Session 1
Distributed Systems

Objectives

At the end of the lecture, the student will be able to

- Describe the basic concepts and importance of Distributed Systems
- Place distributed systems in a realistic context through examples: the Internet, an intranet and mobile computing
- Motivate the benefits of resource sharing and to introduce the Web as an example

Contents

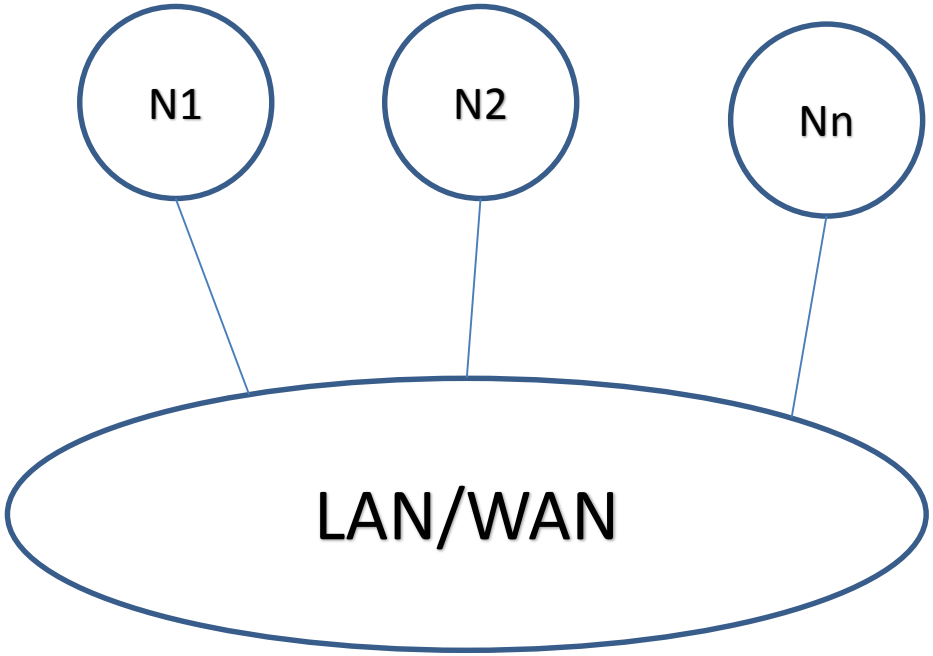
- Introduction of Distributed Systems
- Characteristics of concurrency, independent failure of components and lack of a global clock
- Examples of Distributed Systems

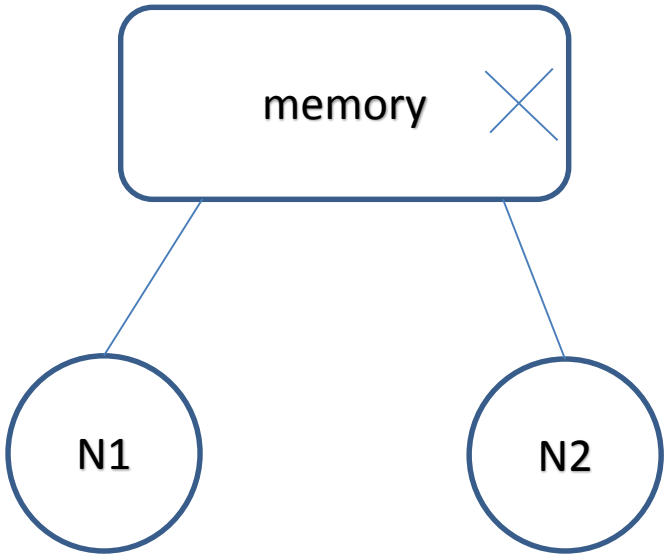
What is a Distributed System?

- A distributed system is one in which components located at networked computers communicate and coordinate their actions only by passing messages
- A distributed system is characterized by multiple processes that are spatially separated and are running independently
- The sharing of resources is a main motivation for constructing distributed systems. E.g., the Web
- Resources may be managed by servers and accessed by clients or they may be encapsulated as objects and accessed by other client objects

What is a Distributed System?

- No physical shared memory between nodes
- Only way message are communicated is via network





Significant Consequences of DS

- Concurrency
  - The coordination of concurrently executing programs that share resources is an important one
- No global clock
  - Close coordination depends on a shared idea of the time at which the programs actions occur
  - The only communication is by sending messages through a network

Significant Consequences of DS

- Independent failures
  - Fault in the network
  - Unexpected termination of a program somewhere in the system /crash
  - The programs may not be able to detect whether the network has failed or has become unusually slow

No Global Clock

- In a distributed system there are as many clocks as there are systems. The clocks are coordinated to keep them somewhat consistent but no one clock has the exact time. Even if the clocks were some what in sync, the individual clocks on each component may run at a different rate or granularity leading to them being out of sync only after one local clock cycle.
- Time is only known within a given precision. At frequent intervals, a clock may synchronize with a more trusted clock. However, the clocks are not precisely the same because of time lapses due to transmission and execution.
- Consider a group of people going to a meeting. Each person has a watch. Each watch has a similar, but different time. Even with the error in time, the group is able to meet and conduct business. This is how distributed time works.

EXAMPLES

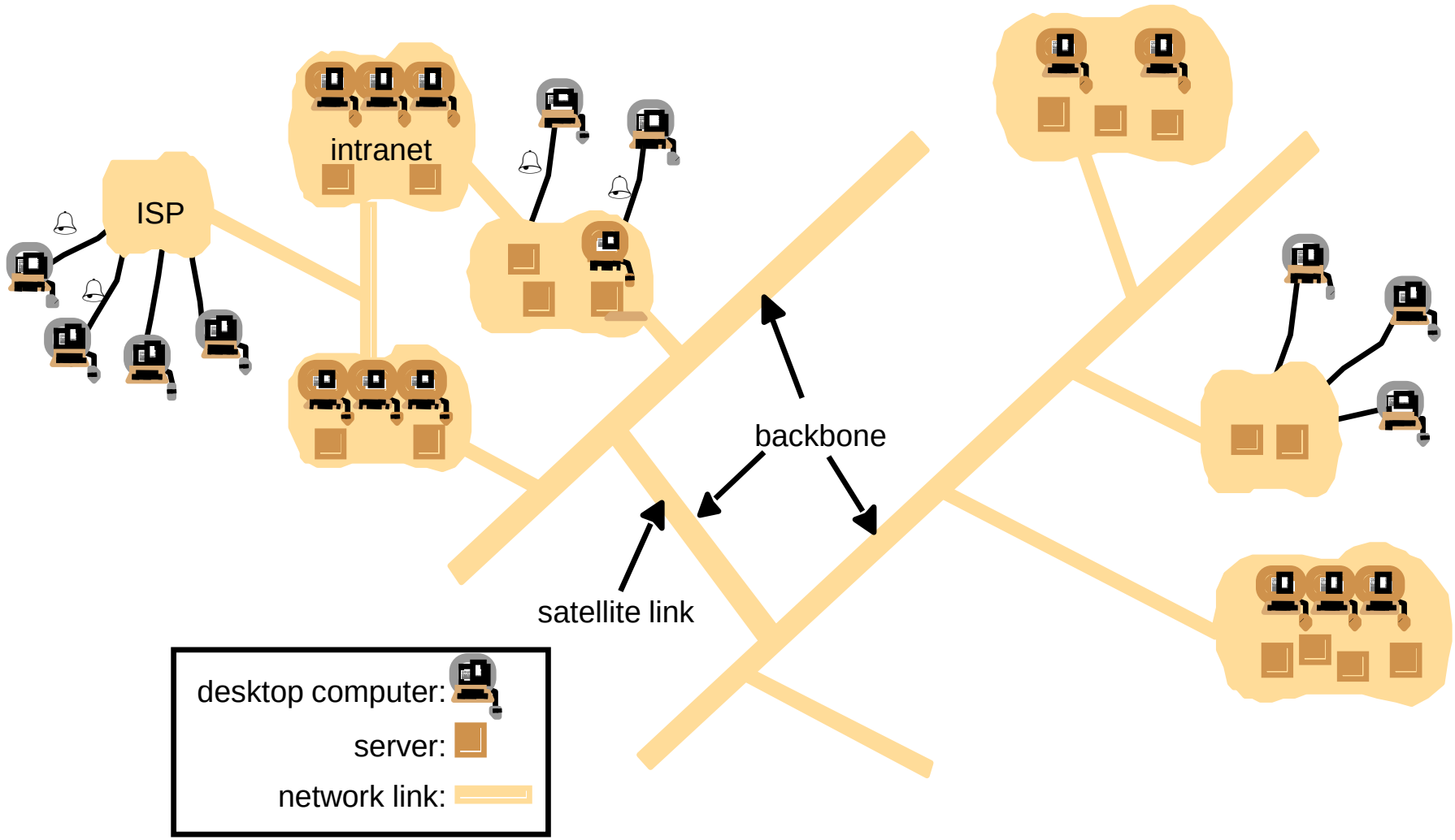
Distributed System Examples

- Three Examples
  - The internet
  - An intranet which is a portion of the Internet managed by an organization
  - Mobile and ubiquitous computing

The Internet

- The Internet is a very large distributed system
  - It is a vast interconnected collection of computer networks of many different types
- Programs running on the computers connected to it interact by passing messages, employing a common means of communication
  - The Internet protocols enable a program running anywhere to address messages to program anywhere else

A typical portion of the Internet



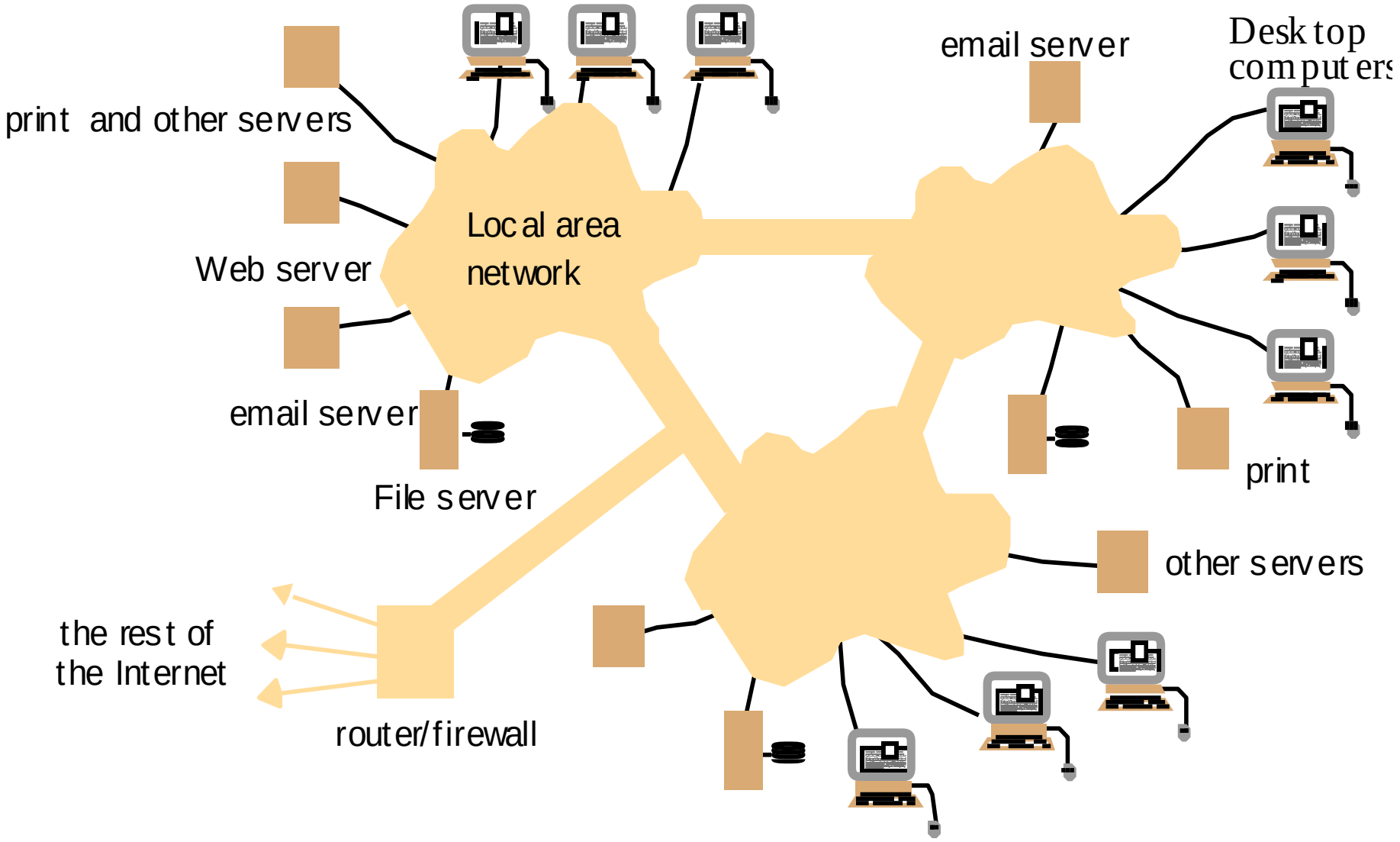
The Internet

- Intranets
  - Sub networks operated by companies and other organizations
- Internet Service Providers
  - Companies that provide modem links and other types of connection to individual users and small organisations
  - Enabling access to services anywhere in the Internet as well as providing local services such as email and web hosting
- Backbone
  - A network link with a high transmission capacity
  - Employing satellite connections, fibre optic cables and other high-bandwidth circuits

Intranets

- An intranet is a portion of the Internet that is separately administered and has a boundary that can be configured to enforce local security policies
- It is composed of several Local Area Networks (LAN) linked by backbone connections
- The network configuration of a particular intranet is the responsibility of the organization that administers it
- It is connected to the Internet via a router

A typical Intranet



Intranets

- The role of the **firewall** is to protect an intranet by preventing unauthorized messages leaving or entering
  - It is implemented by filtering incoming and outgoing messages
- The main issues arising in the design of components for use in intranets are: file services, firewalls, cost of software installation and support
- Some organizations do not wish to connect their internal networks to the Internet at all:
  - Police and other security
  - Law enforcement agencies
  - Military organizations

Mobile and Ubiquitous Computing

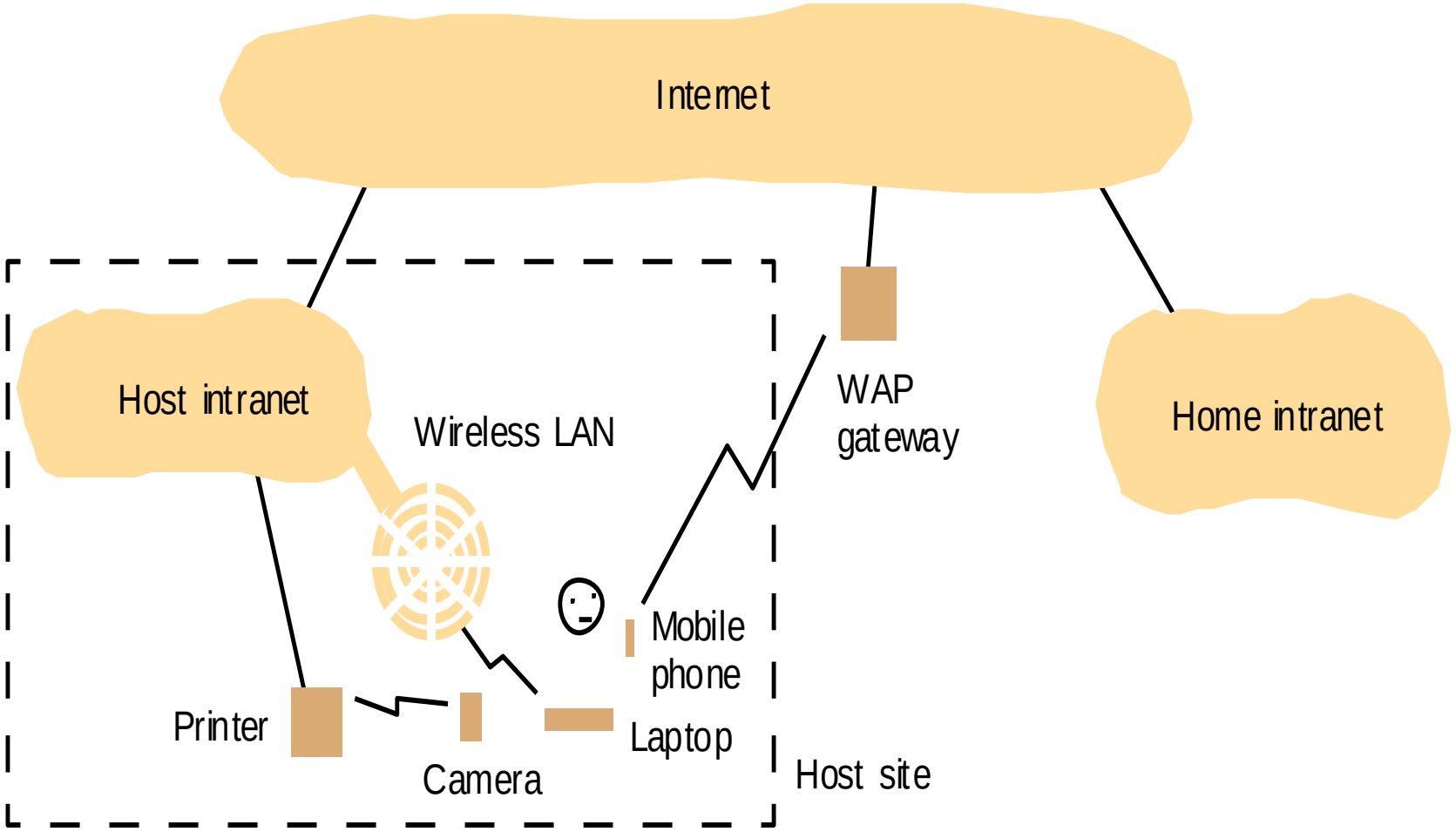
- Technological advances in device miniaturization and wireless networking have led increasingly to the integration of small and portable computing devices into distributed systems.
  - Laptop computers
  - Handheld devices, including mobile phones, pagers, video cameras and digital cameras
  - Wearable devices, such as smart watches
  - Devices embedded in appliances such as washing machines, hi-fi systems, cars and refrigerators

Mobile and Ubiquitous Computing

- **Mobile Computing/Nomadic Computing:** Performance of computing tasks while the user is on the move, or visiting places other than the usual environment

- **Ubiquitous Computing:** Harnessing of many small, cheap computational devices that are present in user's physical environments, including the home and office

Portable and Handheld Devices in a Distributed System



Specific Examples to Distributed Systems:The World Wide Web

- The WWW is a system for publishing and accessing resources and services across the Internet
- A key feature of the Web is that it provides a hypertext structure among the documents that it stores, reflecting the users requirement to organise their knowledge
- Hypertext documents contain links – references to other documents and resources that are also stored in the Web
- The Web is an open system:
  - Its operation is based on communication standards and document standards that are freely published and widely implemented
  - The Web is one with respect to the types of ’resource’ that can be published and shared on

World Wide Web

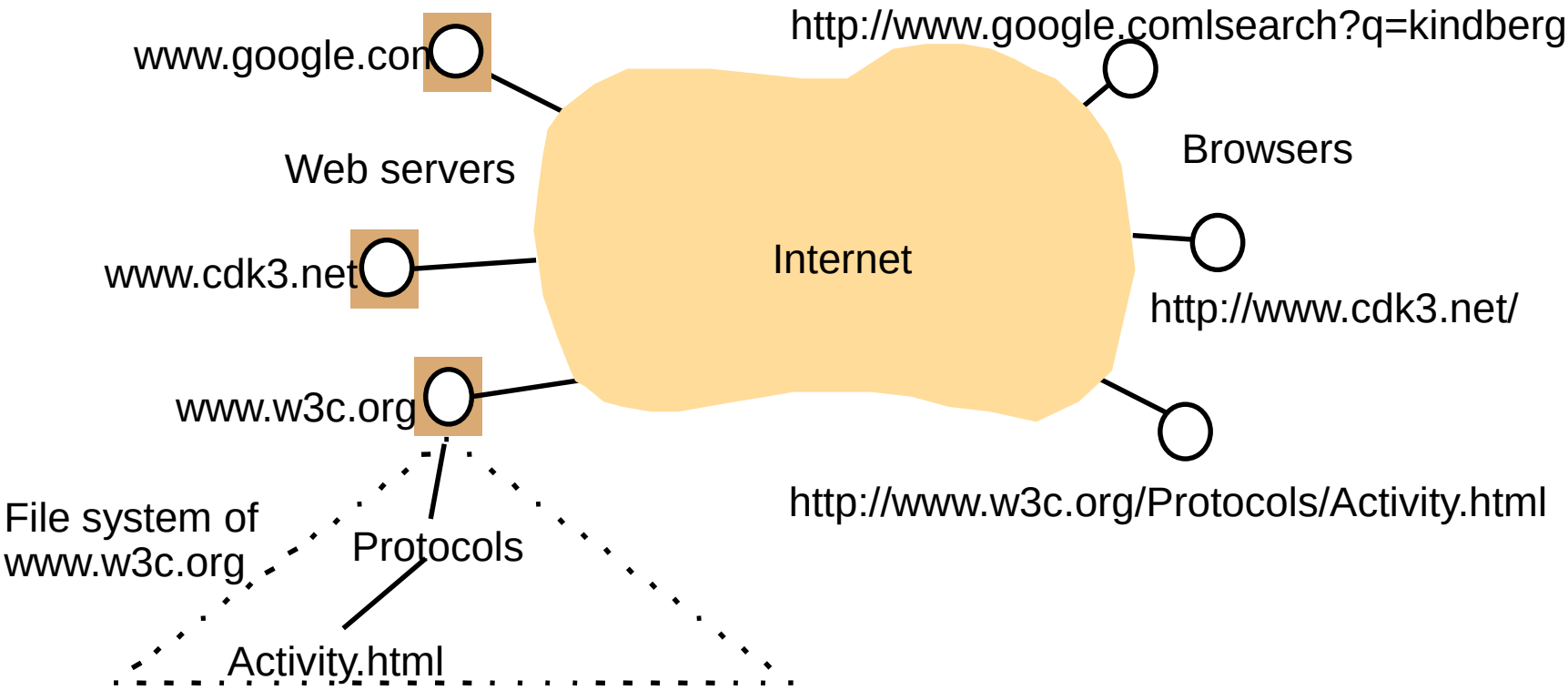
- Service
  - A distinct part of a computer system that manages a collection of related resources and presents their functionality to users and applications.
  - http, telnet, ...
- Server
  - A running program (a process) on a networked computer that accepts requests from program's running on other computers to perform a service, and responds apppropriately.
  - Apache, MySQL RDBMS, ...

Important Terms of Web

- Client
  - The requesting processes.
  - Requests are sent in messages from clients to a server and replies are sent in messages from server to the clients

- Remote Invocation
  - A complete interaction between a client and a server from the point when the client sends its request to when it receives the server's response

Web Servers and Web Browsers



Standard Components of Web

- HyperText Markup Language (HTML)
  - Language for specifying the contents and layout of pages as they are displayed by web browsers
- Uniform Resource Locator (URL)
  - Identifies documents and other resources stored as part of the Web
- HyperText Transfer Protocol (HTTP)
  - HTTP is a `request-reply' protocol
  - Defines the way in which browsers and any other types of client interact with web servers

Additional Features

- Dynamic pages
  - CGI (Common Gateway Interface)
    - Provides the middleware between WWW servers and external databases and information sources
    - A program that webservers run to generate content for their clients
    - It may have any application specific functionality, as long as it can parse the arguments that the client provides to it and produce the content of the required type (HTML text)
    - The program will often consult or update a database in processing the request

Additional Features

Java Script

- A text-based programming language **used** both on the client-side and server-side that allows you to make web pages interactive.
- It is the service related code run inside the browser at the users computer
- Code written in Javascript is downloaded with a webform in order to provide better quality interaction with the user than that supported by HTML's standard widgets
- It can give the user immediate feedback on invalid entries
- It can also be used to update parts of a webpage's contents without fetching an entire new version of the page and re-rendering it

Additional Features

Applet

- A Java program that can be embedded into a web page.
- It runs inside the web browser and works at client side.
- An **applet** is embedded in an HTML page using the **APPLET** or OBJECT tag and hosted on a web server.
- **Applets** are used to make the web site more dynamic and entertaining.
- An application that the browser automatically downloads and runs when it fetches a corresponding webpage
- It may access the network and provide customized user interfaces, using the facilities of the Java language. E.g., chat

Summary

- A distributed system is one in which components located at networked computers communicate and coordinate their actions only by passing messages
- Examples of DS are Internet, intranets, Mobile and Ubiquitous Computing

Any Questions

References

- http://users.ece.utexas.edu/~garg/dist/wiley-encyc.pdf (In this link you can understand limitations of DS and concepts of no global clock and no shared memory)