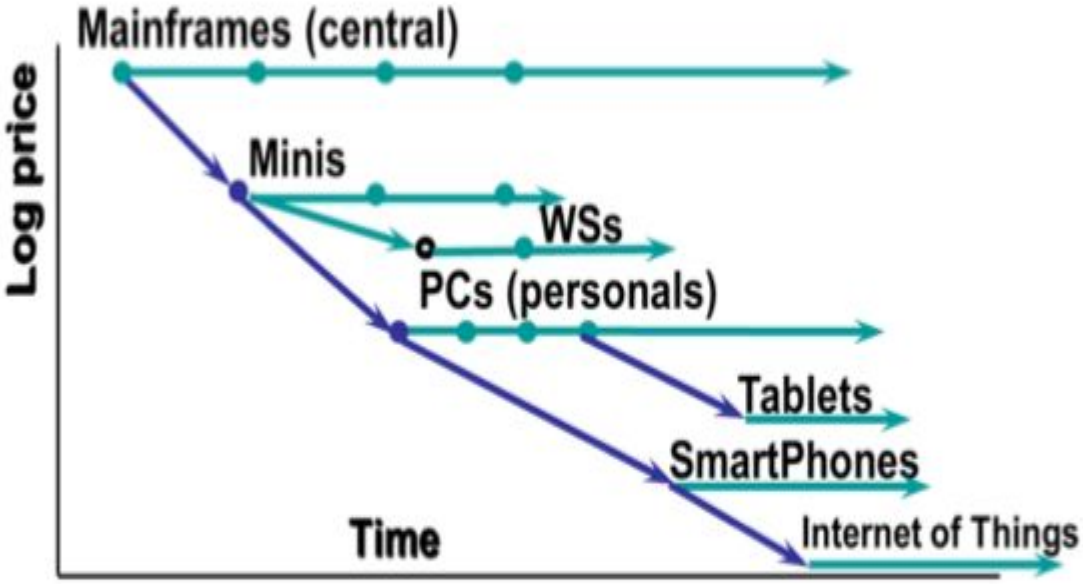
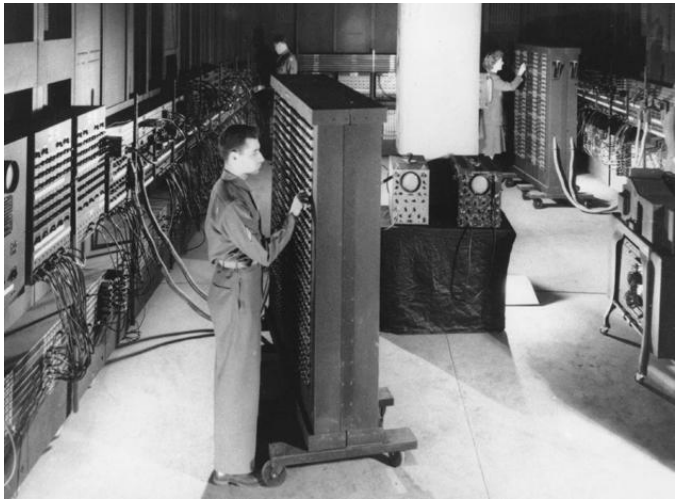
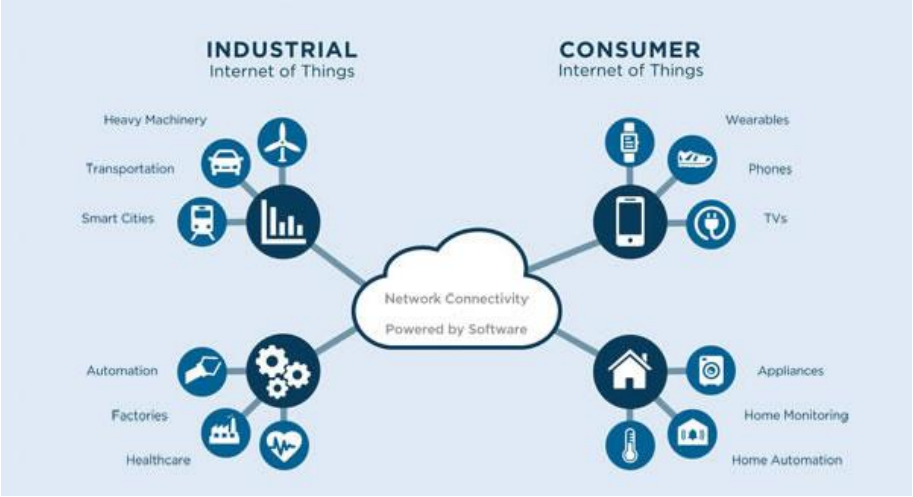
Slides for Chapter 19:
Mobile and Ubiquitous Computing

From **Coulouris, Dollimore, Kindberg and Blair**

Distributed Systems:
Concepts and Design


Mainframes (central)
Log price
Minis
WSs
PCs (personals)
Tablets
SmartPhones
Internet of Things
Time




INDUSTRIAL
Internet of Things
CONSUMER
Internet of Things
Heavy Machinery
Transportation
Smart Cities
Automation
Factories
Healthcare
Wearables
Phones
TVs
Appliances
Home Monitoring
Home Automation
Network Connectivity
Powered by Software

Pervasive (= mobile)

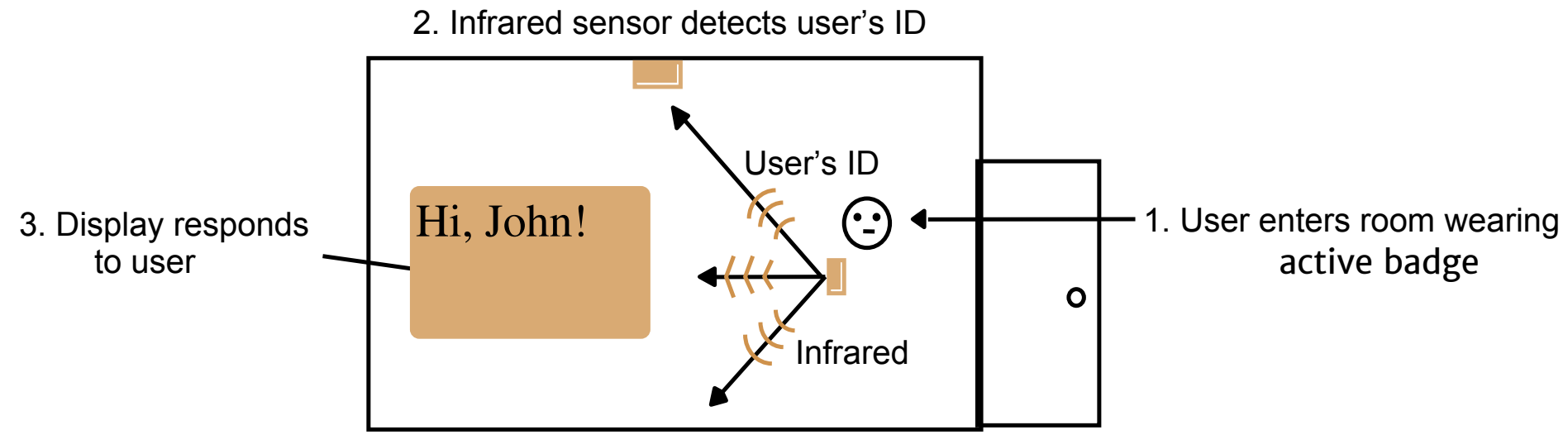
- To be everywhere
- Focus on **connectivity** and **mobility**

Ubiquitous

- To be diffused throughout every part of
- Focus on **embedding** and **integrating** system

https://www.computerworld.com/article/2593079/ubiquitous--pervasive--sorry--they-don-t-compute.html

Figure 19.1
A room responding to a user wearing an active badge

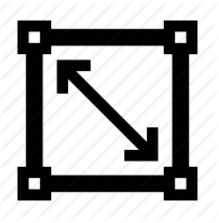


Device model

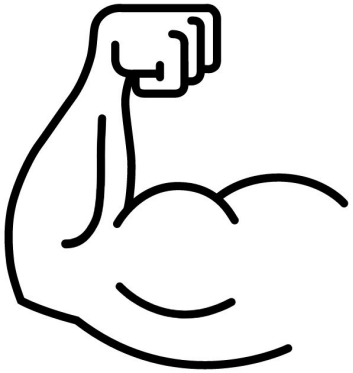
- Limited Energy:
  - the smaller the battery, the lower the capacity
  - Software and hardware tailored to save energy

- Resource constraints (viz. processor and memory)
  - Save energy
  - Shrink devices as much as possible

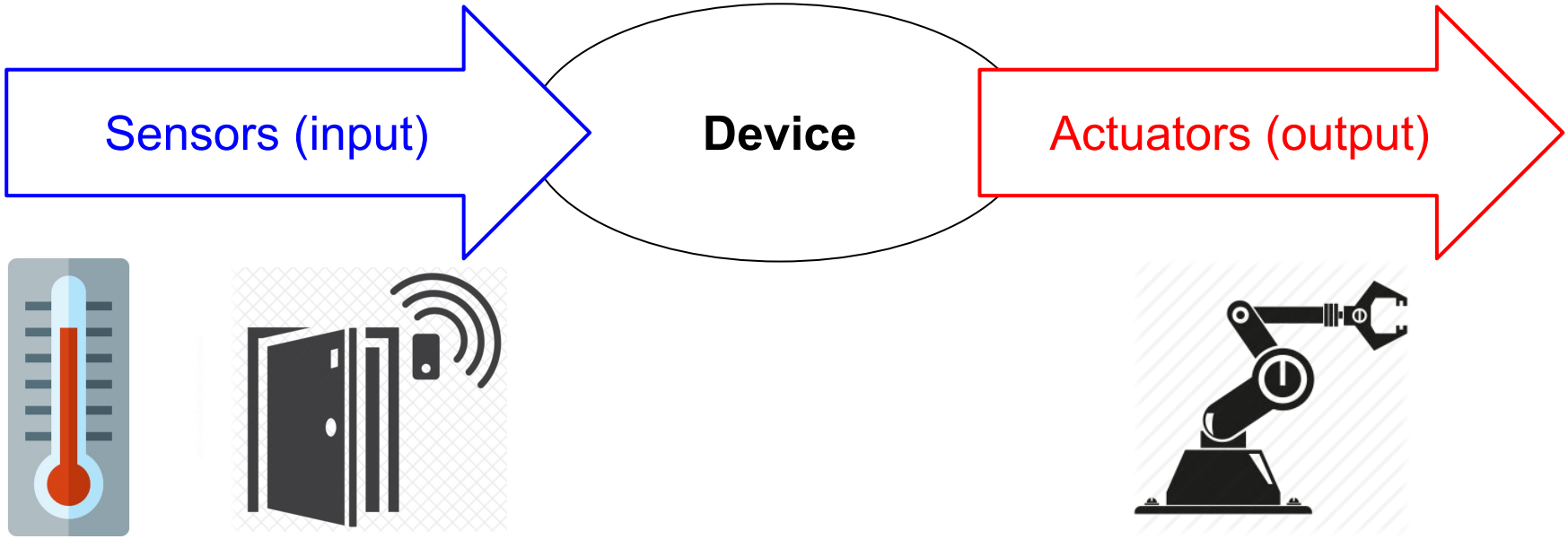
Device model



vs.



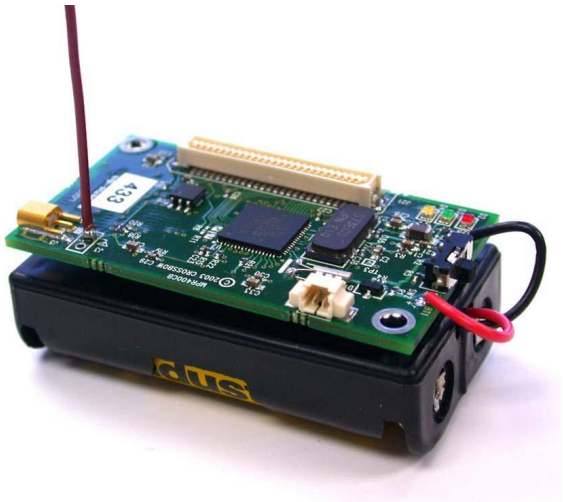
Device model

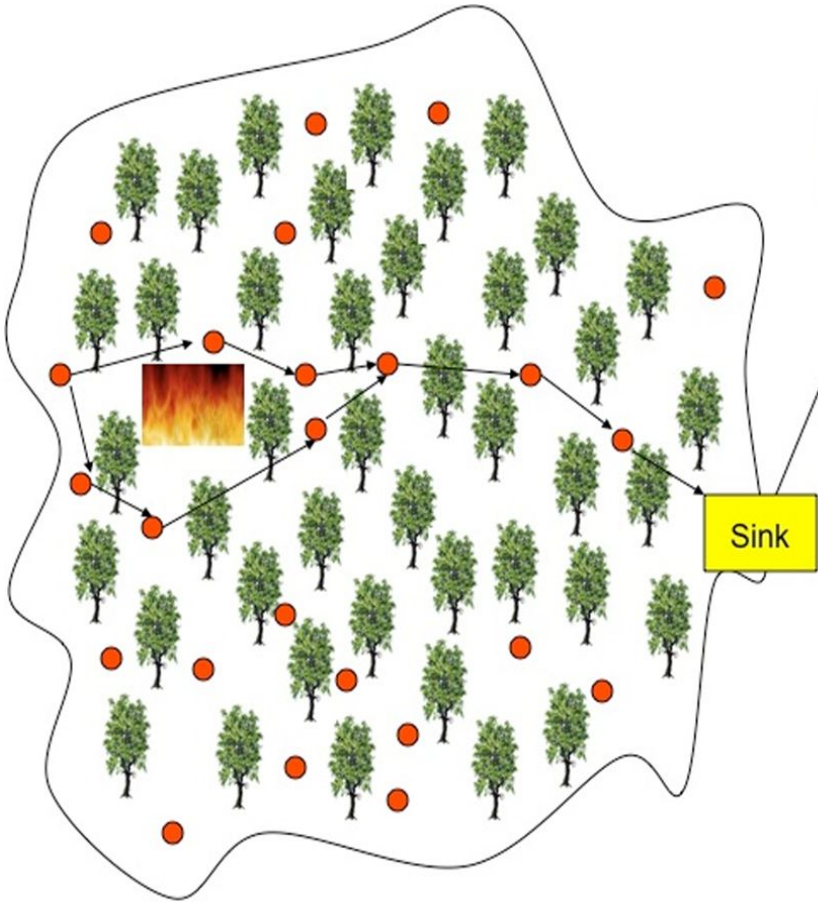


Devices classification: *motes or smart dust*

- Operate autonomously within an environment
- Discover and communicate with other devices

zigbee





Devices classification: *smart phones*

Wi Fi

Bluetooth

5G

GPS

Connectivity

- Set of connected devices changes often and unexpectedly (i.e. *volatile*)
  - Devices are turned off and move in/out the set
  - Variable bandwidth and latency may cause error rates

- Association: logical relationship between devices as they communicate
  - Spontaneous or pre-configured

Figure 19.2
Examples of pre-configured versus spontaneous association

Pre-configured	Spontaneous
Service-driven: *email client and server*	Human-driven: *web browser and web servers* Data-driven: *P2P file-sharing applications* Physically-driven: *mobile and ubiquitous systems*

Association problem

- A smart space = physical place with available embedded services
- As a device D enters in a smart place it faces a problem
  - How to select a device efficiently? (scale)
  - How to rule out devices beyond the smart place? (scope)
- Smart spaces must have meaningful boundaries

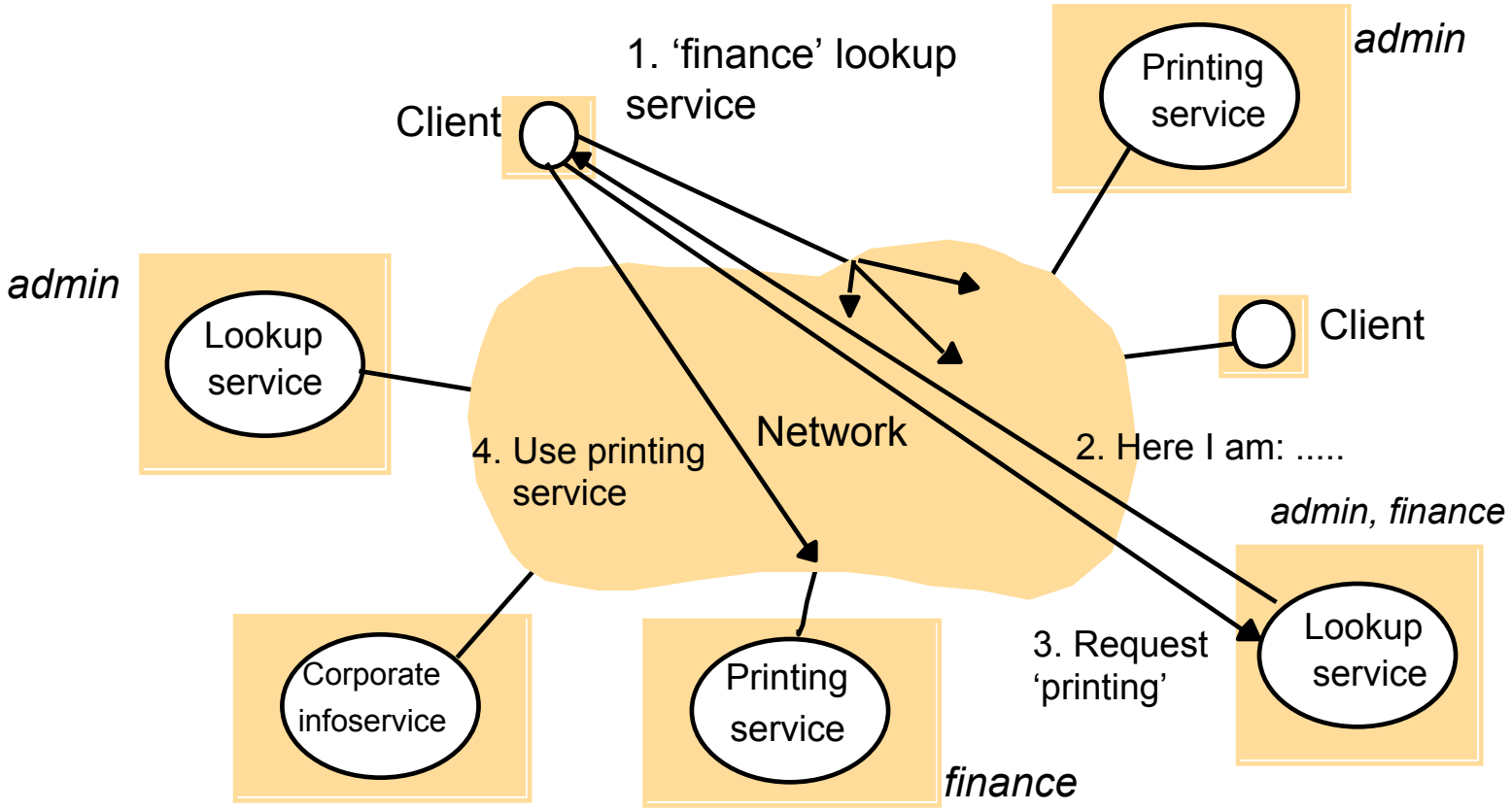
Discovery services

- Allow clients finding out the services of a smart place
- Directory service providing interfaces for:
  - Registering or removing services to be offered
  - Querying available services
- Two implementations
  - Server directory:
  - Serverless directory: push vs. pull modes

Figure 19.3
The interface to a discovery service (server directory)

Methods for service de/registration	Explanation
lease := register(address, attributes)	Register the service at the given address with the given attributes; a lease is returned
refresh(lease)	Refresh the lease returned at registration
deregister(lease)	Remove the service record registered under the given lease
Method invoked to look up a service	
serviceSet := query(attributeSpecification)	Return a set of registered services whose attributes match the given specification

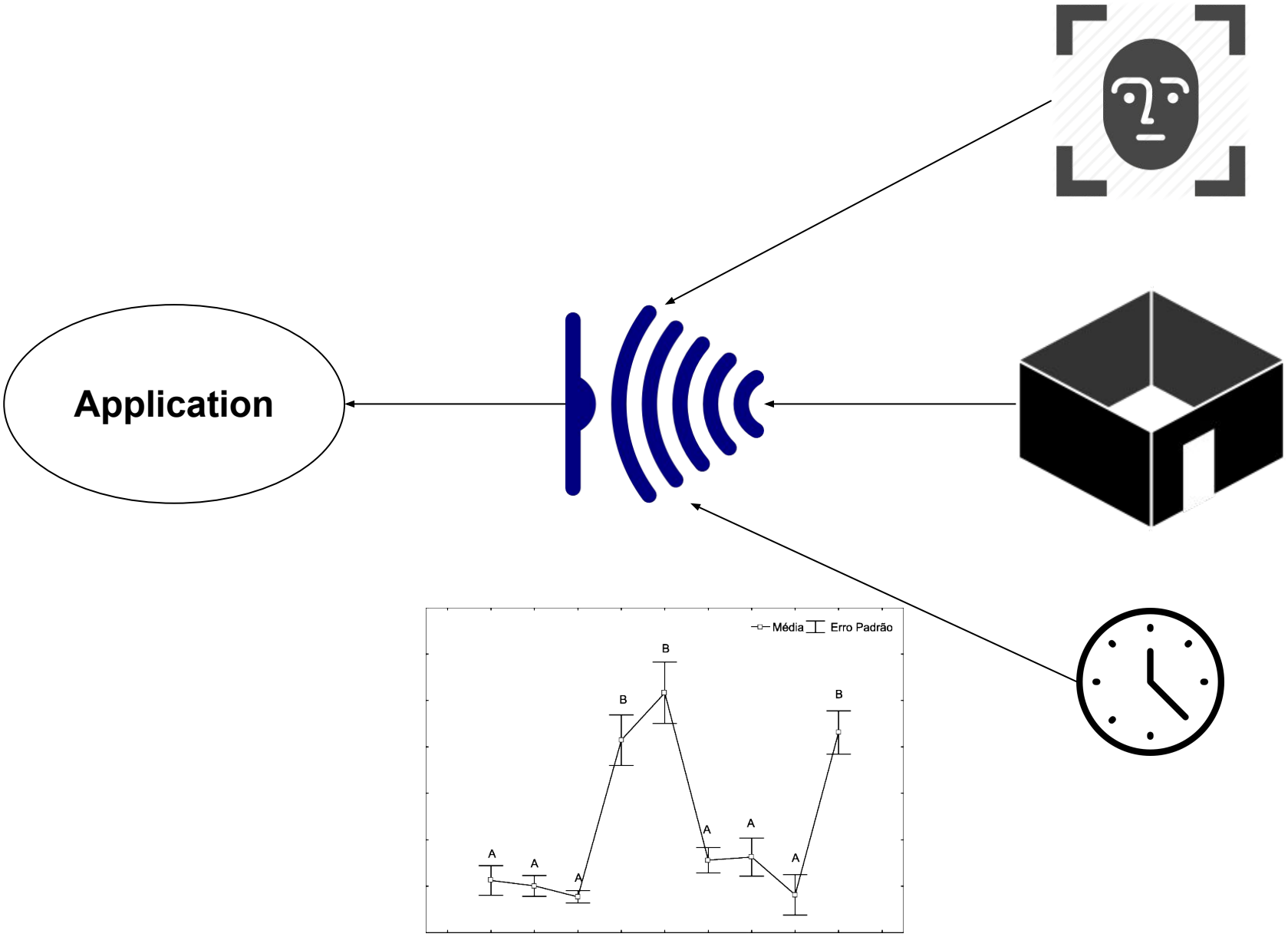
Figure 19.4
Service discovery in Jini



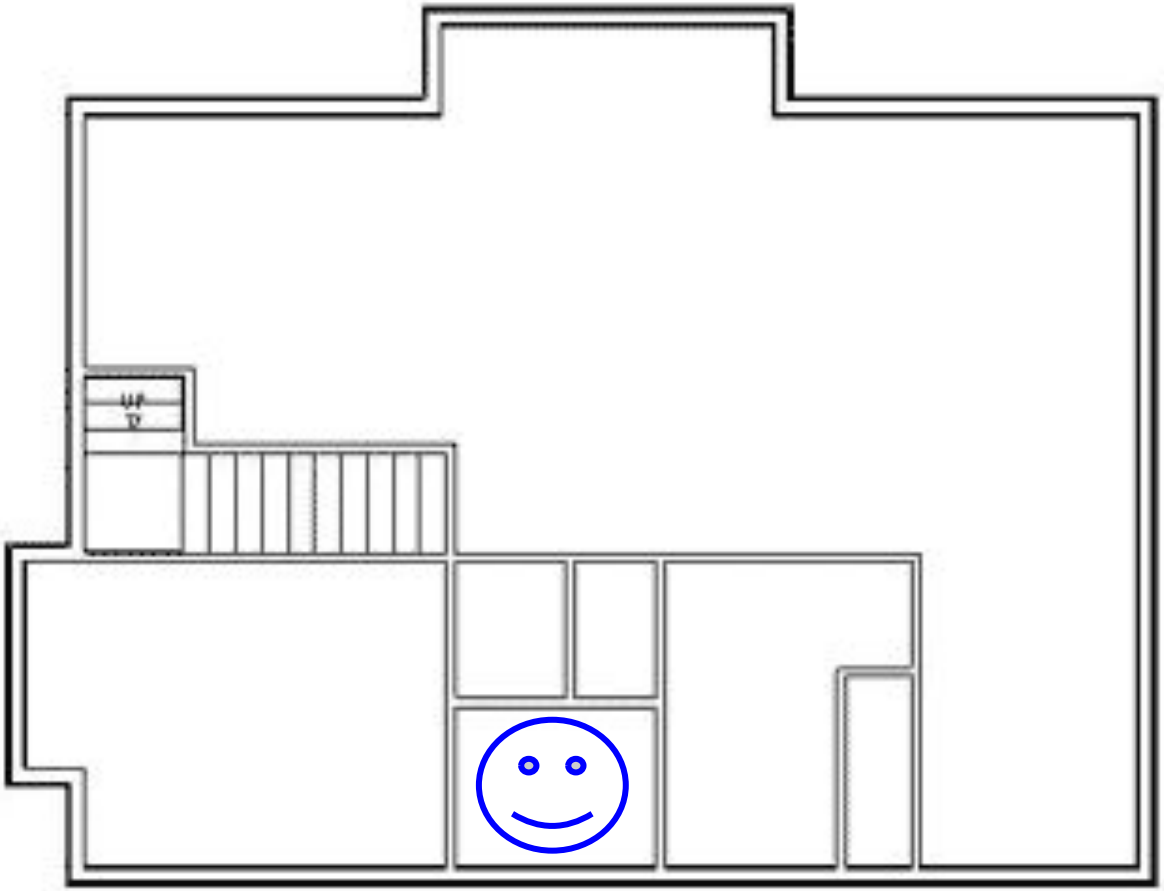
Issues on network discovery method

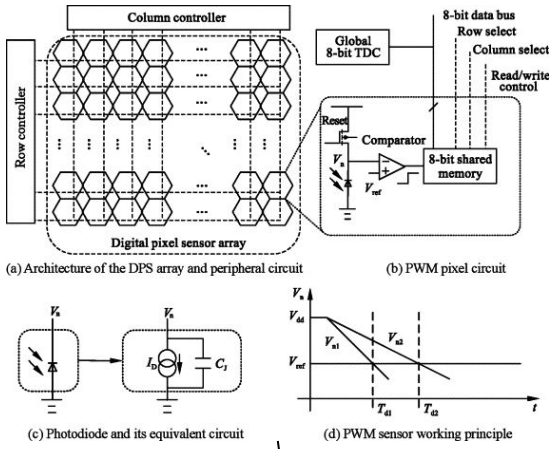
- Subnets poorly approximate smart places
- Inappropriate service descriptions

Context-aware applications



Example of context-aware library of widgets to be used to identify people





(a) Architecture of the DPS array and peripheral circuit

(b) PWM pixel circuit

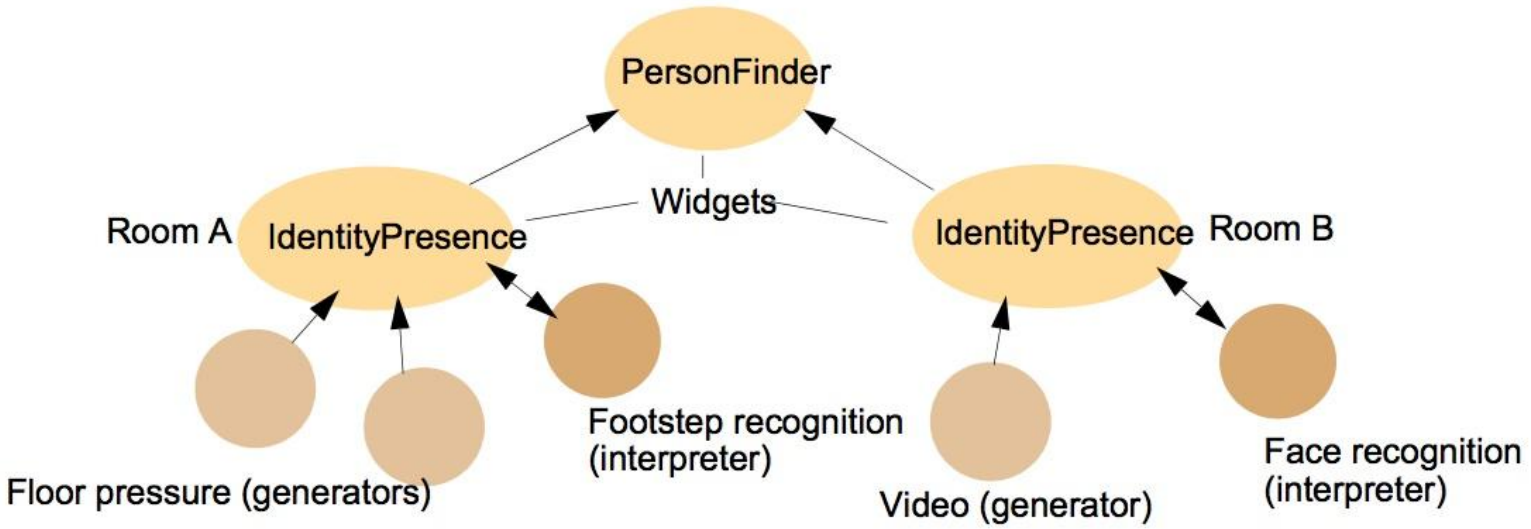
(c) Photodiode and its equivalent circuit

(d) PWM sensor working principle

Figure 19.5
The *IdentityPresence* widget class of the Context Toolkit

Attributes (accessible by polling)	Explanation
Location	Location the widget is monitoring
Identity	ID of the last user sensed
Timestamp	Time of the last arrival
Callbacks	
PersonArrives(location, identity, timestamp)	Triggered when a user arrives
PersonLeaves(location, identity, timestamp)	Triggered when a user leaves

Figure 19.6
A *PersonFinder* widget constructed using IdentityPresence widgets



Volatile sensors network

- Ad hoc network
  - no central, coordinator device
  - Node bootstraps by itself
  - Talk to the nearest node
- Devices can be (un)available unexpectedly

- How to program and communicate in such networks?

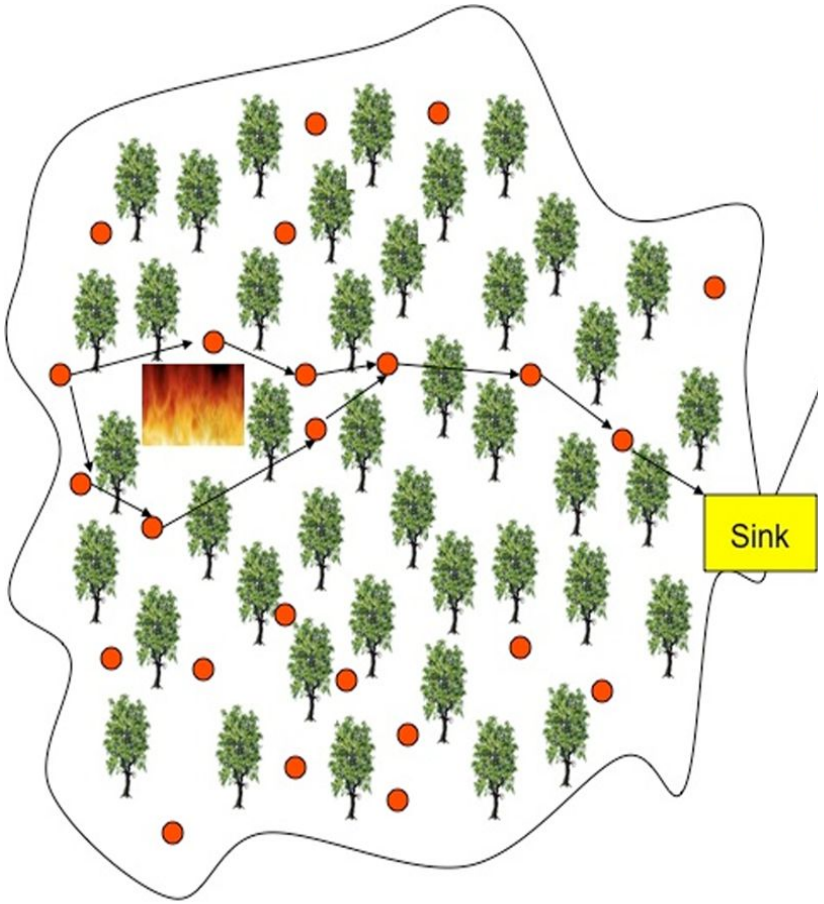
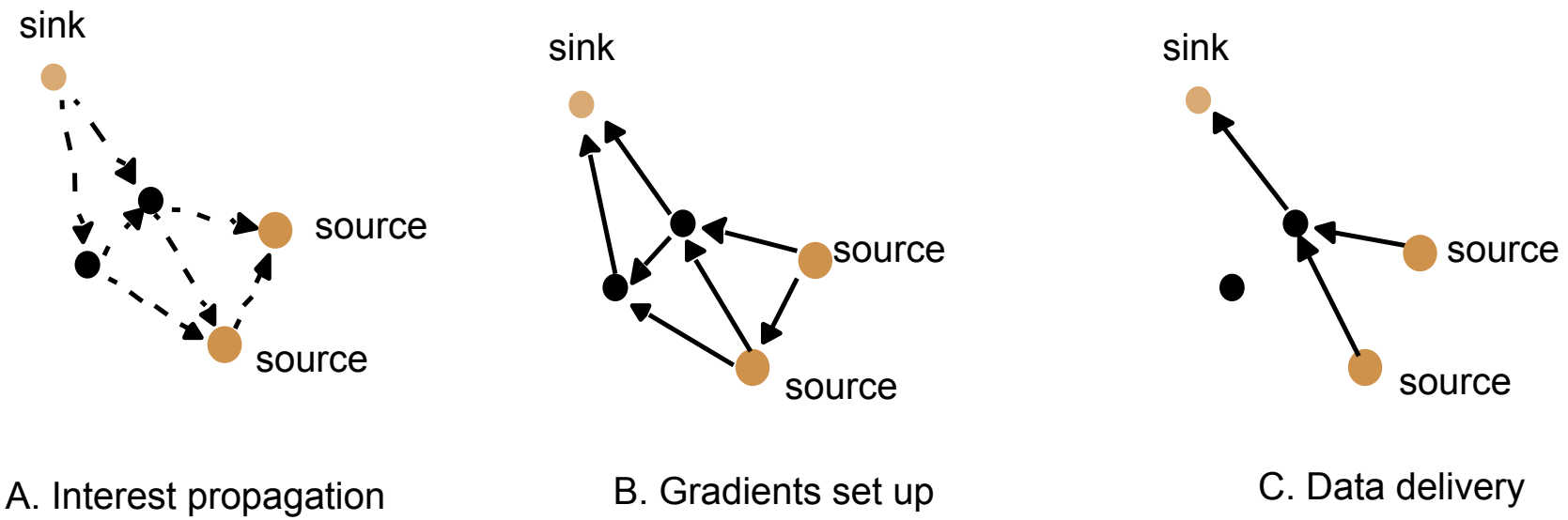


Figure 19.7
Directed diffusion



A. Interest propagation

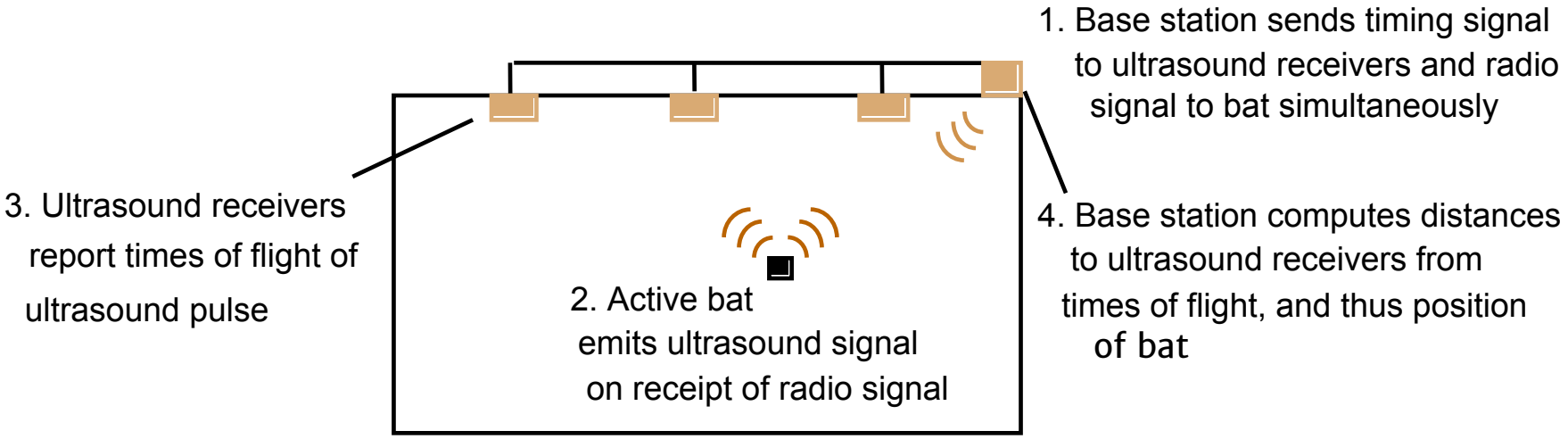
B. Gradients set up

C. Data delivery

Figure 19.8 Some location-sensing technologies

Type	*Mechanism*	*Limitations*	*Accuracy*	*Type of location data*	*Privacy*
GPS	Multilateration from satellite radio sources	Outdoors only (satellite visibility)	1–10m	Absolute geographic coordinates (latitude, longitude, altitude)	Yes
Radio beaconing	Broadcasts from wireless base stations (GSM, 802.11, Bluetooth)	Areas with wireless coverage	10m–1km	Proximity to known entity (usually semantic)	Yes
Active Bat	Multilateration from radio and ultrasound	Ceiling mounted sensors	10cm	Relative (room) coordinates.	Bat identity disclosed
Ultra Wide Band	Multilateration from reception of radio pulses	Receiver installations	15cm	Relative (room) coordinates	Tag identity disclosed
Active badge	Infrared sensing	Sunlight or fluorescent light	Room size	Proximity to known entity (usually semantic)	Badge identity disclosed
Automatic identification tag	RFID, Near Field Communication, visual tag (e.g. barcode)	Reader installations	1cm–10m	Proximity to known entity (usually semantic)	Tag identity disclosed
Easy Living	Vision, triangulation	Camera installations	Variable	Relative (room) coordinates	No

Figure 19.9
Locating an active bat within a room



Summary

- Pervasive & ubiquitous ≠ conventional & wired
  - Volatile configuration
  - Resources restrictions
  - Physical integration