Architectures

Distributed Systems [2]

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Review

- **Definition of Distributed Systems**: a collection of autonomous computing elements that appears to its users as a single coherent system

- **Goals of Distributed Systems**: Making resources available, Distribution transparency, Openness, Scalability

- **Types of Distributed Systems**: Distributed computing systems, Distributed information systems, Distributed pervasive systems

This lesson

- **Distributed System Architecture**: Layered, object-oriented, event-based, shared data spaces-based
- **System Architecture :** Centralized, Decentralized, Hybrid
- **Middleware**
- **Self-managing Distributed Systems**

Distributed System Architecture

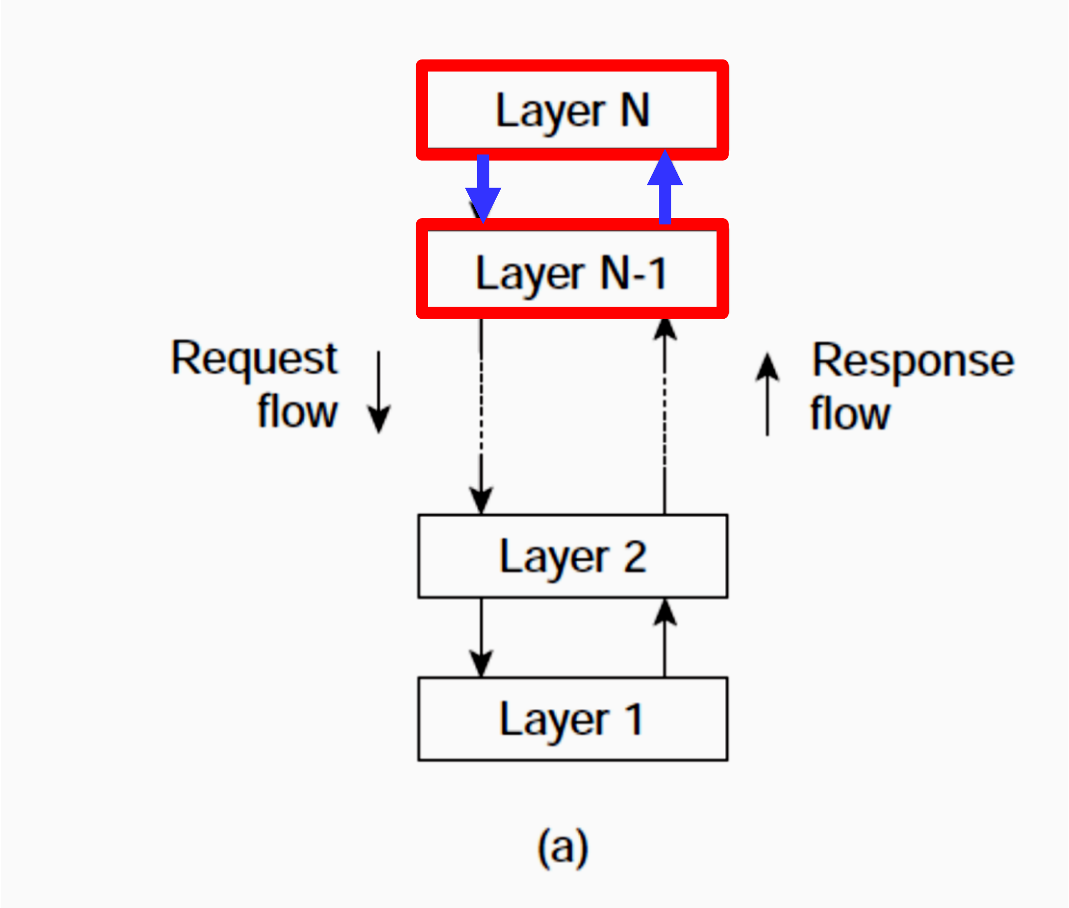
- A ***distributed system*** is many cooperating computers that appear to users as a single service.

- Distributed systems are often complex pieces of software of which the components are by definition dispersed across multiple machines.

- The ***organization of distributed systems*** is mostly about the software components that constitute the system.

Architectural Styles

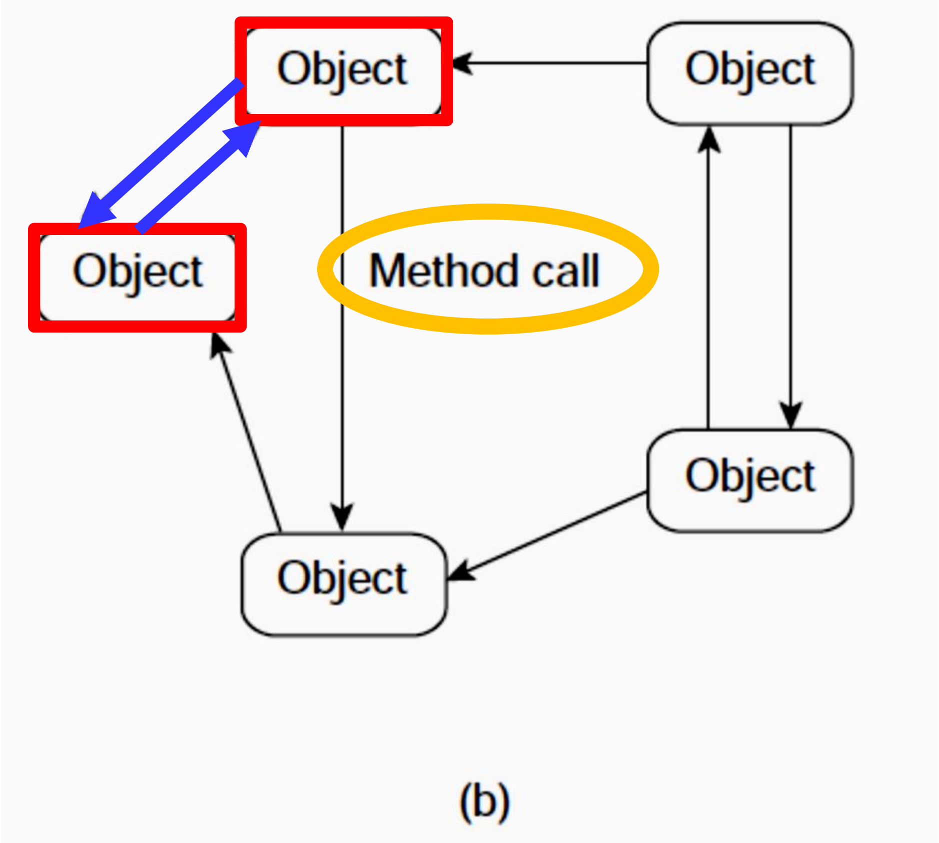
- **Layered style**



(a)

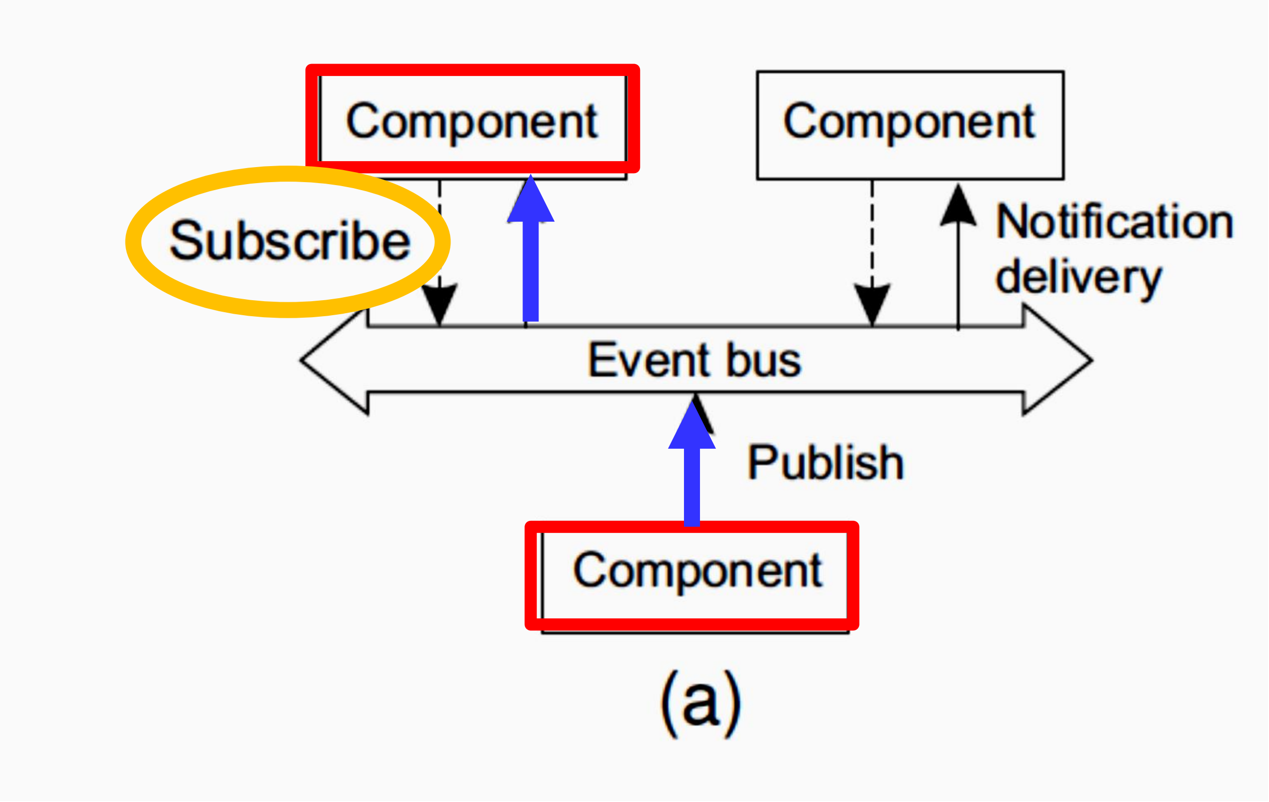
Architectural Styles

- **Object-based style**: distributed object systems.



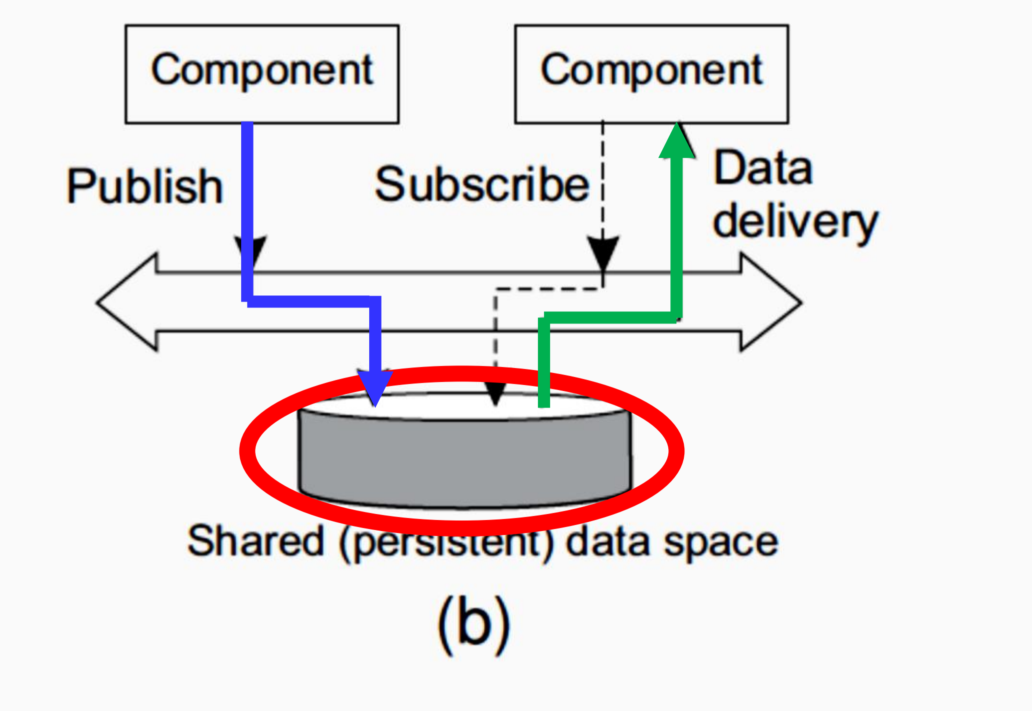
Architectural Styles

- **Event-based**: Publish/subscribe [decoupled in **space**]



Architectural Styles

- **Shared data spaces-based**: Shared dataspace [decoupled in **space** and **time**]



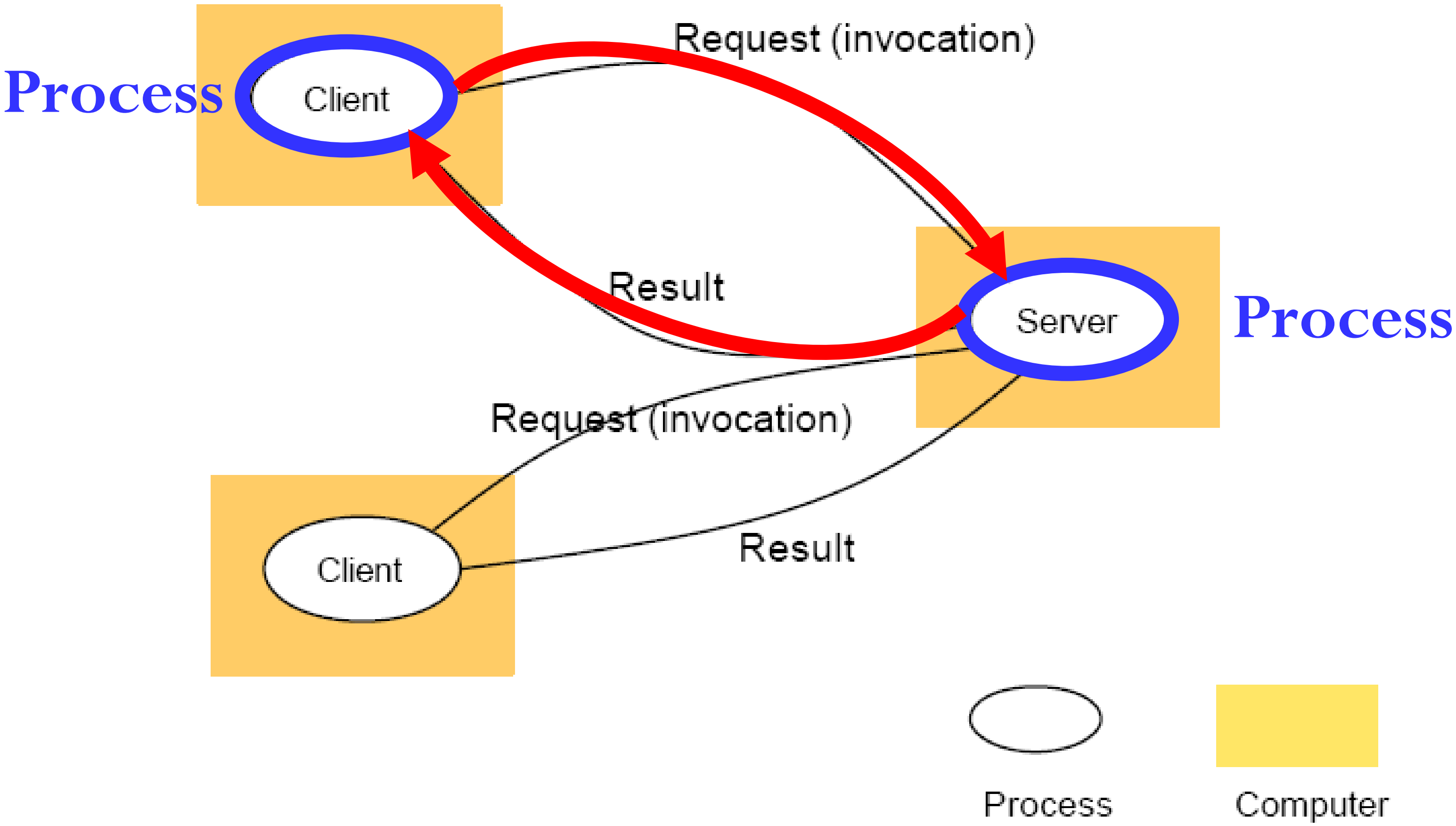
Organization: System Architecture

- **Centralized**
- **Decentralized**
- **Hybrid**

Centralized Architecture

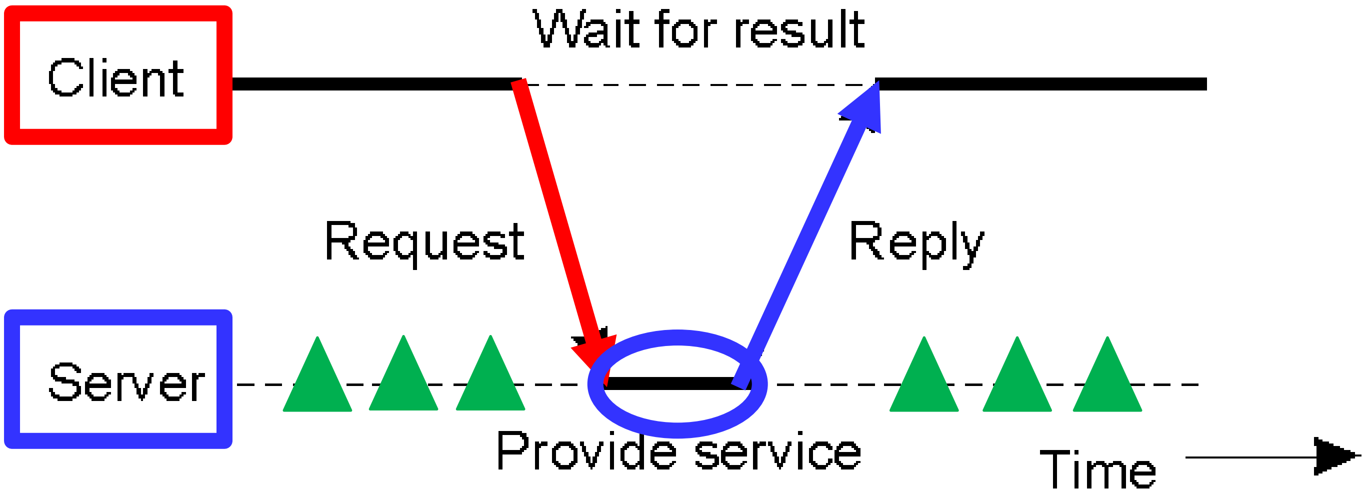
- **Basic Client–Server Model**
- Characteristics:
  - There are **processes** offering services (**servers**)
  - There are **processes** that use services (**clients**)
  - Clients and servers can be on **different machines**
  - Clients follow **request/reply model** wrt to using services

Client-Server Communication

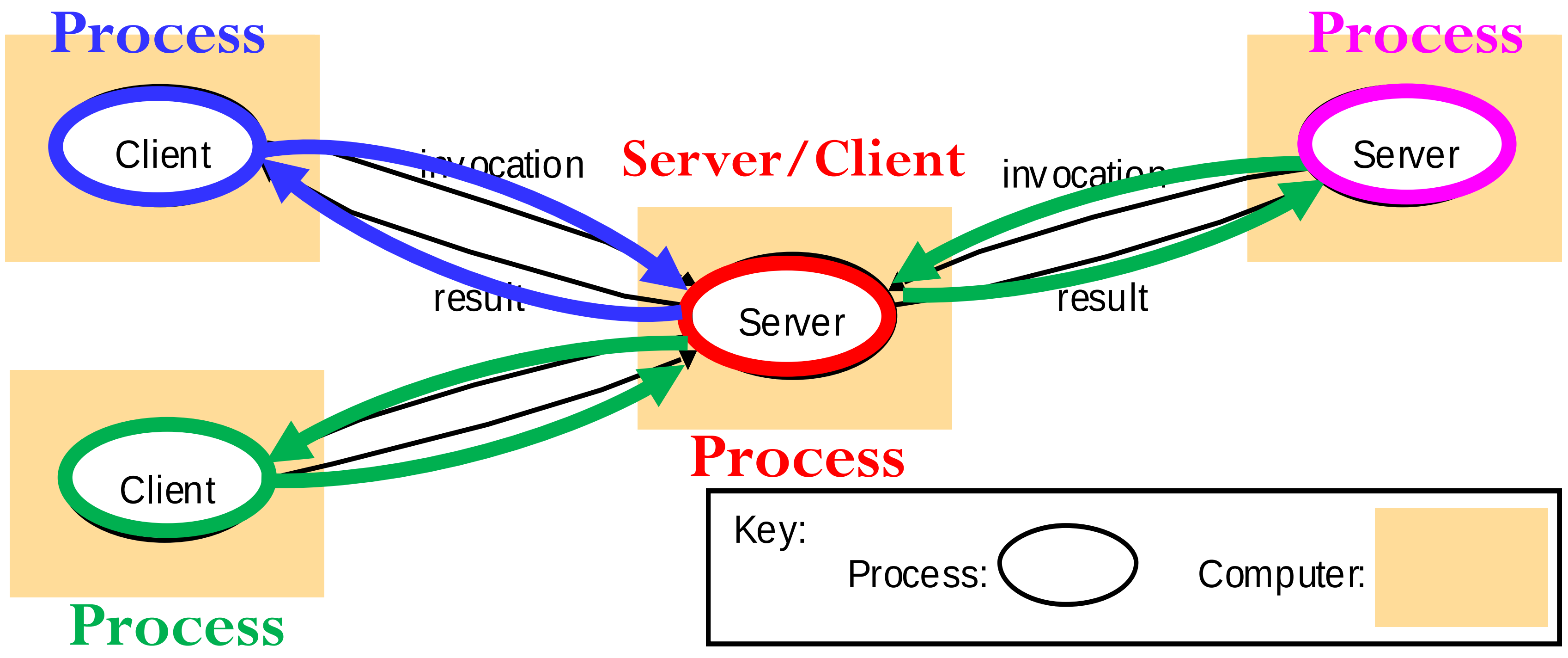


Clients and Servers, Timing

- **General interaction** between a client and a server.

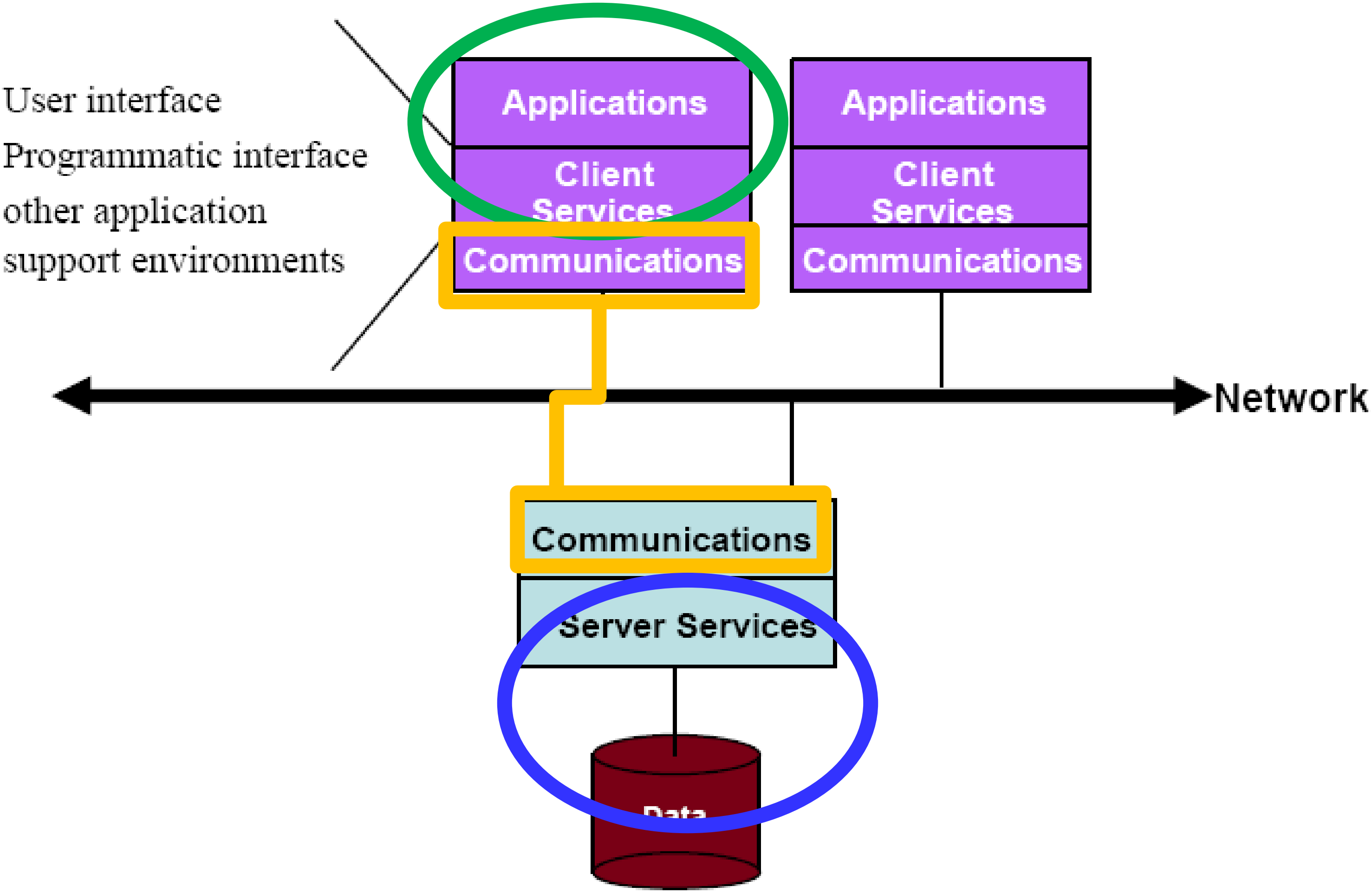


Clients Invoke Individual Servers

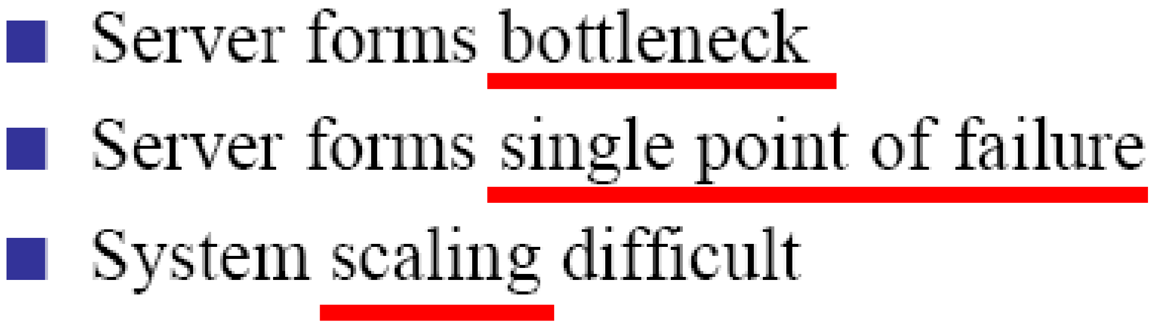


Multiple-Client/Single Server

- User interface
- Programmatic interface
- other application support environments

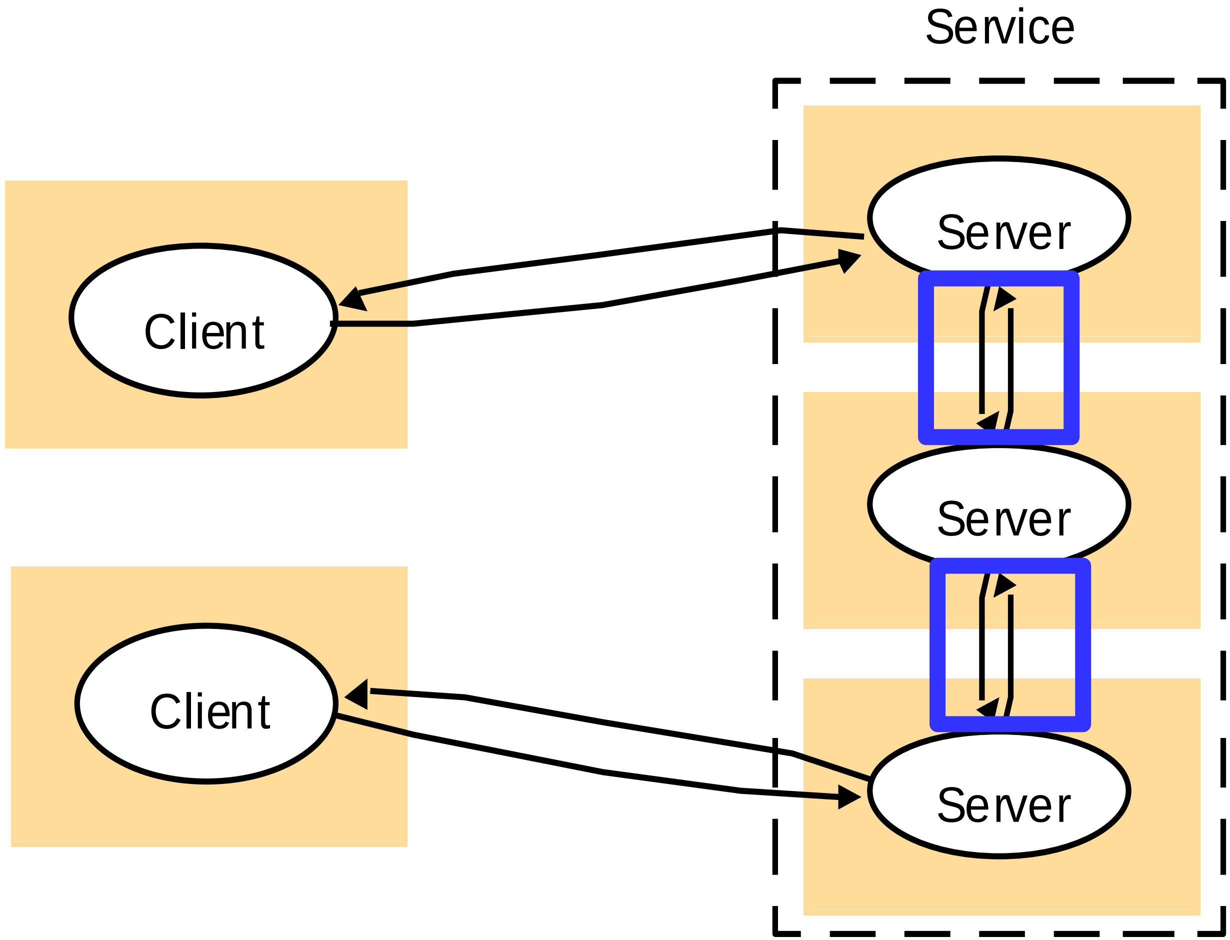


Problems with Multiple-Client / Single Server



- Server forms bottleneck
- Server forms single point of failure
- System scaling difficult

A service provided by multiple servers

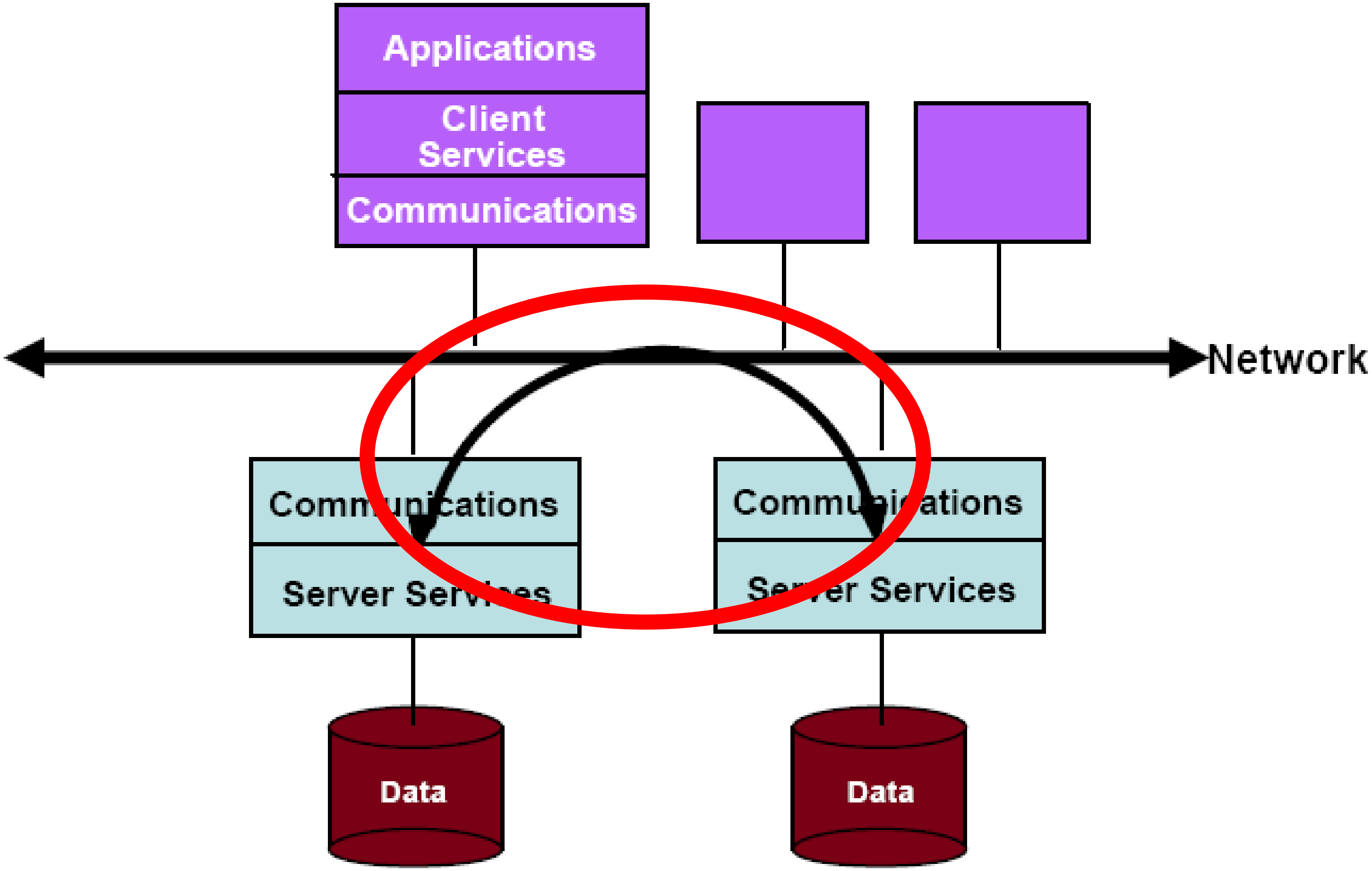


1.单主机多服务器进程

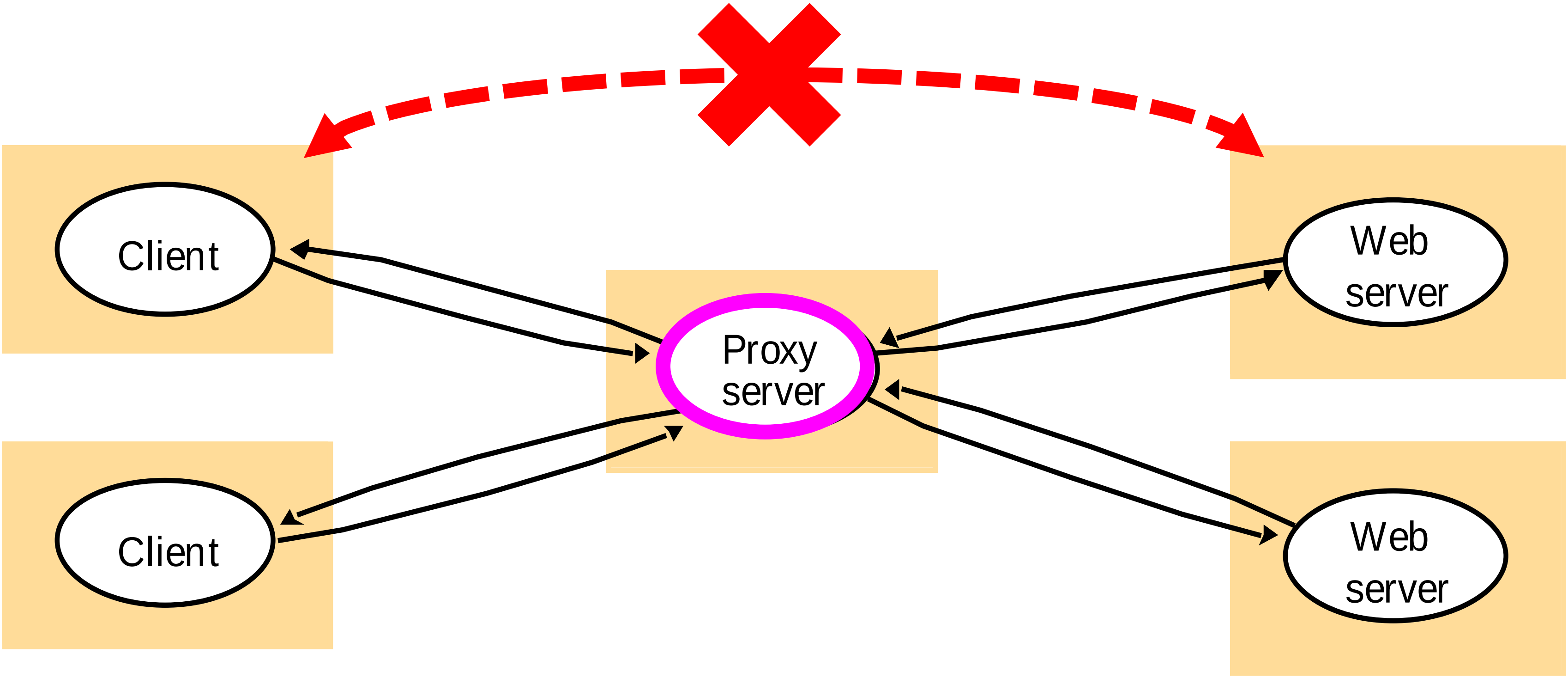
2. 将对象集分区到多个服务器，如web服务器

3. 多主机上维护复制对象集

Multiple Client/Multiple Servers

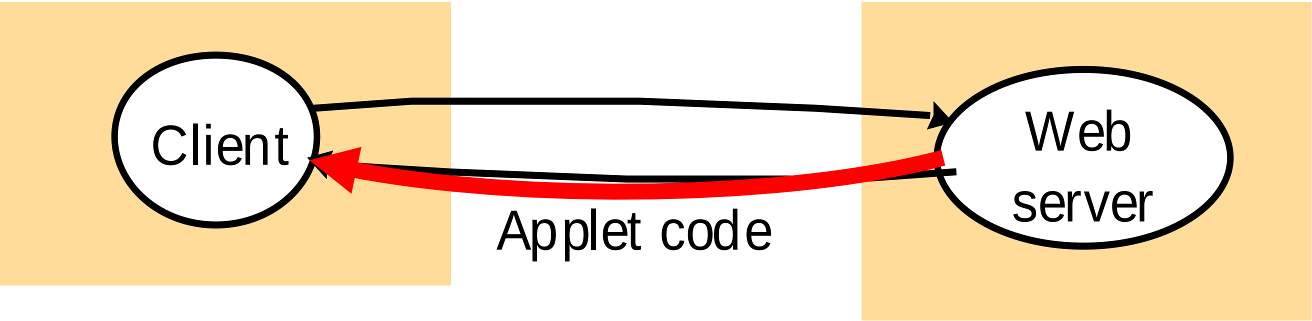


Web proxy server

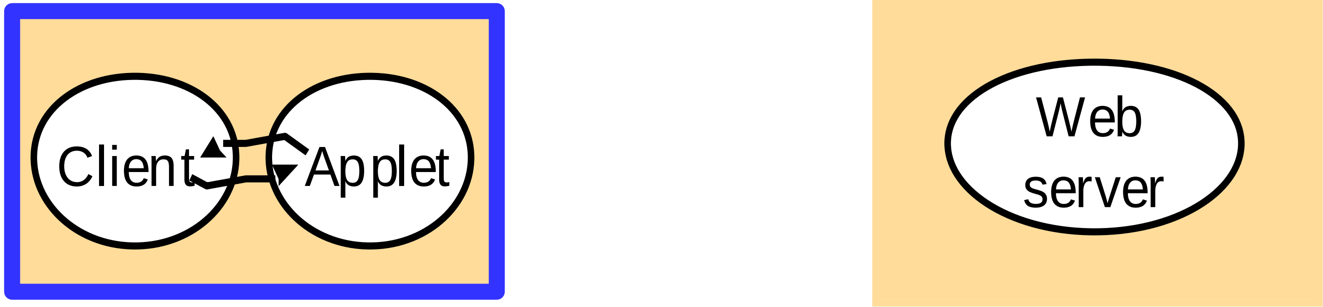


Web Applets

a) client request results in the downloading of applet code



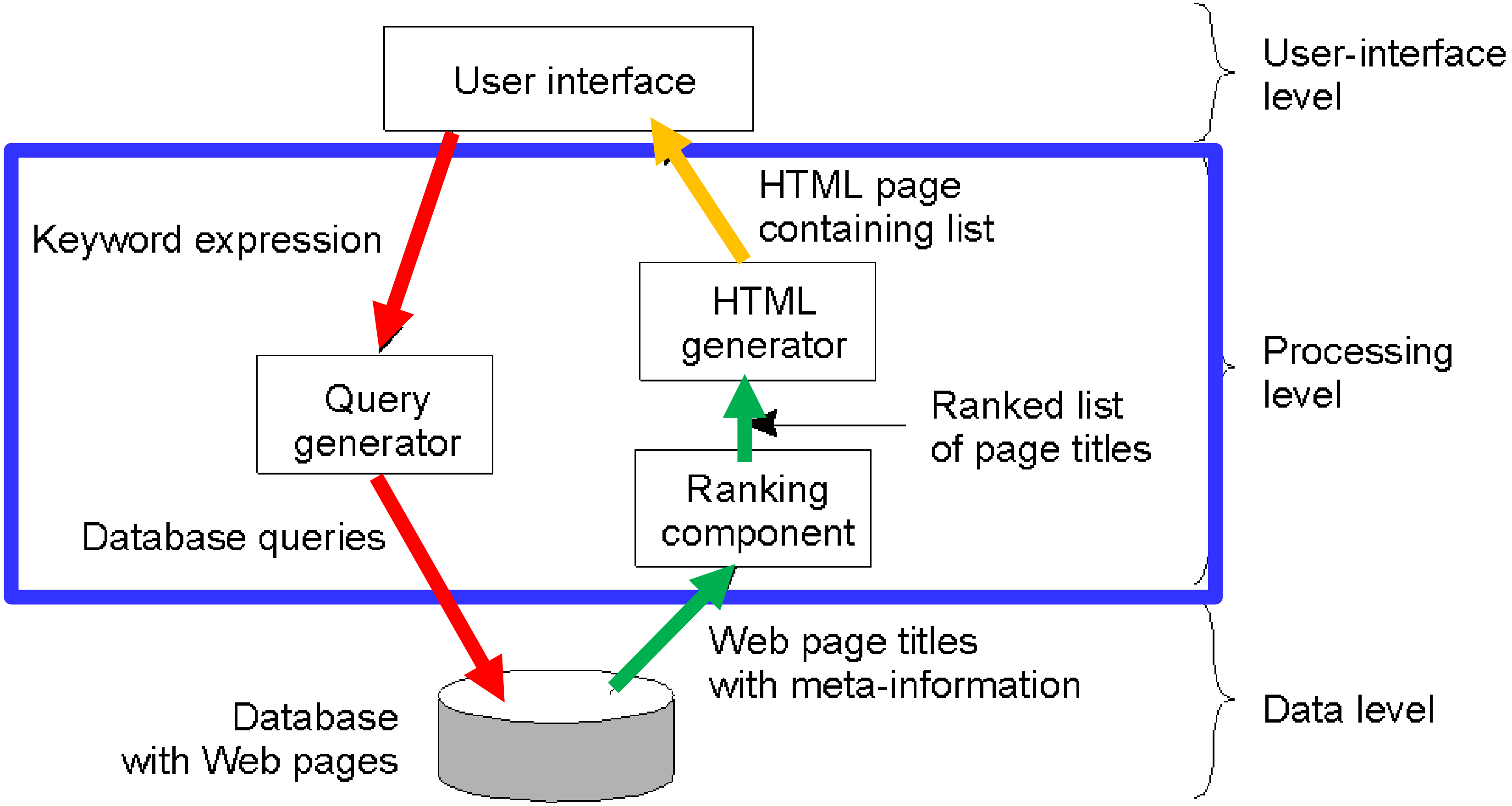
b) client interacts with the applet



Application Layering

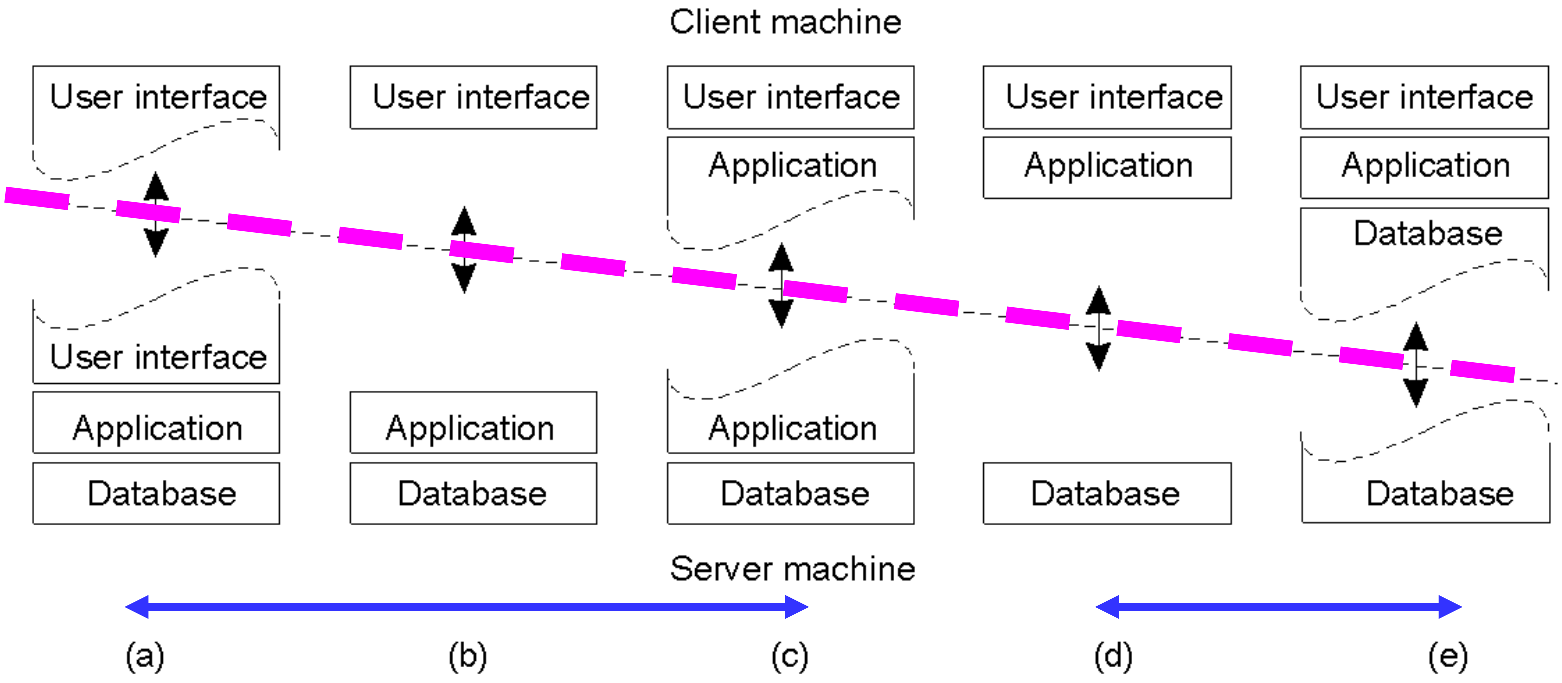
- **Traditional three-layered view**
  - **User-interface layer** contains units for an application's user interface
  - **Processing layer** contains the functions of an application, i.e. without specific data
  - **Data layer** contains the data that a client wants to manipulate through the application components
- This layering is found in many distributed information systems, using traditional database technology and accompanying applications.

Processing Level



Multitiered Architectures (1)

- **Two-tiered:** client/single server configuration

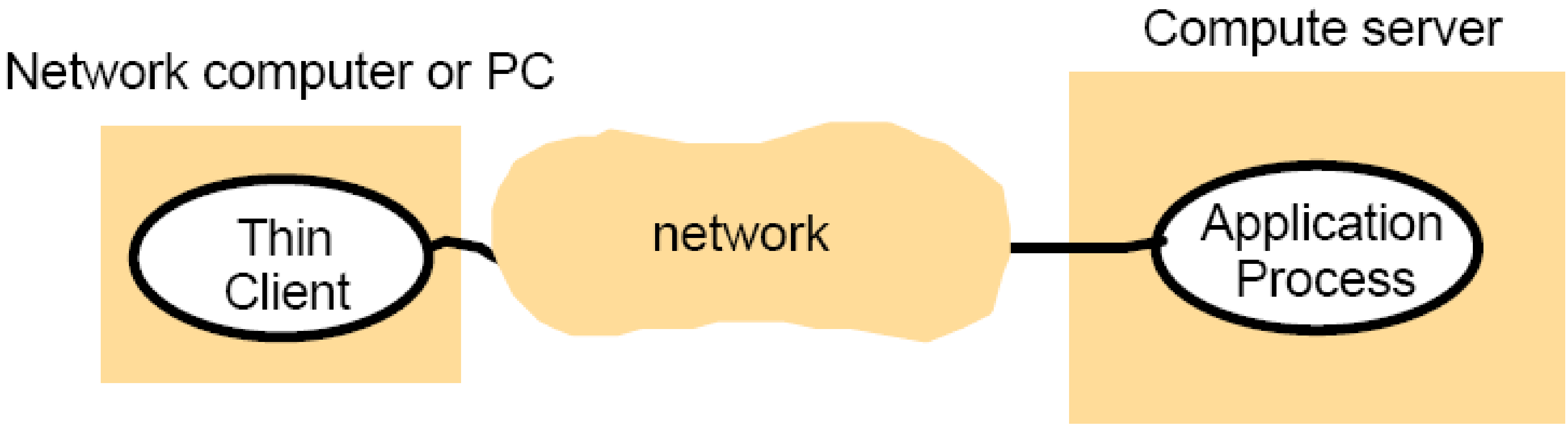


Thin client

Fat client

Thin Clients

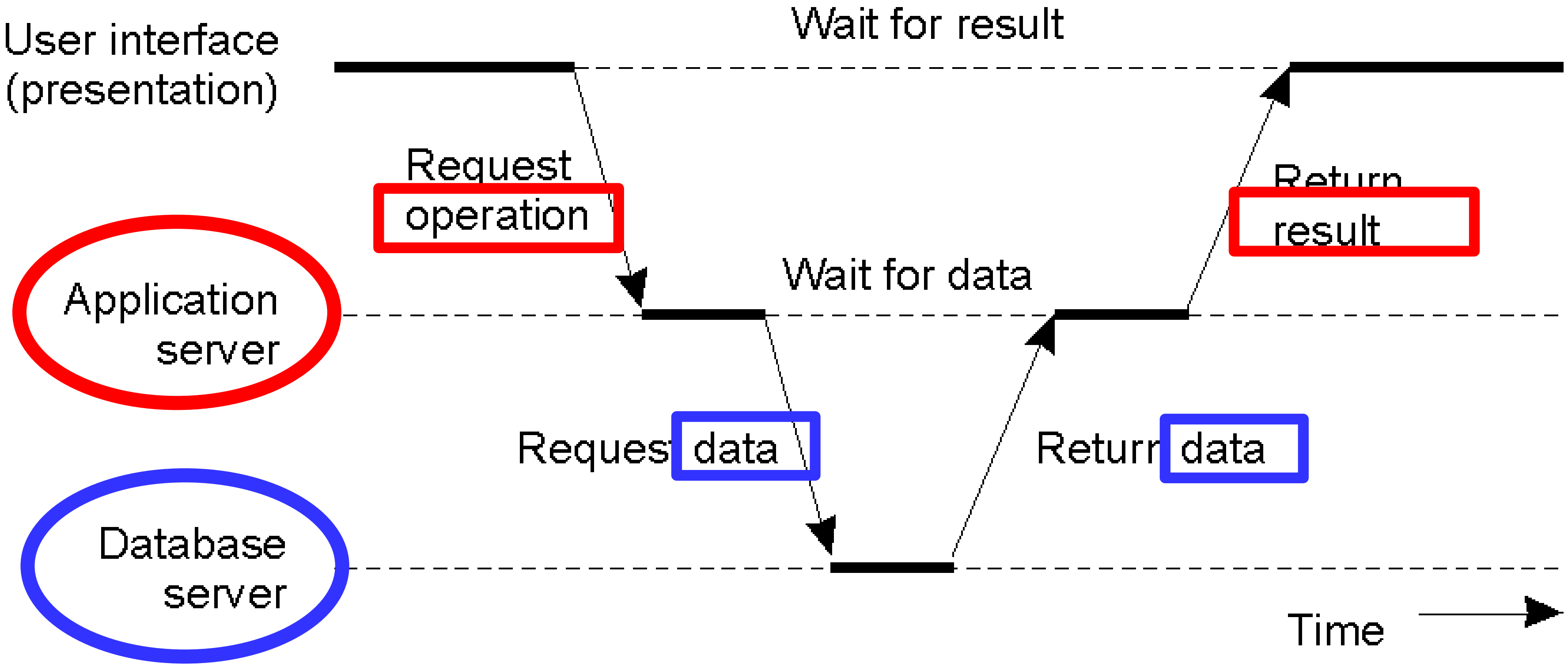
- Thin Clients and Compute Servers
  - Executing graphical user interface on local computer while application executes on compute server
  - Example: X11 server (run on the application client side)
  - In reality: Palm Pilots, Mobile phones



Multitiered Architectures (2)

- An example of a server acting as a client.

Three-tiered

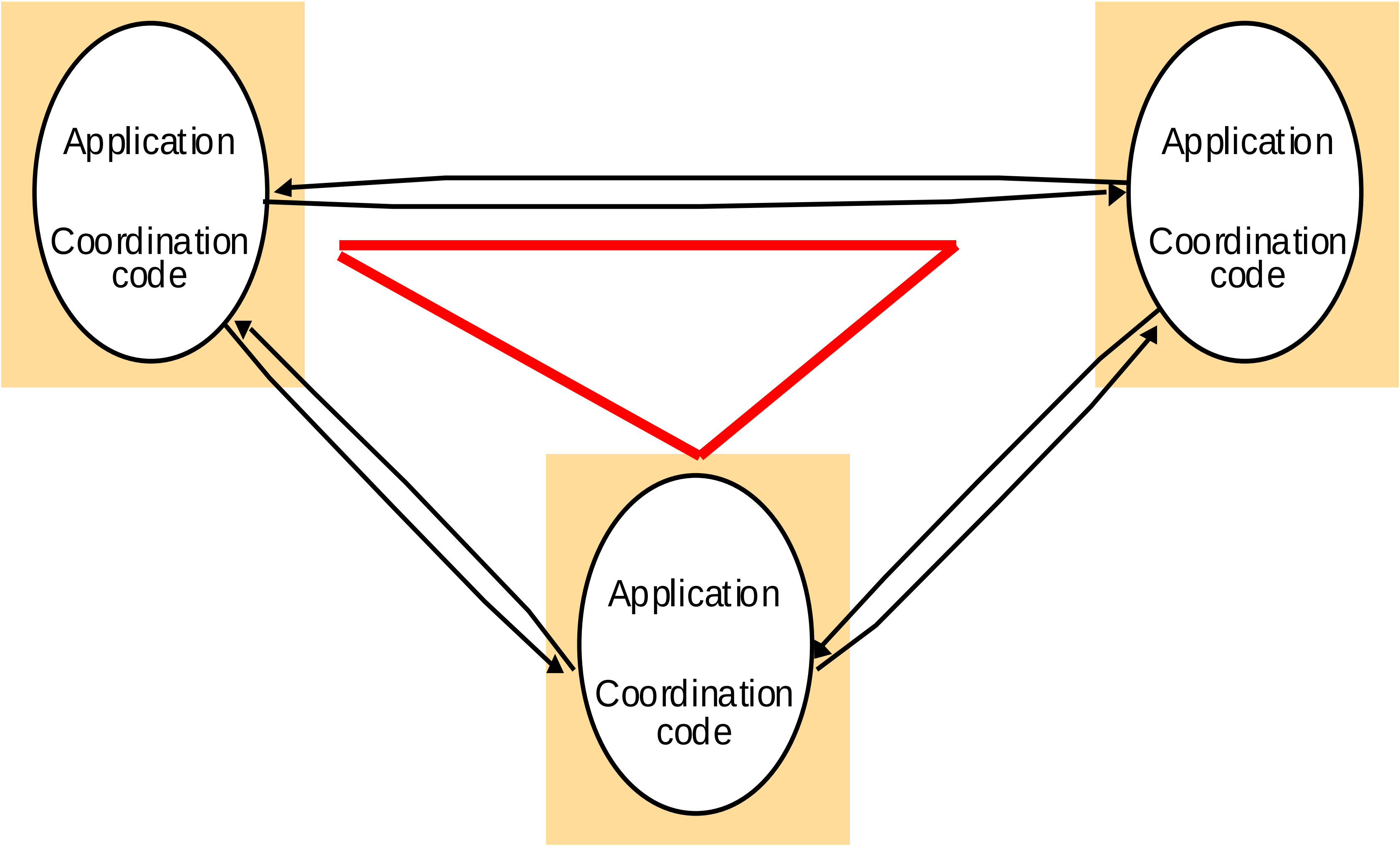


Decentralized Architecture

- **Structured P2P**: nodes are organized following a specific distributed data structure
- **Unstructured P2P**: nodes have randomly selected neighbors
- **Hybrid P2P**: some nodes are appointed special functions in a well-organized fashion

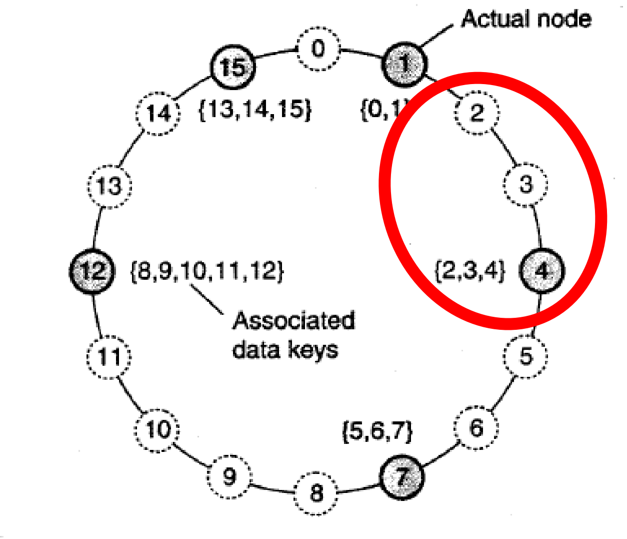
- In virtually all cases, we are dealing with **overlay networks**: data is routed over connections setup between the nodes (cf. application-level multicasting)

A Distributed Application based on Peer Processes

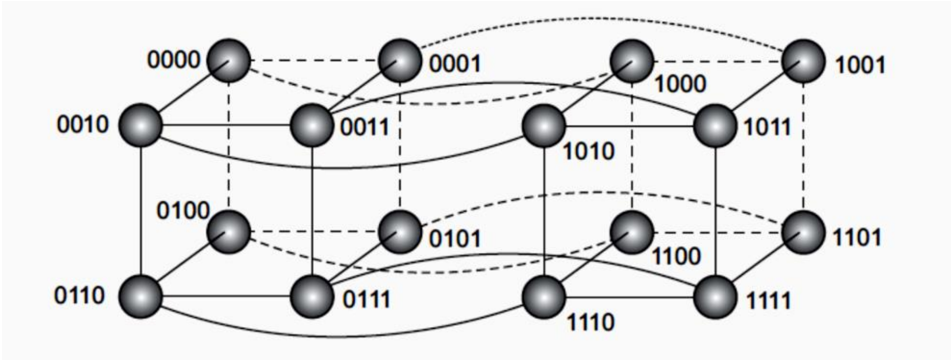


Structured P2P Systems

- Organize the nodes in a **structured overlay network** such as a logical ring, or a hypercube, and make specific nodes responsible for services based only on their ID.



Logical ring



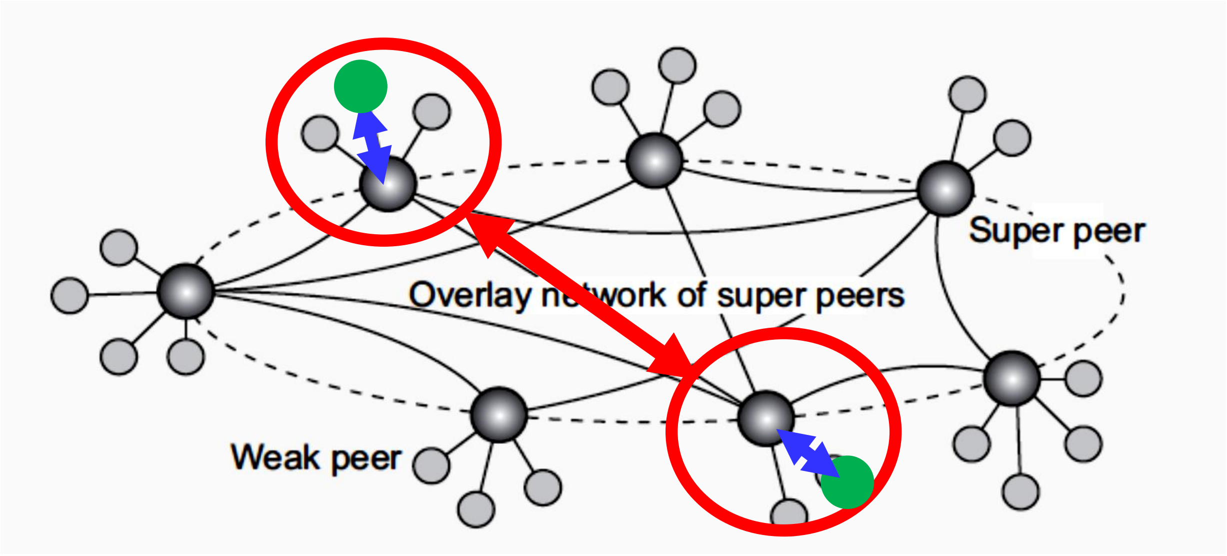
Hypercube

Unstructured P2P Systems

- Many unstructured P2P systems are organized as **a random overlay**: two nodes are linked with probability *p*.
- We can no longer look up information deterministically, but will have to **resort to searching**:
  - Flooding: node *u* sends a lookup query to all of its neighbors. A neighbor responds, or forwards (floods) the request. There are many variations:
    - Limited flooding (maximal number of forwarding)
    - Probabilistic flooding (flood only with a certain probability).
- **Random walk**: Randomly select a neighbor v. If v has the answer, it replies, otherwise v randomly selects one of its neighbors. Variation: parallel random walk. Works well with replicated data.

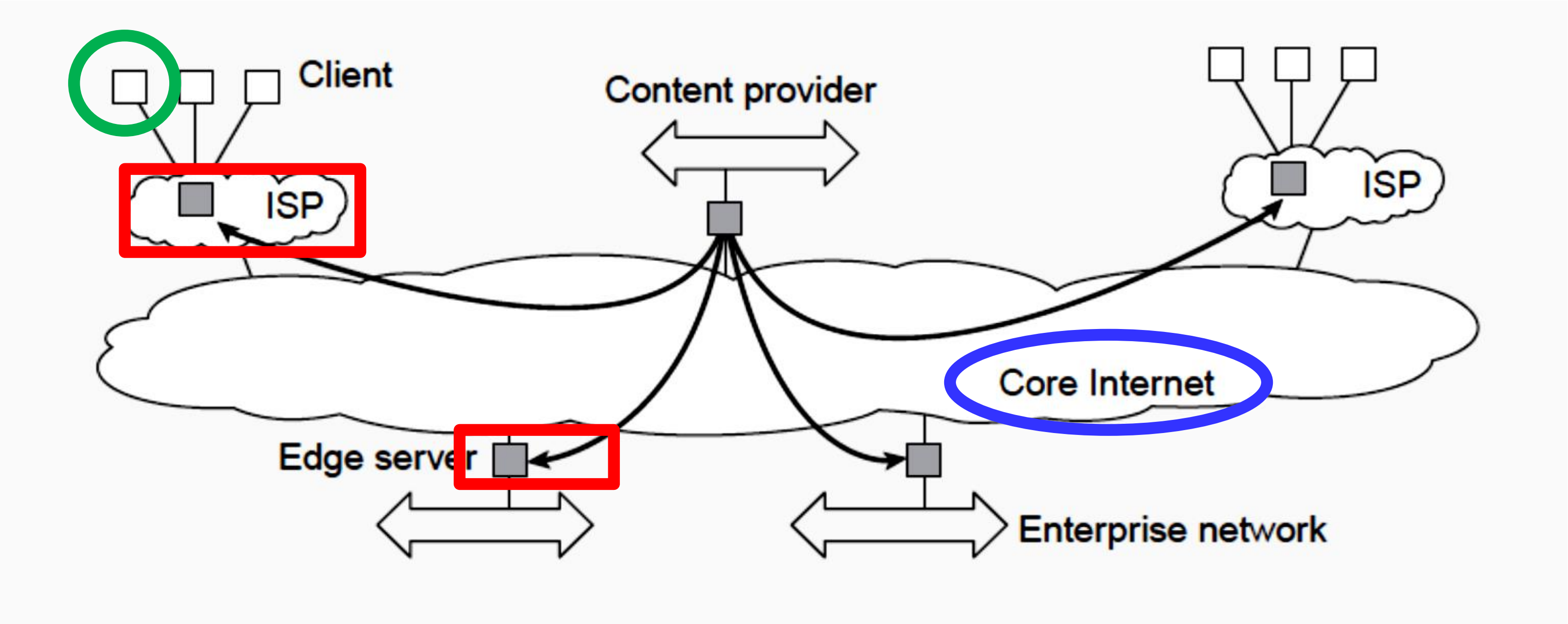
Superpeers

- Sometimes it helps to select a few nodes to do specific work: superpeer.
  - Peers maintaining **an index** (for search)
  - Peers monitoring **the state of the network**
  - Peers being able to **setup connections**



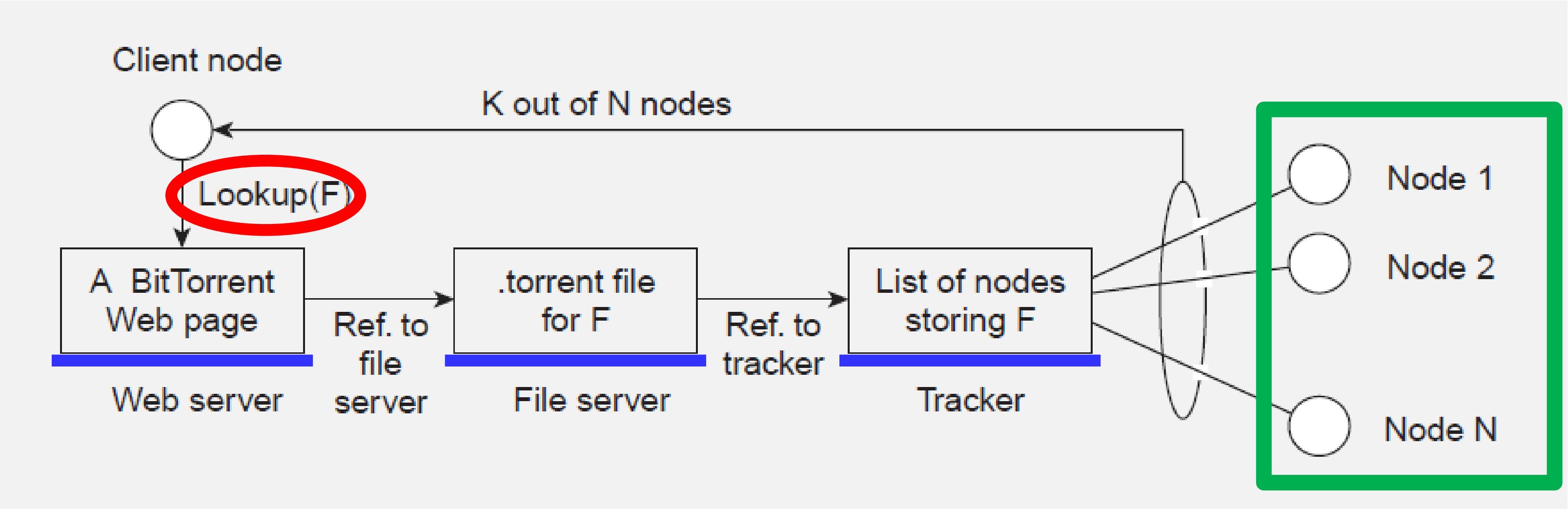
Hybrid Architectures

- **Client-server** combined with **P2P**
- **Edge-server architectures**, which are often used for Content Delivery Networks.



BitTorrent

- Once a node has identified where to **download a file from**, it joins **a swarm of downloaders** who in parallel get file chunks from the source, but also distribute these chunks amongst each other.

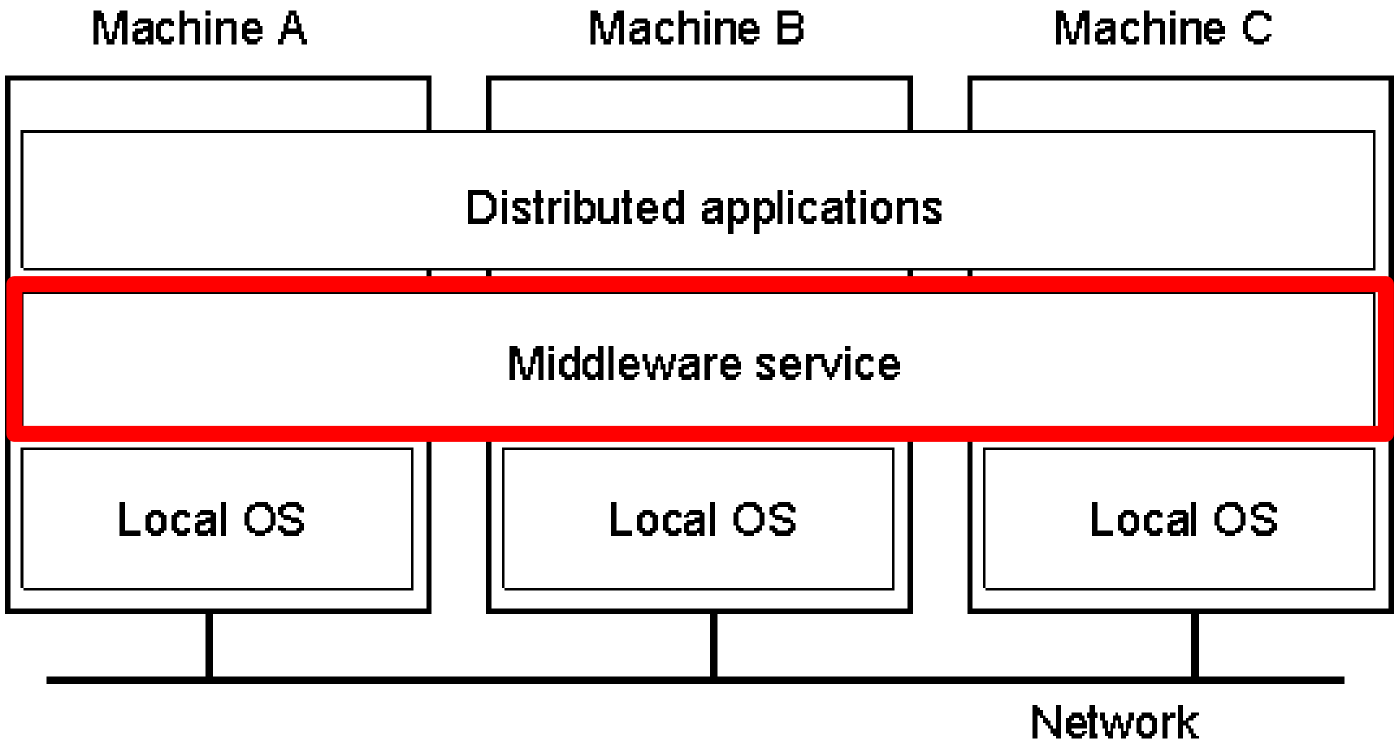


Middleware

- In many cases, distributed systems/applications are developed **according to a specific architectural style**. The chosen style may not be optimal in all cases → need to (dynamically) adapt the behavior of the middleware.

- **Interceptors**
  - Intercept the usual flow of control when invoking a remote object.

A distributed system organized as middleware



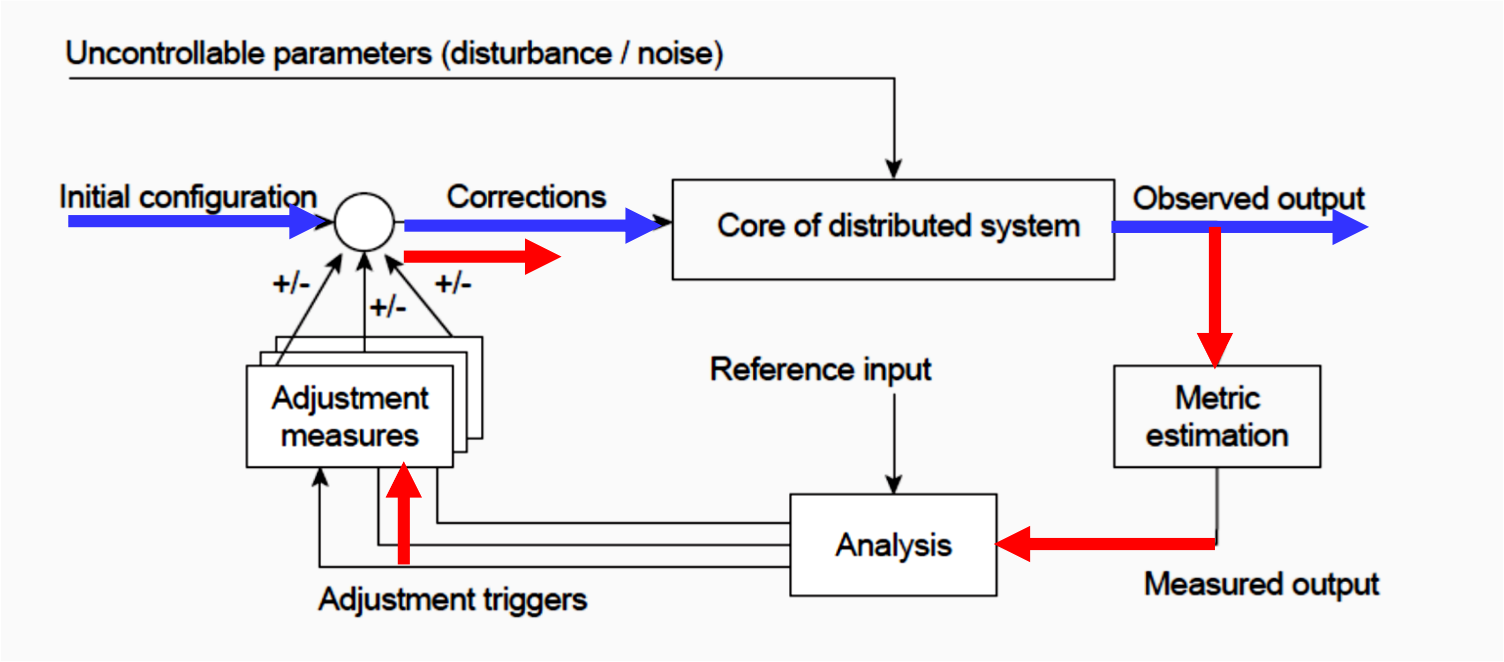
Self-managing Distributed Systems

- Distinction between system and software architectures blurs when **automatic adaptively** needs to be taken into account:
  - Self-configuration
  - Self-managing
  - Self-healing
  - Self-optimizing
  - …

There is a lot of hype going on in this field of autonomic computing.

Feedback Control Model

- In many cases, self-* systems are organized as **a feedback control system**.



Uncontrollable parameters (disturbance / noise)
Initial configuration
Corrections
Core of distributed system
Observed output
+/-
+/-
+/-
Adjustment measures
Reference input
Metric estimation
Analysis
Measured output
Adjustment triggers