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Ad Hoc Networks - Applications and System Design

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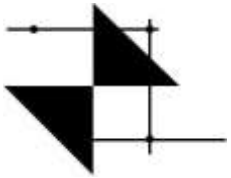
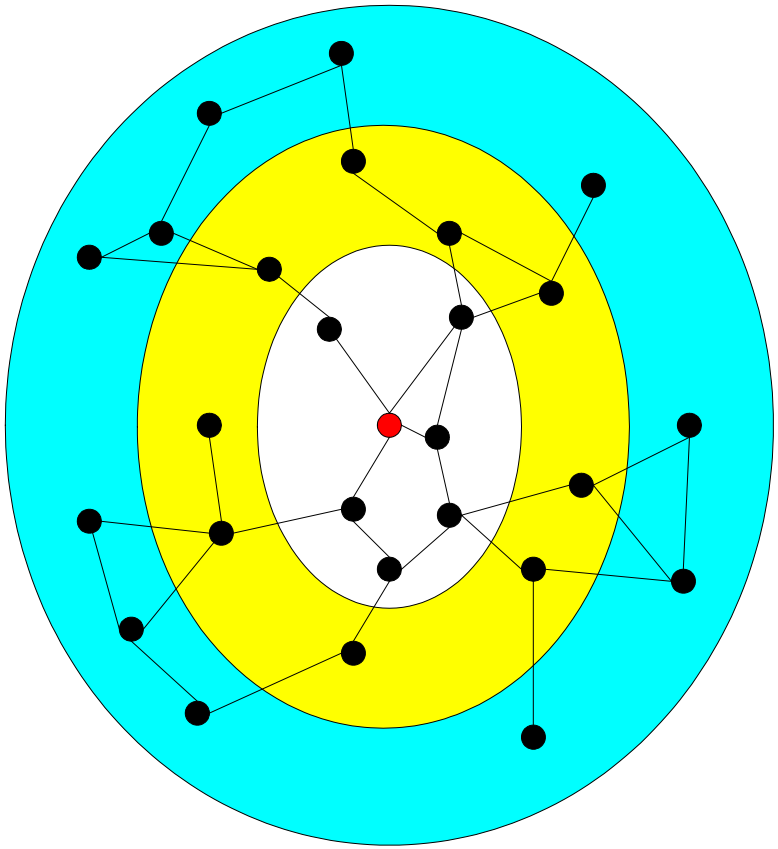


Modelling and Analysis Group of NeTworks (MAGNeT)

Ad Hoc Network - Introduction



- Nodes also act as routers
- Mobile
- Power-limited
- Peer-to-peer

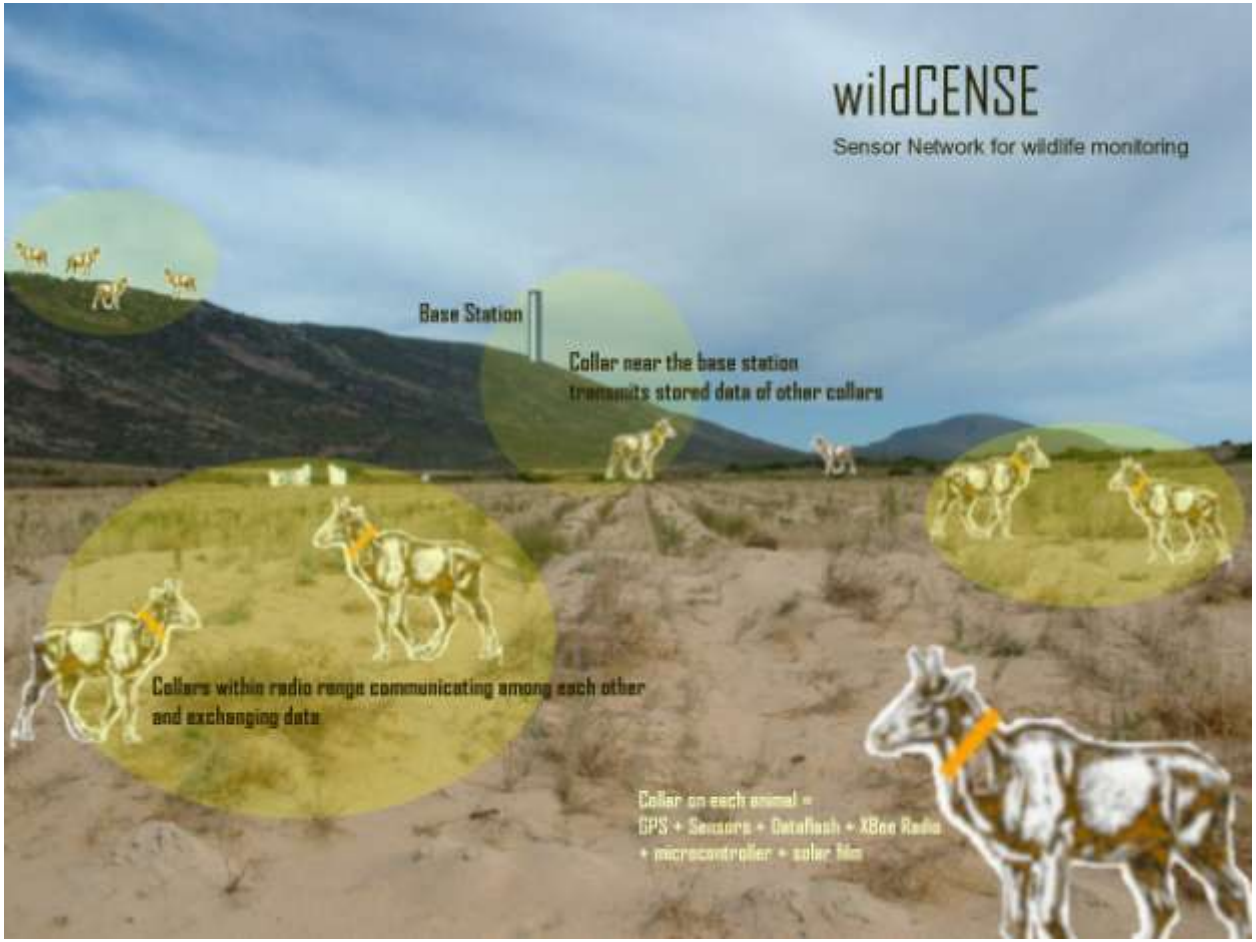
Ad Hoc Network Node - Introduction

- Radio Receiver and Transmitter
- Power Supply
- Mobility Module
- Sensing Module(s)
- Controller/Processor
  - Message Processing, Forwarding
  - Network Control Tasks - Routing

Ad Hoc Network Applications

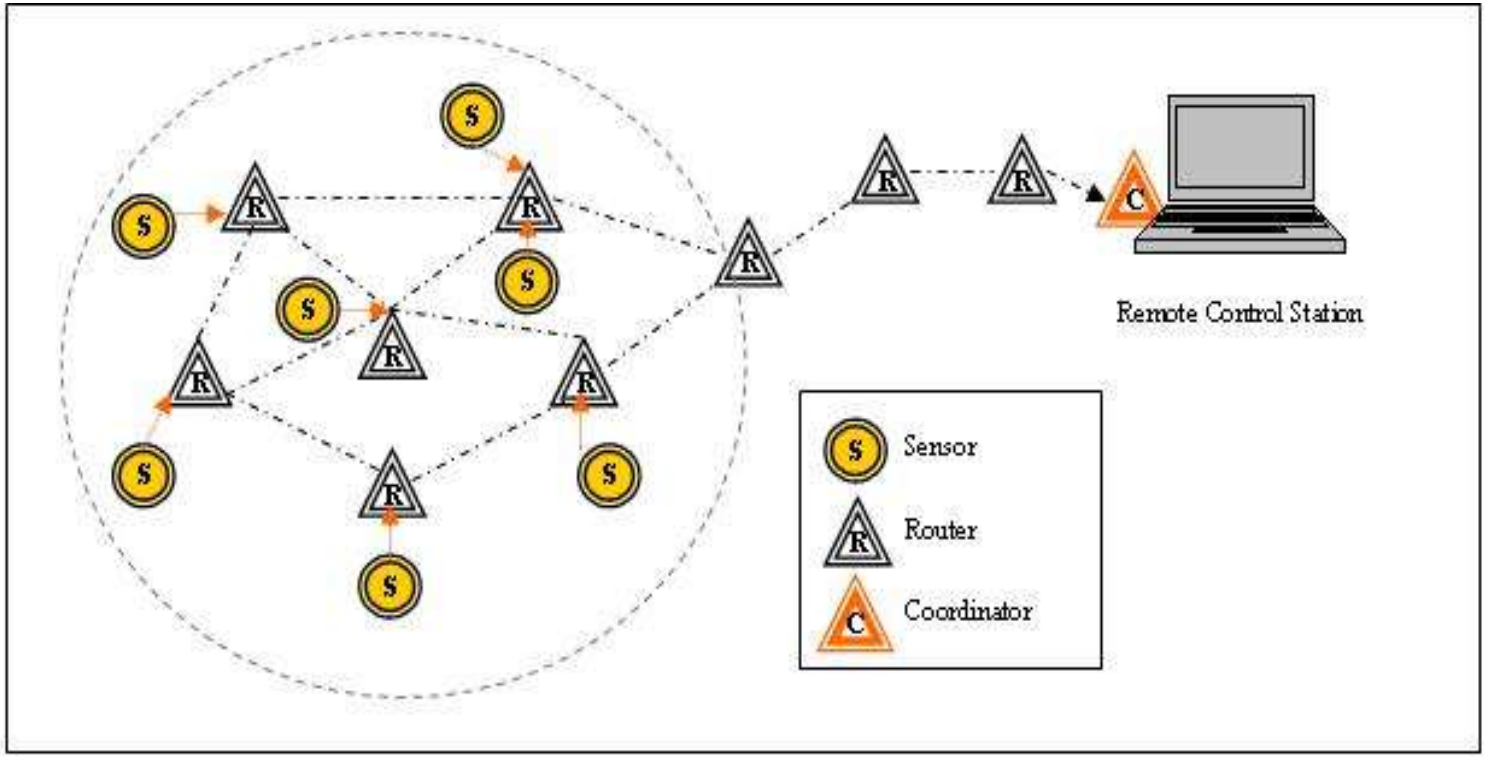
- Wild Life Monitoring
- Precision Agriculture
- Disaster Management Support
- Smart Vehicle, Transport
- Defense Applications
- Pervasive Application

Wild Life Monitoring – WildCENSE



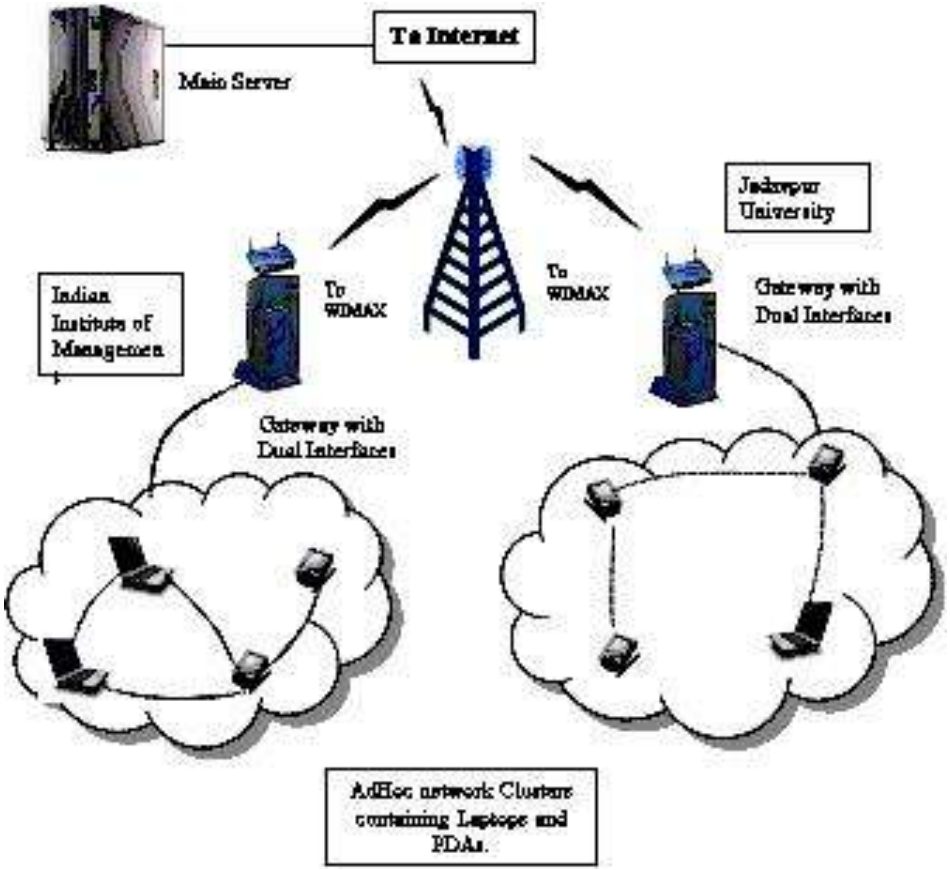
Courtesy: Prof Prabhat Ranjan, DAIICT

Precision Agriculture using sensor based Wireless Mesh Networks



Courtesy: IIM, Calcutta

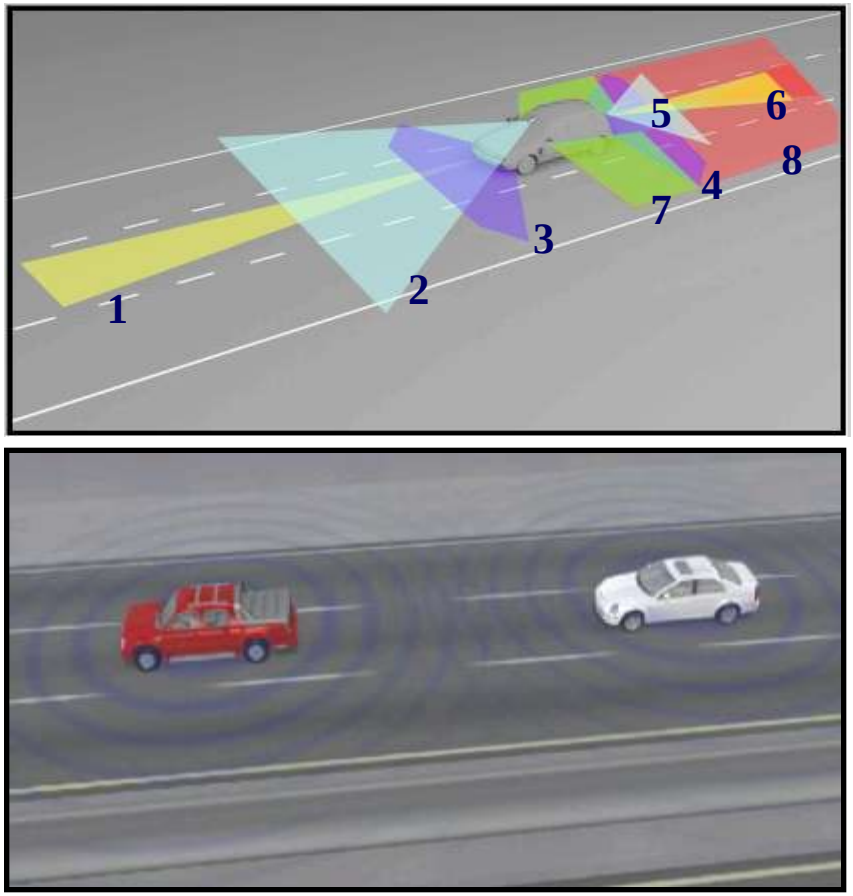
Secure Decentralized Disaster Management



Courtesy: IIM, Calcutta

Vehicular Area Networks – Collision Warning

- **Traditional sensors are not very effective**
  - Limited range, Limited Field
- **Vehicle Mounted Sensors and inter-vehicle communication network can be very effective**
  - Does not depend on road based devices



Courtesy: HRL Lab. ACM VANET 2006

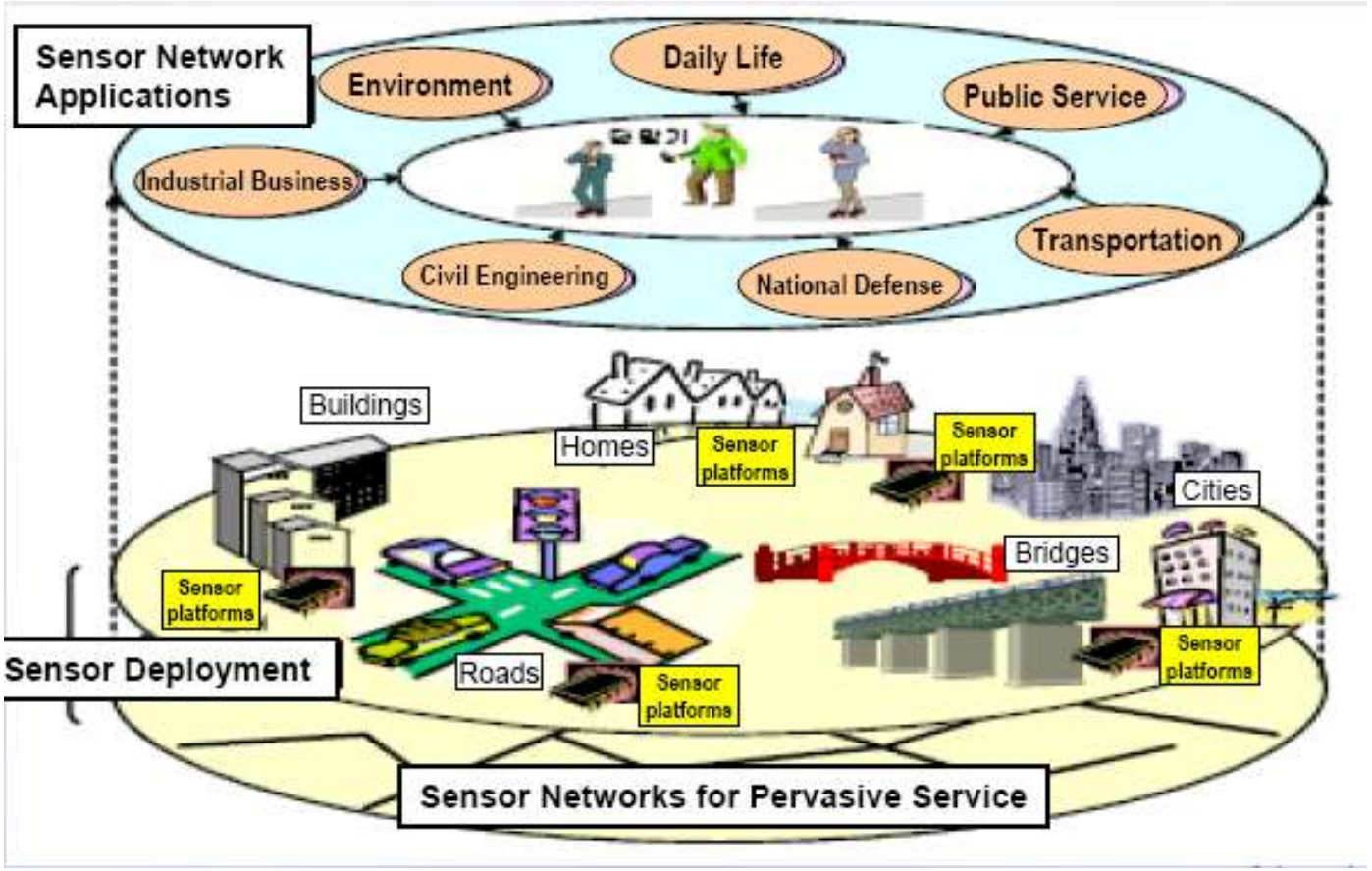
Military Network Requirements

Tactical
Wireless
Mobile Ad hoc
Network

- Radio Silence Zone
  - Event based Communication
  - Bad news gets priority
- Communication on the Move
  - Military personnel in the field
  - Tanks & Helicopters on maneuvers
  - Ships at sea
- Wireless Ad hoc Nets
  - Combat Network Radios
  - SATCOM On The Move (SOTM)

Courtesy: Mk Dhaka, DEAL, Dehradun

Pervasive Computing - Sensor Network



Excerpted from Ubiquitous City Plans, Korea 2005

Ad Hoc Networks - Technology

- Embedded Devices
  - Sensors
  - Wearable Computers
  - Cell phones, Smart PDAs
- Connectivity
  - Wireless – cellular
  - Wireless – Ad Hoc Networks
- Mobility
  - Nomadic
  - Vehicular

Schematic of a Sensor Node

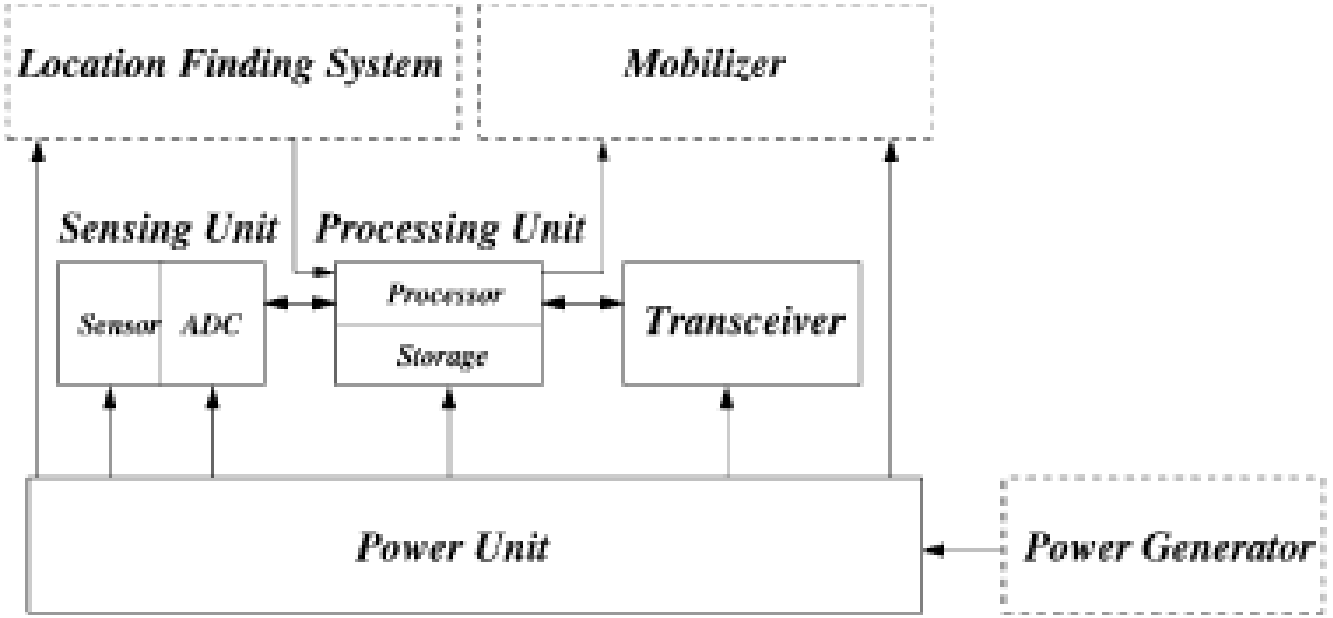


Fig. 1. The components of a sensor node.

Wireless Bands, Data Rates

- GSM phone 9.6 Kbps
- GPRS typical 28Kbps, theoretical 172Kbps max

- Wireless LAN IEEE 802.11b (WiFi) 200 m range
- 2.4 Ghz band: 2-54 Mbps

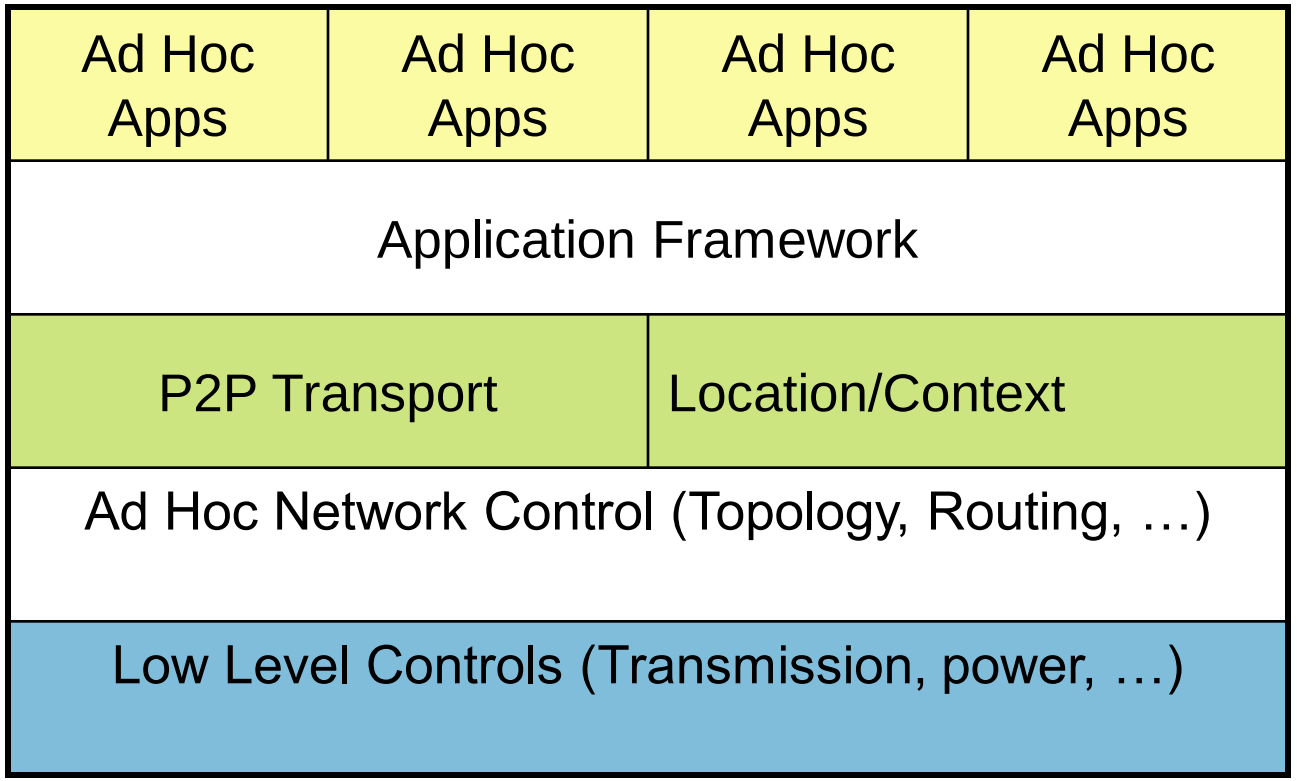
- Bluetooth 10 m range
- 2.4 Ghz band: 1 data (700 kbps) & 3 voice channels

- UMTS – 3G mobile
- 114 kbps (vehicle), 384 Kbps (pedestrian), 2 Mbps (stationary)

Ad Hoc Sensor Networks

- Ad Hoc - Network without Infrastructure
- Sensor – nodes with sensing and communication
  - Temperature, light, pollution
  - Seismic
  - Acceleration etc
- Sensor Network – Embedded devices with both sensing and communication capabilities
  - Can form peer to peer network

Ad Hoc Application Architecture



Ad Hoc Network Design -Factors

- Fault Tolerance
- Scalability
- Hardware Constrains
- Network Topology – Deployment Issues
- Transmission Media
- Power Consumption

Ad Hoc Network Design Issues - Common

- **Node Level**
  - Transmission Characteristics
  - Antenna Design
  - Power Conservation Issues
  - Sharing of Medium

- **Network Level**
- Network Topology – Control
- Routing Issues
- Load Balancing
- Security and Privacy

Design Issues - WildCENCE

- **Node Level**
  - Weight
  - Choice of sensors
  - Radio Range
  - Power Consumption
  - Robustness –Environment
- **Network**
  - Data Exchange and Aggregation
    - Data exchange among animals, aggregation at each node
  - Data Flushing
    - Difficult problem

Applications of VANETs

- **Typical Applications:**
  - **Collision Avoidance,**
  - **Traffic Monitoring, Pollution Monitoring**
  - **Electric Recharge Management**

- **Intelligent Transport System (ITS)**
  - Inter-Vehicle Communication (IVC) Apps
    - Collision avoidance
  - Roadside-to-Vehicle Communication (RVC) Apps
    - Traffic Monitoring

Design Issues - VANETs

- Message Latency
  - For effective collision avoidance, latency must be very low. Of the order of ~1s
- Message Priority
  - For implementing real time applications
- Security and Data Integrity
  - For prevention of mischief

Pervasive Computing - Applications

- Embedded Network Devices + Mobility + Intelligent Environment => Pervasive Computing

- Distributed Object Finder
- Embedded Social Network
- Campus Infrastructure Planning
- Group Tracking

Pervasive Computing - Context

- Current location
  - location detection eg using GPS
- User activity
  - Walking, driving etc.

- Ambient environment
  - theatre, Mall, Meeting etc

- Local resources
  - Device capabilities

Pervasive Computing Framework

- System
  - Handsets with p2p capabilities – bluetooth or wifi
    - Iphone, Gphone, other smart handsets
  - Sensing – GPS, Camera, Accelerometer …
  - Developer Environment – Symbian OS, JavaMobile, Windows Mobile

- Social Network
  - Community – academic campus
  - p2-p cooperative network
  - Server for collating information
  - applications

Pervasive Computing – Design Issues

- Social Issues
  - Cooperation and Incentives
- Privacy
  - Notion of K-anonymity
- Security and Authentication
  - Malicious Behaviour

End of Part I

Questions?

Questions that come to mind? - Nodes

- Behaviour of transmitter, receiver
  - Medium, environment, other emitters
  - Radio range as a function of transmitted power r(p)
- How to conserve energy of the node
  - Embedded controller architecture
  - Real time OS issues
  - Distributed processing of date
- Very cheap nodes
  - At the cost of high failure rate?

Questions that come to mind? - Topology

- **Topology Issues**
  - Connectivity is a function of transmission power (goes up)
  - Routing performance is a function of connectivity (improves)
  - Throughput (think contention) – (deteriorates)
  - Node Life time (goes down with power)
  - Deployment Flexibility – (connectivity is controllable)

Questions that come to mind? - Routing

- **Routing Issues**
  - Mobility Induced problems
    - Links break, Neighbourhood changes
  - Reduce overhead or improve performance
    - Performance
      - low delay
      - high delivery ratio
      - Robustness to mobility
  - Routing + Data Aggregation - Tree

Questions that come to mind? – Pervasive Computing

- **Context Generation**
- **Context obfuscation**
- **Cooperation**