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CENTER FOR WIRELESS COMMUNICATIONS AND SIGNAL PROCESSING RESEARCH

Neighbor Discovery Implementation for IEEE 802.11

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Agenda

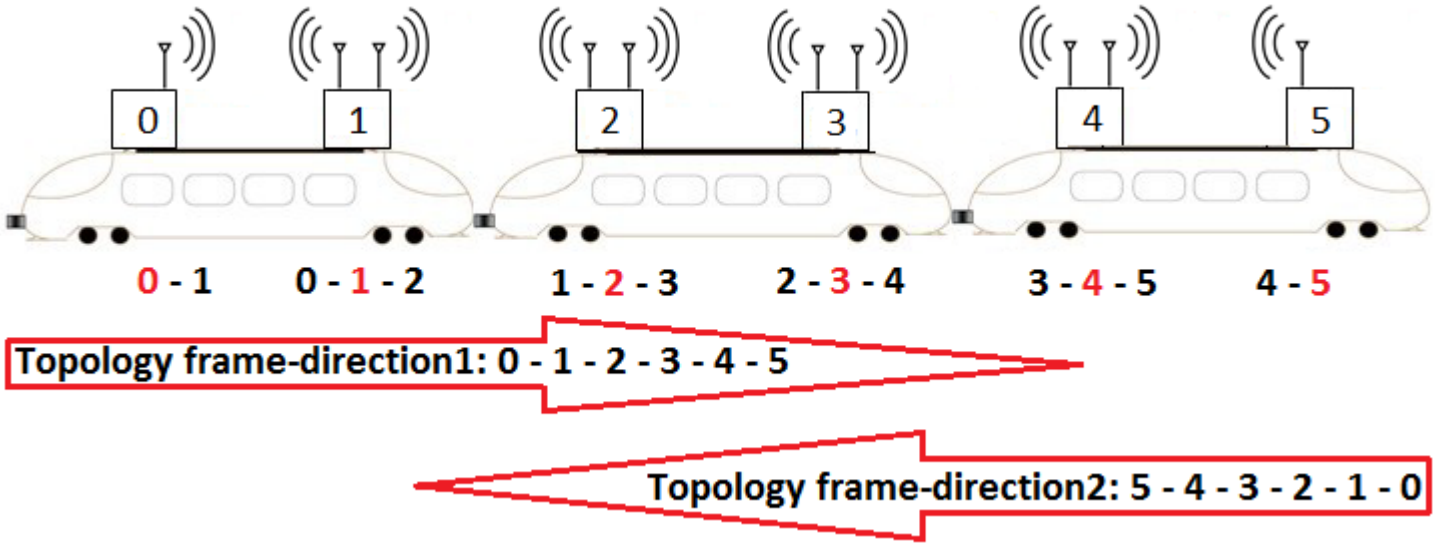
- Motivation
- Topology discovery
- Neighbor discovery
- IEEE 802.11 – Wireless LAN
- Simulation
- Results
- Conclusions

Motivation

- The current train control network (TCN) is Ethernet based.
- CSR project goal is to implement IEEE 802.11 based TCN.
- TCN is the nervous system of the train (control and entertainment).
- Challenge is the broadcast nature of IEEE 802.11.
- Solution: Topology (and neighbor) discovery.

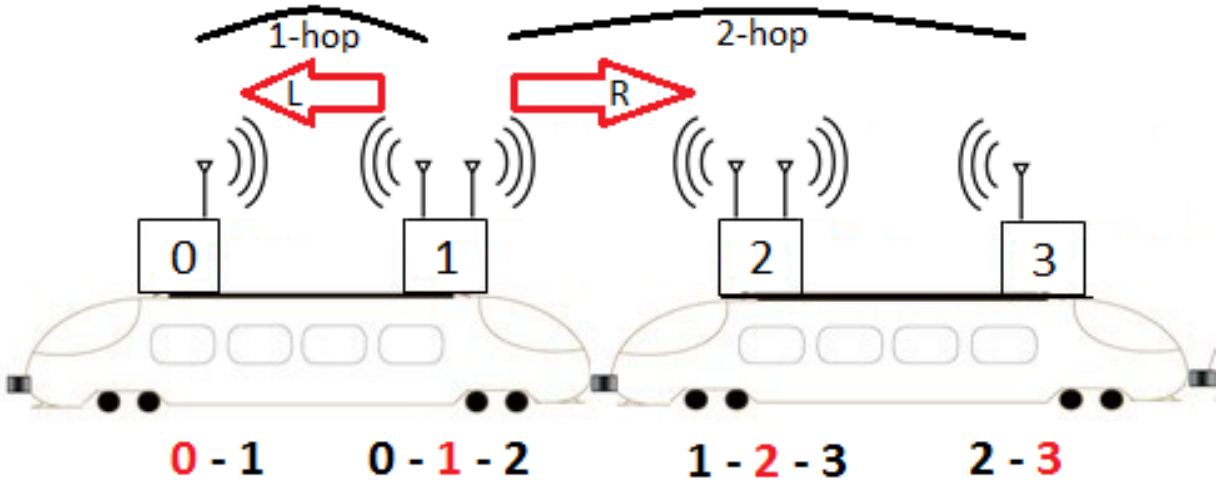
Topology discovery

- Topology, by definition, is the order of nodes in a network.

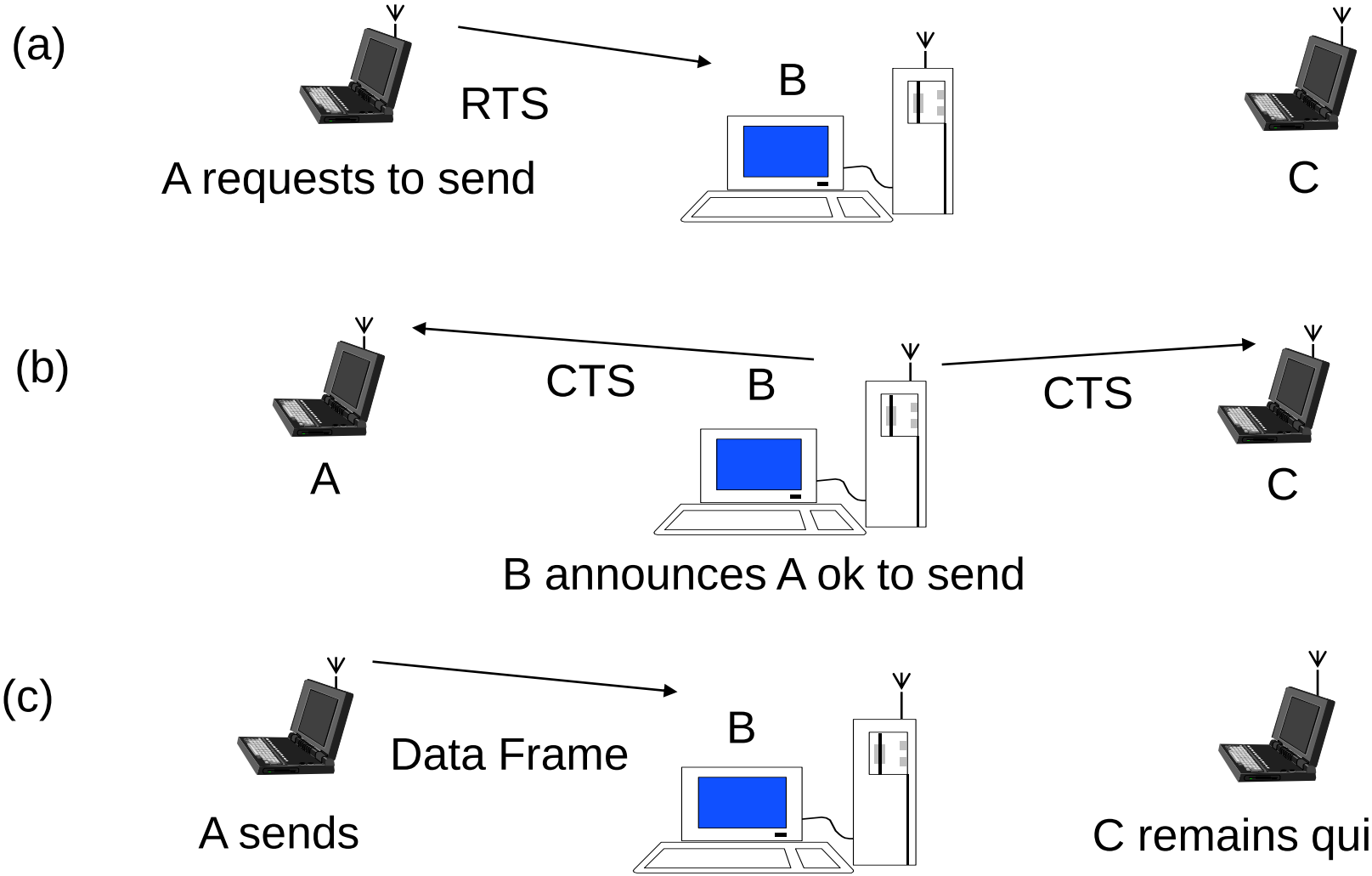


Neighbor discovery

- A neighbor node is defined as a node that is exactly one hop away from the node of interest [1].
- Neighbor discovery is the process of discovering right and left one hop neighbors of the node of interest.



CSMA-CA


(a)
RTS
B
A requests to send
C
(b)
CTS
B
CTS
A
C
B announces A ok to send
(c)
Data Frame
B
A sends
C remains quiet

IEEE 802.11 – Wireless LAN

Signal reception mechanism

- In PHY layer CST is used to determine whether one frame is detected by the receiver.
- Again, in PHY layer, RST is used to see if the packet can be received correctly by the receiver.
- In MAC layer CPT is used when multiple frames are received simultaneously by one mobile node.

Simulation

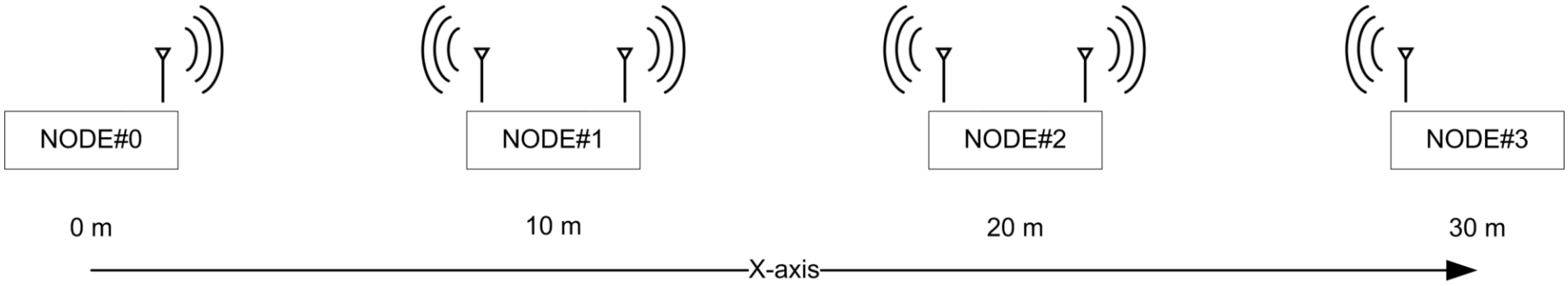
Network Simulator-2 (NS-2)

- NS-2 is a discrete event simulator targeted at networking research and the most commonly used network simulator.
- Two languages used to work with NS-2: C++ and OTcl.
- OTcl is short for MIT Object Tcl, an extension to Tcl/Tk for object-oriented programming.
- OTcl is used to build the network structure and topology which is just the surface of the simulation, and configure network parameters.
- C++ is the most important and kernel part of the architecture and protocol designs.

Simulation

Simulated topology

- Simulated topology has a total number of 6 wireless nodes aligned along the same axis and employ directional antennas with 45 degrees main-lobe width.
- Edge nodes (0 and 3) have only one neighbor each. Center nodes (1 and 2) have two neighbors at each side.



Simulation

Neighbor discovery mechanism

- Each antenna in the topology periodically broadcasts hello frames with probability of 30%.
- Implemented and simulated neighbor discovery mechanism employs a hello frame count threshold (M_H).
- A node keeps independent counts of received hello frames for each sender node and discovers the first node with the counter that reaches M_H as its neighbor.
- Neighbor discovery time for all nodes is the latest discovery time in the topology.
- If not all 6 of the discoveries complete, neighbor discovery success is 0.

Simulation

Topology discovery mechanism

- Each antenna in the topology periodically transmits topology frames with probability of 30%.
- Planned topology discovery mechanism employs a topology frame count threshold (M_T).
- After each node discovers their own one hop neighbors, they pass their neighbor list to their neighbor nodes (one direction at a time).

Simulation

Topology discovery mechanism (Cont.)

- A node keeps independent counts of received topology frames for each sender node and takes the topology data from the first node with the counter that reaches M_T.
- Then the node adds its own address into this topology data and passes the list to its next hop neighbor in the same direction. When both terminal nodes receive topology frames, topology discovery is complete.

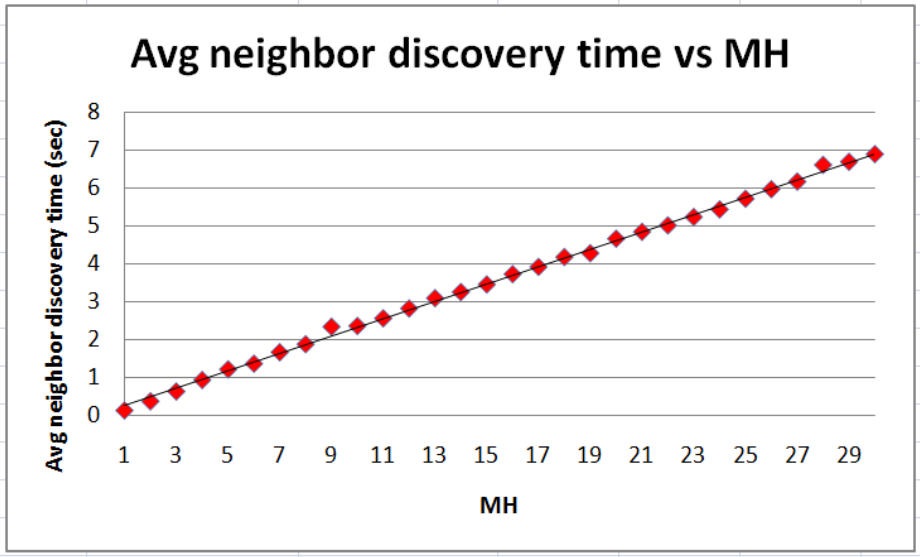
Simulation

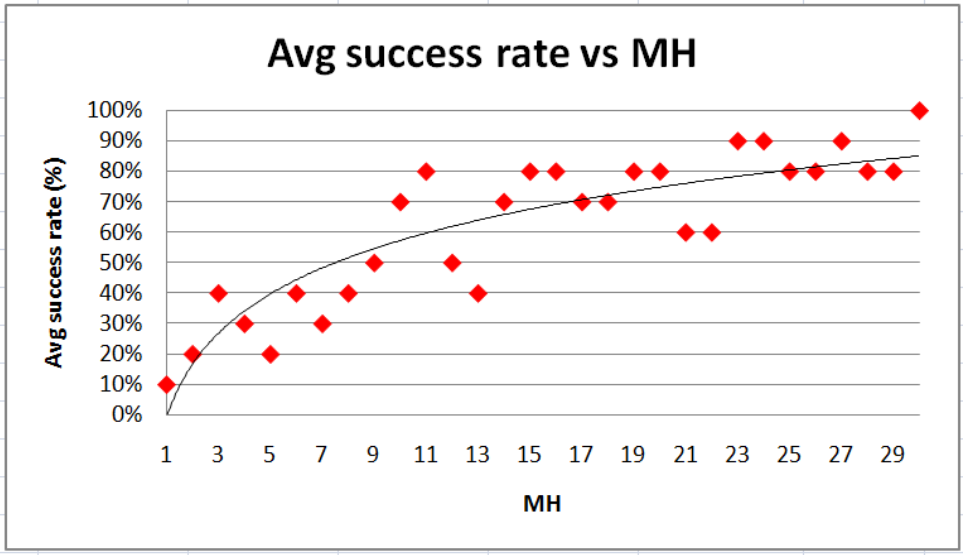
NS-2 simulation parameters

Parameter	Value
MAC layer model	IEEE 802.11
PHY layer model	IEEE 802.11
Frequency	2.472 GHz (Channel 13)
Data rate	10 Mbps
Carrier sensing threshold	-74.374692 dBm
Receiving threshold	-64.374692 dBm
Capture threshold	0 dBm
Hello period	100 ms
Neighbor discovery timeout	2 s
Number of Monte Carlo simulations (per point)	10

Results

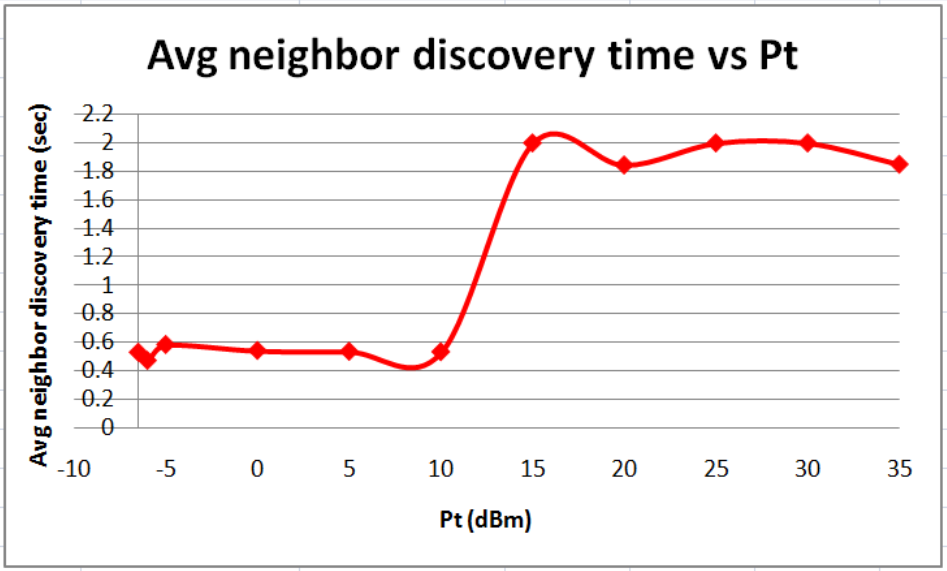
Effect of hello counter threshold (M_H)

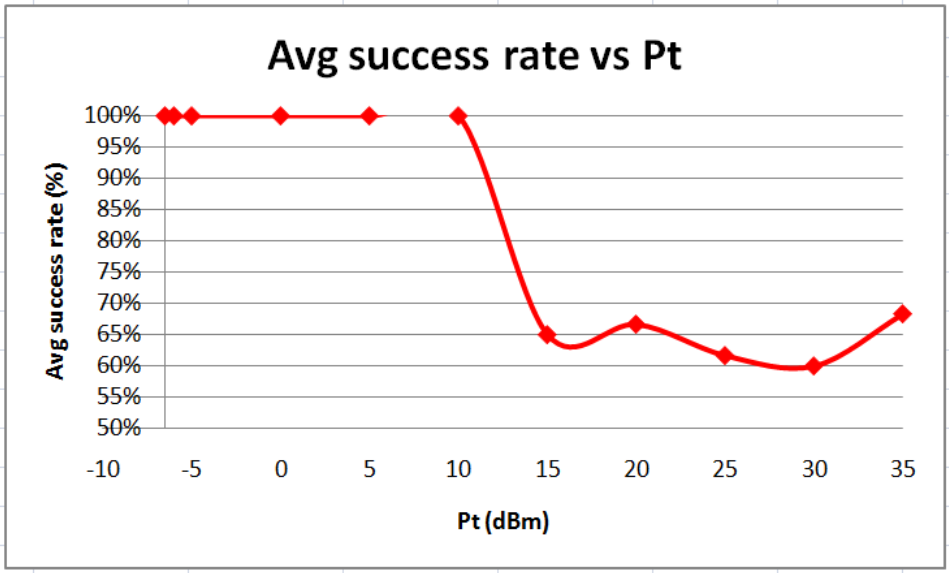




Results

Effect of transmit power level





Conclusions

- Neighbor discovery is the most important step in topology discovery in WLAN networks.
- Routing in data link layer cannot be performed efficiently, if the network topology is not correctly discovered by all nodes.
- Employing directional antennas help to distinguish the direction of the neighbor (right or left) and reduce interference level at each node.
- Simulating network operation in NS-2 gives a more realistic approximation to the real life operation of WLANs.

Conclusions (Cont.)

- Increasing P_{TX} reduces the neighbor discovery success rate.
- Increasing P_{TX} increases the average time neighbor discovery takes.
- Increasing M_H enhances the success.
- Increasing M_H increases the average time neighbor discovery takes.

References

[1] Kim, Daehyon, and Aura Ganz. "Fair and efficient multihop scheduling algorithm for IEEE 802.16 BWA systems." Broadband Networks, 2005. BroadNets 2005. 2nd International Conference on. IEEE, 2005.

[2] http://en.wikipedia.org/wiki/IEEE_802.11 , Last accessed: May 20, 2014.

[3] http://www.isi.edu/nsnam/ns/ , Last accessed: May 20, 2014.

THANK YOU

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THE EDGE IN KNOWLEDGE

QUESTIONS?