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* Wireless Sensor Network

- 17/01/2023
- 18/01/2023
- 19/01/2023
- 24/01/2023
- 01/02/2023
- 02/02/2023
- 07/02/2023
- 08/02/2023
- 09/02/2023
- 23/02/2023
- 28/02/2023
- 01/03/2023

CS442

WIRELESS SENSOR NETWORK

17/01/2023

* Syllabus:
  - Introduction
  - Wireless fundamentals
  - Standards - Imp
  - Medium Access Control
  - Network layer / Routing
  - Localization - Assignment (wont come for Exam)
  - Application
  - ...

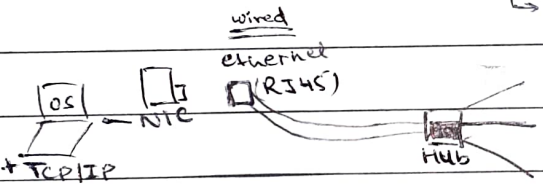
  Mid Sem | End Sem

Mid sem: 30 ; End sem: 50 ; Sessional: 20.
- → Class Test/Minor: 10
- → Class Performance: 10

Books:
Williams Stalling, Wireless Communications and Networks,
T.S. Rappaport, Wireless Comm: Principles and Practices.

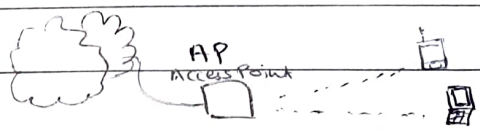
Unit 1

- Introduction: Sensor Network is composed of a large number of sensor nodes, which are densly deployed either inside the phenomenon or very close to it.
  - → Random Deployment (mostly)
  - → Cooperative capabilities.

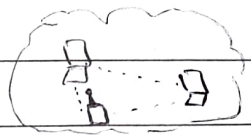


- wifi (802.11)
- bluetooth (802.15.1)
- Infra red

Infrastructure :→



Infrastructureless : → (Adhoc)



Mobile Adhoc Network
(MANET)
Wireless Sensor Network
(WSN)

Wired Network is ALWAYS infrastructured.
Wireless Network can be infrastructured or infrastructureless.

MANET : Battery can be recharged. (25-500 nodes)
WSN : Battery cannot be recharged. if battery is discharged, the network device will be disposed. (Thousands of nodes 1000+)
Not economical to recharge, hence disposed.

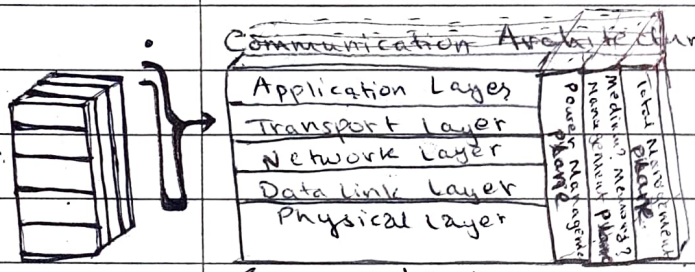
__/__/____

- WSN works as the perception layer for IoT networks.
- WSN Architecture: Diagram (User, Sink node, Event, Sensor Node, Monitored Area).
- Sensor Network: One sink node and many sensor nodes.
- Architecture of Sensor Node.: sensing ~~Node~~ Unit
  Processing Unit
  Power Unit
  Transceiver Unit
  Additional Units
- Static Sensor: Example: MICA2 (first commercial sensor).
- Sensor Node Platform Software: OS: TinyOS, TinyDB etc.
  Programming lang.:
- Applications of WSN.
- Difference of WSN with other networks: - Sensor Network vs Adhoc Network
- Factors influencing Sensor network Design.

18/01/2023

- Factors influencing Sensor Network Design
  - Fault Tolerance
  - Scalability
  - Production Cost
  - Hardware Constraint
  - Sensor Network Topology
  - Target Environment
  - Transmission Media
  - Power Consumption
- Direct connection and Multihop connection/communication
- Density = $\mu(R) = (N\pi R^2)/A$ (R → Radio Transmission Range)

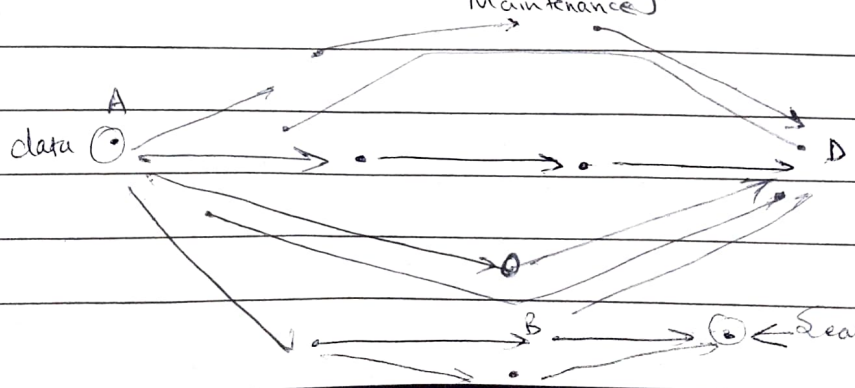
- ~~Communication Architecture~~ of Sensor Networks.



Sensor Network Protocol Stack

19/01/2023

Routing - → Route Discovery
→ ~~Route~~ Route Maintaining?
Maintenance



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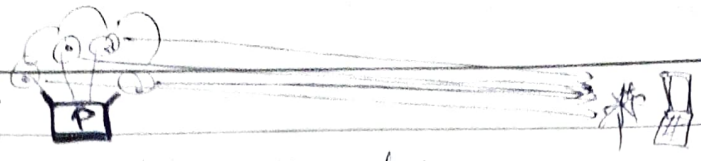
co-related: 

Co-related. energy efficient.

- Transport layer : TCP
  UDP
- Application layer : SMP TADAP
  SQDBP
- Deployment : Random Deployment
  Mobile Sensors
- Query Pattern of the WSN → Periodic
  Event driven

* • COMMUNICATIONS : QUERY PATTERN

- LOCALISATION
- DATA GATHERING
- Barrier Coverage, Target coverage, Target Tracking, Navigation,
- UNDERWATER WSN

COMPLETION OF UNIT ONE . G-Class. Recommended

WSN book (Kaul): Ch. 1, 2.
Papers : WSN-A Survey

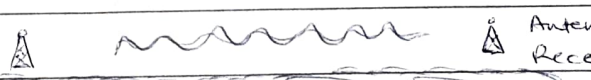
Unit 2

24/01/2023

- Antennas, propagation, path loss, digital radio comm. RF spectrum, Modulation, 2-ray model, others. (Wireless Fundamentals).

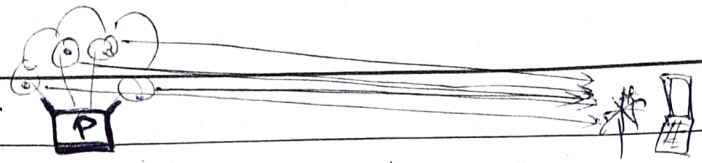
WL LAN PAN - { 802.11 wifi
802.15 Bluetooth 802.3 802.5

MAN - 802.16

- Wired v/s Wireless Networks.
  - Regulations of frequencies
  - Bandwidth and delays.
  - Always shared Medium
  -
- Wireless Link Characteristics
- Wireless Technology Landscape.
- OSI Reference Vs. Wireless Networks
- RF Basics. : RF Spectrum
  WL = Radio
- ~~wireless~~ Factors affecting Wireless ~~System~~ Design.
- CSMA/CD - Carrier ~~Sensed~~ Shells? Collision Detection.
  CSMA/CA ✓ for WSN
  (ALOHA, CSMA, CSMA/CD, CSMA/CA,) for wireless, cannot used CSMA/CD.
- Wireless Transmission. Antenna Transmitter  Antenna Receiver

Transmitter: Source → Amplifier → Mixer → Filter → Amplifier → Antenna
Oscillator
TRANSMITTER

__/__/____



co-related:

∴ Co-related. energy efficient.

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  (ALOHA, CSMA, CSMA/CD, CSMA/CA,) for wireless, cannot used CSMA/CD.
- Wireless Transmission. Antenna Transmitter  Antenna Receiver 

Transmitter: Source → Amplifier → Mixer → Filter → Amplifier → Antenna
Oscillator
TRANSMITTER

__/__/____

- Antennas: Electrical conductor or system of conductors to send/receive RF signals.
  - Omnidirectional → Lower freq.
  - Directional → Higher freq.

  Antenna: isotropic radiator.
  Antenna: simple dipoles.
- Directional Communication: Received Power ∝ (Transmit Power) * (Tx Gain) * (R_x Gain)

  Directional Gain is higher.
- Antennas: diversity

31/01/2023

- Wireless Communication Fundamentals.

Book Suggestions:
Tolkiens ?
Rowlings ?

- Line of Sight Communication:
- Multipath ? Multiple?
- ? Path-Cost formula ?

Two path / Three Path Models ? Modules ?

- Power Transmitted
- Power Gain
- Height of Transmitter
- Path

01/02/2023

Signal Attenuation:
- Path loss Exponents for Different Environments.
- Models derived from Empirical Measurements.

Review - Attenuation, Fading.

- Fading
  - Doppler Spread
  - Multipath
- Noise
  - Thermal
  - Intermodulation
  - Crosstalk
  - Impulse Noise.

02/02/2023

Channel Correction Techniques.
- Examples of Analog and Digital data.
- Analog and Digital Signals.
- Channel capacity
- Modulation
  - Digital Modulation
  - Analog Modulation
  - Motivation
  - Basic Schemes
    - Amplitude Modulation
    - Frequency Modulation
    - Wavelength Modulation.
    - ? Phase ?
- MODEM

- Shift Keying:
  - → Amplitude Shift Keying (ASK)
  - → Binary Frequency-Shift Keying (BFSK)
  - → Multiple Frequency Shift Keying (MFSK)
  - FSK: Frequency Shift Keying
  - Phase Shift Keying (PSK)

07/02/2023

- frequency domain concept
- Modem
- Encoding Techniques
- Multiplexing
- CDMA
- OFDM
- Spread spectrum Technology.

* OFDM (orthogonal Frequency Division Multiplexing).

+ t, f, c, space, OFDM
Sync, GB, Others

→ AKa multicarrier modulation
→ Start with a data stream of R bps.
→ Splits into N parallel data streams.

GSM → CDMA
No. of codes
↓ capacity.

Rel. Communication (Anil Ambani)

Jio (Mukesh) → OFDM

3G, GSM
↓ ↑ easy to switch
4G

- Orthogonality:
  - Spacing of f_b frequencies allows tighter packing of signals.
  - Choice of f_b is related to bit rate to make the signals orthogonal.
  - Traditional FDM makes signals completely avoid frequency overlap.
    - OFDM allows overlap which greatly increases capacity.

- Benefits of OFDM → Frequency selective fading only affects some subcarriers
  → overcomes intersymbol interference (ISI).
- OFDM Applications → OFDM created great expansion in wireless networks.

* Spread Spectrum: → Problem of Radio transmission & solution.
  → Side effects and Alternatives.

→ DSSS → Direct sequence Spread Spectrum – 802.11
→ FHSS → Frequency Hopping Spread spectrum – BT, GSM, wifi, 4G

- Spread Spectrum Technique

- DSSS : CDMA – Basic Principles of CDMA
  – CDMA Example.
  ↳ DSSS Transmit / Receive

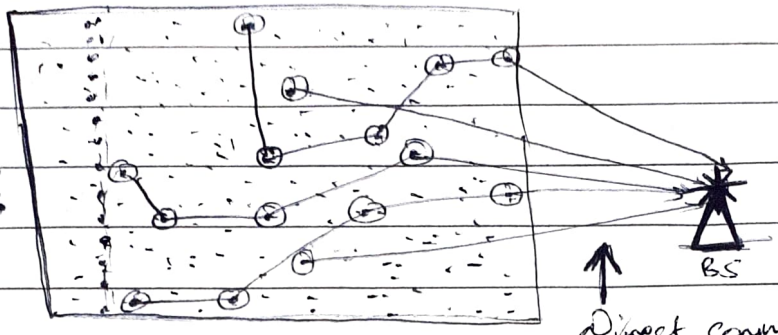
Direct Sequence

- Al Bates Founder Series: Mother of wireless Technology – Hedy Lamarr
- FHSS – Transmit / Receive
- Forward Error Correction.

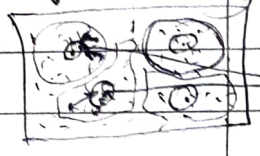
08/02/2023

TP Assignment.

Area of Interest, AOI



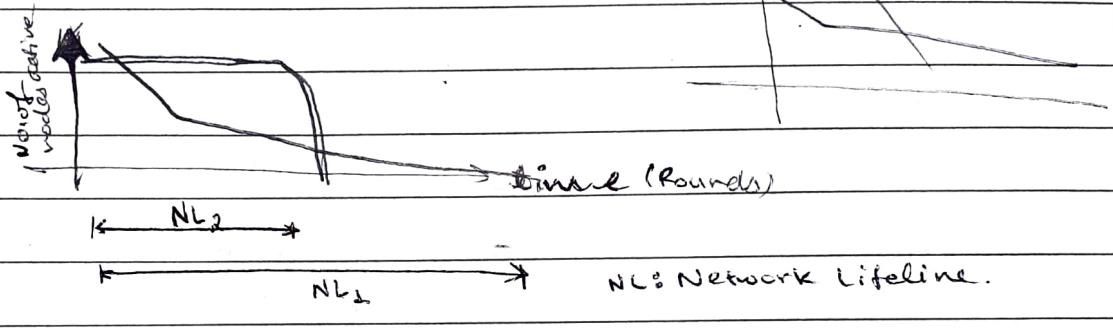
Hierarchical Routing



Direct communication.

Problem

"Energy Hole"



Flat ✗
DVR ✗
LSR ✗

① "Energy Hole"
② Non Uniform Energy Usage

WHY

WHAT

WHT

- Clustering → How to form the efficient cluster
  → How to select CH efficiency.

"LEACH"

- Reception
- Chain based ✗ Cluster based
- Load balanced clustering / Routing

Mule-based clustering and Routing

Heterog... ?

- Clustering & Routing;

Cluster based	Chain based	Mule based	Load balanced
Clustering and Routing			

1 PPt; 10 slides per group

either or → only one topic per group.

10 diff protocol, 1 protocol per student / member.

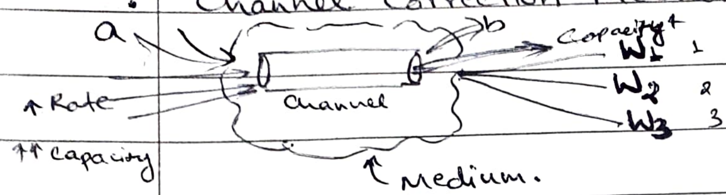
No need of equations; fundamentals required.

09 / 02 / 2023

Unit-2 - Recommend Reading.
See in G-drive following PDF:
Stalling's book
Rappel's book
. . . . 's book

~~• Bit level error detection/~~

• Channel Correction Mechanisms

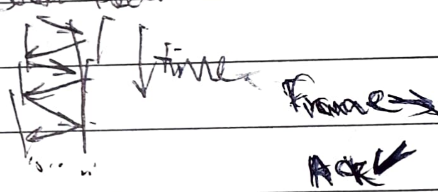


[a≠b] error —— detection
correction

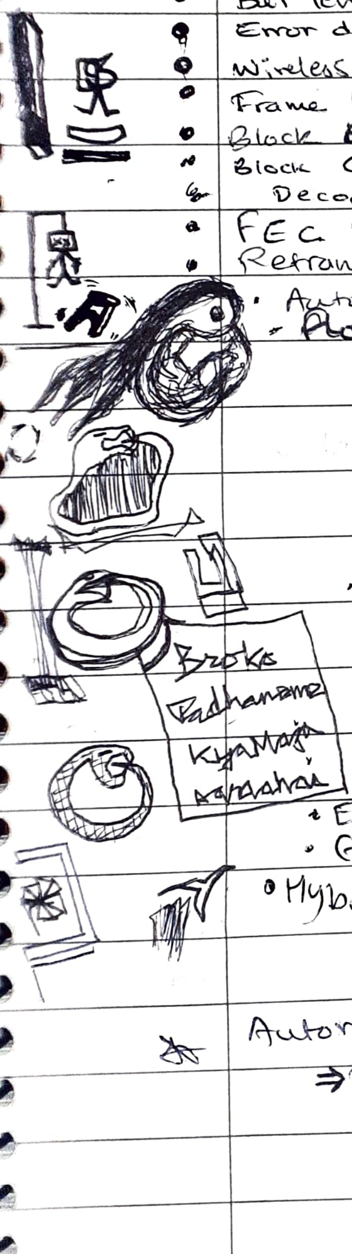
• Bit level error detection/correction.
• Error detection Phase/Process.
• Wireless Transmission Errors.
• Frame level error correction → Forward Error Correction (FEC)
→ Automatic Repeat Request (ARQ)
• Block Error Correction Codes.
• Block Code Principles
• Decoding Process.
• FEC Decoder outcomes
• Retransmission required.
• Automatic Repeat Request
• Flow control.

IDC! END ME

• Stop and Wait ARQ.
Sliding window Protocol.
Sliding Window Depiction

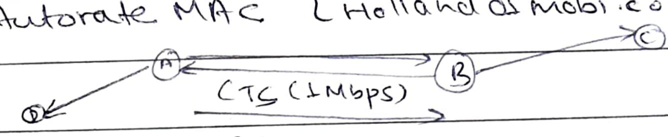


• Example of Sliding Window ARQ Protocol
• Error Control
• Go-back-N ARQ
• Hybrid ARQ



23/02/2023.

Autorate fallback!
⇒ Receiver Based Autorate MAC [Holland@mobi.com]



⇒ Channel correction Mechanisms

• Adaptive Equalisation.
• Diversity Techniques → selection - select best signal
→ Combining - Combine all signals

__/__/____

- Multiple input Multiple Output (MIMO) antennas
  - Use Antenna Arrays for
    - Diversity
    - Multiple Streams
    - Beamforming
    - Multi-user MIMO
- Bandwidth Expansion.

28/02/2023

Unit-3

Wireless LAN Standard. → 802.11

Low power WLAN ----------→ 802.15

↳ 802.15.1
↳ 802.15.4

Standards

IEEE : 802.1 → 802.11, 802.15, 802.16

802.1	802.2	802.3	802.4	802.5	802.6	802.7	...
overview Architecture	Logical Link Control	Ethernet	Token Bus	Token Ring			

LAN/Wired.

802.11 wifi, WLAN — 802.15 PAN — 802.16

Wireless

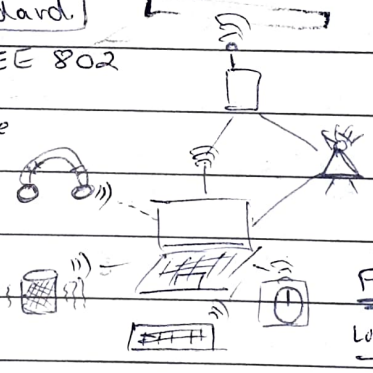
Interface, Protocol, Standard.

IEEE 802

- 802.15.1 → Bluetooth
- This is the future → 802.15.4 → ZigBee

IoT

Smarthome



* Wireless Network
  - → Base Station or Access Point
  - → Infrastructure oriented
  - → Infrastructureless (Adhoc)

Changes in Physical Layer and Data link layer (OSI model) when moving from wired to wireless Standard.

CSMA/CA
↳ DCA

* IEEE 802.11 :

- Architecture → Infrastructure
  → Infrastructureless (Adhoc)
- Component ① → Station (any device having 802.11)
  - ② → Access Point (Base station; either fixed or mobile)
  - ③ → Basic Service Set (basic service set, BSS)
    - ↳ Independent BSS (IBSS) (simple BSS)
  - ④ → Extended Service Set (ESS)
  - ⑤ → Distribution System (DS)
  - ⑥ Portal

__/__/____

MAC:

IEEE 802.11 → DCF (Distributed coordination function) } Two variants
→ PCF (Point Coordination function)
↳ Adhoc

• MAC of 802.11
↳ ALOHA Protocol
↳ CSMA Protocol
↳ 1 → continuous channel
↳ Persistant channel
↳ np → non persistant channel

Collison Detection → CSMA/CD Protocol } → Good for wired network; but not for wireless network
Collison Avoidance → CSMA/CA

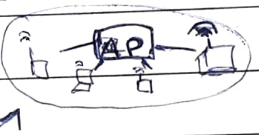
↳ Two problems in wireless Network
(i) Hidden Terminal Problem
(ii) Exposed Terminal Problem.

Solve using CSMA/CA

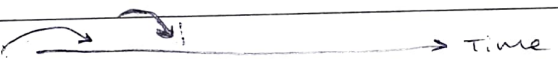
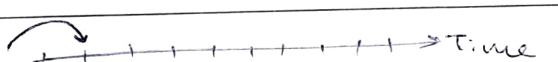
01/03/2023

Infrastructureless → Adhoc → does not necessarily have Access Point

Infrastructured → has Access Point.



• PCF (optional AP)
• DCF (Compulsory AP)

- Aloha →  → Time
- S-Aloha  → Time
- CSMA → Non Persistant (BEB0)
  → persistant
  ↳ 1-persistant
  ↳ p-persistant
- CSMA/CD → Hidden Terminal Problem
  → Exposed Terminal Problem.
- CSMA/CA (or, MACA)
  ↳ Request to send (RTS), Clear to Send (CTS), DATA, [redacted]
- MACA-W (MACA-wireless) → RTS, CTS, DATA, ACK
  • Physical Carrier-Sensing (CS) } → Network Allocation vector (NAV)
  • Virtual carrier-Sensing (CS)

Distributed Foundation of Wireless MAC (DFWMAC).

If DATA < [redacted] RTS; then can directly send DATA without sending RTS; and receive Ack.

1) RTS, CTS, DATA, ACK (4-way handshake) } Asynchronous. (handshake)
2) DATA, ACK (2-way handshake)

3) PCF

→ Interframe Spacing (IFS)
↳ Short IFS (SIFS)
↳ DCF-IFS (DIFS)
↳ PCF-IFS (PIFS)
↳ EIFS

SIFS < PIFS < DIFS < EIFS