Distributed Systems Lecture 16

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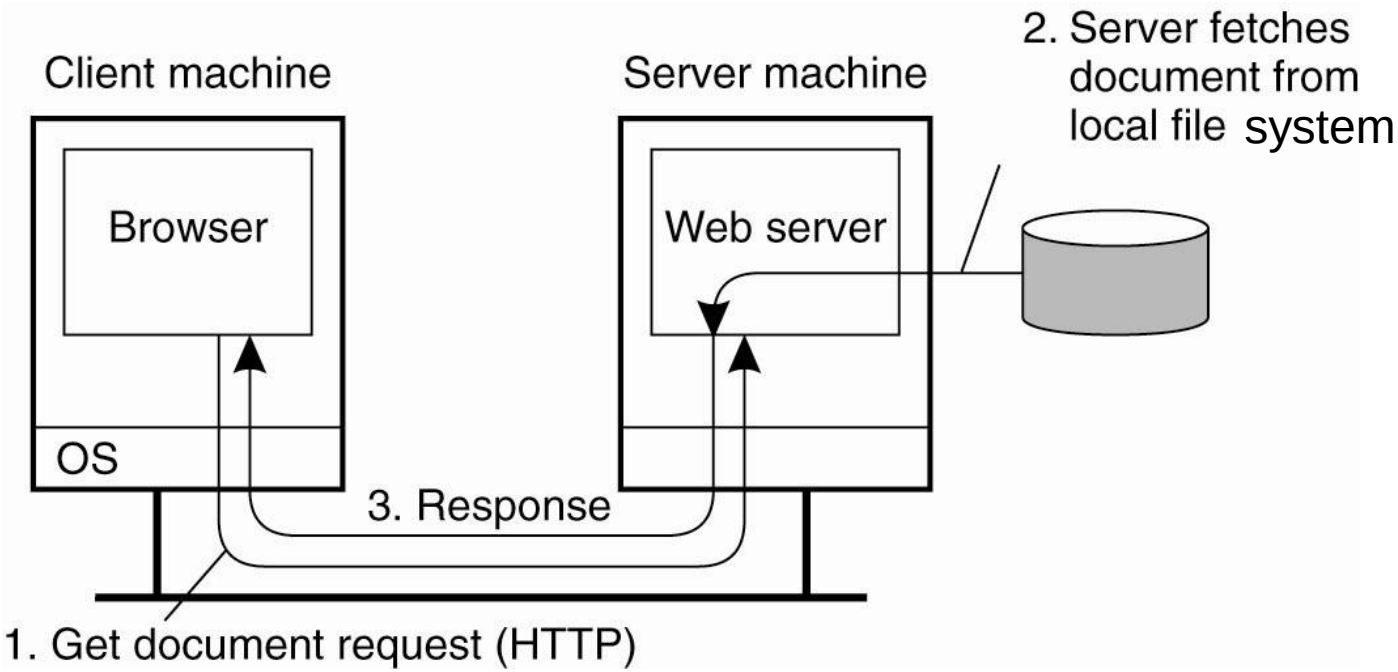
Spring 2013

Distributed Web-Based Systems

- **Web Servers**
  - Apache
  - HTTP
- **Web Services**
  - SOAP
  - REST

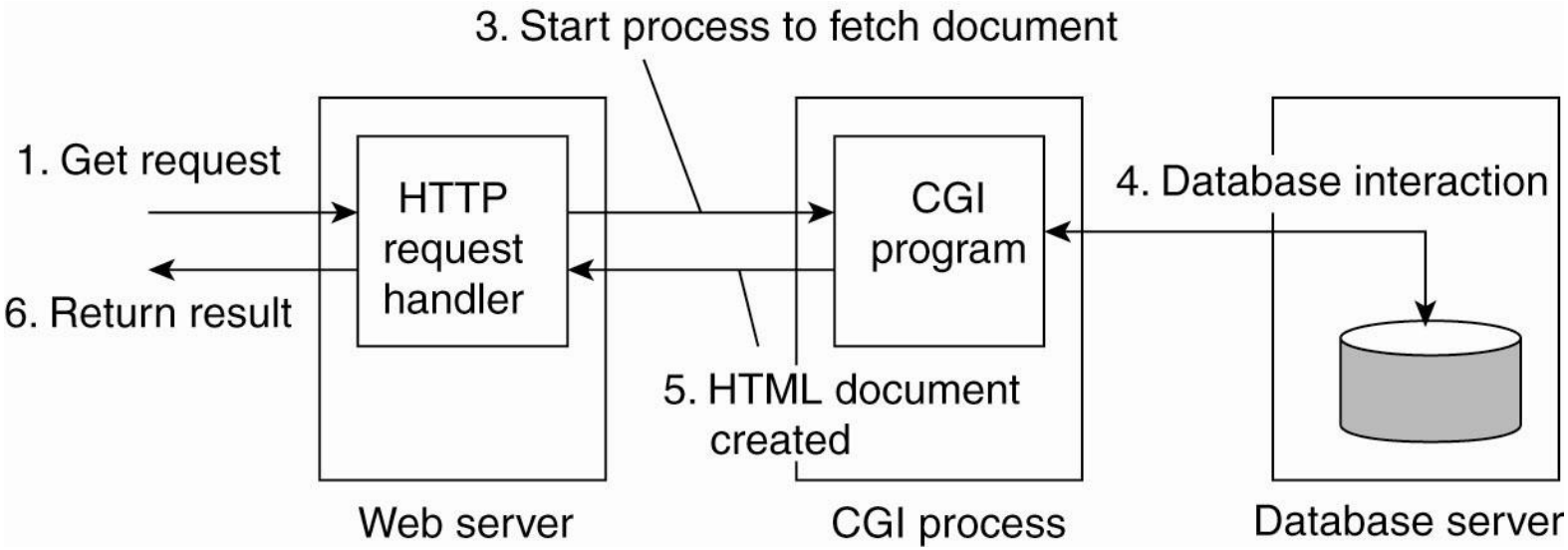
Traditional Web-Based System

- A traditional Web-based system produces a **static** Web page by fetching an HTML document from the local file system



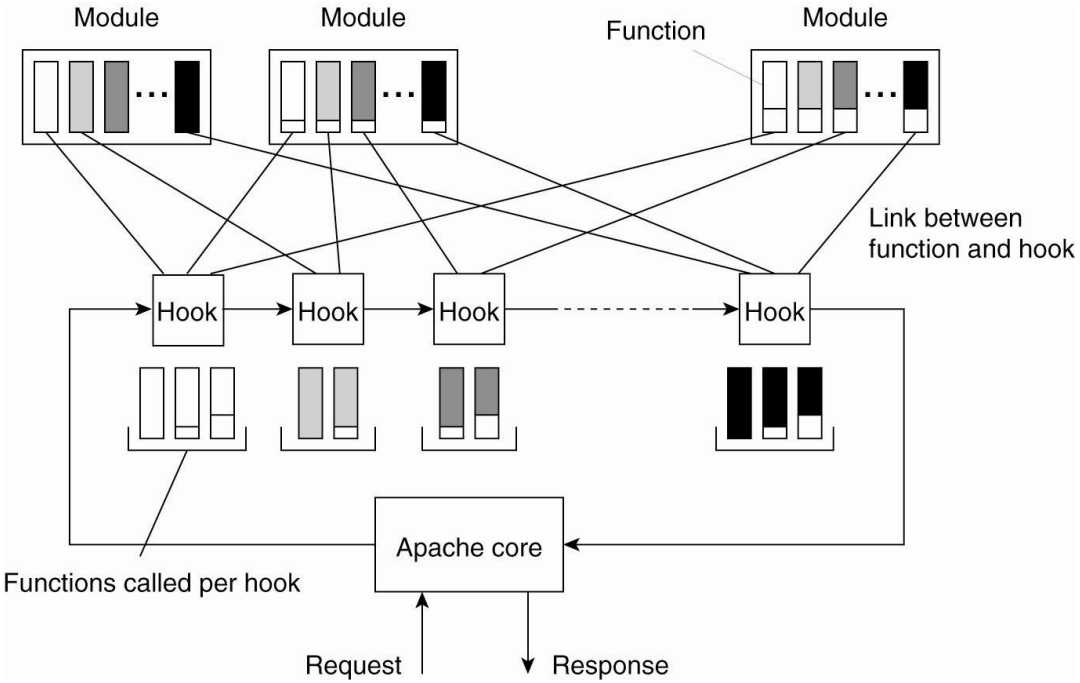
Modern Web-Based System

- A modern Web-based system produces a **dynamic** Web page, i.e, an HTML document with dynamic content, using the Common Gateway Interface (CGI) or a Java servlet/Java server page (jsp), etc.



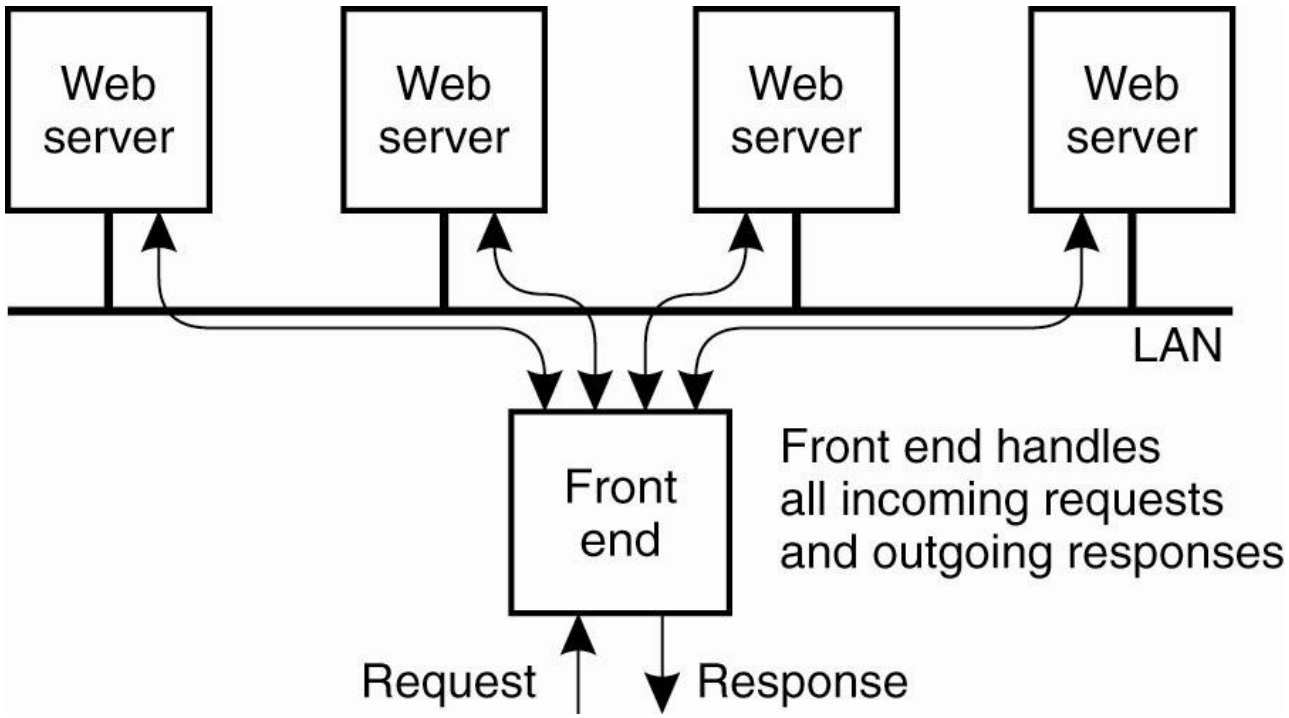
The Apache Web Server

- Each **hook** provides several functions that need to be executed to satisfy a request, such as:
  - **Translate a URL to a local file name**
  - **Write information to a log**
  - **Check a client's id**
  - **Check the MIME type of a request**



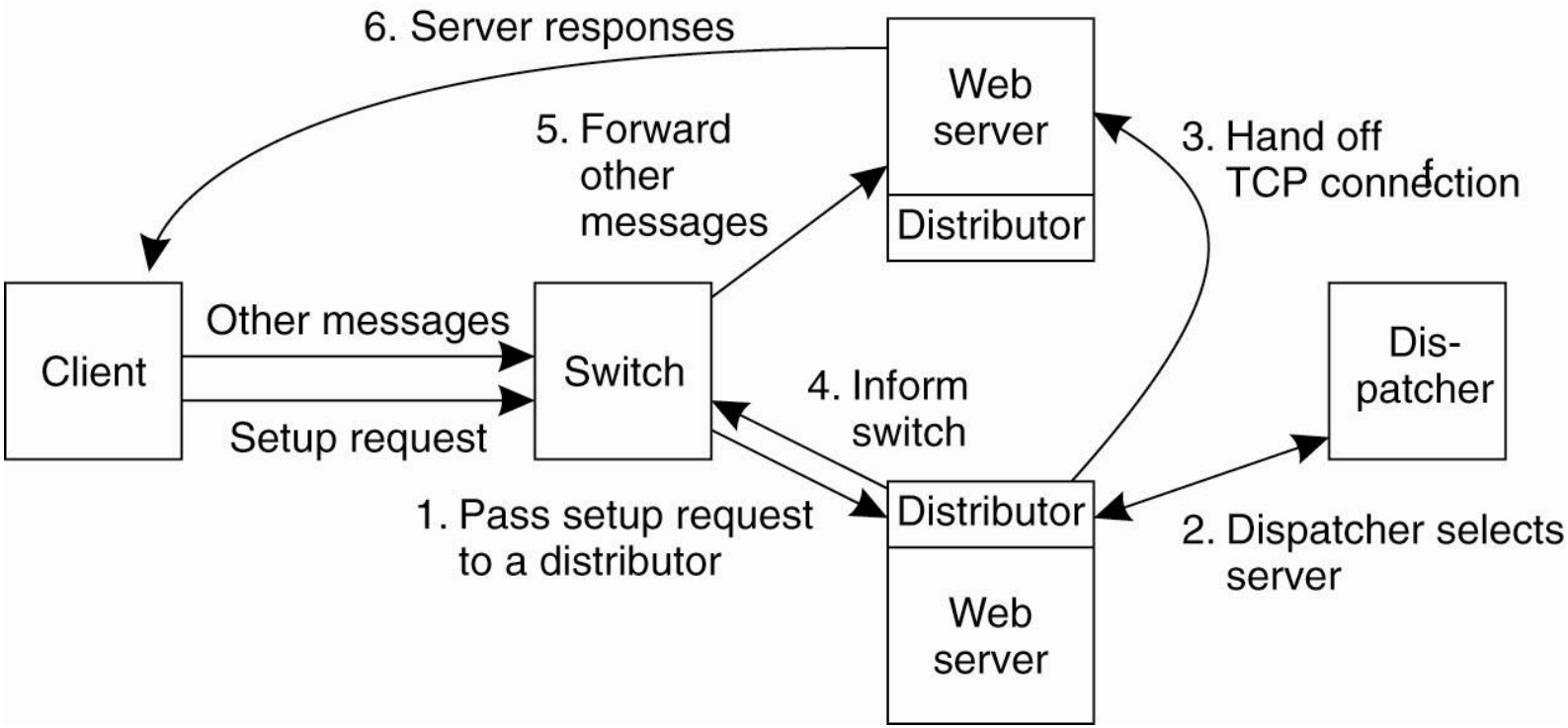
Web Server Clusters

- A Web server cluster with a **front end** that performs **load balancing** across the Web servers in the cluster



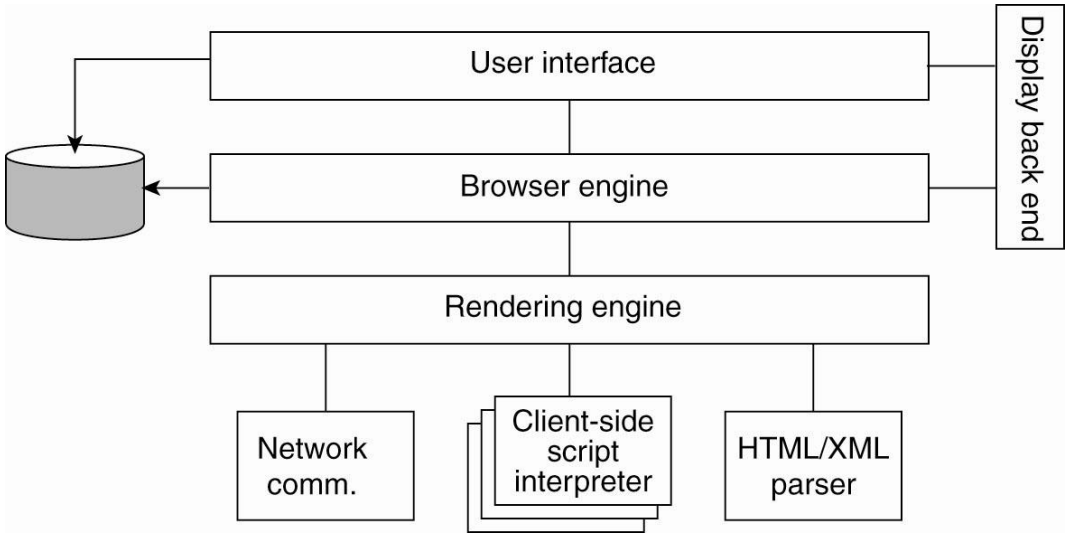
Web Server Clusters

- A Web server cluster that is **content-aware**



The Client Side

- **Display back end** provides standard graphical libraries that are platform independent
- **Browser engine** allows the user to select parts of a document, activate hyperlinks, etc.
- **Rendering engine** handles parsing HTML/XML, interpreting Java scripts, etc.

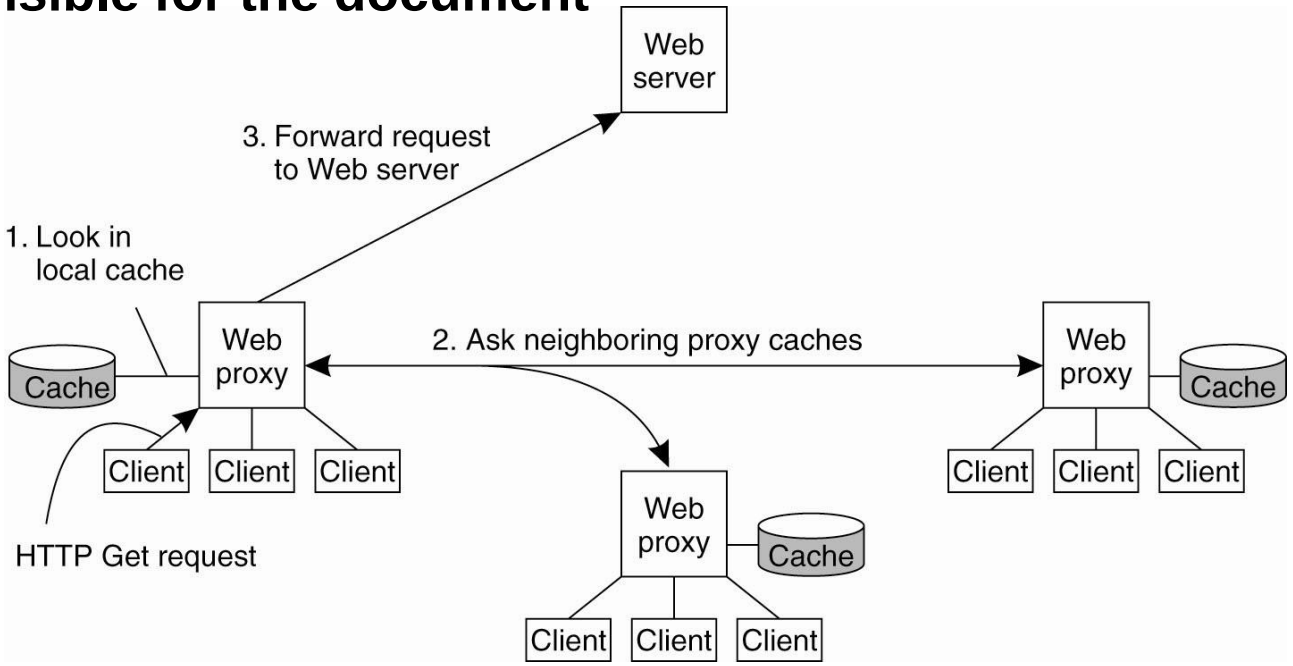


The Client Side

- A browser that doesn't speak FTP and, thus, forwards an FTP request to a **Web proxy** that does speak FTP

Web Proxy Caching

- **Cooperative caching**
  - If a cache miss occurs at a Web proxy, the Web proxy checks neighboring Web proxies to see if one of them has the requested document
  - Else the Web proxy forwards the request to the Web server responsible for the document



Web Documents

- Six top-level **MIME types** and some common subtypes

Type	Subtype	Description
Text	Plain	Unformatted text
	HTML	Text including HTML markup commands
	XML	Text including XML markup commands
Image	GIF	Still image in GIF format
	JPEG	Still image in JPEG format
Audio	Basic	Audio, 8-bit PCM sampled at 8000 Hz
	Tone	A specific audible tone
Video	MPEG	Movie in MPEG format
	Pointer	Representation of a pointer device for presentations
Application	Octet-stream	An uninterpreted byte sequence
	Postscript	A printable document in Postscript
	PDF	A printable document in PDF
Multipart	Mixed	Independent parts in the specified order
	Parallel	Parts must be viewed simultaneously

HyperText Transfer Protocol

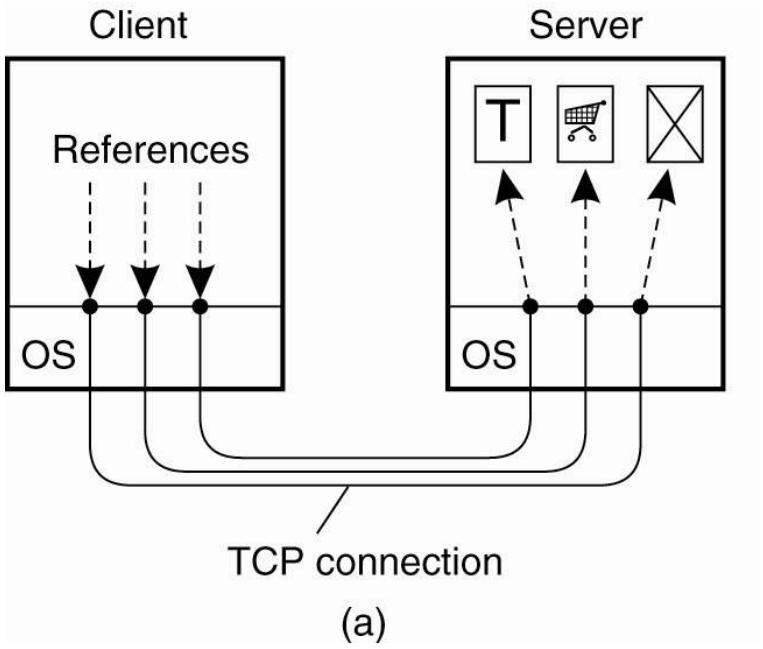
- The **Hyper-Text Transport Protocol (HTTP)** is an application-layer protocol that operates over TCP and that is used to access documents on the Web
- Operations supported by HTTP

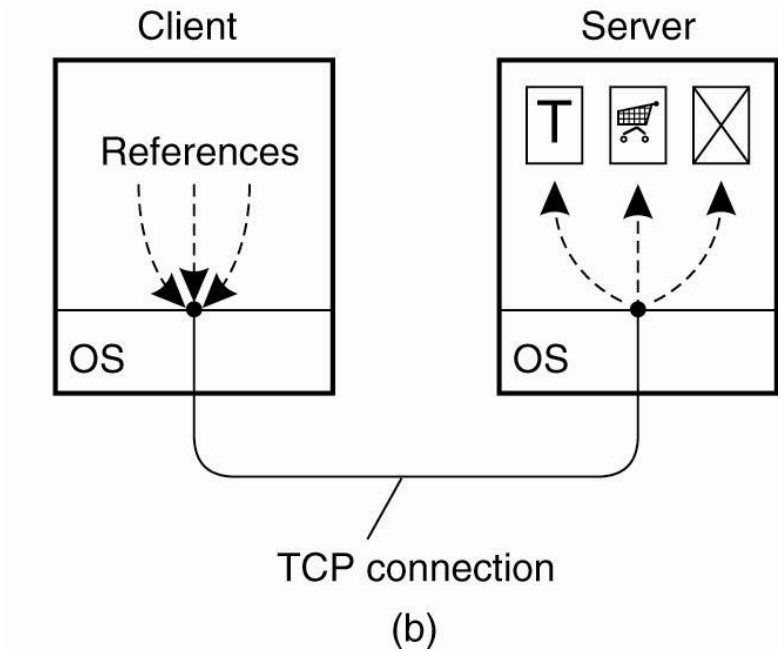
Operation	Description
Head	Request to return the header of a document
Get	Request to return a document to the client
Put	Request to store a document
Post	Provide data that are to be added to a document (collection)
Delete	Request to delete a document

HTTP Connections

(a) **Non-persistent** connections

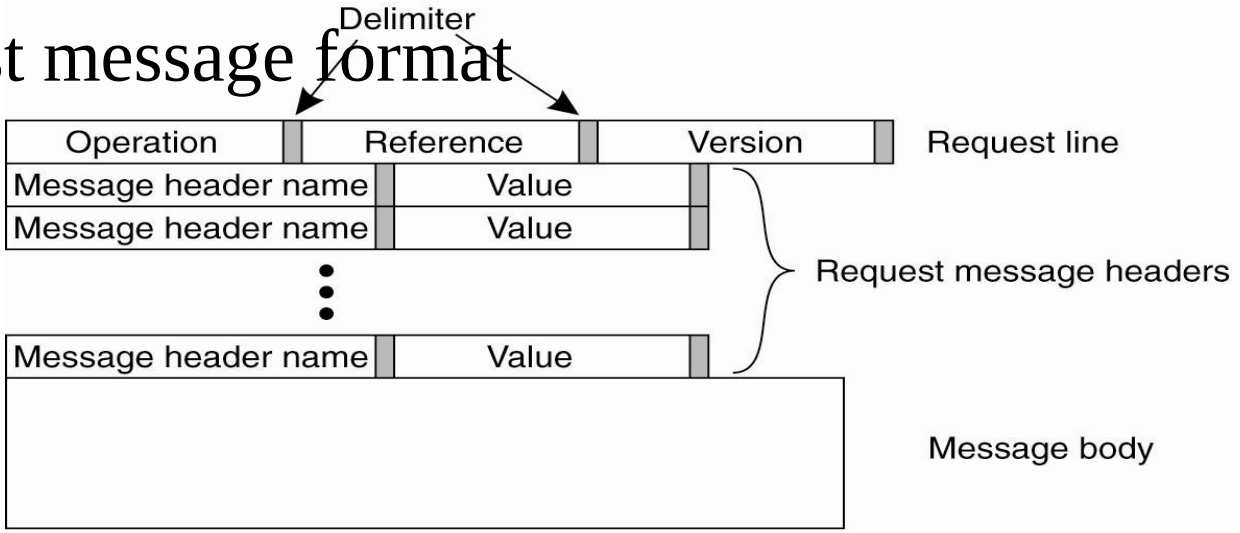
(b) **Persistent** connections





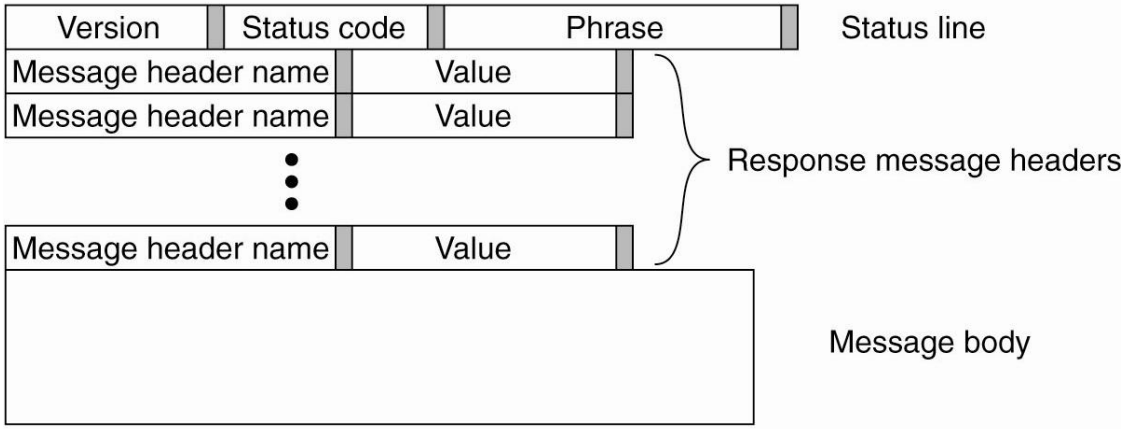
HTTP Messages

(a) HTTP request message format



(a)

(b) HTTP response message format



(b)

HTTP Message Headers

- Some HTTP message headers

Header	Source	Contents
Accept	Client	The type of documents the client can handle
Accept-Charset	Client	The character sets are acceptable for the client
Accept-Encoding	Client	The document encodings the client can handle
Accept-Language	Client	The natural language the client can handle
Authorization	Client	A list of the client's credentials
WWW-Authenticate	Server	Security challenge the client should respond to
Date	Both	Date and time the message was sent
ETag	Server	The tags associated with the returned document
Expires	Server	The time for how long the response remains valid
From	Client	The client's e-mail address
Host	Client	The DNS name of the document's server

HTTP Message Headers

- More HTTP message headers

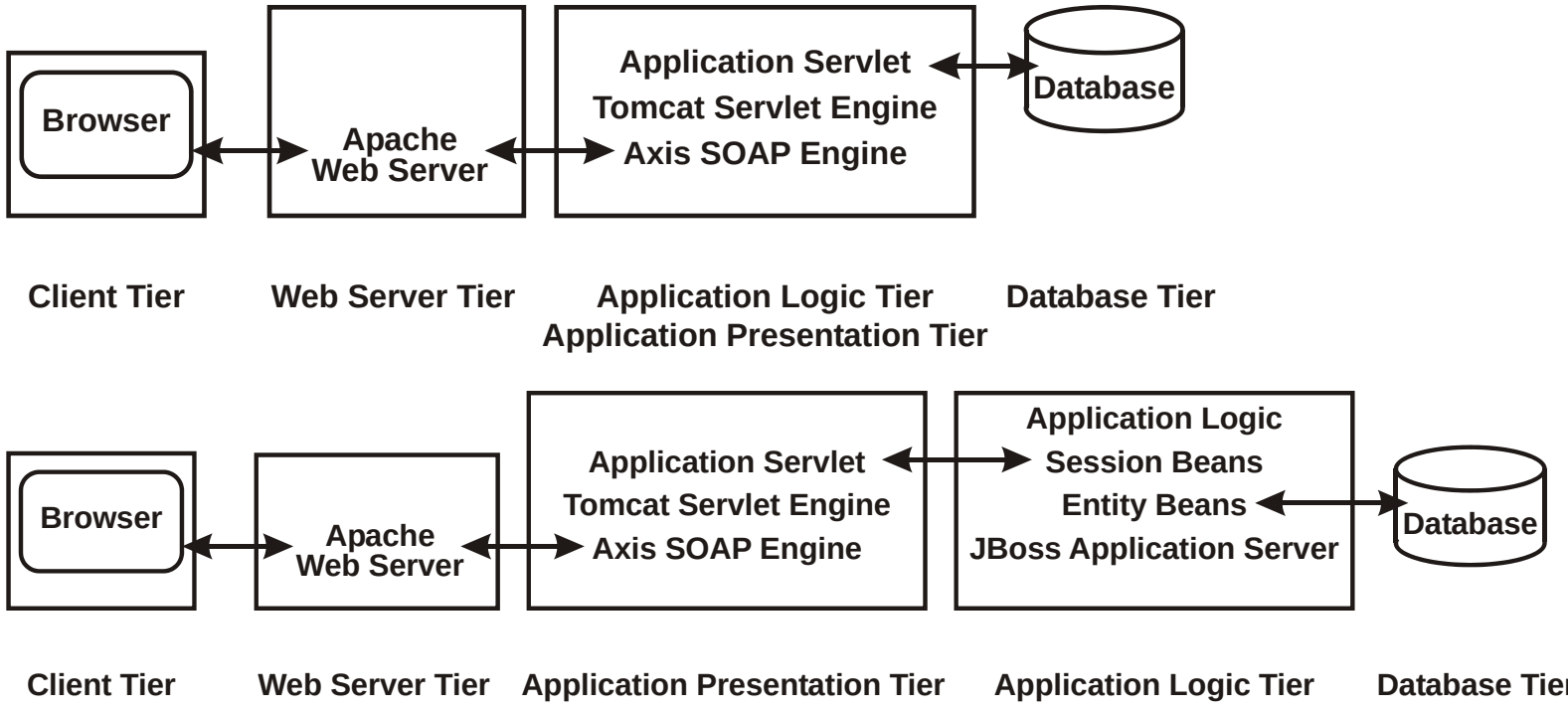
Header	Source	Contents
If-Match	Client	The tags the document should have
If-None-Match	Client	The tags the document should not have
If-Modified-Since	Client	Tells the server to return a document only if it has been modified since the specified time
If-Unmodified-Since	Client	Tells the server to return a document only if it has not been modified since the specified time
Last-Modified	Server	The time the returned document was last modified
Location	Server	A document reference to which the client should redirect its request
Referer	Client	Refers to client's most recently requested document
Upgrade	Both	The application protocol the sender wants to switch to
Warning	Both	Information about the status of the data in the message

Web Services

- A **Web Service** is a service offered by one application to other applications on the World Wide Web
- A Web Service is software designed to support interoperable machine-to-machine interactions over the Internet
- **Two major classes of Web Services**
  - **Simple Object Access Protocol (SOAP) – Service is exposed via an arbitrary set of operations, which are conveyed in XML-formatted SOAP messages over HTTP**
  - **REpresentational State Transfer (REST) – Service uses a uniform set of stateless operations (HTTP methods) to manipulate XML representations of Web resources, which are conveyed directly over HTTP**

Web Services

- A Web Service is a **server-side application** that implements procedures that clients can call
- A Web Service is deployed in a **service-side container** that is either a Servlet container in the Apache Tomcat servlet engine, or an EJB container in an EJB/J2EE application server, e.g., JBoss



Web Services

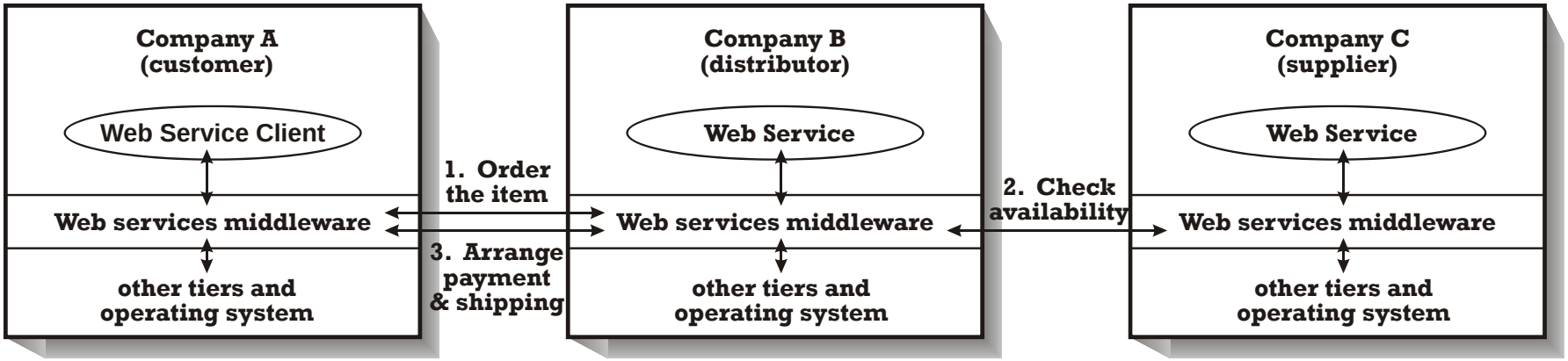
- In a typical Web Services scenario
  - **An application sends a request to a Web Service at a given URL using the SOAP protocol over HTTP**
  - **The Web Service receives the request, processes it, and returns a response**
- Web Services and their consumers are often businesses, in which case Web Services are **Business-to-Business (B2B)** applications
  - **A business can be both a consumer and a provider of Web Services**
- The most important requirement of a Web Service is that it is **interoperable** across clients and servers

Web Services Examples

- A **Stock Quote Service** where
  - **The request from the client asks for the current price of a specific stock**
  - **The response of the Web Service is the price of that stock**
- A **Parcel Delivery Service** where
  - **The request contains one or more delivery destinations**
  - **The response of the Web Service is the most cost-effective delivery route**
    - The time it takes to calculate the best route depends on the complexity of the route, so the response is sent separately from the request, i.e., asynchronously
- A **Wholesale Coffee Bean Distributor** that is
  - **A consumer when it uses a Web Service to check on the availability of coffee beans**
  - **A provider when it supplies a prospective customer with different suppliers' prices for coffee beans**

Web Services in B2B Applications

- Company A (the customer) orders goods from Company B (the distributor)
- Company B checks the availability of the goods from Company C (the supplier) and arranges payment and shipping of the goods to Company A, without human intervention

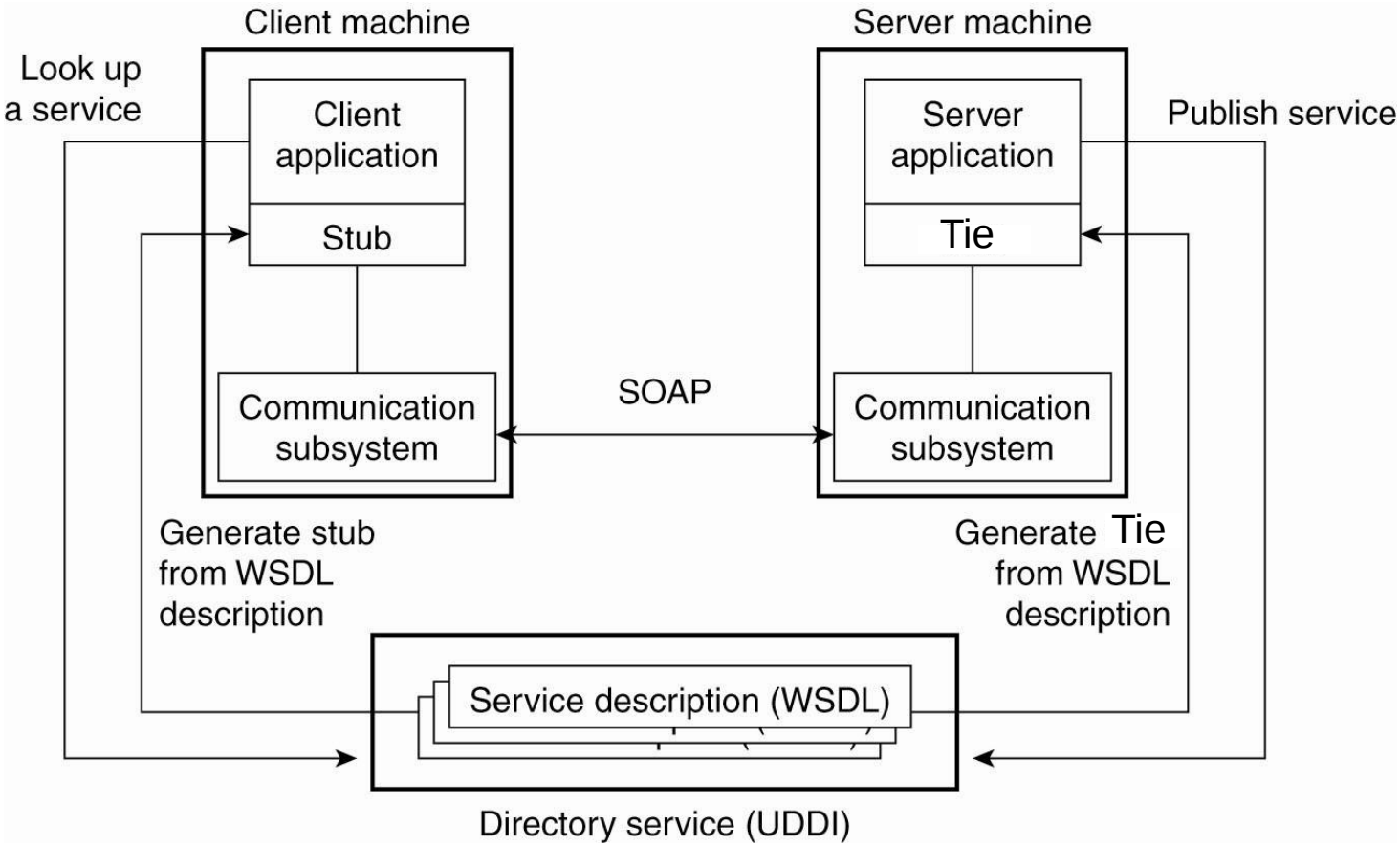


Web Services Standards

- **Web Services** are based on the following standards
  - **eXtensible Markup Language (XML) - Defines the syntax of Web Services documents, so that the information in those documents is self-describing**
  - **Simple Object Access Protocol (SOAP) - Provides a standard way to encode different protocols and interaction mechanisms in XML, so that XML documents can be easily exchanged across the Internet**
  - **Web Services Description Language (WSDL) - An advanced form of Interface Definition Language (IDL) that has been augmented to define additional aspects of a service description**
  - **Universal Description Discovery and Integration (UDDI) - Used by the Service Registry where service providers publish and advertise available services, and service consumers query and search for services**

Web Services Standards

- The organization of a Web Service, based on the XML, SOAP, WSDL, and UDDI standards



eXtensible Markup Language

- The **eXtensible Markup Language (XML)** makes **data portable** and allows data to be integrated easily
  - **Internally, within an enterprise for sharing legacy data between different departments of the enterprise**
  - **Externally, between enterprises for sharing data**
- In contrast, **Java** makes **code portable** and allows enterprises using different computing platforms to communicate with each other

Simple Object Access Protocol

- The **Simple Object Access Protocol (SOAP)** is an application-level protocol that operates over HTTP
- SOAP defines standards for **XML messaging** and **mapping of data types**, so that applications adhering to the standards can communicate with each other
- SOAP messages are given in XML, which enables SOAP to provide **interoperability** for Web Services
- The SOAP specification available at *http://www.w3.org/* defines:
  - **What is required and optional in a SOAP message**
  - **How data can be encoded and transmitted**

Simple Object Access Protocol

- An example of an XML-based SOAP message

```
<env:Envelope xmlns:env="http://www.w3.org/2003/05/soap-envelope">
    <env:Header>
      <n:alertcontrol xmlns:n="http://example.org/alertcontrol">
        <n:priority>1</n:priority>
        <n:expires>2001-06-22T14:00:00-05:00</n:expires>
      </n:alertcontrol>
    </env:Header>
    <env:Body>
      <m:alert xmlns:m="http://example.org/alert">
        <m:msg>Pick up Mary at school at 2pm</m:msg>
      </m:alert>
    </env:Body>
</env:Envelope>
```

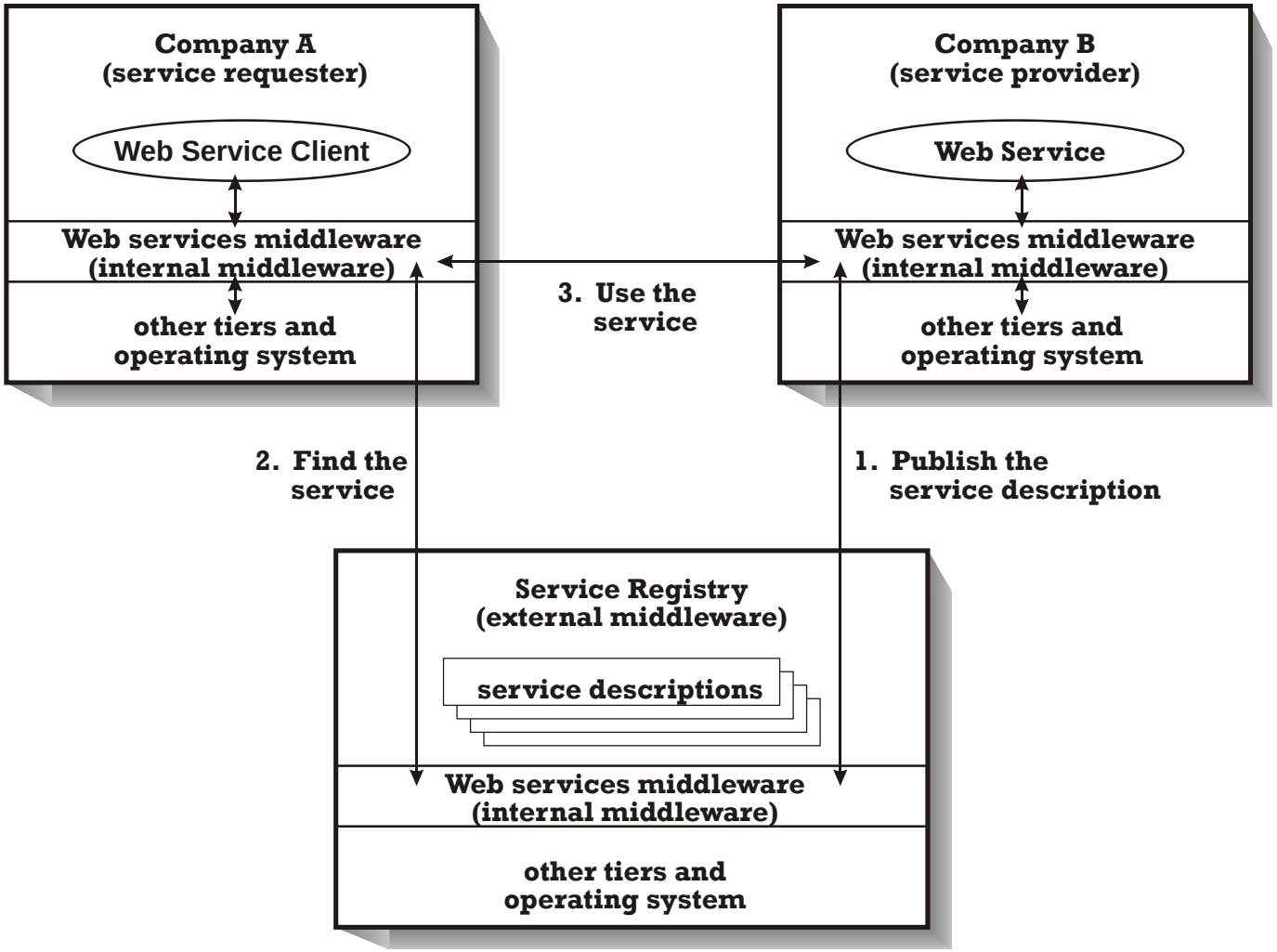
Web Services Description Language

- The **Web Services Description Language (WSDL)** is the language used to make a Web Service available to potential clients
  - **A WSDL document is an XML document that gives information about a Web Service (its name, operations that can be called on it, parameters for those operations, the location to send requests)**
  - **A client uses the WSDL document to discover what the Web Service offers and how to access it**
- WSDL allows you to describe a Web Service as an **XML document**, which makes the **description portable**

Service Registry

- An **XML business registry** provides WSDL documents that contain information about Web Services
- There are two standards for business registries
  - **electronic business XML (ebXML) Registry and Repository standard**
  - **Universal Description Discovery and Integration (UDDI) project**
- When searching an XML business registry, a client might get several WSDL documents, one for each Web Service that satisfies its search criteria

Service Registry Usage



A Java Web Service

- A **Java Web Service** basically consists of two files that contain
  - **An interface that declares the Web Service's remote methods**
  - **A class that implements those methods**
- The interface extends *java.rmi.Remote* and its methods throw a *java.rmi.RemoteException*
- A **JAX-RPC Remote Procedure Call** is implemented as a request-response SOAP message
  - **A client written in a language other than Java can access a Web Service developed and deployed on the Java platform**
  - **Conversely, a client written in Java can communicate with a Web Service developed and deployed on another platform**

REST Web Services

- **REpresentational State Transfer (REST) Web Services**
  - **Are based on the notion of a Resource with a Uniform Resource Identifier (URI)**
    - Services and servers are resources; clients may or may not be resources
  - **Are lighter weight than SOAP Web Services**
  - **Require little infrastructure support other than HTTP and XML**
  - **Use the standard HTTP methods**
    - GET – Obtain a representation of a resource
    - PUT – Create a representation of a resource
    - POST – Update or create a representation of a resource
    - DELETE – Remove a representation of a resource
  - **Messages are in XML format, but are confined to a particular schema written in a schema language like XML Schema**

REST Web Services

- **REpresentational State Transfer (REST) Web Services**
  - **Descriptors are written in the Web Application Description Language (WADL)**
  - **Web Application Description Language (WADL) is similar to the Web Services Description Language (WSDL)**
  - **A WADL descriptor describes the service, including the attributes and methods of the service**
  - **WADL also aids in the construction of stubs that are used with the service clients**