An Adaptive Multi-channel MAC protocol for Wireless Ad Hoc Networks

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Outline

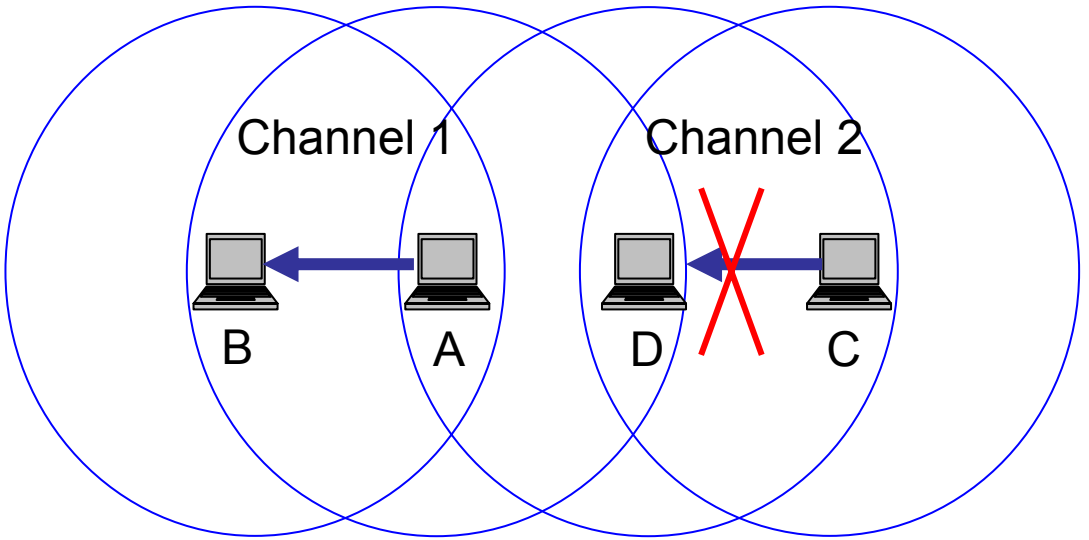
- Introduction
- Related works
- Proposed method
- Simulation results
- Conclusion
- References

Introduction

- The bandwidth of wireless networks is low
  - 802.11b: 1, 2, 5.5, and11(Mbit/s)
  - 802.11a: 6, 9, 12, 18, 24, 36, 48, and 54(Mbit/s)
  - 802.11g: 1, 2, 5.5, 6, 9, 11, 12, 18, 22, 24, 33, 36, 48, and54(Mbit/s)
- 802.11x provides multiple channels for using
  - 802.11b: 14 available channels, 3 non-overlap channels
  - 802.11a: 12 available channels(8 channels for outdoor use , and 4 channel for indoor use)

Introduction

- The 802.11 standard provides multiple channels for use, but we use just only one channel at a time now.
- It is an effective way to increase the networks capacity.



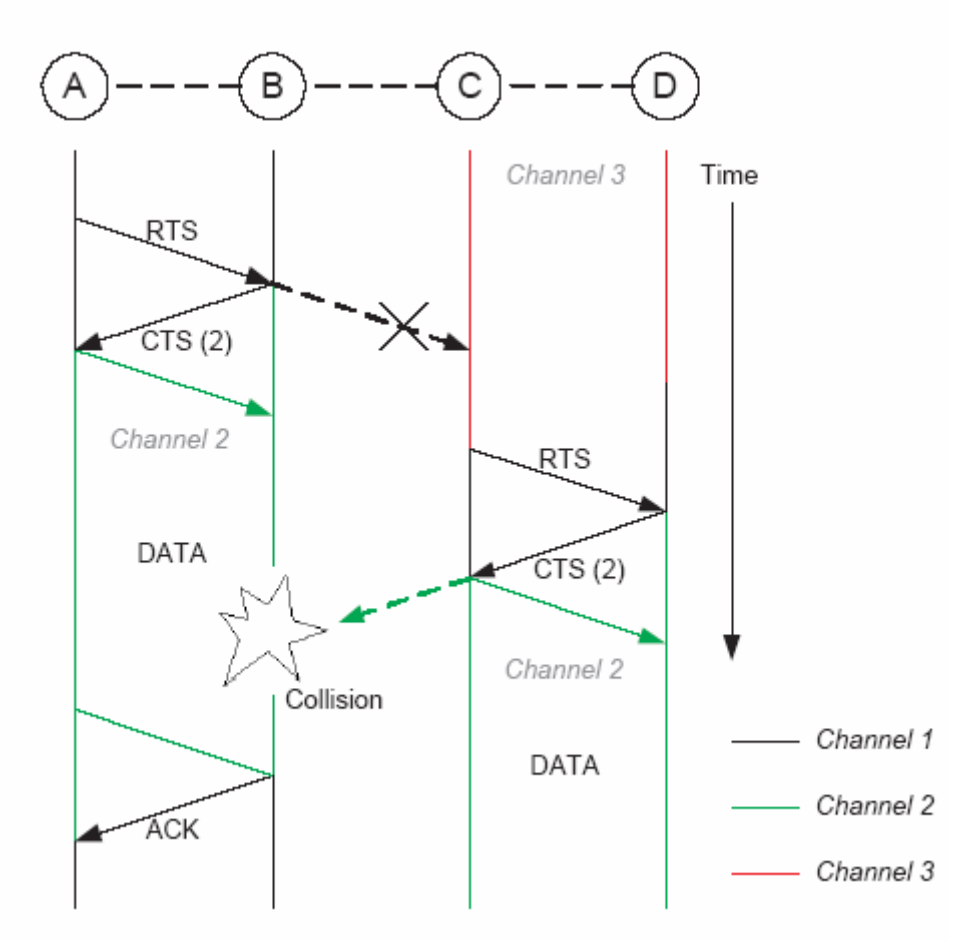
Introduction

- Multi-channel MAC protocols can be divided into two parts:
  - Channel assignment
  - Medium access

Related Works

- The Carrier Sense Multiple Access/Collision Avoidance (CSMA/CA) is not suitable for multi-channel wireless networks.
- New Multi-channel hidden terminal problem

New multi-channel hidden terminal problem



Related Works

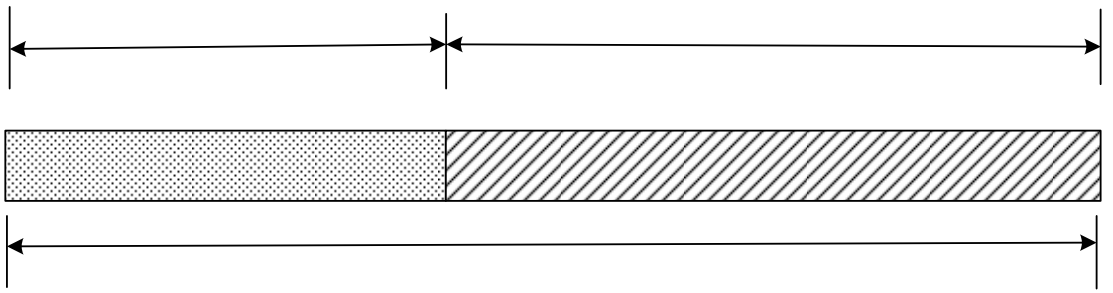
- Previous works
  - Each host is equipped with multiple transceivers.(as much as the number of channels) [2]

Related Works

- [3,4,5,6] divide the channels into two classes:
  1. Control channel
  2. Data channels
- Each host is equipped with two transceivers, one for control channel and the other for data channels.

Related Works

- [7, 8] take the hardware cost and energy consumption into consideration.
- Not only divide the channels into two classes but also spilt the time interval



- Each host is equipped with just one transceiver
- Fixed interval size limits the channel utilization

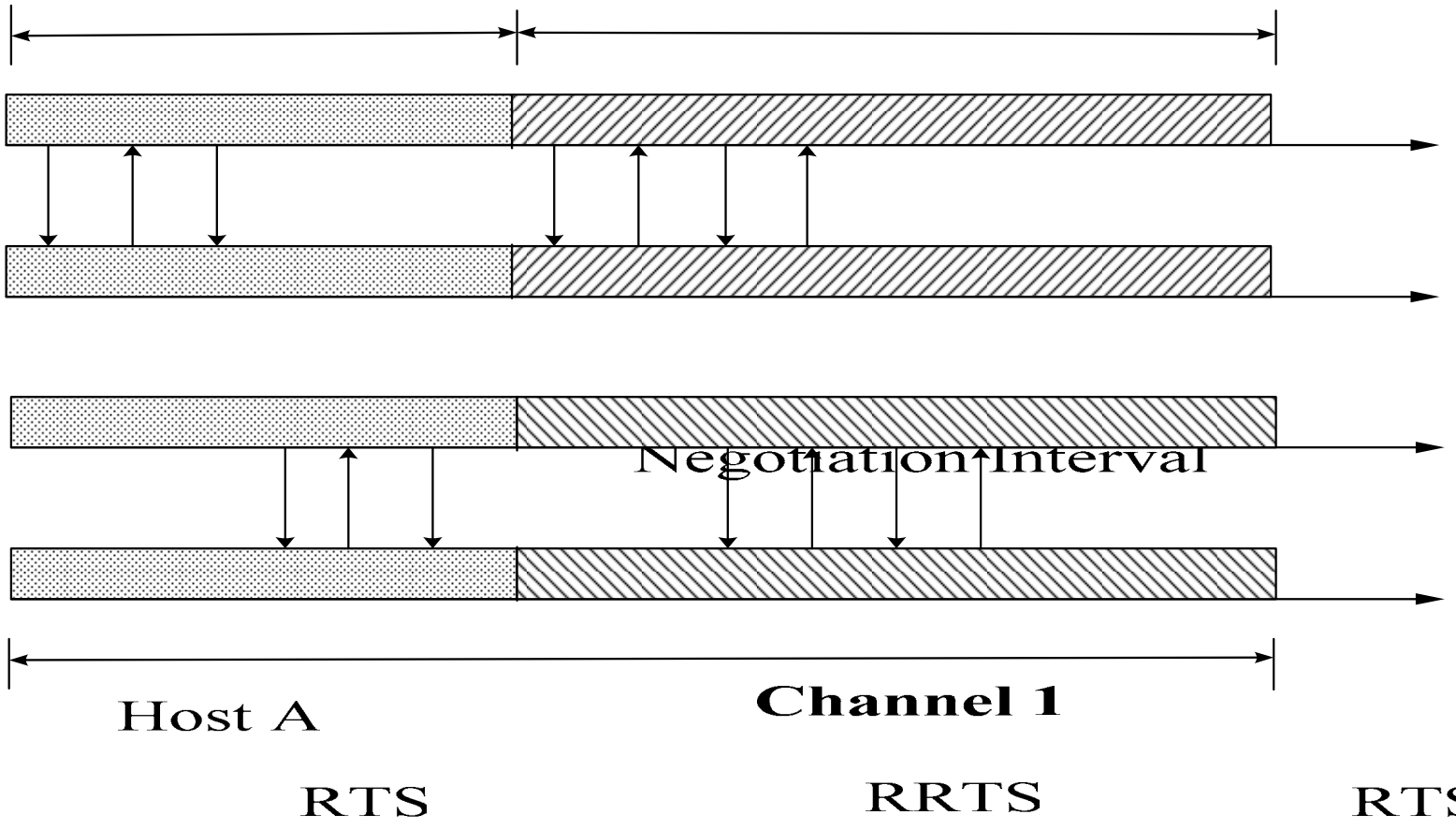
Proposed Method

A. Channel Negotiation and Data Exchange

B. Procedure of Channel selection

C. Dynamic Interval Adjustment

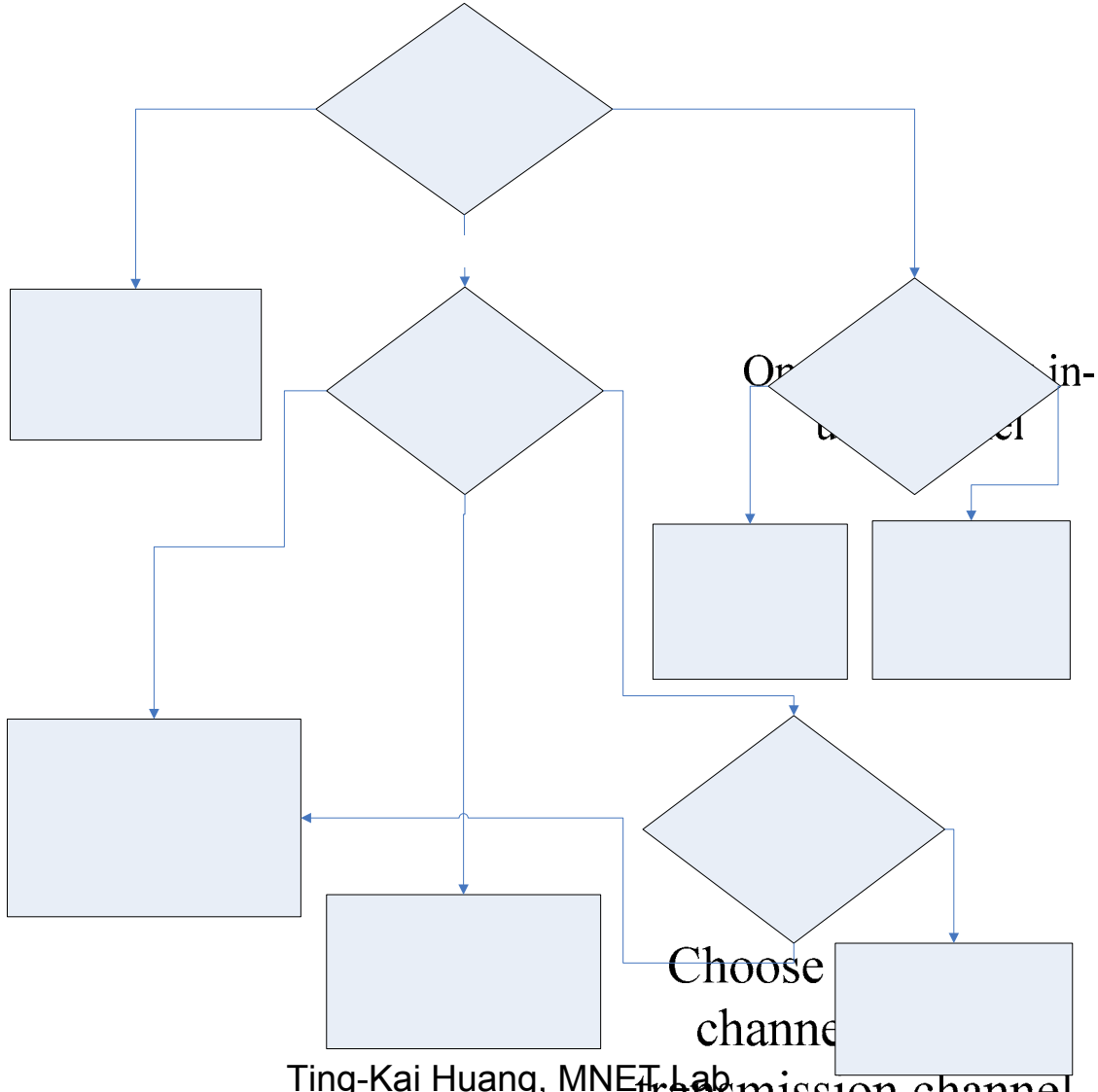
Channel Negotiation and Data Exchange



Channel status information

- Each host maintains one in-use channel and two channel list , Good channel list , and Bad channel list, to keep track of necessary information for channel selection.
- In-use channel: the channel that the host will use for data transmission in this time frame
- Good channel list: the channels that no other neighboring hosts are using.
- Bad channel list: the channels that are selected by host's neighbors.
  - counter

Procedure of Channel selection

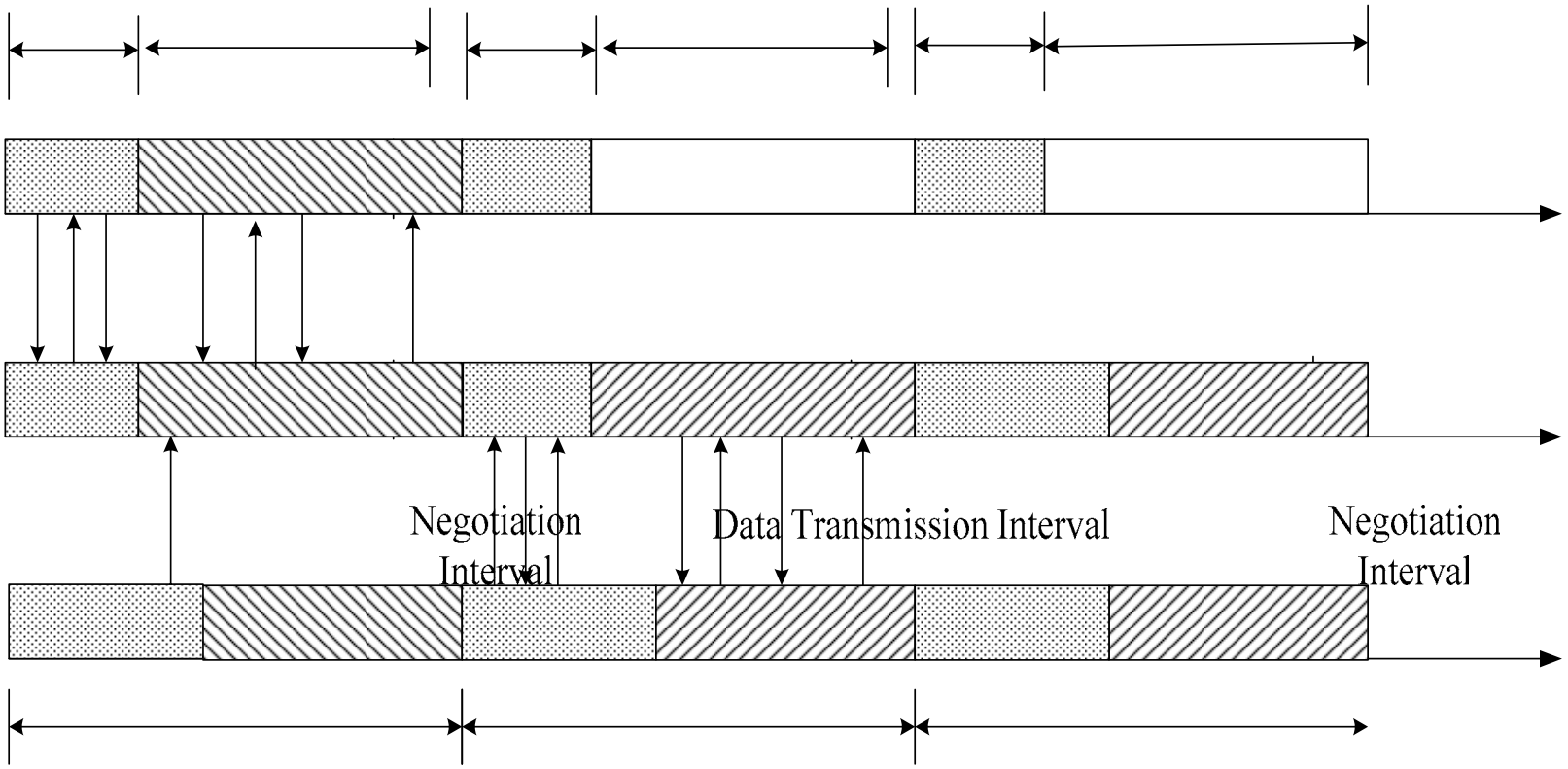


Dynamic Interval Adjustment

- The operations
  1. Making just one negotiation with per destination
  2. Increasing and decreasing the negotiation interval size
     - Maximum, minimum,
     - The size of increment is fixed
  3. Piggybacking of negotiation interval size

Dynamic Interval Adjustment

4. Packet marking



Dynamic Interval Adjustment

- The rules for adjusting Negotiation interval
- Increasing rules
  1. Based on the number of pending packets that the host could not negotiate with their destination successfully
  2. Overhearing the packets on the air
  3. Receiving the negotiation packet in data transmission
  4. Receiving the marked packets

Dynamic Interval Adjustment

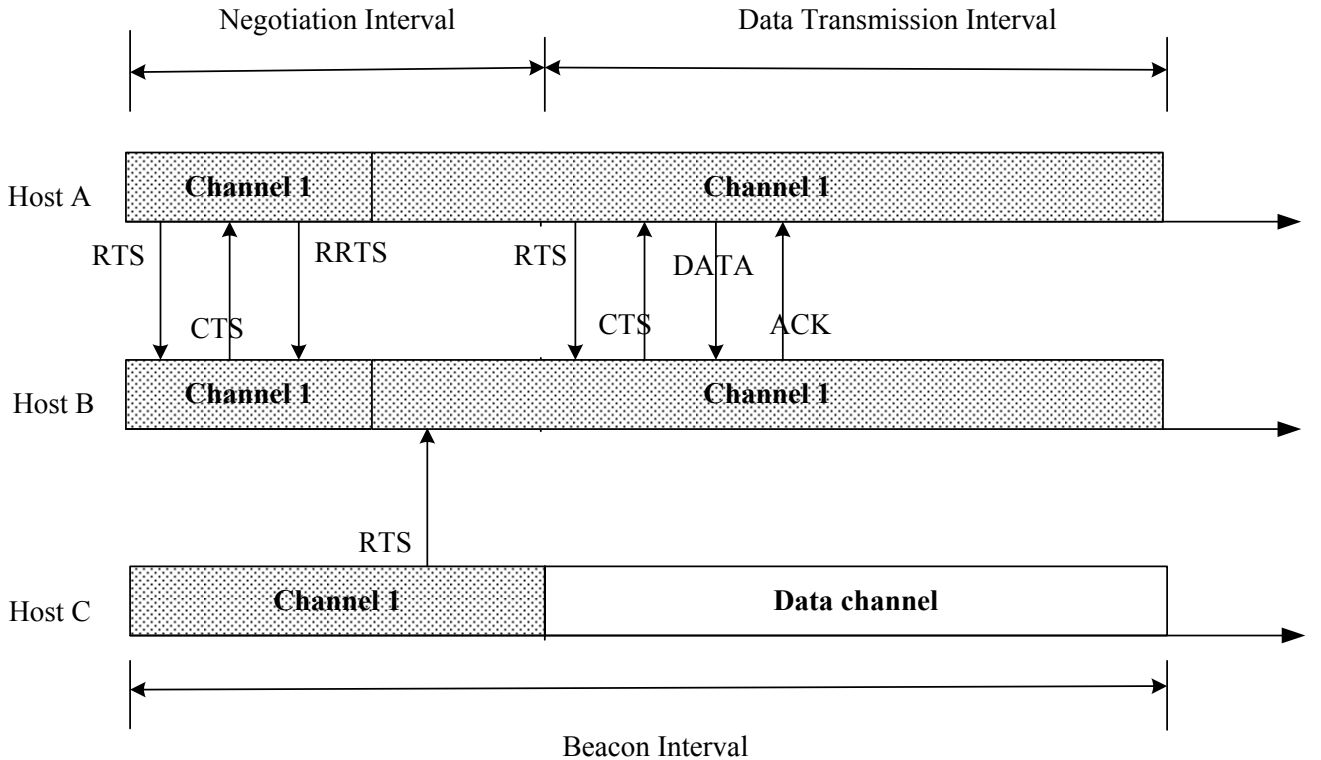
1. Based on the number of pending packets that the host could not negotiate with their destination successfully
   - If the sum of pending packets to each destination exceeds the threshold, the host increases the size of negotiation interval by one level.

Dynamic Interval Adjustment

2. Overhearing the packets on the air
   - Hosts increase the size of interval by one level if they find that the interval size of the overhearing packages is at least two levels larger than themselves.

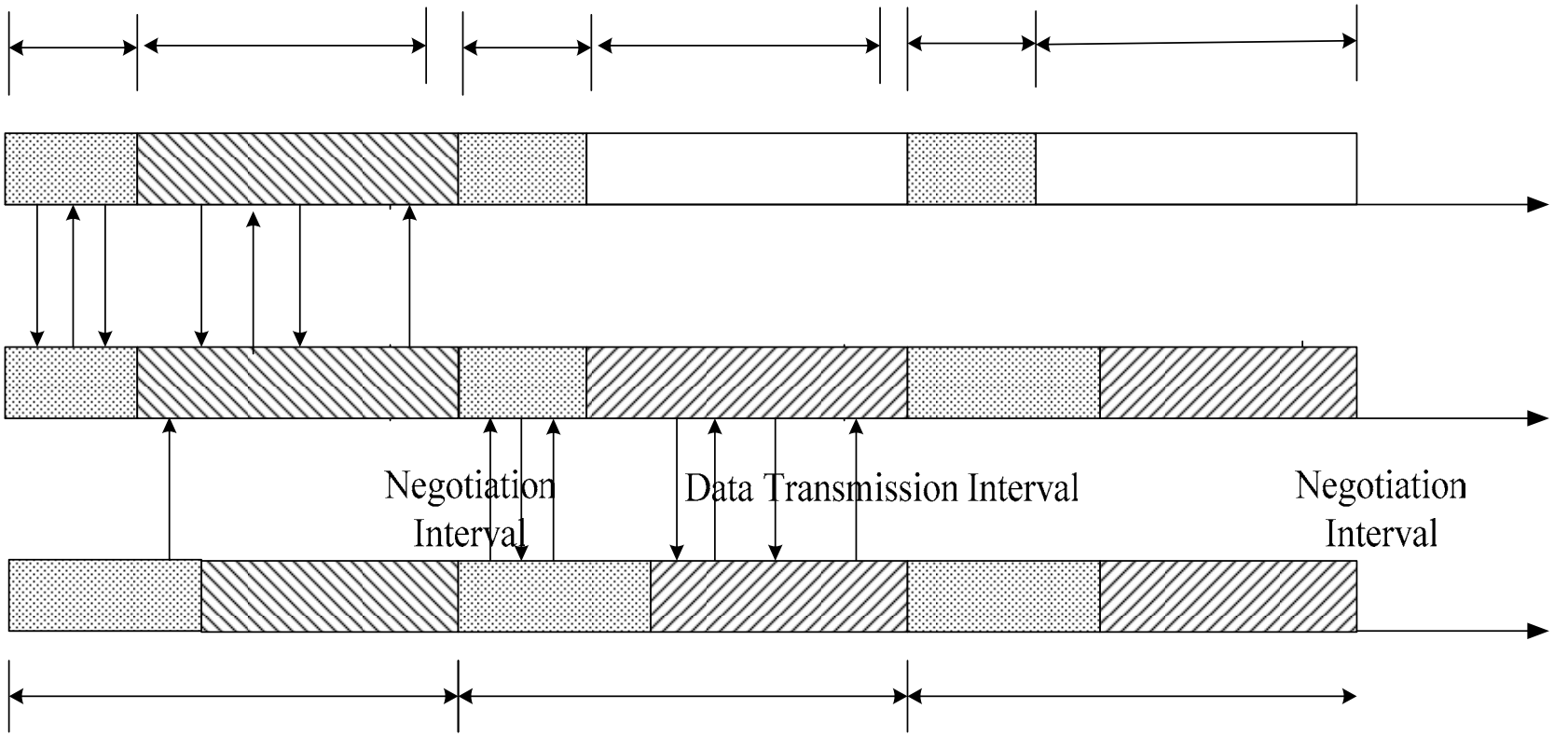
Dynamic Interval Adjustment

3. Receiving the negotiation packet in data transmission interval



Dynamic Interval Adjustment

4. Receiving the marked packets



Channel Channel

Dynamic Interval Adjustment

- Decreasing rule
  - If a host announces all the packets to the destinations, it sets it negotiation interval size to be minimum.

Simulation Models

- Aggregate throughput over all flows in the network
- Average packets delivery delay over all flows in the networks

Simulation Models

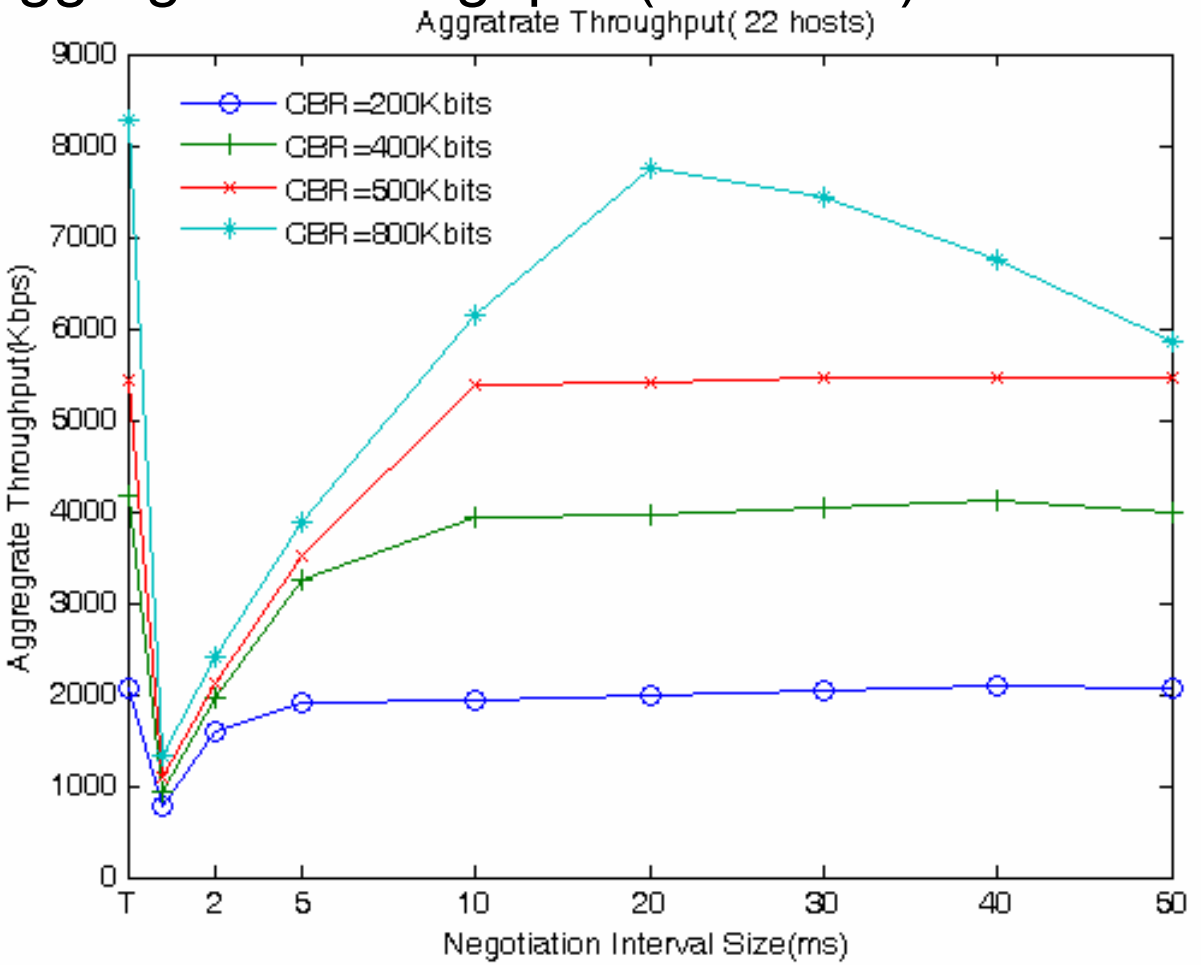
- All hosts are within each other's transmission range.
- In each case, half of the hosts are source hosts and the rest are destination, for the simulated flows
- Each flow transmits Constant Bit Rate (CBR) traffic
- The parameters we vary are:
  - numbers of hosts in the networks,
  - the networks load, and
  - the NTI interval size.

Simulation Models

Parameters	Values
Length of beacon interval	100ms
Number of channels	3
Bandwidth of channel	11Mbps
Packet size	512bytes
Max negotiation interval size	50 ms
Min negotiation interval size	5 ms
Slot time	0.1ms
Length of SIFS	0.01ms
Length of DIFS	0.05ms
Length of MRTS	20bytes
Length of MCTS	14bytes
Length of RRTS	14bytes

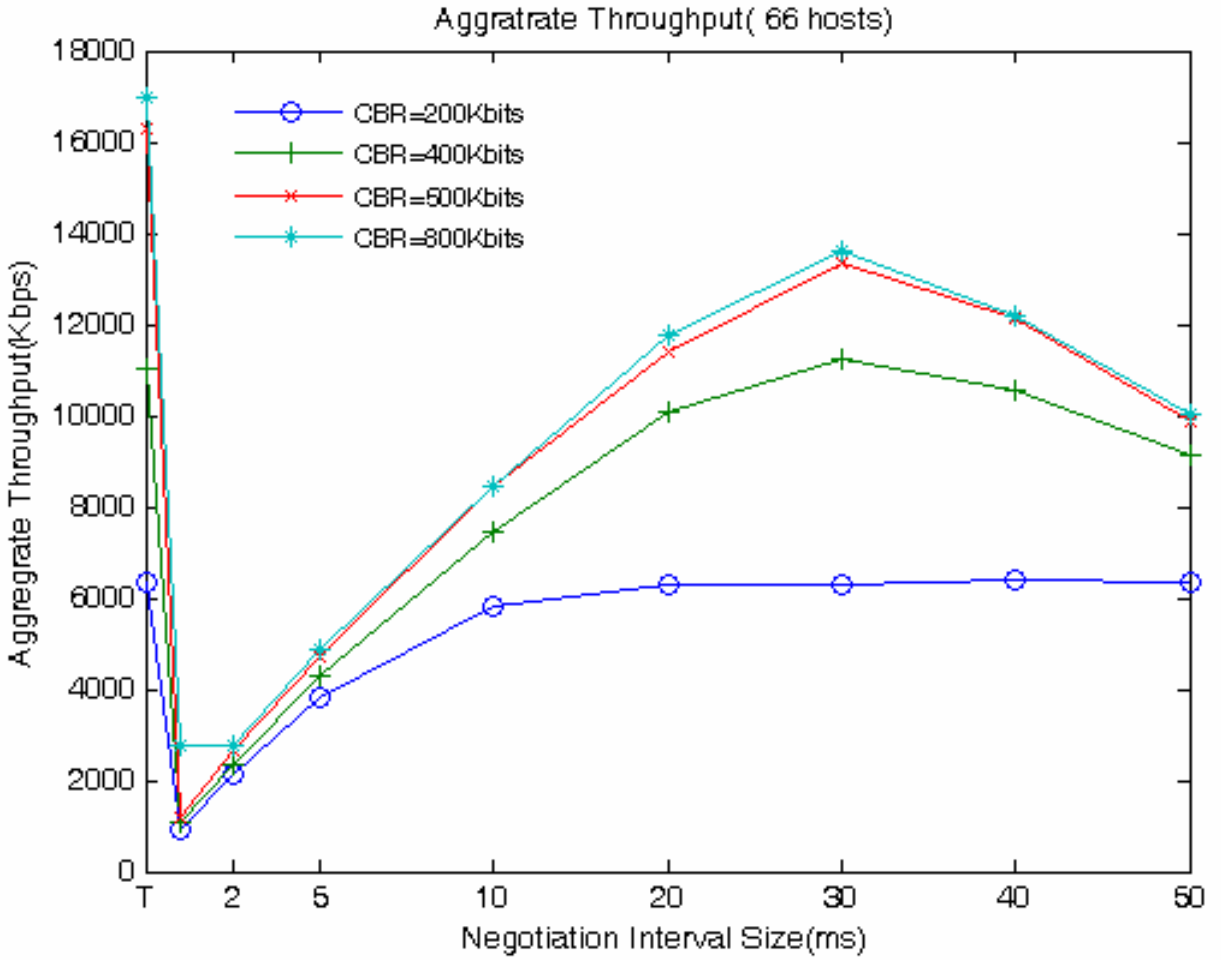
Simulation Results

(a) Aggregate Throughput (22 hosts)



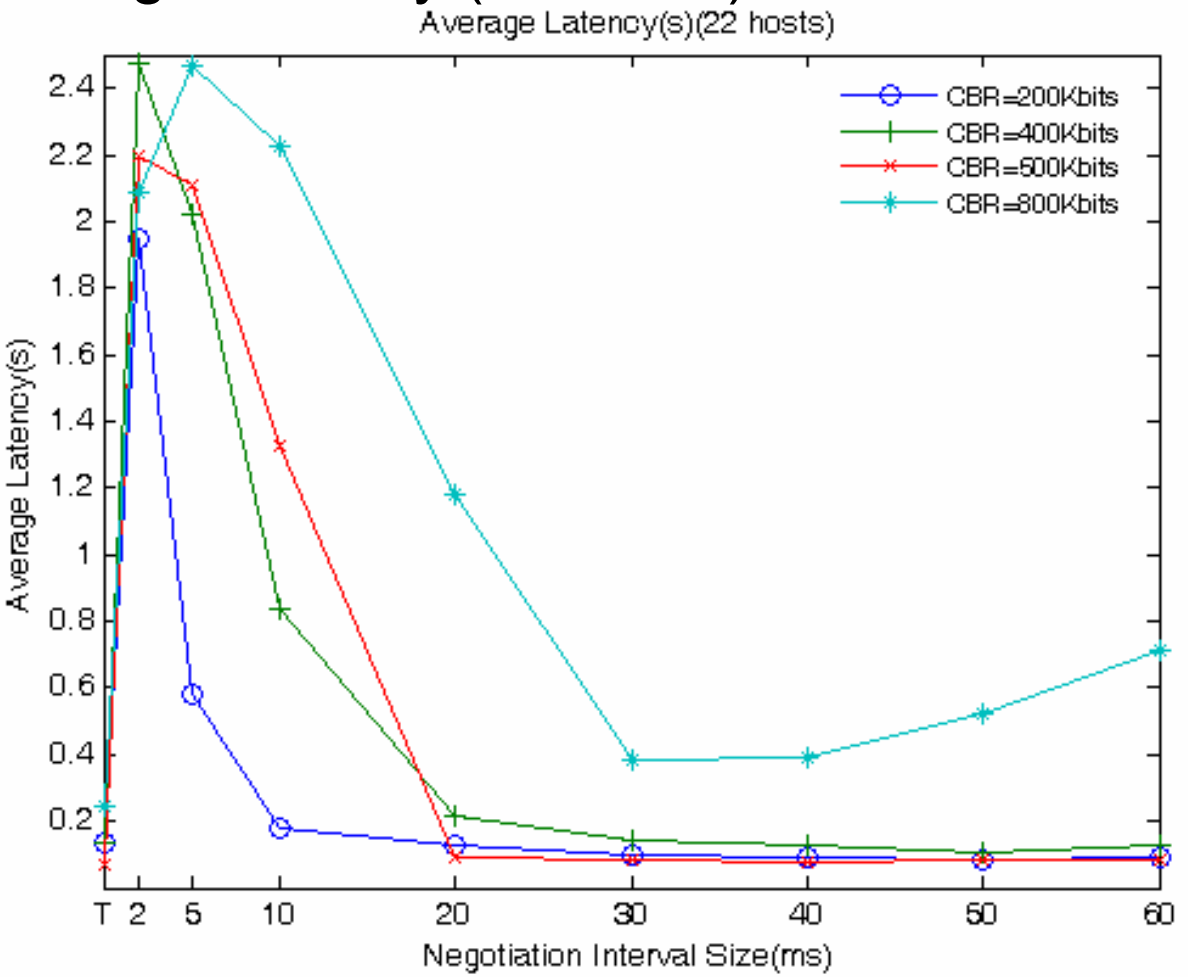
Simulation Results

(b) Aggregate Throughput (66 hosts)



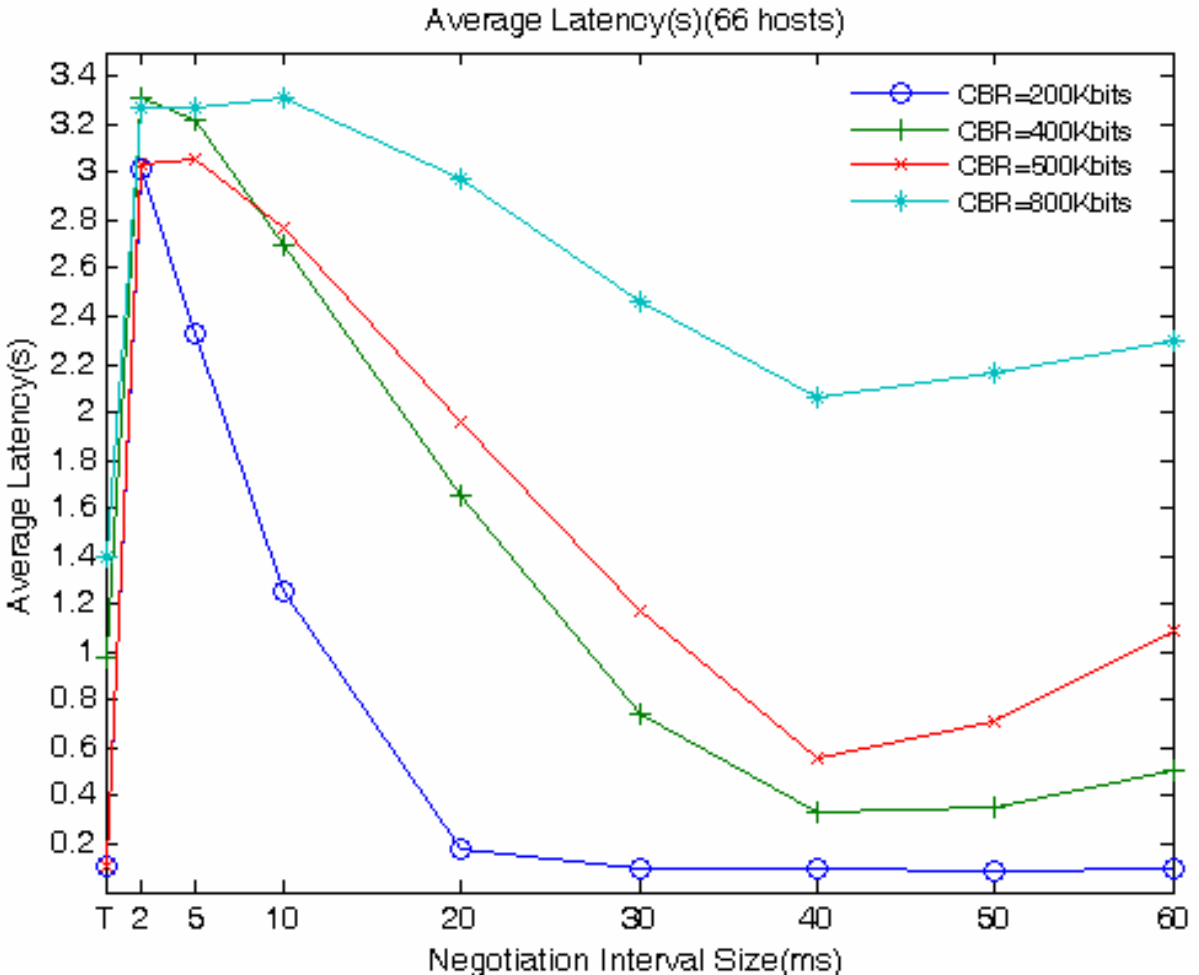
Simulation Results

(a) Average Latency (22 hosts)



Simulation Results

(b) Average Latency (66 hosts)



Conclusions

- A new MAC protocol that can exploit multiple channels effectively by only using one transceiver per host.

- Our protocol can adjust to different traffic load in order to maximize the channel utilization.

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