Wireless Sensor Network UNIT-2

Medium Access Control Protocol for Wireless Sensor Network

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Topics of Discussion

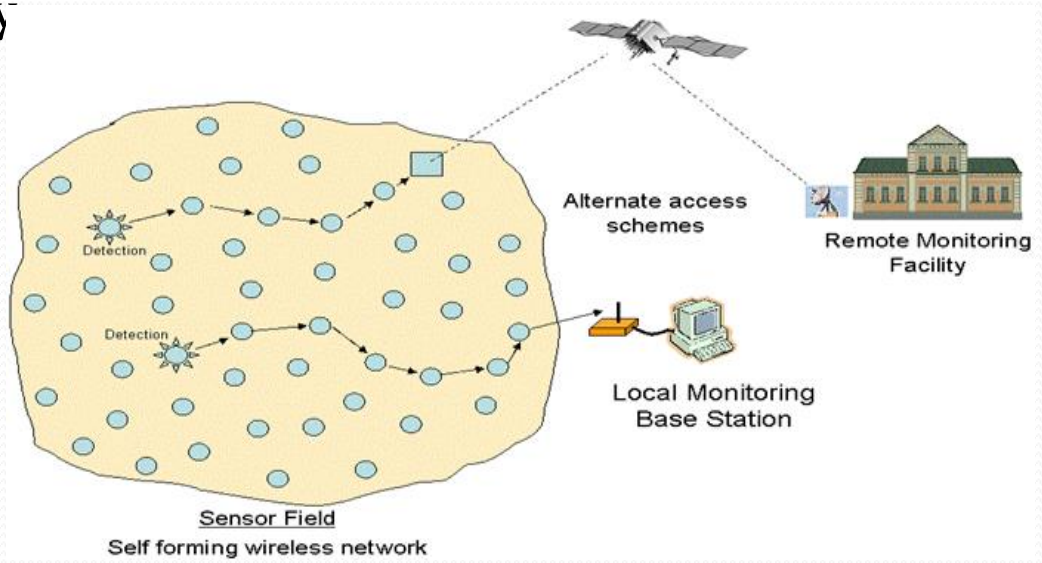
- Introduction
- Power consumption in WSN's
- Wireless MAC protocols
- Differences and Constraints
- Attributes to WSN
- Wireless Sensor network MAC protocols
- Summary

Introduction

Wireless Sensor Network?

- It's a collection of devices " sensor nodes"
- They are small, inexpensive, with constrained power
- They are organized in a cooperative network
- They communicate wirelessly

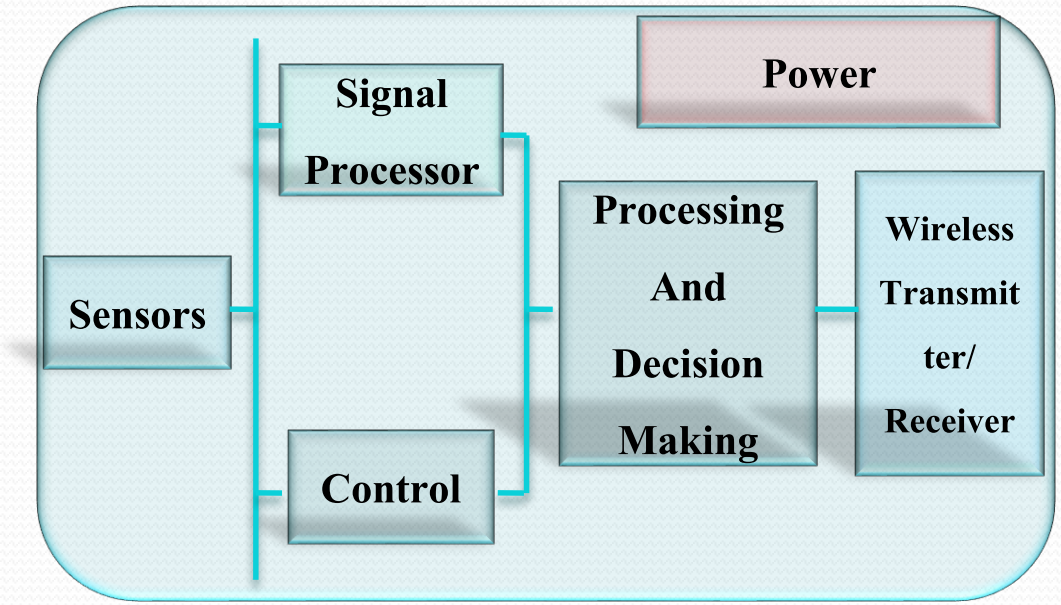
  in multi hop routing
- Heavily deployment
- Changing network topology



Introduction (Cont.)

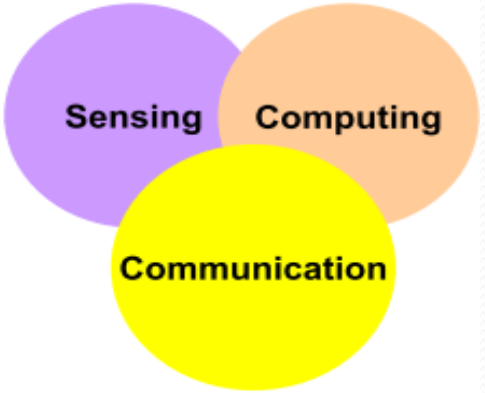
Component and Schematic of Node

- Processor.
- Memory.
- RF Radio.
- Power Source.
- Sensor.
- GPS



Introduction (Cont.)

Goal of Wireless Sensor Network



- Collect data at regular intervals.
- Then transform data into an electrical signal.
- Finally, send the signals to the sink or the base nod.

Types of Wireless Sensor Network

- Temperature sensor.
- Light sensor.
- Sound sensor.
- Vibration Sensor.

Introduction (Cont.)

Communication pattern:

- Broadcast : Base station transmits message to all its immediate neighbors.
- Converge cast : a group of sensors communicates to a specific sensor
- Local gossip: a sensor node sends a message to its neighboring nodes within a range.

Introduction (Cont.)

Applications of Wireless Sensor Network

- Global scale
- Battle field
- Factories
- Buildings
- Homes
- bodies

Power consumption in WSN's

The power consumption in WSN's is one of the biggest challenges because:

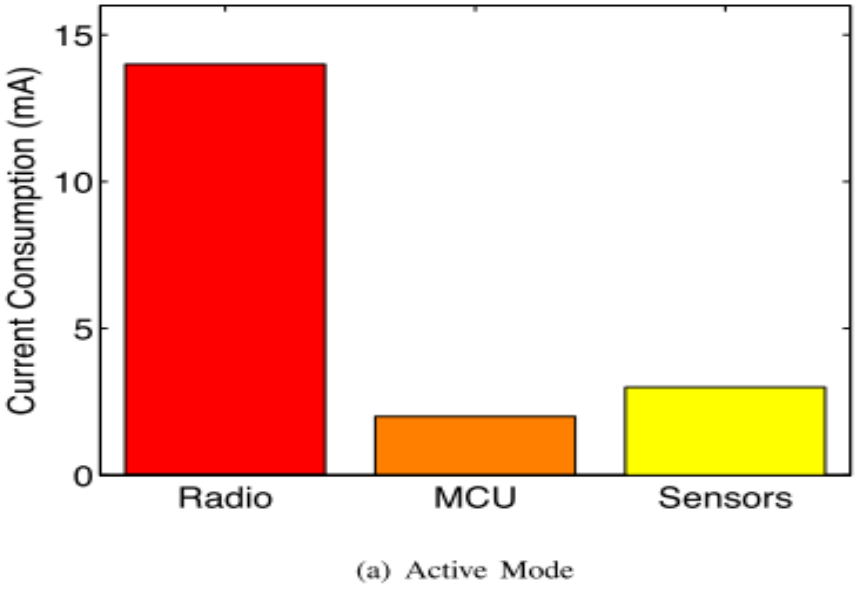
- Sensors have a limited source of power and it's hard to replace or recharge " e.g sensors in the battle field, sensors in a large forest.. Etc".

Power consumption in WSN's

Energy consumption of typical node components.

Radio mode	Power consumption (mW)
Transmit (T_x)	14.88
Receive (R_x)	12.50
Idle	12.36
Sleep	0.016

Source: MAC Essentials for Wireless Sensor Networks



(a) Active Mode

g. 1. Energy consumption of typical node components. Measuren

Sources of power consumption in WSN's

1- useful power consumption:

- Transmitting or receiving data.
- Processing queries requests.
- Forwarding queries and data to the neighbours.

Source of power consumption in WSN's (Cont.)

2- wasteful power consumption:

- Idle listening to the channel " waiting for possible traffic".
- Retransmitting because of collision: " e.g two packets arrived at the same time at the same sensor"
- Overhearing: when a sensor received a packet doesn't belong it".
- Generating and handling control packets.

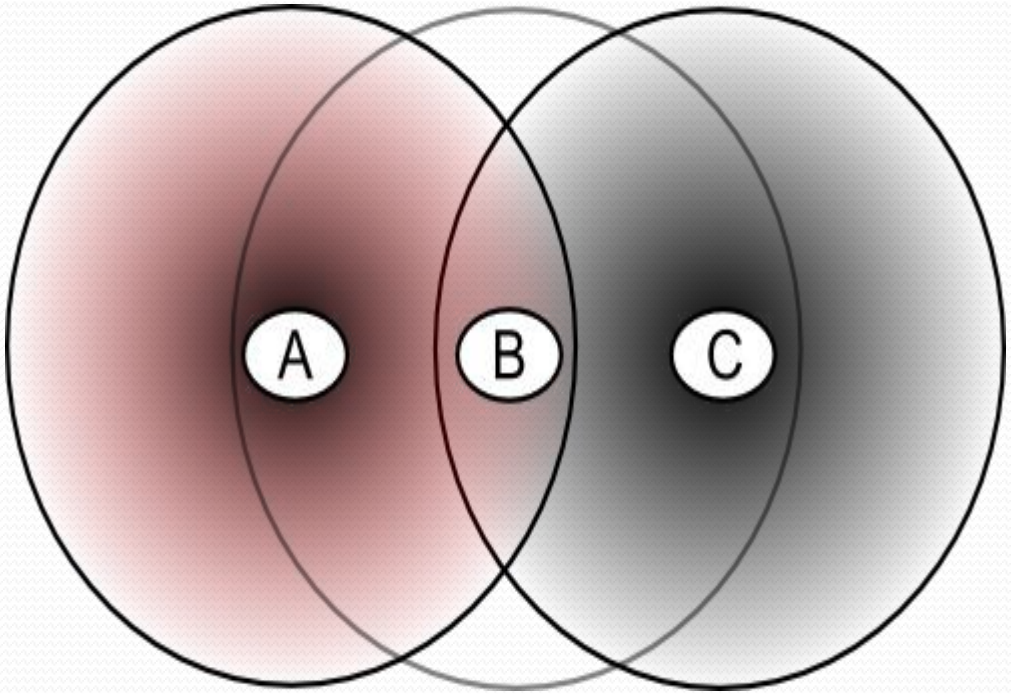
Power consumption in WSN's

How to minimize the energy consumption of sensor nodes while meeting the application requirements?

- Use Protocols that aim mainly to increase the sleep periods as much as possible

Another problem in Wireless Network

Hidden/Exposed terminal problem



Hidden terminal problem

- B, A hear each other
- B, C hear each other
- A, C can not hear each other

means A, C unaware of their interference at B

Wireless MAC Protocols

Conventional of MAC Protocols

Wireless MAC Protocols (Cont.)

1- CSMA :

- Non Persistent: if the device detects activity on the channel, it performs a back off by waiting before attempting to transmit.
- P- Persistent: if it detects activity on the channel, it continuous to sense the channel instead of delaying.
- CSMA requires devices to remain in the receive state when not transmitting

Disadvantages: the transceiver consumes energy too quickly.

Wireless MAC Protocols (Cont.)

2- CSMA/CA :

- Control messages were introduced such as (RTS and CTS) to reserve the channel
- The source first performs CSMA algorithm
- If it determines appropriate time for transmission, it sends RTS
- Then, the destination responds with CTS

Disadvantages: it might still have some collision in RTS

Wireless MAC Protocols (Cont.)

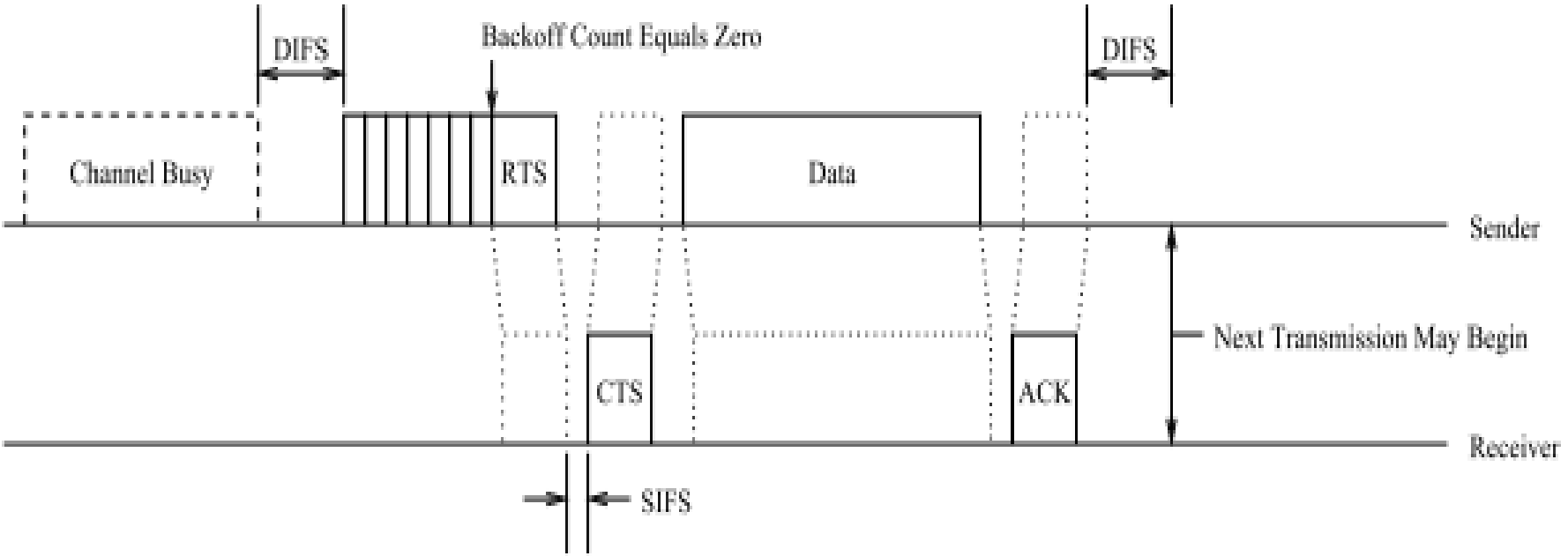
3-IEEE 802.11 :

- Infrastructure mode :devices communicate through a central entity called an access point (AP) using the point coordination function (PCF),
- Ad hoc mode: devices communicate with each other directly using the distributed coordination function (DCF)
- Both the PCF and DCF use a channel access mechanism similar to CSMA/CA and use acknowledgments for reliability.
- In addition to physical carrier sensing, IEEE 802.11 devices perform virtual carrier sensing " NAV"

Wireless MAC Protocols (Cont.)

Disadvantages:

- IEEE 802.11 devices consume large amounts of energy due to the high percentage of time spent listening without receiving messages



802.11 Data Transfer

Differences and Constraints

Traditional MAC protocol provides:

- High throughput
- Low latency
- Fairness
- Mobility

But : have little consideration for energy

Improved MAC protocol provides:

- Best performance of smallest amount of energy

Attributes to Wireless Sensor Networks

The following attributes should be taken in WSN

Energy conservation

- Scalability and adaptively
- throughput

primary goal

- Fairness
- Latency

less important

MAC protocol must achieve

- Establish communication link between the sensor nodes
- To share the communication medium fairly and efficiently

Wireless Sensor Network MAC Protocols

Unscheduled MAC protocols (Cont.)

1- Unscheduled MAC:

Strategy:

- Before sending a message, a sensor listens to the medium. If it's busy, wait a random time then retry again and if it's free then it will send the message.

Unscheduled MAC protocols (Cont.)

Advantages:

- It can adapt for changes " in the node density, traffic load or the topology" better than scheduled protocol.
- The sensors don't have to be synchronized together.

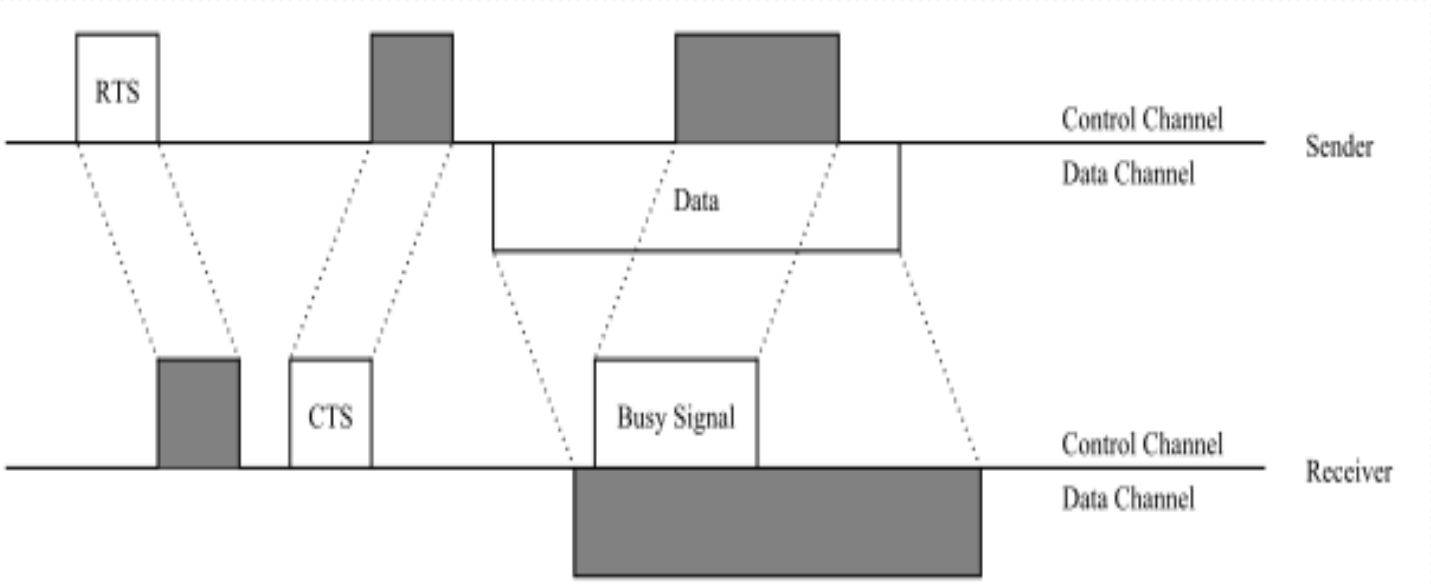
Disadvantages:

- It's worst than scheduled MAC protocols from the power saving perspective, since all sensors listen to the channel.

Unscheduled MAC protocols (Cont.)

1.1- PAMAS: stands for Power Aware Multi-Access

Strategy : It uses multiple transceivers on each node



PAMAS Data Transfer

Unscheduled MAC protocols (Cont.)

Advantages:

- Prevent collision

Disadvantages:

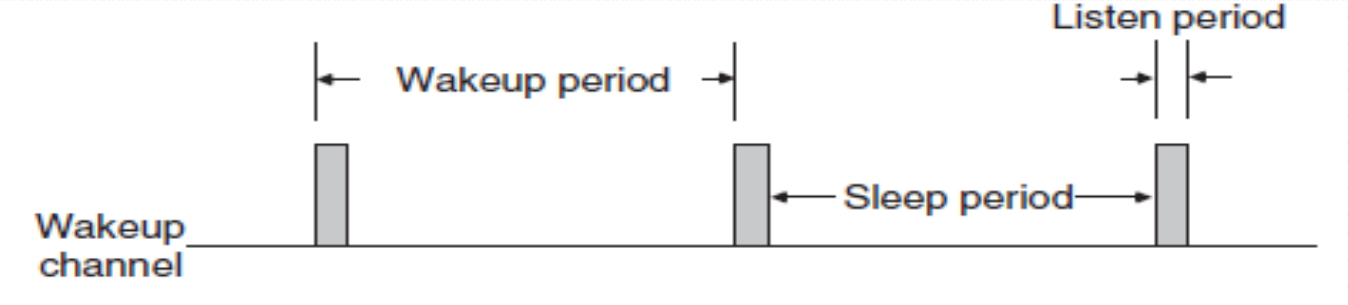
- Multiple radio requirement
- Increase energy consumption
- Increase device complexity and cost

Unscheduled MAC protocols (Cont.)

1.2- STEM: stands for Sparse Topology and Energy Management

Strategy:

- uses two different channels, the wakeup channel and the data channel,
- requires two transceivers in each node



STEM duty cycle for single node

Unscheduled MAC protocols (Cont.)

1.2.1- STEM-B:

Strategy : sensor nodes wakes a neighbour by transmitting a beacon

(no RTS/CTS)

advantages:

- Lower Latency

Disadvantages:

- More complex
- High energy consumption

Unscheduled MAC protocols (Cont.)

1.2.2- STEM-T:

Strategy : sensor nodes wakes a neighbour by transmitting a tone of sufficient length that destination will have a high probability of sensing

- Busy tone contains no destination address

Disadvantages:

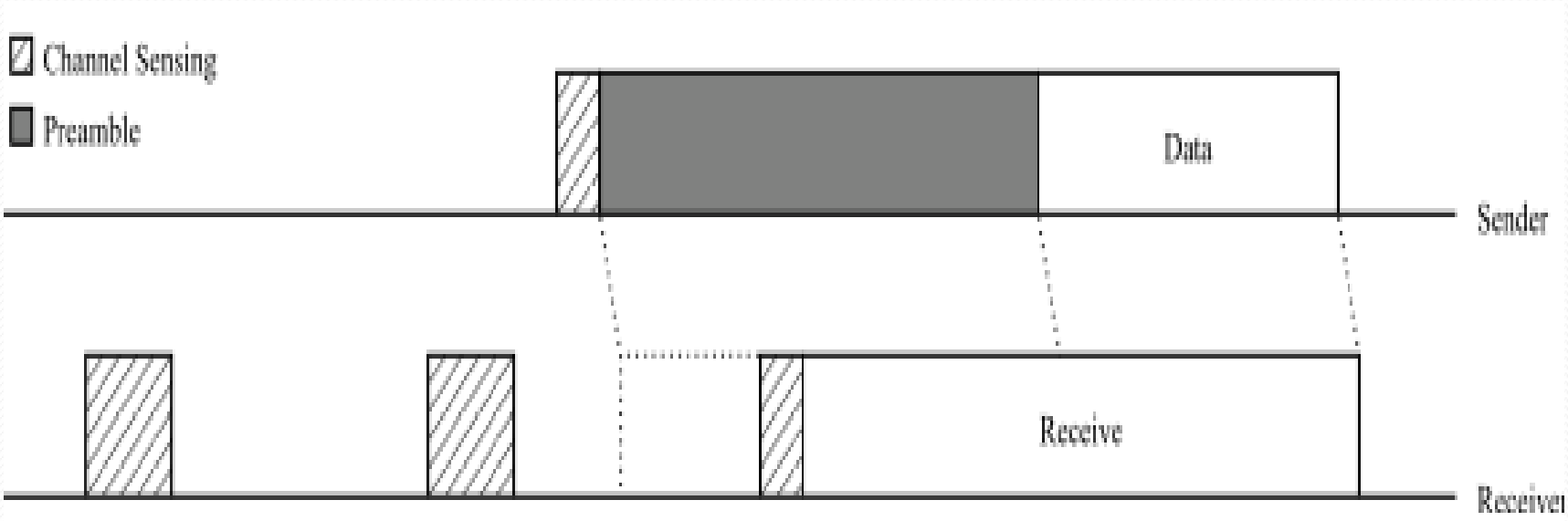
- High latency
- Results in overhearing

Unscheduled MAC protocols (Cont.)

1.3- B-MAC:

Strategy :

- It uses a tone to wake up sleeping neighbouring similar to STEM-T
- It uses very long preambles for message transmission.



B-MAC Data Transfer

Unscheduled MAC protocols (Cont.)

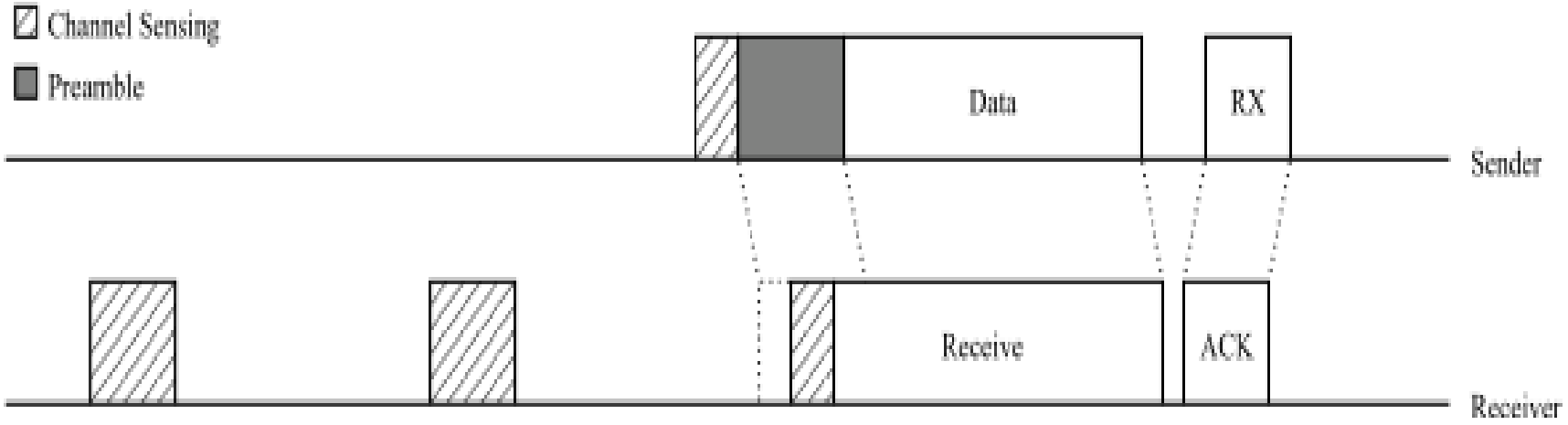
disadvantages:

- B-MAC suffers from the overhearing problem
- The long preamble dominates the energy usage.

Unscheduled MAC protocols (Cont.)

1.4- Wise MAC:

Strategy : it uses similar technique in B-MAC but it attempt to reduce the energy consumption by having sensor nodes remember the sampling offset of their neighbour



Wise MAC Data Transfer

Unscheduled MAC protocols (Cont.)

advantages:

- It decreases the amount of time a sensor node transmits preambles and the number of sensor nodes that overhear each message

Disadvantages:

- the cost of an extra field in the ACK messages and the memory required to store neighbor's sampling offsets.

WSN MAC protocols (Cont.)

2- Scheduled MAC:

Strategy : it attempts to reduce the energy consumption by coordinating sensor nodes with a common schedule

scheduled MAC protocols (Cont.)

Advantages:

- Saving the power from being wasted by turning off the radio out the allocated time slot.
- Limits the collision, idle listing, and overhearing

Disadvantages:

- when sensor node enters net, must wait till they learn, some delay exist
- Cost of increased messages
- Not flexible to changes in sensor density or movements.
- All sensors should be well synchronized.

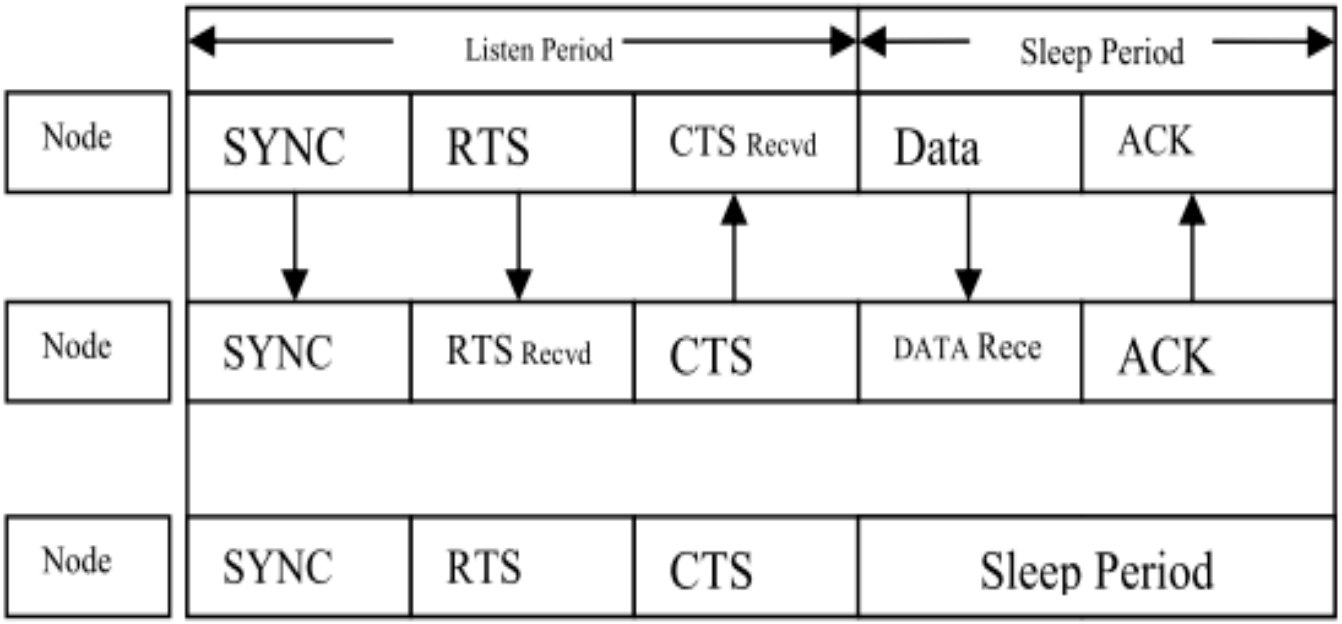
scheduled MAC protocols (Cont.)

2.1 - S-MAC:

Strategy :

- the sensor node periodically goes to the fixed listen/sleep cycle.
- A time frame in S-MAC is divided into two parts: one for a listening session and the other for a sleeping session.

scheduled MAC protocols (Cont.)



S-MAC Frame Format

scheduled MAC protocols (Cont.)

Disadvantages:

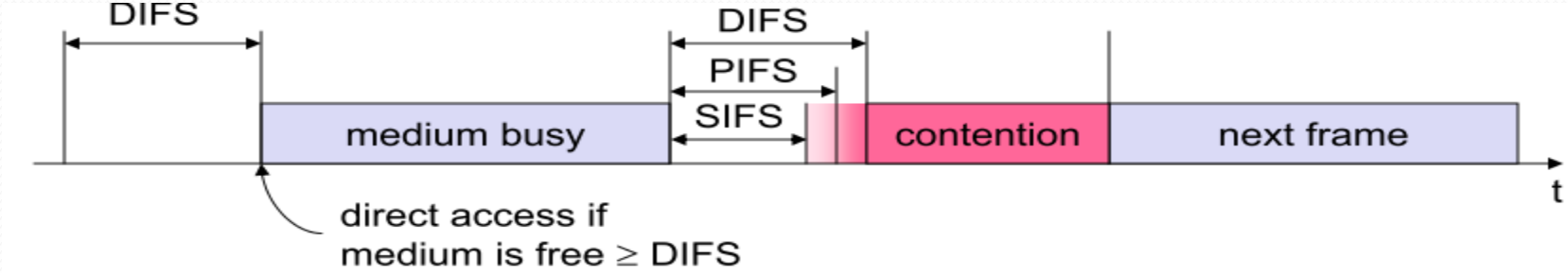
- energy is still wasted in this protocol during listen period as the sensor will be awake even if there is no reception/transmission.

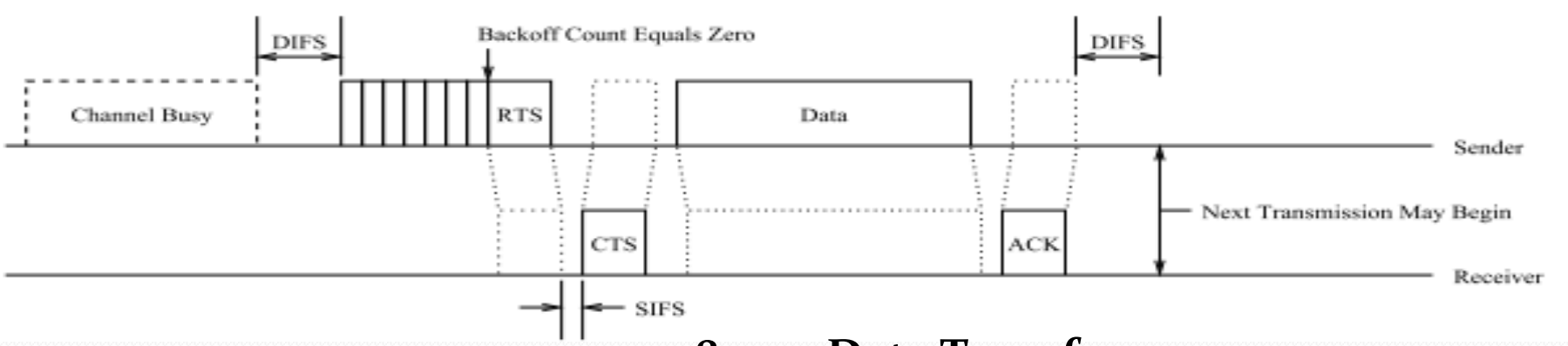
Questions?

Tute questions (Q1)

Q1: Why IEEE 802.11 defines a SIFS shorter than a DIFS ?

ANS: SIFS (Short Inter Frame Spacing) has highest priority, for ACK, CTS, polling response while DIFS (Distributed Inter Frame Spacing) has lowest priority, for asynchronous data service. Having SIFS smaller than DIFS prevents ACK and important control packets from getting killed.





802.11 Data Transfer

Thank you