ENSC 835: High-Performance Networks
Spring 2008

Implementation of a Multi-Channel Multi-Interface Ad-Hoc Wireless Network

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Final Project Demo

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Roadmap

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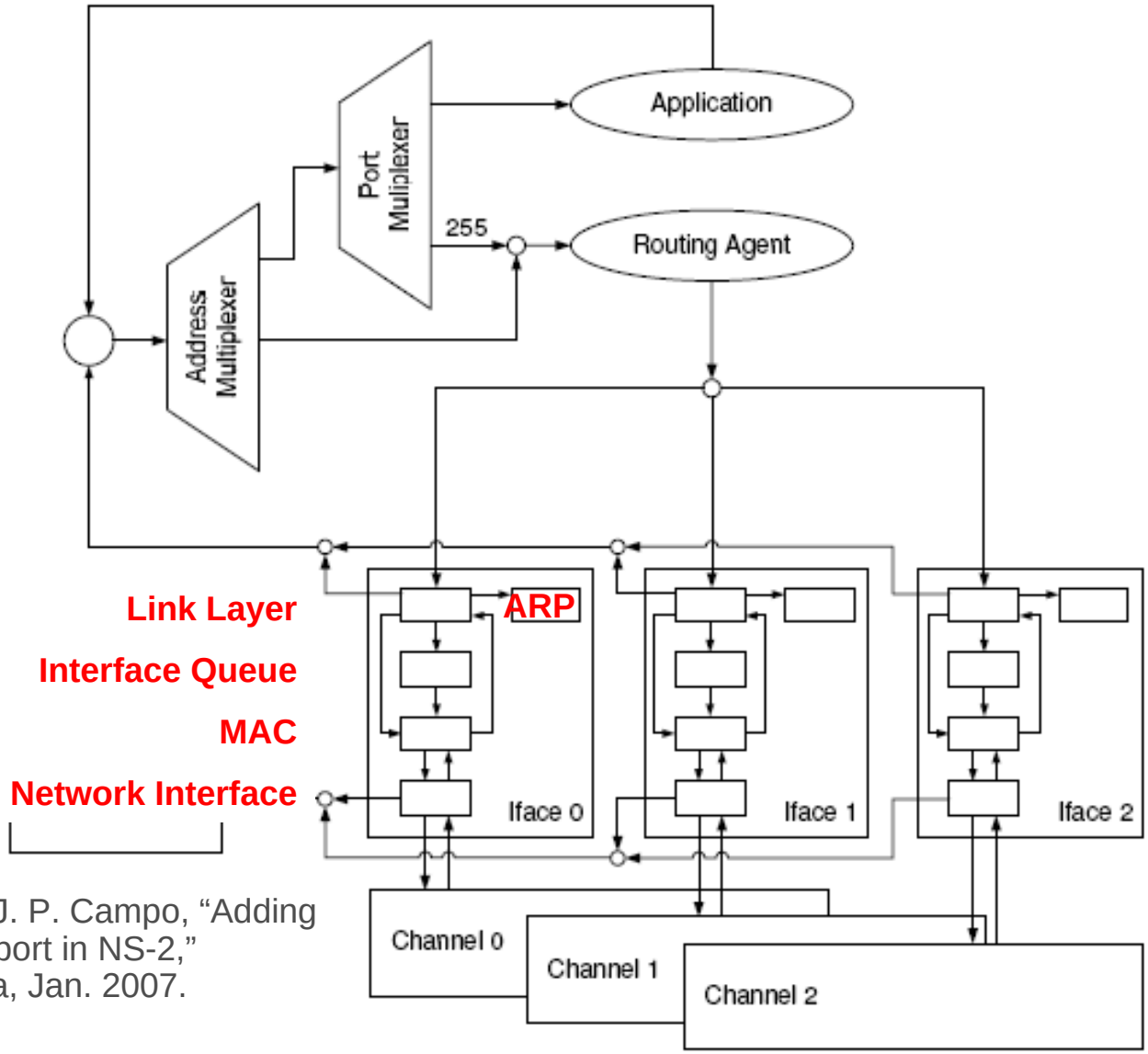
Project Description

- Extend the Network Simulator (ns-2.32) to support multiple channels and multiple interfaces by referring to [1]
  - modify ns-2's MobileNode library to support multiple interfaces
  - preserve the legacy operations of IEEE 802.11 interfaces
- Implement the interface switching protocol proposed in [2]
  - integrate this algorithm in the existing AODV routing agent in ns-2
- Simulate a multi-channel multi-interface ad-hoc wireless network (in chain topologies) using the modified ns-2
  - demonstrate the effectiveness of interface switching and the improvement in the network throughput

AODV	Ad-hoc On-demand Distance Vector
[1]	R. A. Calvo and J. P. Campo, "Adding Multiple Interface Support in NS-2," University of Cantabria, Jan. 2007 (User Guide).
[2]	P. Kyasanur and N. H. Vaidya, "Routing and Link-layer Protocols for Multi-Channel Multi-Interface Ad Hoc Wireless Networks," SIGMOBILE Mobile Computing and Communications Review, vol. 10, no. 1, pp. 31-43, Jan. 2006.

Modified MobileNode in ns-2

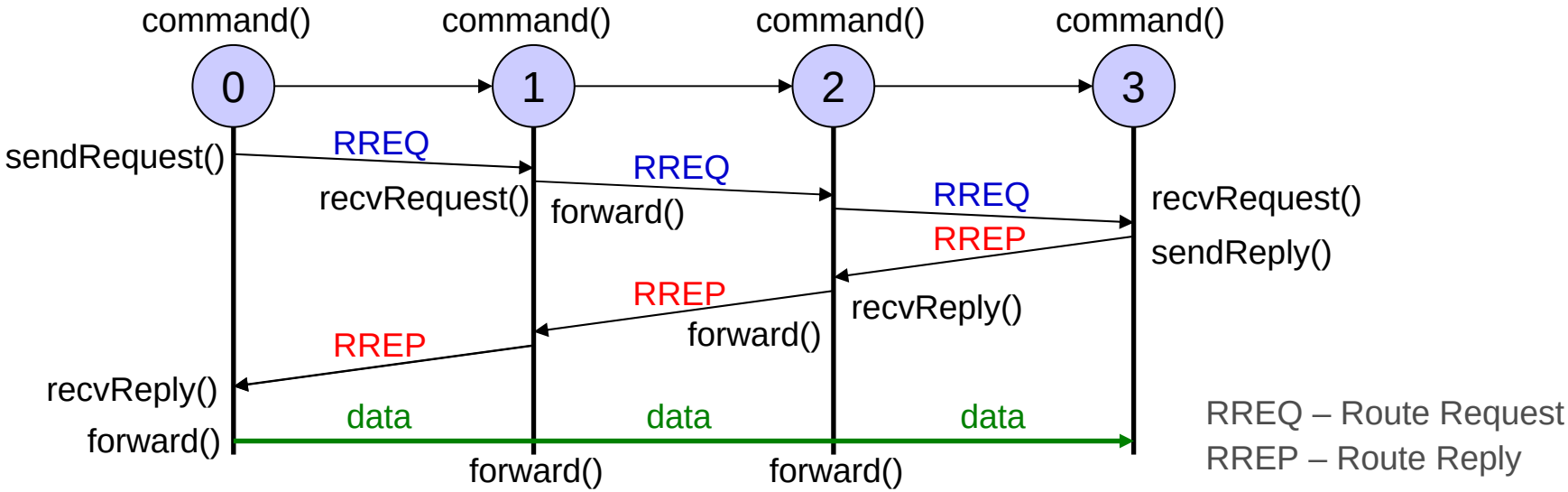
- Each node can have as many instances of the link layer, ARP, interface queue, MAC, network interface and channel entities as the number of interfaces



From: [1] R. A. Calvo and J. P. Campo, "Adding Multiple Interface Support in NS-2," University of Cantabria, Jan. 2007.

AODV Routing in ns-2

- Route establishment:
  - source node broadcasts a RREQ to find a route to destination node
  - each node receiving the RREQ forwards to the next node
  - a route is determined when the RREQ reaches a node that offers accessibility to destination node
  - the route is established by sending a RREP back to source node



Modified AODV with Interface Switching Capability

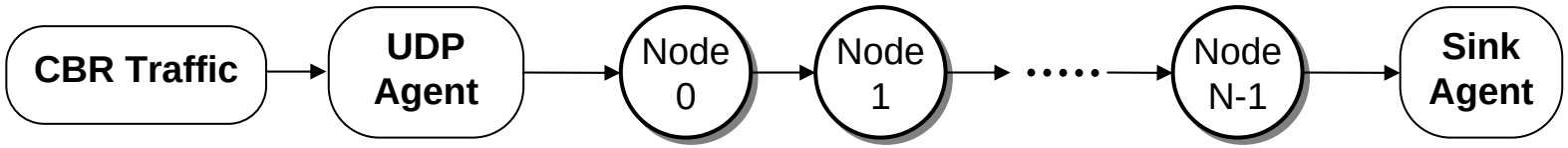
- command()
  - initially, the node chooses a random channel for its fixed interface and switchable interface
  - add the fixed channel used by this node to its NeighbourTable
  - update the node's ChannelUsageList with its fixed channel
- sendRequest(), sendReply(), sendHello()
  - add the fixed channel used by this node and its NeighbourTable to the outgoing RREQ, RREP, or Hello packet
- recvRequest(), recvReply(), recvHello()
  - when the node receives a RREQ, RREP, or Hello packet from a neighbour, it updates:
    - the node's NeighbourTable with the fixed channel of that neighbour
    - the node's ChannelUsageList using the NeighbourTable of its neighbour.

Modified AODV with Interface Switching Capability

- forward()
  - RREQ or RREP:
    - add the fixed channel used by this node and its NeighbourTable to the outgoing packet
  - data:
    - consult the node's ChannelUsageList, find the channel with the largest usage
    - if the node's fixed channel has the largest usage:
      - with a probability of 0.4 (from paper [2]), the node:
        - reverses its ChannelUsageList about the fixed channel previously used
        - changes its fixed channel to a less used channel
        - transmits a new Hello packet informing neighbours of its new fixed channel → sendHello()
    - if the usage of the node's fixed channel is ok:
      - look up the fixed channel of the next node in NeighbourTable
      - assign this fixed channel to the node's switchable interface

Simulation: Configuration

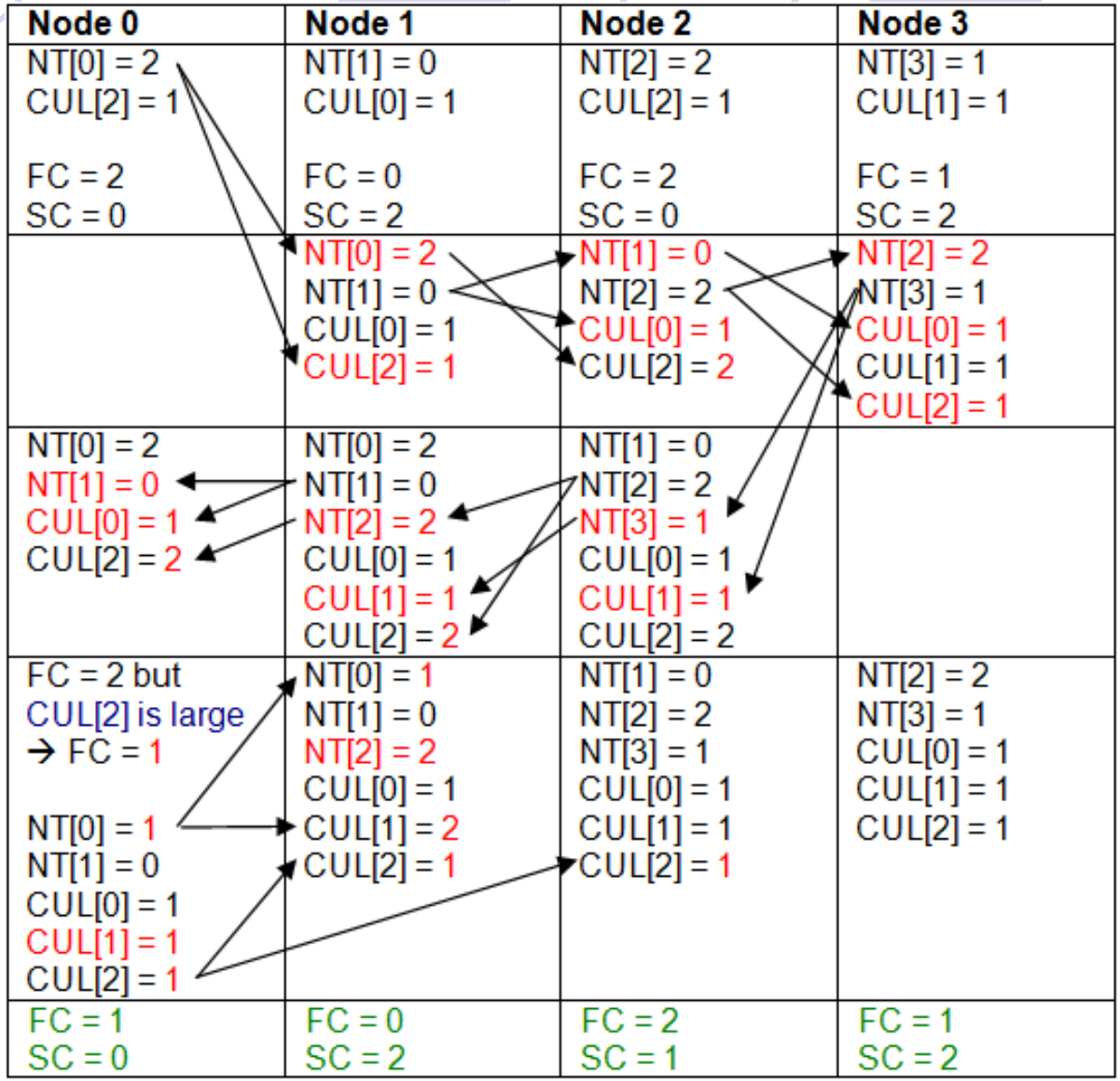
- Using the modified ns-2.32:
  - test the effectiveness of interface switching and throughput in multi-channel and multi-interface ad-hoc wireless networks



- Scenarios:
  - simple chain topologies of 2-11 stationary nodes (single route)
  - 2-4 channels per node
  - 2 interfaces per node (1 fixed, 1 switchable)
  - simulation duration: 60 s (actual simulation time is slightly longer)
  - channel capacity: 5.4 Mbps
  - constant bit-rate (CBR) traffic flow from Node 0 to Node N-1
    - transmitted over UDP (no flow and congestion controls)
    - 1000 bytes per packet, sent every 1.4 ms

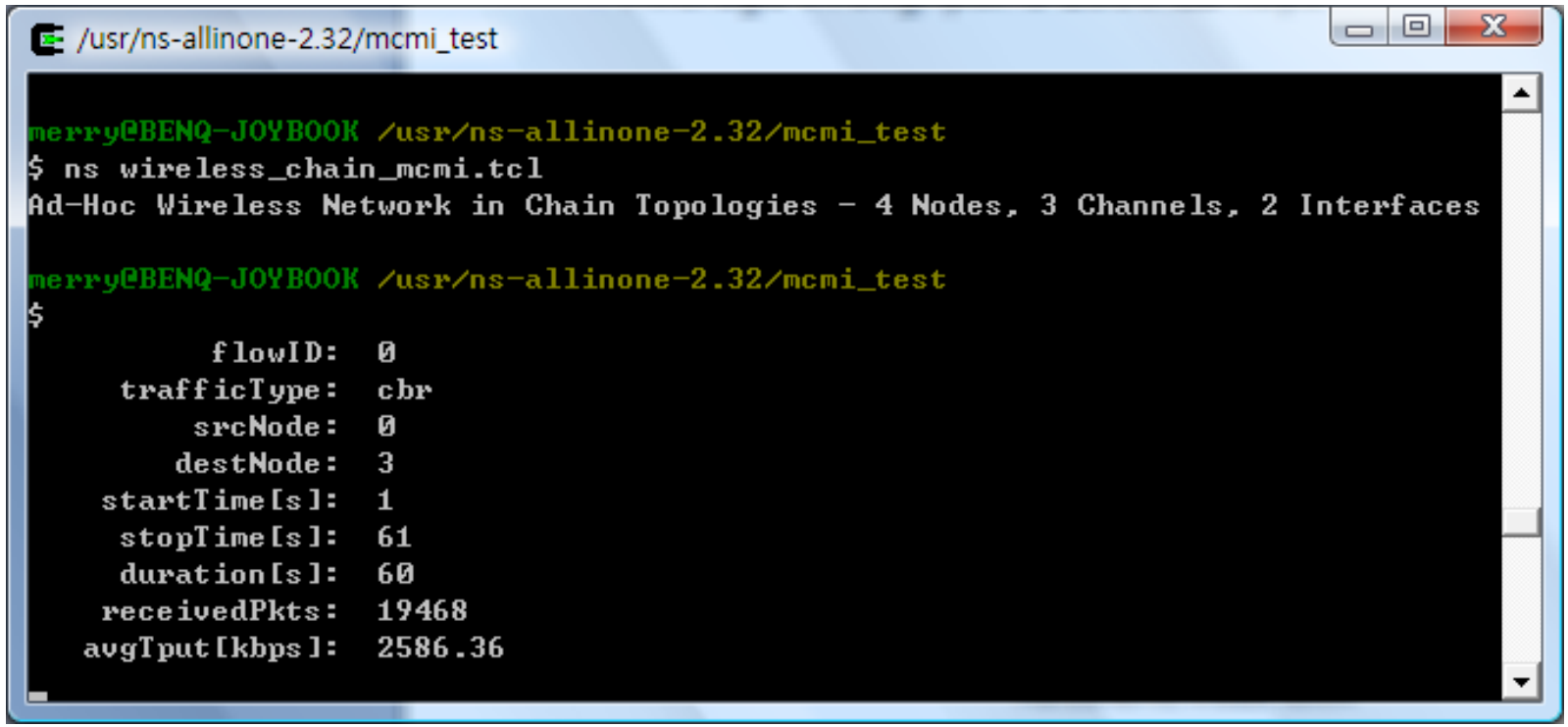
Simulation: Interface Switching

- Example: 4 nodes, 3 channels [0, 1, 2], 2 interfaces [0, 1]
- NT[n] is the fixed channel used by node n
- CUL[c] is the number of nodes using c as their fixed channel
- Fixed Channel (FC)
- Switchable Channel (SC)



Simulation: Sample ns-2 Output

- 4 nodes, 3 Channels, 2 interfaces:
  - CBR traffic from Node 0 to Node 3
  - Average throughput is 2586.36 kbps

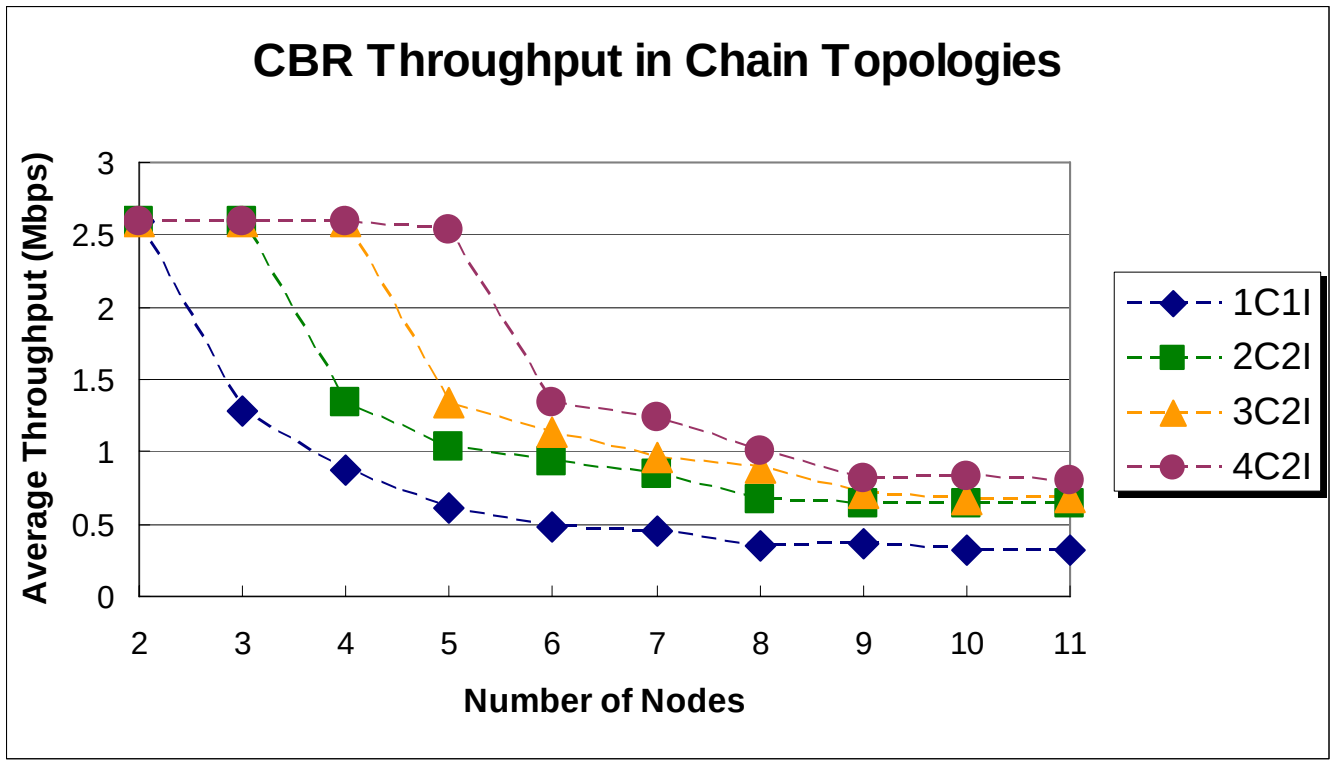


Simulation: Sample nam Output

- Network Animator (nam) in ns-2.32:
  - only nodes can currently be seen
  - dumping of traffic data and thus visualization of data packet movements for wireless scenarios is still not supported
- The following is a chain topology with 4 wireless nodes:

Simulation: Results

- Average throughputs while varying the number of channels, n → nC2I vs. 1C1I



Simulation: Observations

- The throughput of 1C1I networks degrades as the number of nodes increases by 1 each time
  - intermediate nodes cannot send and receive data at the same time
  - interference within the carrier sense range
- Higher throughput with multiple channels and 2 interfaces on each node
  - interface switching assigns the fixed channel of successive nodes to different channels
  - intermediate nodes can send data to the next node using its switchable interface, while receiving data on its fixed interface
- Smaller throughput improvement when the number of nodes > number of channels + 1
  - some nodes will be on some common channels → interference
  - however, generally still higher than the case of 1C1I

Questions?

- Thank you!