Introduction to Wireless Sensor Networks (WSN)

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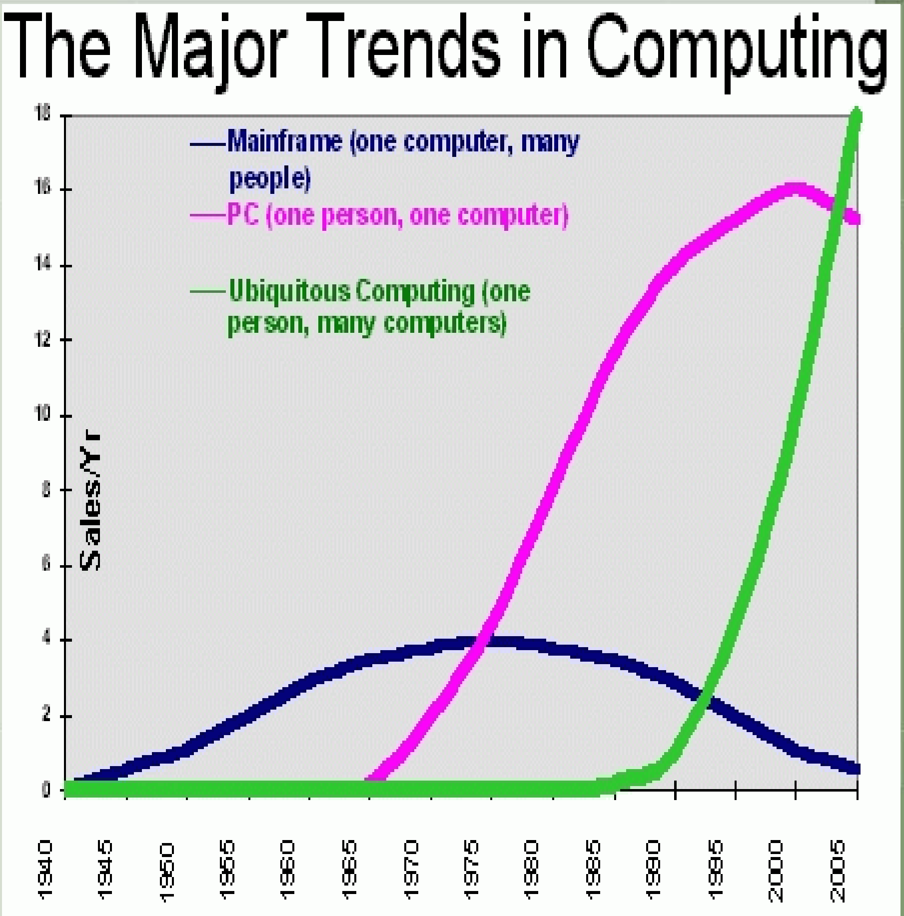
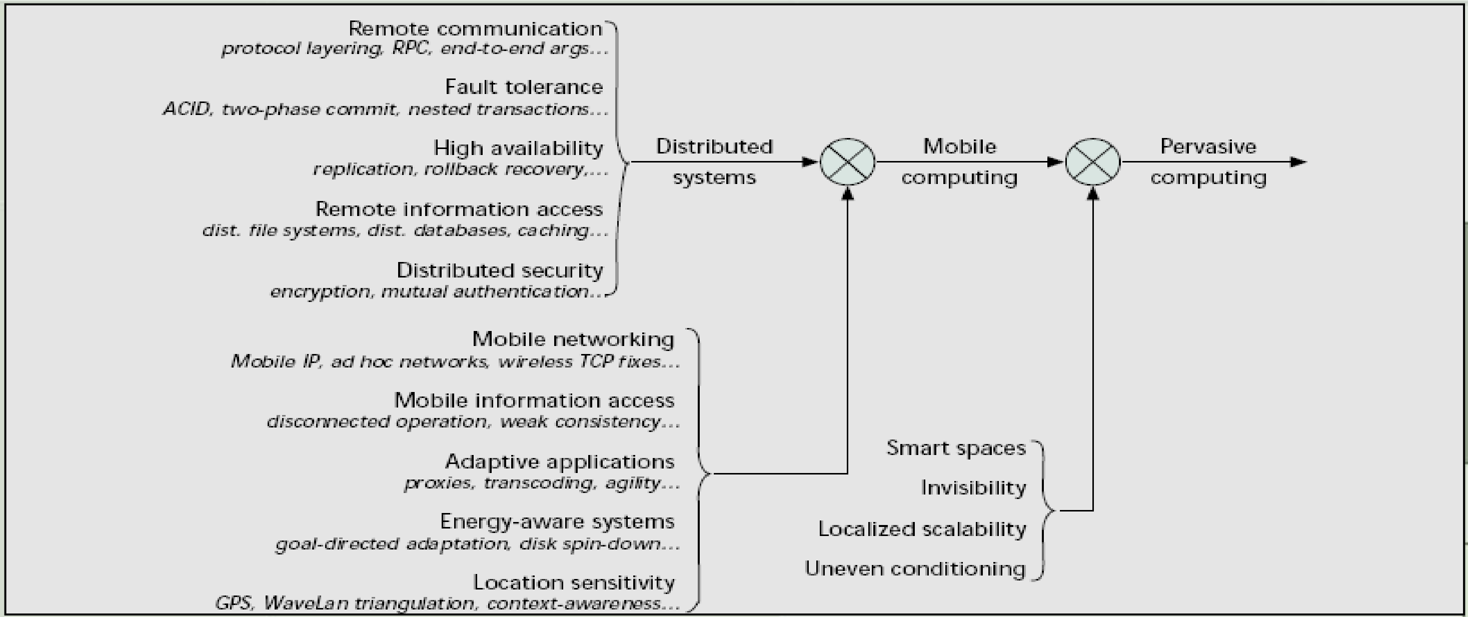
Wieser's Vision

- "The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it. "[1]
- "Its essence was the creation of environments saturated with computing and communication yet gracefully integrated with human users "[2]



Building Blocks



- How did Pervasive computing systems come into being?
- What is its relationship with other fields of computing?

The Ambient Intelligent World

- An Example of an Intelligent Work Place
  - Smart Space – Knows when you enter and when you have left.
  - Invisibility – Avoids distracting its occupant.
  - Localized Scalability- Reduce interactions with user if he is in conference room and not in office.
  - Masking Uneven Conditioning- Multiple modes of receiving the same information.

The role of WSN in AmI

- Xerox PARC, 1988-1994.
  - Tabs, Pads and Boards
    http://www.ubiq.com/parctab/csl9501/paper.html
  - User Friendly interfaces only
- WSN
  - Detailed Context
  - Self-* Properties

Overview

- Kris Pister an EECS professor at UC Berkeley coined the phrase “smart dust” to describe individual sensor nodes:
  - Small size with a small footprint (HW\SW).
  - Monitor Environment.
  - Wireless transmission.
  - Self-Configuring and Dynamic Routing.

MICAz Processor and Radio Platform (MPR2400)

Processor/Radio Board	MPR2400CA	Remarks
Processor Performance		
Program Flash Memory	128K bytes	
Measurement (Serial) Flash	512K bytes	> 100,000 Measurements
Configuration EEPROM	4K bytes	
Serial Communications	UART	0-3V transmission levels
Analog to Digital Converter	10 bit ADC	8 channel, 0-3V input
Other Interfaces	Digital I/O,I2C,SPI	
Current Draw	8 mA	Active mode
	< 15 µA	Sleep mode
RF Transceiver		
Frequency band[1]	2400 MHz to 2483.5 MHz	ISM band, programmable in 1 MHz steps
Transmit (TX) data rate	250 kbps	
RF power	-24 dBm to 0 dBm	
Receive Sensitivity	-90 dBm (min), -94 dBm (typ)	
Adjacent channel rejection	47 dB	+ 5 MHz channel spacing
	38 dB	- 5 MHz channel spacing
Outdoor Range	75 m to 100 m	1/2 wave dipole antenna, LOS
Indoor Range	20 m to 30 m	1/2 wave dipole antenna
Current Draw	19.7 mA	Receive mode
	11 mA	TX, -10 dBm
	14 mA	TX, -5 dBm
	17.4 mA	TX, 0 dBm
	20 µA	Idle mode, voltage regular on
	1 µA	Sleep mode, voltage regulator off

Crossbow Sensors

MTS 310

- Light
- Temperature
- Sound Sensor
- Dual- Axis Accelerometer
- Dual Axis Magnetometer

MTS 420

- Temperature & Humidity
- Humidity Accuracy < 3.5%
- Temperature Accuracy < 0.5 Deg. C
- Barometric Pressure
- Ambient Light Sensor
- 2-Axis Accelerometer

Crossbow Base Stations

Features	MIB 600	MIB 520
Description	Ethernet Port Programmer	USB Programmer
Mote/Board Connectors	· MICA, MICA2, MICAz · MICA2DOT (with MPC100)	· MICA, MICA2, MICAz · MICA2DOT (with MPC100)
Programming Port	Ethernet	USB
Data Port	Ethernet	USB

Background

Radio Module

Sensor node

Sensor Module

Gateway

Base Station

Basic Requirements for WSN

- Low Power Consumption
- Ease of Use
- Scalability
- Responsiveness
- Range
- Bi-Directional Communication
- Reliability
- Small Module Form Factor

Topologies

- Wireless Links – Numerous paths to Connect to the same destination
- Topology
  - Star
  - Mesh
  - Hybrid

Star Topology

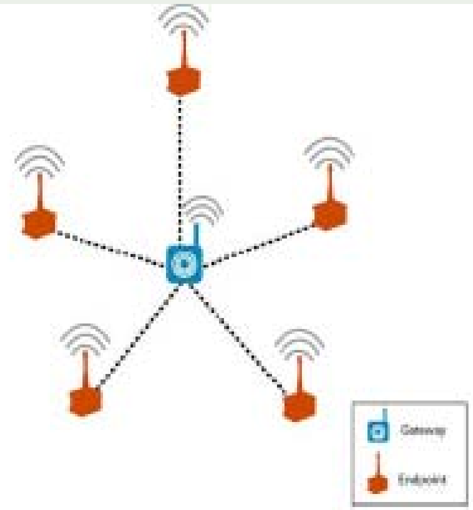


Figure 1-1. Diagram showing a Star Topology

- Single Hop to Gateway
- Gateway serves to communicate between nodes
- Nodes cannot send data to each other directly

Star Topology (Contd...)

- Pros
  - Lowest Power consumption
  - Easily Scalable
- Cons
  - Not very reliable as one point of failure
  - No alternate communication paths

Mesh Topology

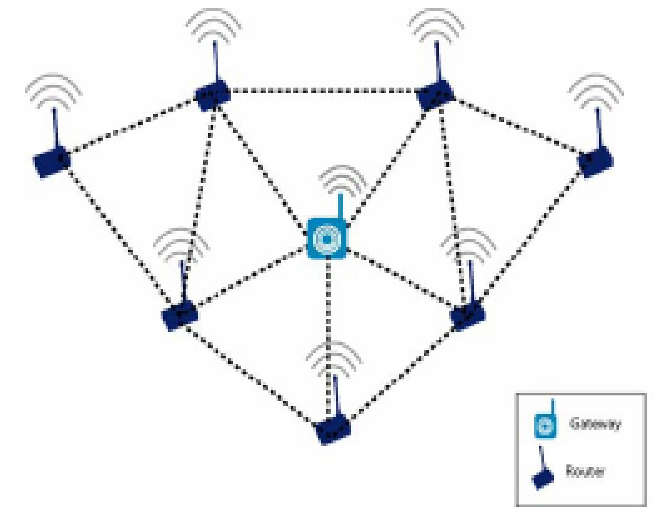


Figure 1-2. Diagram showing a Mesh Topology

- Multi-Hopping Systems
- Nodes can communicate with each other directly

Mesh Topology (Contd...)

- Pros
  - Reliable as no single point of failure
  - Many alternate communication paths
  - Easily Scalable
- Cons
  - Significantly higher power consumption
  - Increased Latency

Hybrid Topology

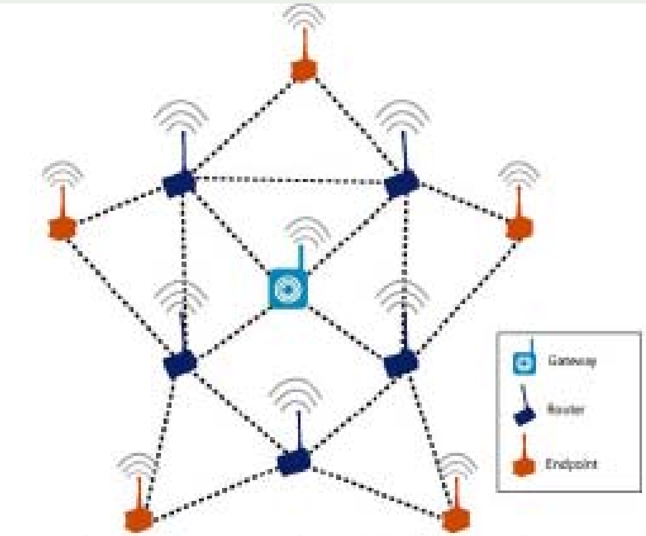


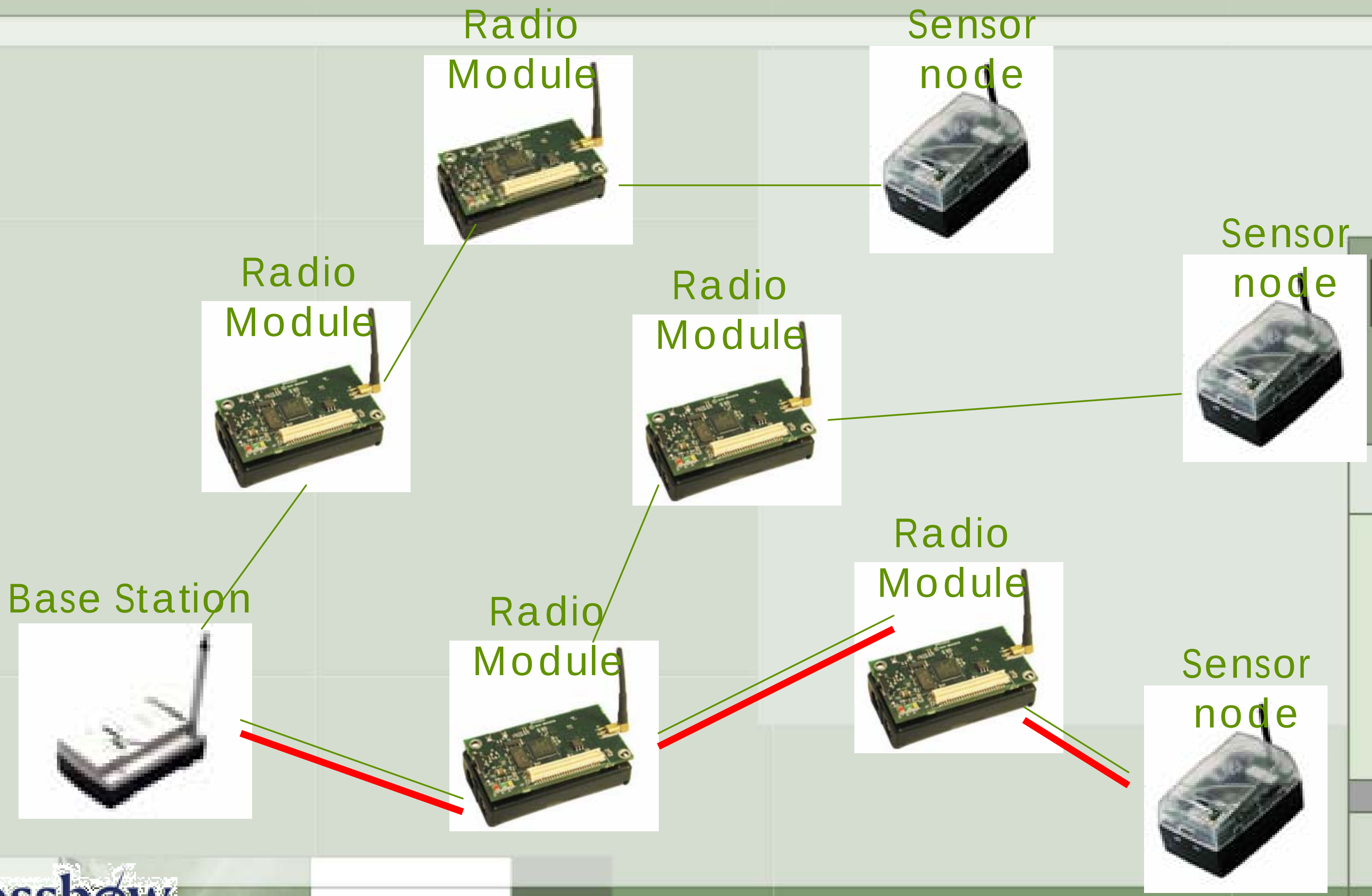
Figure 1-3. Diagram showing a Hybrid Star/Mesh Topology

- Sensors are arranged in a star topology around the routers
- The routers arrange themselves in a mesh form

Hybrid Topology (Contd…)

- Pros
  - Reliable as no single point of failure
  - Many alternate communication paths
  - Lower power consumption as compared to mesh topology
- Cons
  - Scalability becomes an issue when range is extended

Wireless Sensor Network



MoteWorks

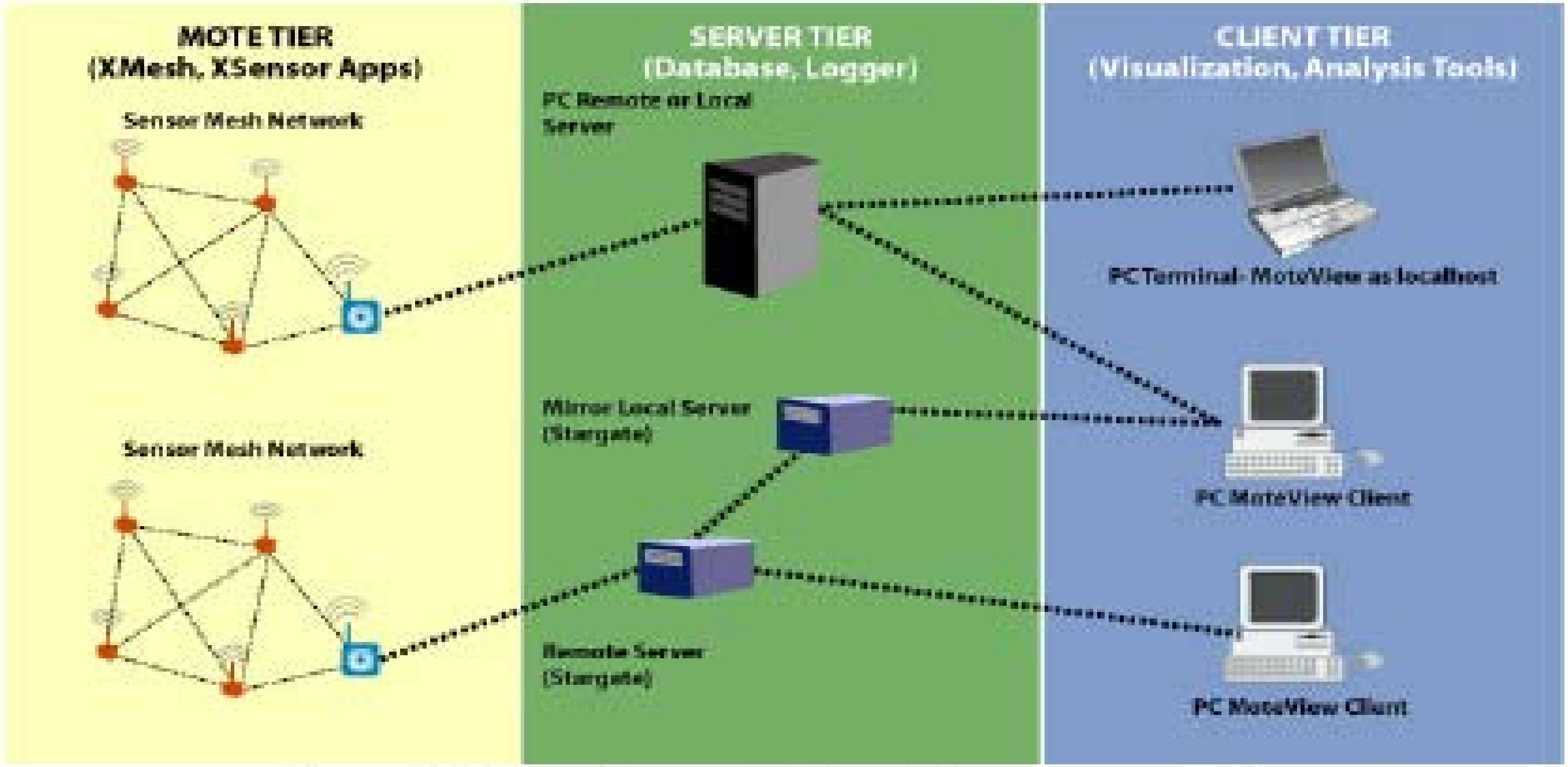
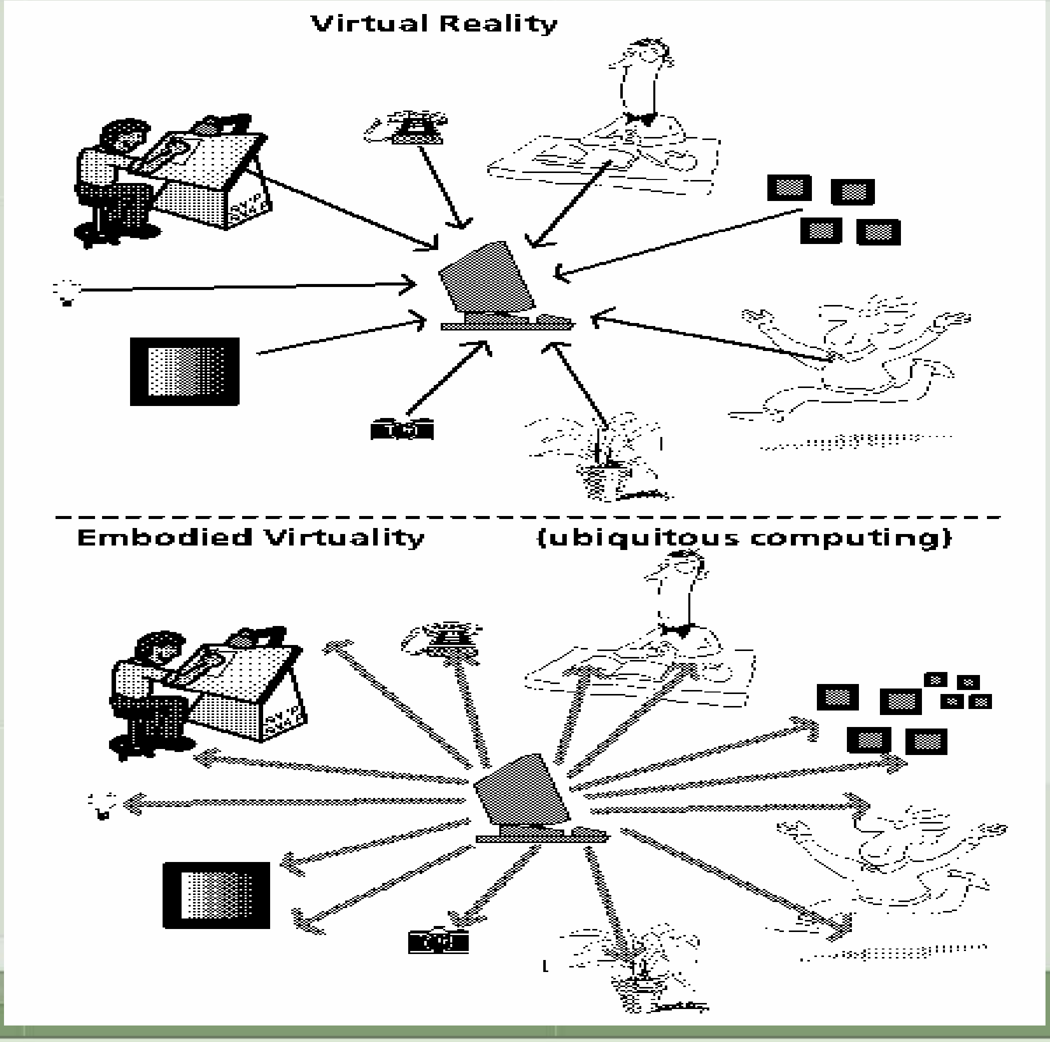
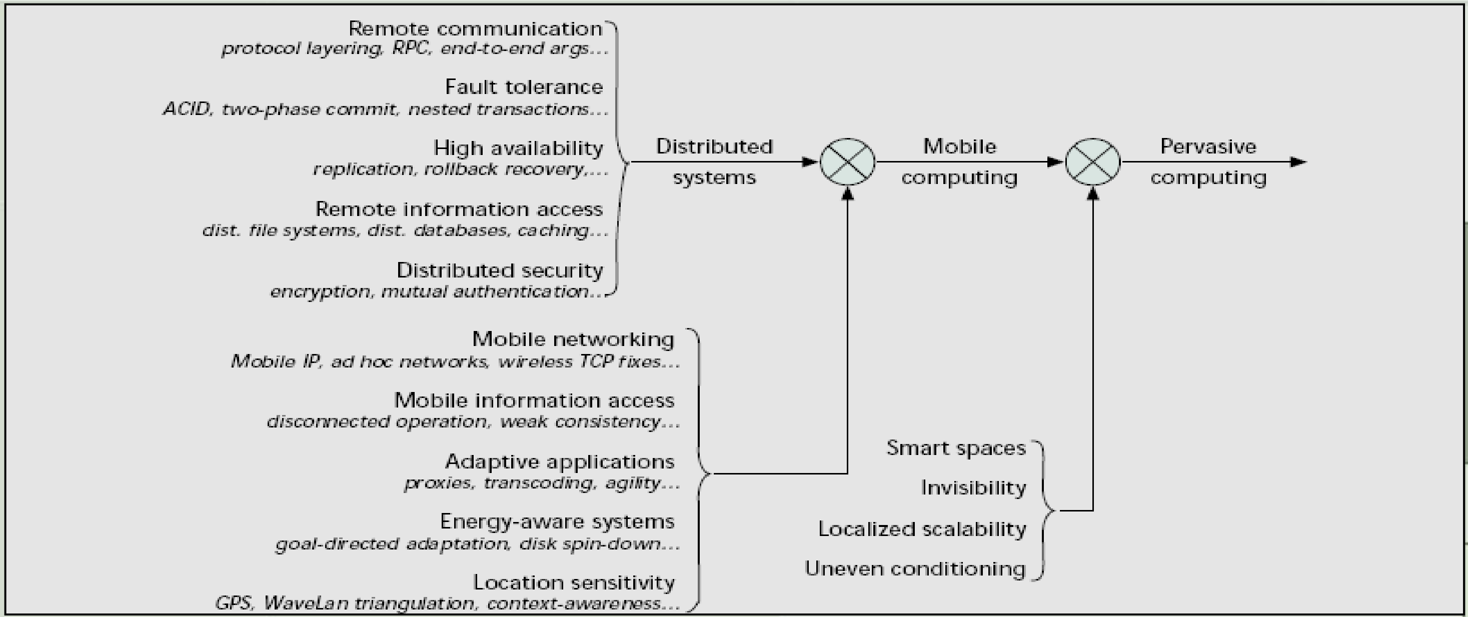


Figure 1-1. Software framework for a wireless sensor network

Virtual Reality and Ubiquitous computing



Building Blocks



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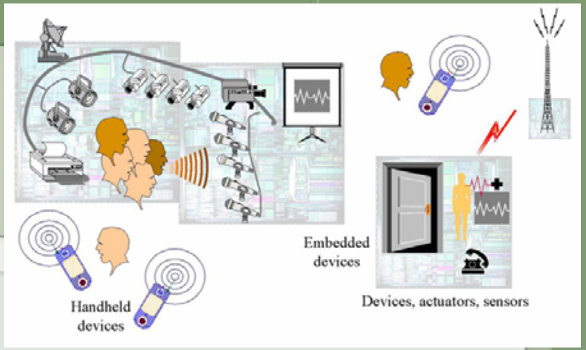
Smart Spaces

- WSN and Smart Spaces
  - iDorm and iDrom2 Project
    http://iieg.essex.ac.uk/index.htm

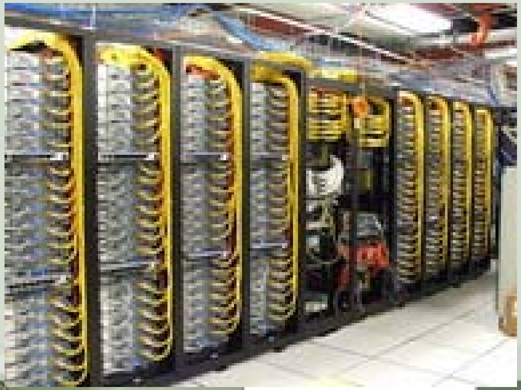
Invisibility

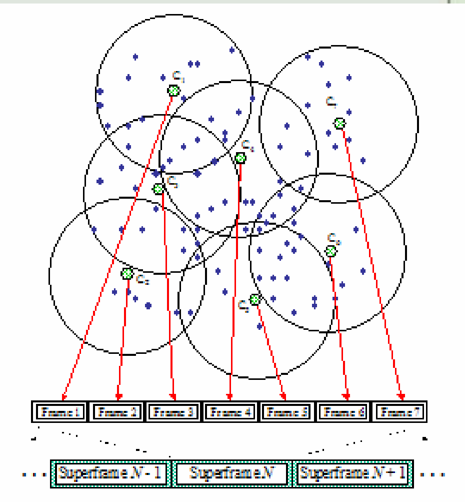


- WSN and Invisibility
  - MIT - Oxygen project
    http://www.oxygen.lcs.mit.edu/Speech.html
    http://www.oxygen.lcs.mit.edu/Vision.html
  - University of California, Berkeley - Project Endeavour
    http://endeavour.cs.berkeley.edu/related.html

Localized Scalability

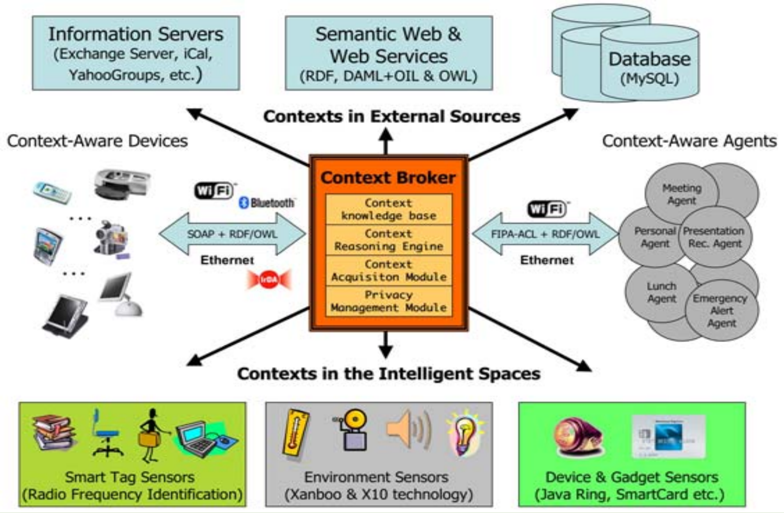
- WSN and Localized Scalability
  - UR-Wireless Communications and Networking Group http://www.ece.rochester.edu/research/wcng/
  - University of Utah – Emulab Project http://www.emulab.net/index.php3?stayhome=1



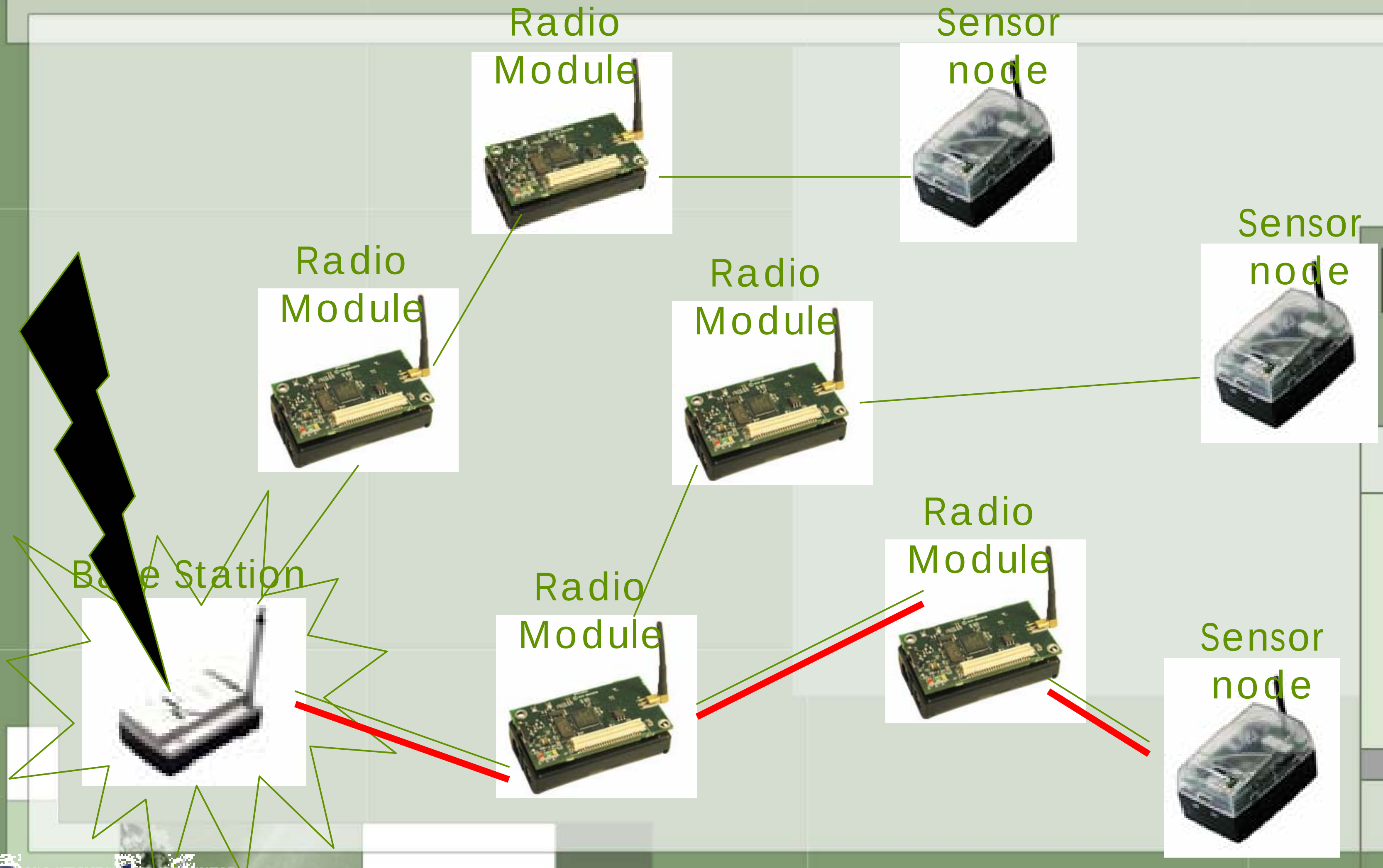


Masking uneven Conditioning

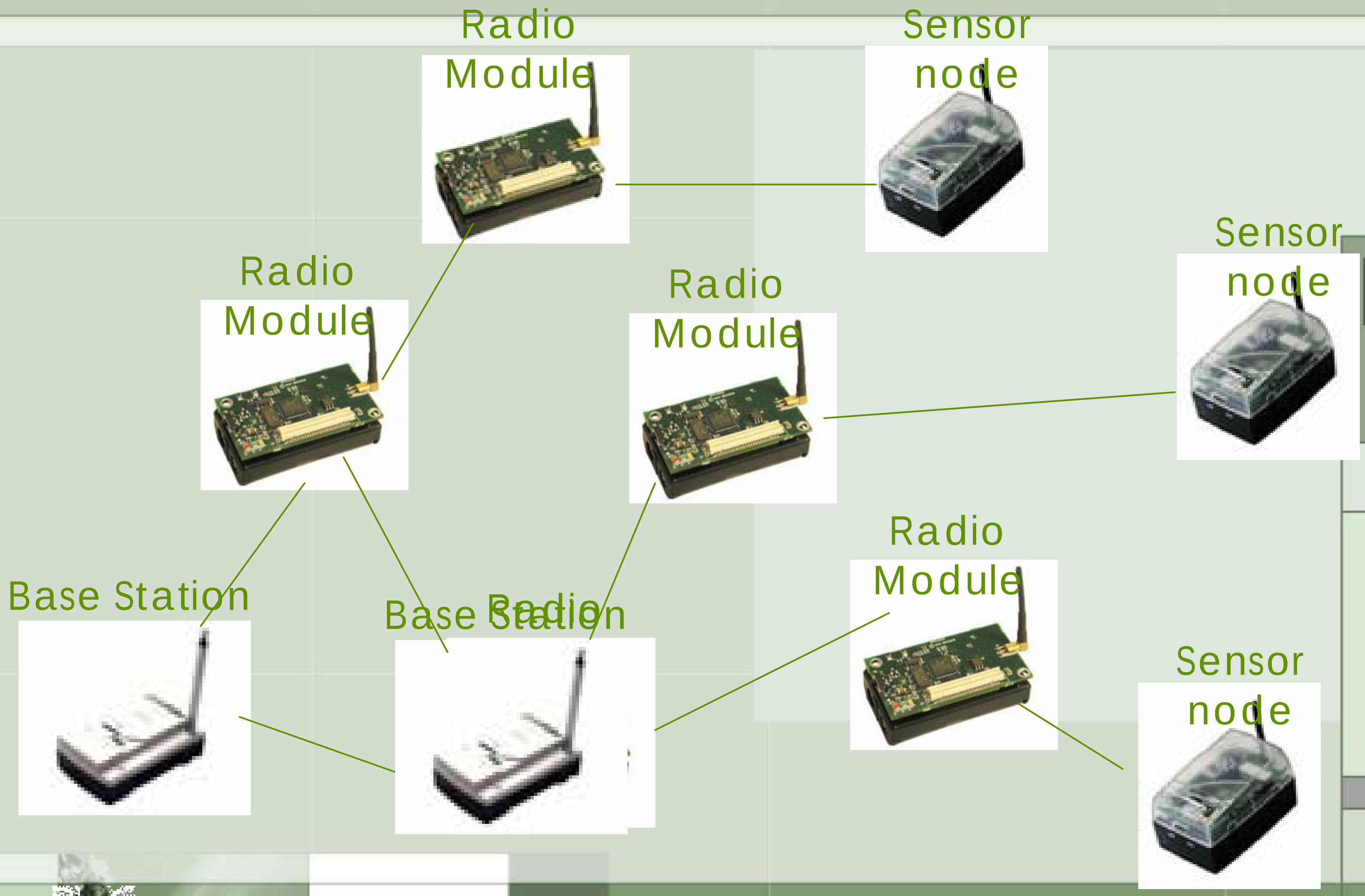
- WSN and Masking Uneven Conditioning
  - UMBC – CoBrA
    http://ebiquity.umbc.edu/project/html/id/1/Context-Broker-Architecture-CoBrA-
  - Commercial Availability of Sensors
    - Crossbow
    - MeshNetics
    - MicroStrain
    - Dust Networks



Problem


Radio Module
Sensor node
Radio Module
Radio Module
Sensor node
Base Station
Radio Module
Radio Module
Sensor node

Proposed Solution



Crossbow