



Emerging Network Technologies

NetSim

Exercise 13 (Optional)

Faculty of Architecture, Computing and Engineering

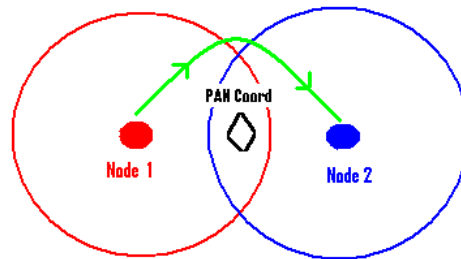
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13. Analyze the scenario shown, where Node 1 transmits data to Node 2, with no path loss and obtain the theoretical throughput based on IEEE 802.15.4 standard. Compare this with the simulation result.



13.1 Introduction:

IEEE Standard 802.15.4 defines the protocol and compatible interconnections for data communication devices using low-data-rate, low-power, and low-complexity short-range radio frequency (RF) transmissions in a wireless personal area network (WPAN). In Wireless sensor network IEEE 802.15.4 standard is used in MAC and PHY layers.

IEEE 802.15.4 PHYs provide the capability to perform CCA in its CSMA-CA mechanism. The PHYs require at least one of the following three CCA methods: Energy Detection over a certain threshold, detection of a signal with IEEE 802.15.4 characteristics or a combination of these methods.

13.2 Theory:

- A packet transmission begins with a random backoff (in number of slots, each slot of T_{fs} duration) which is sampled uniformly from $2^{macminBE} - 1$ to $2^{macmaxBE} - 1$ and followed by a CCA.
- CCA failure starts a new backoff process with the backoff exponent raised by one, i.e., to $macminBE+1$, provided it is lesser than the maximum backoff value given by $macmaxBE$.
- Maximum number of successive CCA failures for the same packet is governed by $macMaxCSMABackoffs$, exceeding which the packet is discarded at the MAC layer.
- A successful CCA is followed by the radio turnaround time and packet transmission.

- If the receiver successfully receives the packet i.e., without any collision or corruption due to PHY layer noise, the receiver sends an ACK after the radio turnaround time.
- A failed packet reception causes no ACK generation.
- The transmitter infers that the packet has failed after waiting for macAckWaitDuration and retransmits the packet for a maximum of aMaxFrameRetries times before discarding it at the MAC layer.

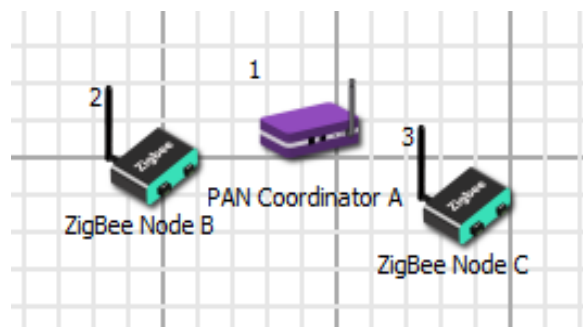
Note: In NetSim the radio turnaround time after a CCA success is not considered.

13.3 Procedure

How to Create Scenario:

In NetSim, Select –Simulation → New → Zigbee Networks||

Create the scenario as shown:



Set the properties as shown below:

Node Properties:

Node Properties	Zigbee Node B
Global Properties	
X_Coordinate	15
Y_Coordinate	20
Interface1_Zigbee : Data Link Layer	
AckRequest	Enable
MaximumFrameRetries	7

Node Properties	Zigbee Node C
Global Properties	
X_Coordinate	25
Y_Coordinate	20
Interface1_Zigbee : Data Link Layer	
AckRequest	Enable
MaximumFrameRetries	7

PAN Coordinator Properties:

Sink Node Properties	Values
Global Properties	
X_Coordinate	20
Y_Coordinate	20
Interface1_Zigbee : Data Link Layer	
Beacon Mode	Disable

Environment Properties:

Environment Properties	Values
Channel Characteristics	No Path Loss

Click and drop Application and edit the following properties:

Application Properties	
Application Type	Custom
Source_Id	2 (Zigbee Node B)
Destination_Id	3 (Zigbee Node C)
Packet_Size	
Distribution	Constant
Value(Bytes)	70

Inter_Arrival_time	
Distribution	Constant
Value(micro sec)	4000

(Note: If the size of the packet size at the Physical layer is greater than 127 bytes, the packet gets fragmented. Taking into account the various overheads added at different layers (which are mentioned below), the packet size at the application layer should be less than 80 bytes.)

Simulation Time: 100 Sec

Throughput obtained from the simulation is **100.408kbps** (0.100408 Mbps)

Note: This throughput is obtained when the nodes are placed at the closest possible distance from the PAN coordinator. As the distance is increased, the throughput would reduce.

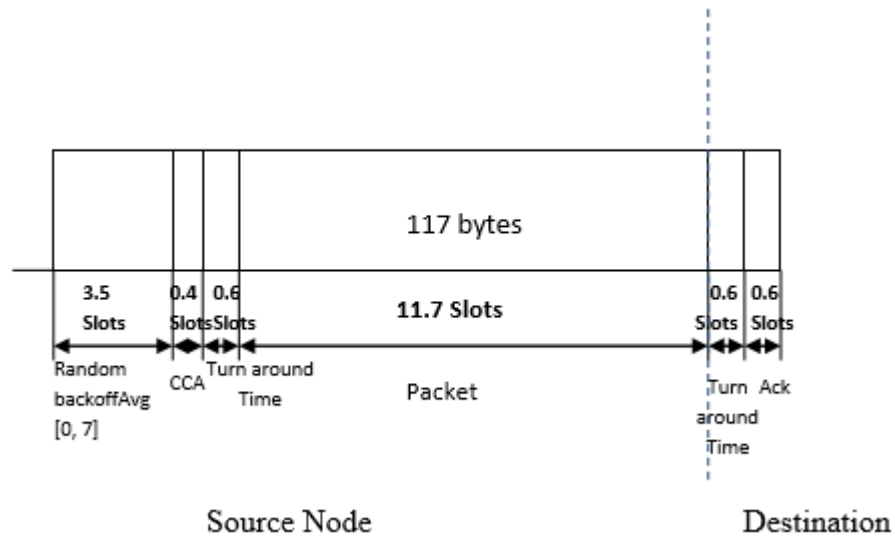
Theoretical Analysis:

We have set the Application layer payload as 70 bytes in the Node1 properties and when the packet reaches the physical layer various other headers gets added like

App layer Payload	70 bytes
Transport Layer Header	8 bytes
Network Layer Header (IP + DSR)	28 bytes
MAC Header	5 bytes
PHY Header	6 bytes
Packet Size	117 bytes

In simulation, by default NetSim uses Unslotted CSMA/CA and so a packet transmission happens after random backoff, CCA and turn-around-time and is followed by turn-around-time and ACK packet and each of them occupies specific time set by the IEEE 802.15.4 standard as per the timing diagram shown below.

117 bytes



From IEEE standard, each slot has 20 Symbols in it and each symbol takes 16 μ s for transmission:

Symbol Time	T_s	16 μ s
Slot Time	$20 * T_s$	0.32 ms

Random Backoff Average	$3.5 * Slots$	1.12 ms
CCA	$0.4 * Slots$	0.128 ms
Turn-around-Time	$0.6 * Slots$	0.192 ms
Packet Transmission Time	$11.7 * Slots$	3.744 ms
Turn-around-Time	$0.6 * Slots$	0.192 ms
ACK Packet Time	$0.6 * Slots$	0.192 ms
Total Time	$17.4 * Slots$	5.568ms

$$Application\ Throughput = \frac{70(bytes)inApplayer}{5.568\ ms} = 100.574\ kbps$$

13.4 Inference:

Throughput from simulation	100.408 kbps
Throughput from analysis	100.574 kbps

Throughput from theoretical analysis matches the results of NetSim's discrete event simulation.

(Note: The slight difference in throughput is due to fact that the average of random numbers generated for backoff need not be exactly 3.5 as the simulation is run for short time and also in Network layer DSR protocol is running, so route setup process will take some time.)

As we go on increasing the simulation time, the throughput value obtained from simulation approaches the theoretical value as can be seen from the table below:

Simulation Time (sec)	Throughput (kbps)
10	99.680
50	100.486
100	100.408
200	100.486

Note: In NetSim Academic version to run the simulation with 200 sec simulation time we can use CLI.