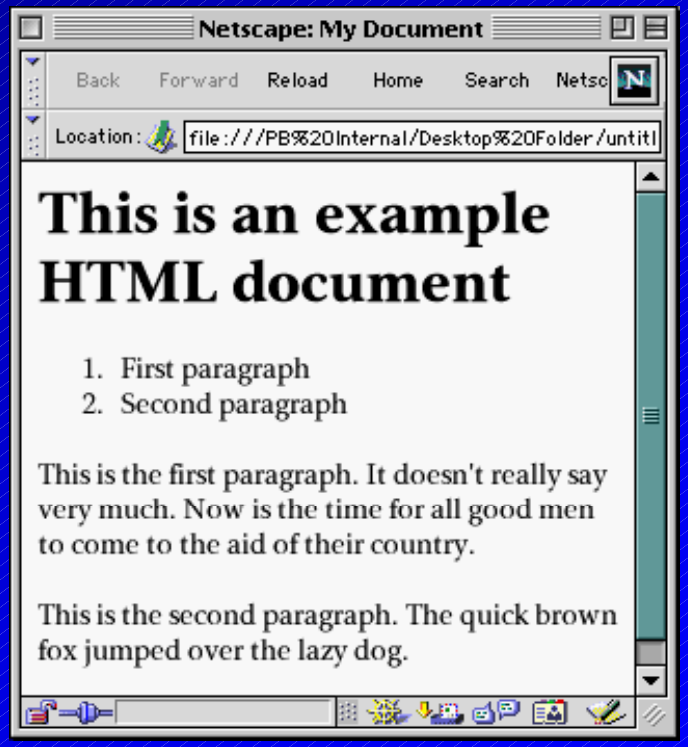
World Wide Web Documents

- Integrated display of many data types (assembly of multiple files)
- Constructed using Hypertext Markup Language (HTML)
- Document-to-document linkage
- Point-and-click interface
- Connectivity to other systems at the server



A Hypertext Markup Language Document

```
<html>
<head>
<title>My Document</title>
</head>
<body>
<h1>This is an example HTML document</h1>
<ol>
<li>First paragraph</li>
<li>Second paragraph</li>
</ol>
<p>This is the first paragraph. It doesn't really
say very much. Now is the time for all good men
to come to the aid of their country.</p><p>This
is the second paragraph. The quick brown fox
jumped over the lazy dog.</p>
</body>
</html>
```

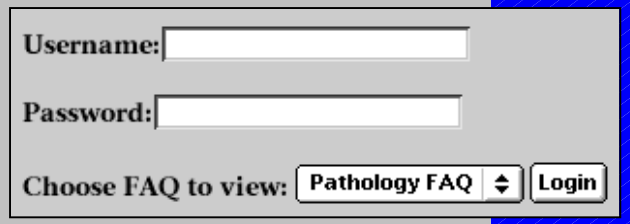


Text editors for simple documents
Web management software:
FrontPage, Dreamweaver, GoLive

Interactivity: HTML Web Forms

- Create interface elements to accept input
- Return input text to the server as "fieldname=value" pairs:
  - http://jhh.cbmi.upmc.edu/cgi-bin/kbm/admin.pl?Username="harrison" &Password="2bornot2b"&kb_id="1"

```
<form action="/cgi-bin/kbm/admin.pl" name="theform" method=post>
<b>Username:</b><input type=text name="Username"><p>
<b>Password:</b><input type=password name="Password"><p>
<b>Choose FAQ to view:</b>
<select name="kb_id">
  <option value="1" selected>Pathology FAQ
  <option value="2">Pharmacy FAQ
  <option value="3">Radiology FAQ
</select>
<input type=submit value="Login">
</form>
```



HTML Document Design

- Documents can be longer than the screen (scrolling is OK), but the content of the document should be clear in the first screen
- Allow the user as much control as possible (fonts, etc.)
- Documents are ideally simple to use and information-rich
  - 1000 text characters ~ 1K
  - 0.25" square full color ~ 1K (will compress, but…)
  - Know your audience: images dramatically slow page access
  - Each file access (including image files) counts as a server "hit"
- Simple documents are compatible across more browsers, less expensive to create, and easier to maintain
- Web management software packages encourage complex pages
- Brochures and reference books are styled differently for good reason

Differences in Web Browsers

- Most browsers handle simple documents similarly
- Complex documents may appear different and may required multiple versions for different browsers
- Browsers may differ between developers, between versions with a single developer, and between platforms with a single developer
- Browsers may handle html errors differently:
  - > CiNA: looks OK in Internet Explorer but errors in HTML are apparent in some other browsers

HTML as a Markup Language

- HTML is a lightweight, standard, simple way to specify document structure (and appearance)
- HTML tags are tightly tied to visual display
  - Tag function is hard-coded into HTML browsers
  - Complex formatting leads to complex HTML
  - Limited ability to create interactive user interfaces
  - Available tags are specified by the HTML DTD (cannot create new, special-purpose tags)
  - Cannot represent data structures from databases
- HTML documents are difficult to maintain in large numbers
  - Inefficient to index and search
- HTML does not provide control over data entry
  - Any text is OK

From HTML to XML…

- HTML originally specified structural components of documents
  - HTML has evolved to become a presentation syntax
  - HTML was created based on the SGML framework
- XML is a simplified markup language framework
  - Allows creation of special-purpose markup languages
  - Can represent a variety of data structures and semi-structured data
  - Arbitrary tag nesting, recursion and markup detail
  - Human-readable and machine readable
  - Expected to be useful for creation of vertical-market data-interchange standards
  - HL7 v3 uses XML-based messages; SOAP; GTDS in Germany
  - High quality software to send, receive and parse XML is available at low cost to both users and vendors

Document Markup -- HTML

```
<h2>Patient Information</h2>
<ul>
    <li><b>Name:</b>Henry Levin, the 7th</li>
    <li><b>MRN:</b> 123456789</li>
    <li><b>DOB:</b> May 13, 1923</li>
</ul>

<h2>Clinical Data</h2>
<p>History of smoking for 40 years.</p>

<h2>Procedure</h2>
<p>Chest X-ray</p>

<h2>Findings</h2>
<p>Comparison is made with a chest-x-ray ... </p>

<h2>Impressions</h2>
<p>RLL nodule, suggestive of malignancy. Compar
with a prior CXR from 6 months ago, nodule size ha
increased.</p>

<h2>Recommendations</h2>
<p>I notified the ordering physician of this finding l
phone.</p>
```

Radiology Report - Chest X-Ray

Patient Information
- **Name:** Henry Levin, the 7th
- **MRN:** 123456789
- **DOB:** May 13, 1923

Clinical Data
History of smoking for 40 years.

Procedure
Chest X-Ray

Findings
Comparison is made with a chest x-ray ...

Impressions
RLL nodule, suggestive of malignancy. Compared with a prior CXR from 6 months ago, nodule size has increased.

Recommendations
I notified the ordering physician of this finding by phone.

- Markup is restricted to display information only.
- Clinical information must be contained in free text.
- Available tags are specified in a rigid HTML "DTD"

Document Markup -- XML

```
<RadiologyReport>
<PatientInfo>
    <Name>Henry Levin, the 7th</Name>
    <MRN>123456789</MRN>
    <DOB>May 13, 1923</DOB>
</PatientInfo>

<ClinicalData>History of smoking for 40
years.</ClinicalData>
<Procedure>Chest X-ray</Procedure>

<Findings>
Comparison is made with a chest-x-ray ...
</Findings>

<Impressions>
RLL nodule, suggestive of malignancy. Compared w
prior CXR from 6 months ago, nodule size has incre
</Impressions>

<Recommendations>
I notified the ordering physician of this finding by p
</Recommendations>
</RadiologyReports>
```

Radiology Report - Chest X-Ray

Patient Information
- **Name:** Henry Levin, the 7th
- **MRN:** 123456789
- **DOB:** May 13, 1923

Clinical Data
History of smoking for 40 years.

Procedure
Chest X-Ray

Findings
Comparison is made with a chest x-ray ...

Impressions
RLL nodule, suggestive of malignancy. Compared with a prior CXR from 6 months ago, nodule size has increased.

Recommendations
I notified the ordering physician of this finding by phone.

- Markup can identify specific data elements.
- Markup is flexible to accommodate new data elements and additional metadata.
- Metadata can be contained within tags.
- New DTDs can be created.

XML Document Detail

Opening tag

Element name

Attribute

```
<procedure cpt="1234">
    <pat_phys pnum="abcd">
        <firstName>Elmer</firstName>
        <lastName>Fudd</lastName>
        <degree>M.D.</degree>
    </pat_phys>
    <proc_name>Upper endoscopy of gizzard</proc_name>
    <proc_date>09/09/1999</proc_date>
    <location name="ER"/>
</procedure>
```

Content

Singleton tag

Closing tag

HL7 2.3 Message Format

```
MSH|^~\&|LABGL1||DMCRES||199812300100||ORU^R01|LABGL1199510221838581|P|2.3
    |||NE|NE
PID|||6910828^Y^C8||Newman^Alfred^E||19720812|M||W|25 Centscheap Ave^^
    Whatmeworry^UT^85201^^P||(555)777-6666|(444)677-7777||M||773789090
OBR||110801^LABGL|387209373^DMCRES|18768-2^CELL COUNTS+DIFFERENTIAL TESTS
    (COMPOSITE)^LN|||199812292128||35^ML||||||IN2973^Schadow^Gunther^^^^M
    D^UPIN
    ||||||||||^Once||||||CA20837^Spinosa^John^^^^MD^UPIN
OBX||NM|4544-3^HEMATOCRIT (AUTOMATED)^LN||45||39-49
    ||||F|||199812292128||CA20837
OBX||NM|789-8^ERYTHROCYTES COUNT (AUTOMATED)^LN||4.94|10*12/mm3
    |4.30-5.90||||F|||199812292128||CA20837
```

Figure 7-4. OBR attributes

```
MSH
PID
{ [ ORC ]
    { OBR
      { OBX }
    }
}
```

SEQ	LEN	DT	OPT	RP/#	TBL#	ITEM #	ELEMENT NAME
1	4	SI	C			00237	Set ID - OBR
2	22	EI	C			00216	Placer Order Number
3	22	EI	C			00217	Filler Order Number +
4	200	CE	R			00238	Universal Service ID
5	2	ID	X			00239	Priority

From Rishel, "HL7 Modeling & Methodology and Control-Query Comm

HL7 v3 Message Format

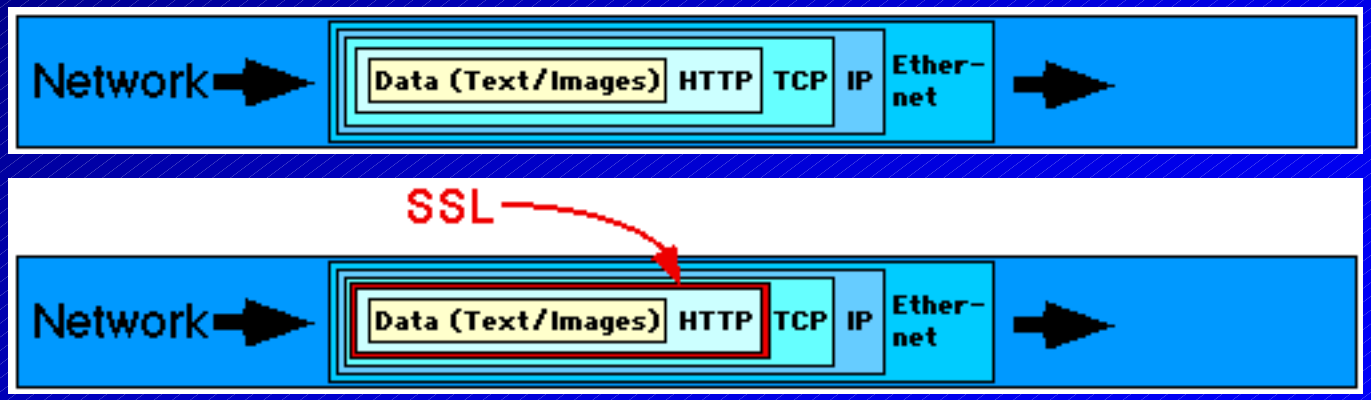
```
<Labrs3P00 T="Labrs3P00">
    <Labrs3P00.PTP T="PTP">
        <PTP.primrPrsnm T="PN">
            <fmn T="ST">Sample</fmn>
            <gvn T="ST">George</gvn>
            <mdn T="ST">H</mdn>
        </PTP.primrPrsnm>
    </Labrs3P00.PTP>
    <Labrs3P00.SIOO_L T="SIOO_L">
        <SIOO_L.item T="SIOO">
            <SIOO.filrOrdId T="IID">LABGL110801</SIOO.filrOrdId>
            <SIOO.placrOrdId T="IID">DMCRES387209373</SIOO.placrOrdId>
            <SIOO.InsncOf T="MSRV">
                <MSRV.unvSvcId T="CE">18768-2</MSRV.unvSvcId>
                <MSRV.svcDesc T="TX">CELL COUNTS+DIFFERENTIAL TESTS (COMPOSITE)</MSRV.svcDesc>
            </SIOO.InsncOf>
            <SIOO.SRVE_L T="SRVE_L">
                <SRVE_L.item T="SRVE">
                    <SRVE.name T="CE">4544-3</SRVE.name>
                    <SRVE.svcEvntDesc T="ST">HEMATOCRIT (AUTOMATED)</SRVE.svcEvntDesc>
                    <SRVE.CLOB T="CLOB">
                        <CLOB.obsvnValu T="NM">45</CLOB.obsvnValu>
                        <CLOB.refsRng T="ST">39-49</CLOB.refsRng>
                        <CLOB.clnRlvnBgnDtm T="DTM">199812292128</CLOB.clnRlvnBgnDtm>
                    </SRVE.CLOB>
                    <SRVE.spcmRcvdDtm T="DTM">199812292315</SRVE.spcmRcvdDtm>
                </SRVE_L.item>
        </SIOO_L.item>
    </Labrs3P00.SIOO_L>
</Labrs3P00>
```

Tag names from HL7 RIM

From Rishel, "HL7 Modeling & Methodology and Control-Query Comm

Security

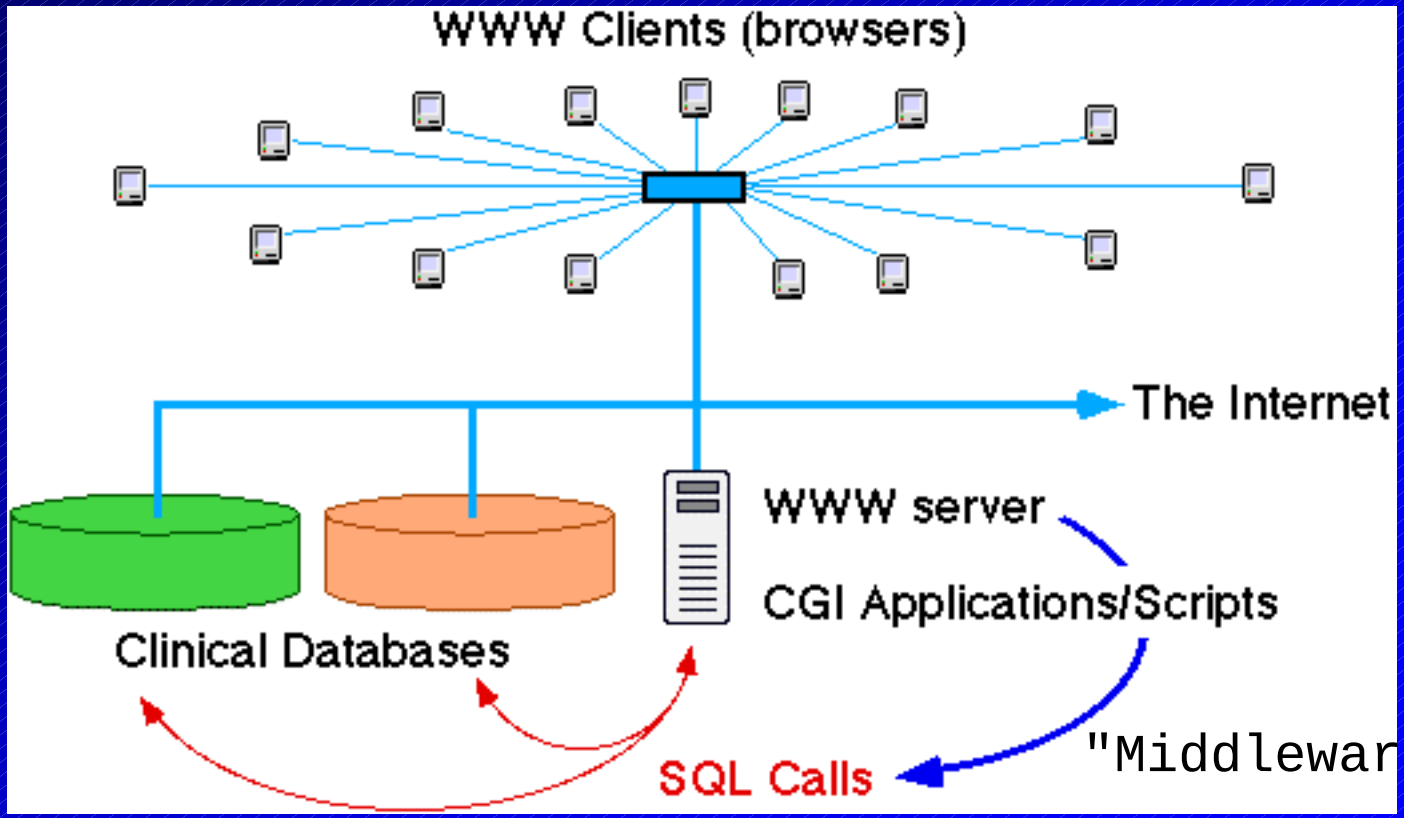
- Secure Sockets Layer (SSL)
  - > Public/private key encryption/digital signature
  - > Digital certificates in browser and server, certificate brokers
  - > Secures all protocols (HTTP, FTP, Telnet, etc.)
  - > Note different needs for e-commerce and clinical systems



- Other issues: browser caching/history, automated logoff

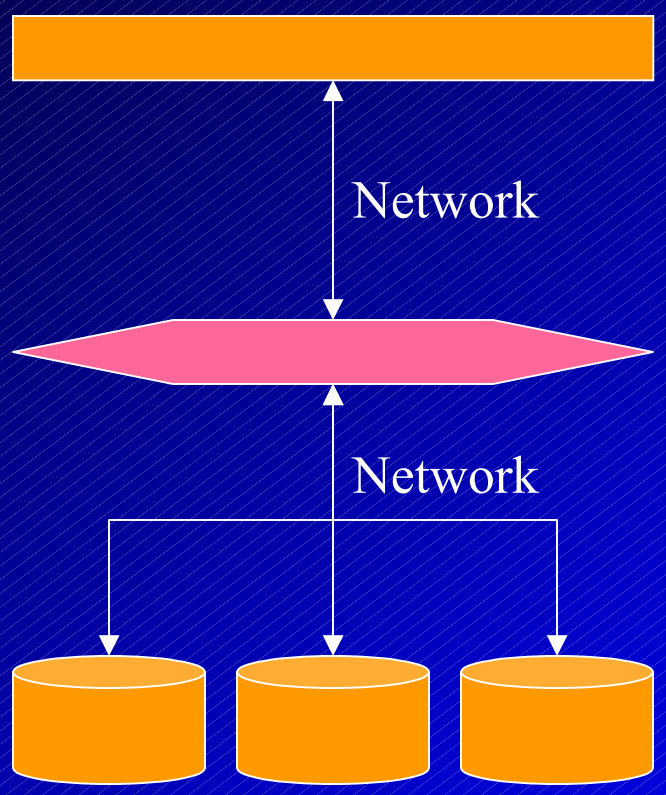
Web "Front Ends" to Clinical Systems

- Common Gateway Interface (CGI) and related protocols (Perl, etc.)
- Java servlets
- Application/middleware toolkits (e.g., PHP, Zope, Cold Fusion, WebSphere, Weblogic)



Logical Design of Clinical Web Systems

"Three-tier" design



Presentation Layer

Web browser
Client software
Java applet

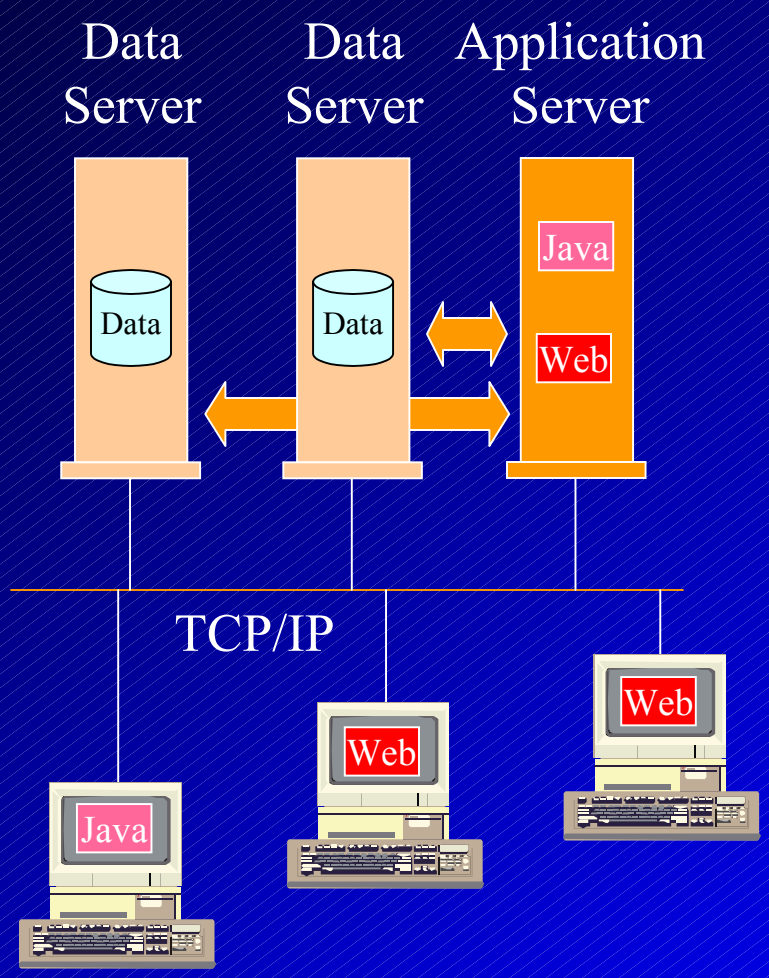
Middleware

Web server
Application server
Interface engine
Business rules
Database connectivity

Data Sources

DB managers
Legacy systems
MARS system

Technical Structure of Web-based Clinical Systems



- Standard client-server hardware
- Shared network
- Familiar graphical interface
- Web forms provide limited interface capability
- Java running in browsers can provide more functionality
- "Just-in-time" software distribution
- Currently relatively slow performance
- Specialized "browsers" may also provide improved interface function

Workstations with standard browsers (provide application shell)

Review

- The Web provides a relatively low cost and capable information system front end that is broadly accessible
- The primary expenses in Web development are expertise and time
- Registries are currently using the Web for marketing and data distribution
- Simple, information-rich page design has merit
- Registry software is likely to include Web-based components, particularly as useful XML syntaxes for cancer registries develop
- Managing secure information on the Web requires care and expertise
- Web servers and associated software serve as middleware to mediate between users and clinical data management systems