Multi Channel Problem Analysis

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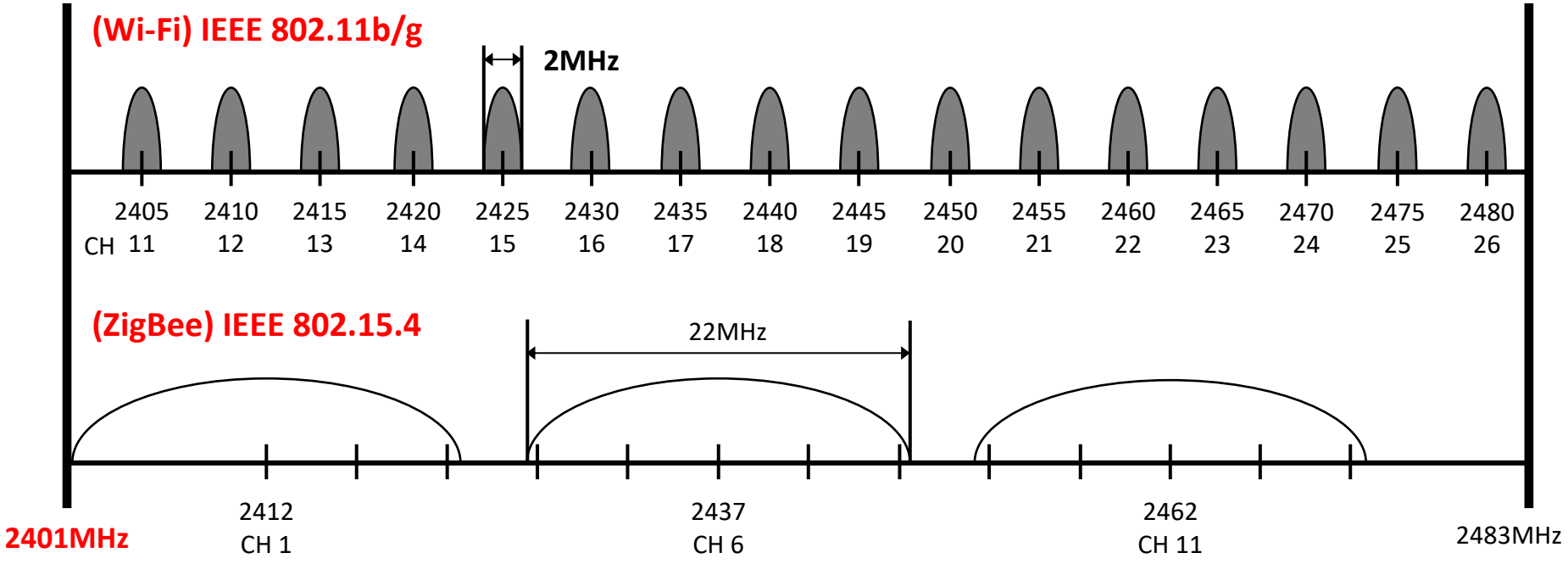
Introduction

Wi-Fi

- Using 2.4 GHz ISM Band
- Channel CH11~CH26: 16 channels
- Channel interval: 5MHz
- Channel bandwidth: 2MHz
- IEEE 802.11

ZigBee

- Using 2.4 GHz ISM Band
- Channel CH1~CH13: 13 channels
- Channel interval: 5MHz
- Channel bandwidth: 22MHz
- IEEE 802.15.4

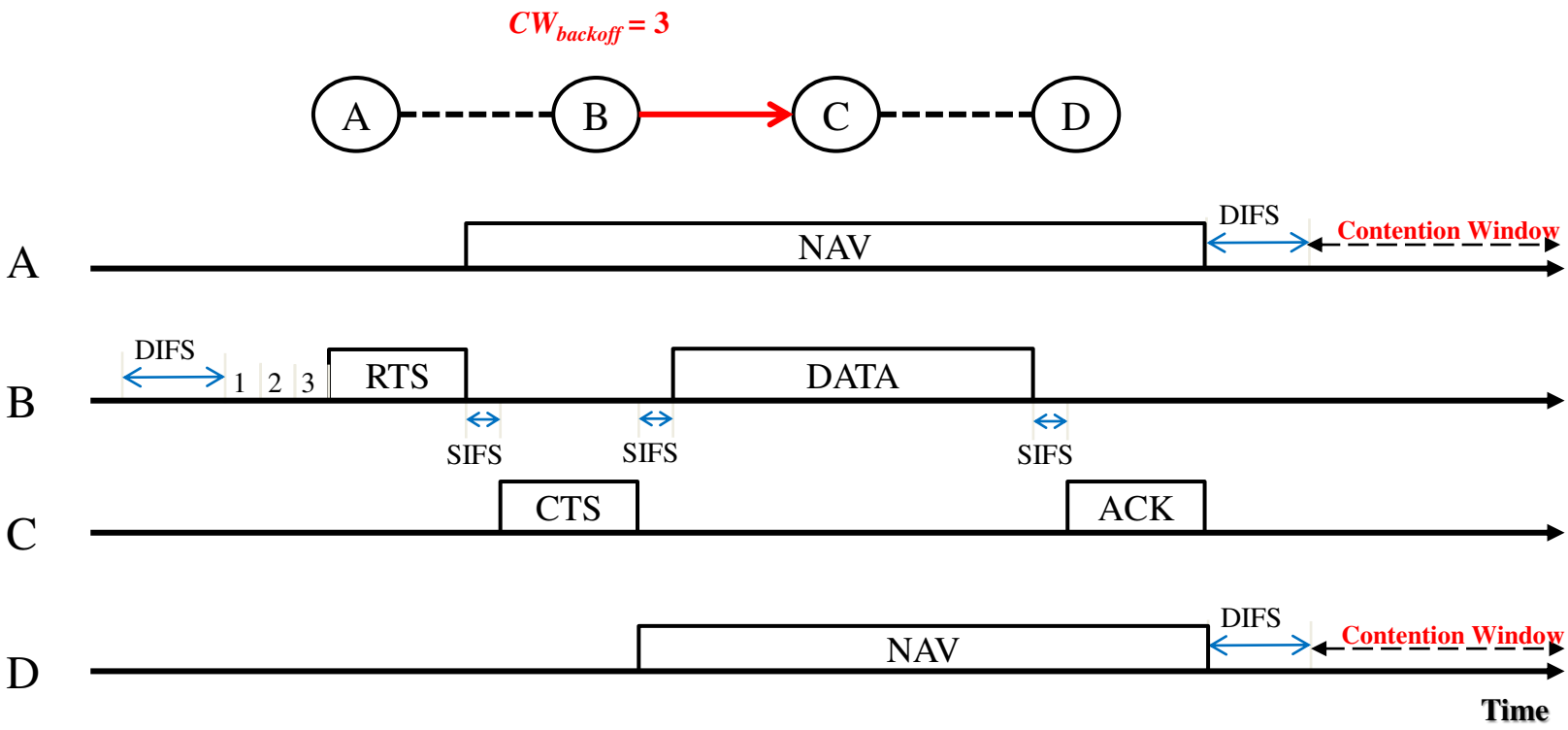


IEEE 802.11 Distributed Coordination Function (DCF)

- In DCF: Before transmitting a packet, a node has to wait for a small duration of time even if the channel is idle.
- This is called *interframe spacing.*
- **SIFS, PIFS, DIFS**, and **EIFS** are the four interframe spacings.
- A node waits for a **DIFS** before transmitting an **RTS**.
- Waits for a **SIFS** before sending a **CTS** or an **ACK**.
- **SIFS** duration is **smaller** than a **DIFS**.

Introduction

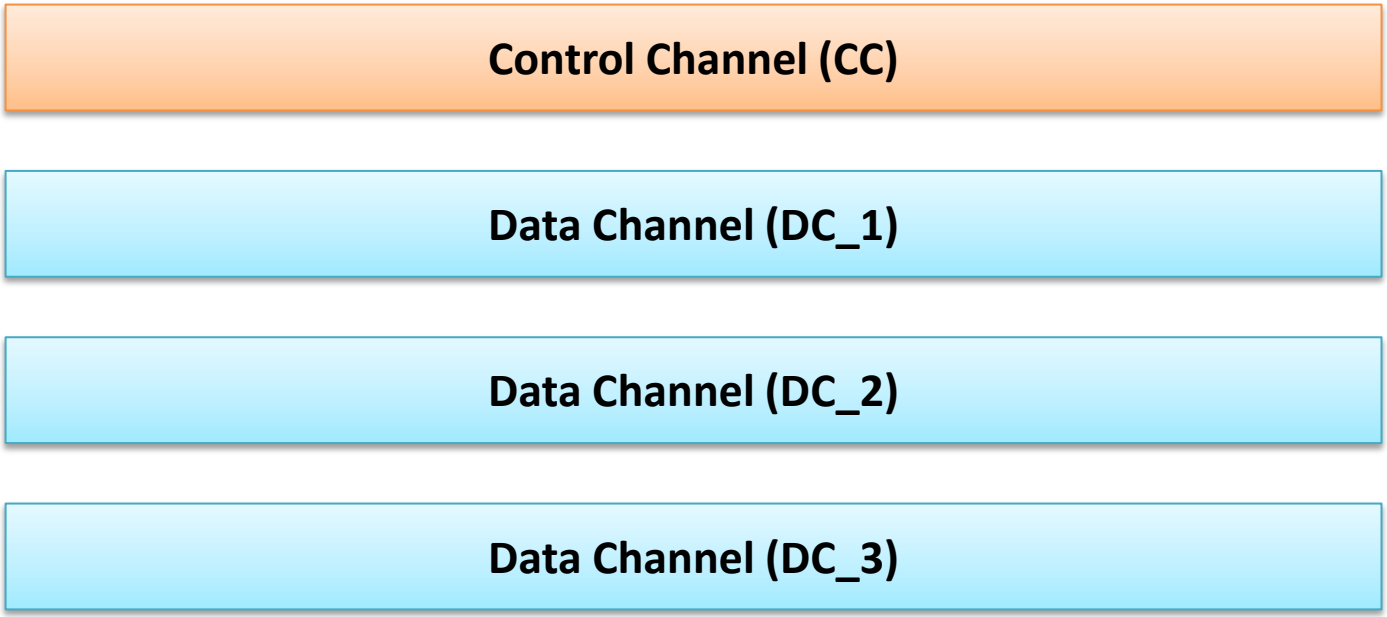
- Distributed Coordination Function (DCF)
  - Use CSMA/CA to sense the medium is busy or idle.
  - Exchange short control frames (RTS/CTS) to further minimize collisions.
  - Use a random backoff procedure to resolve contention conflicts



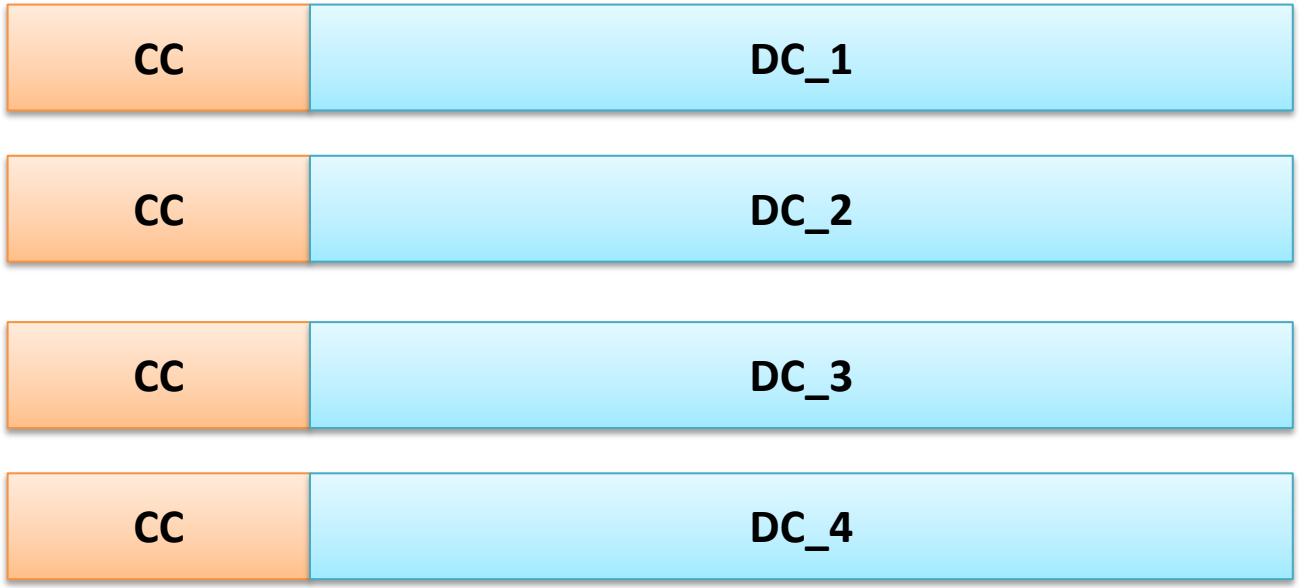
Channel Comparison

- **Single channel:**
  - **control channel and data channel on the same channel.**
- **Multi channel:**
  - **Reduce contention**
  - **Improve throughput**

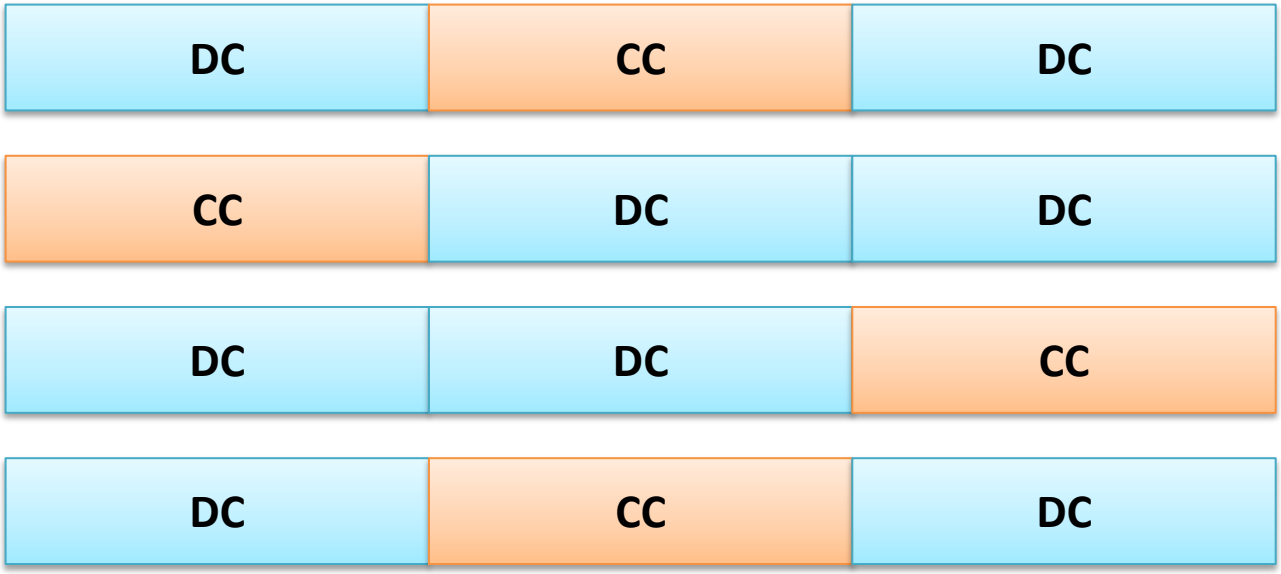
Multi-channel: Case 1



Multi-channel: Case 2



Multi-channel: Case 3

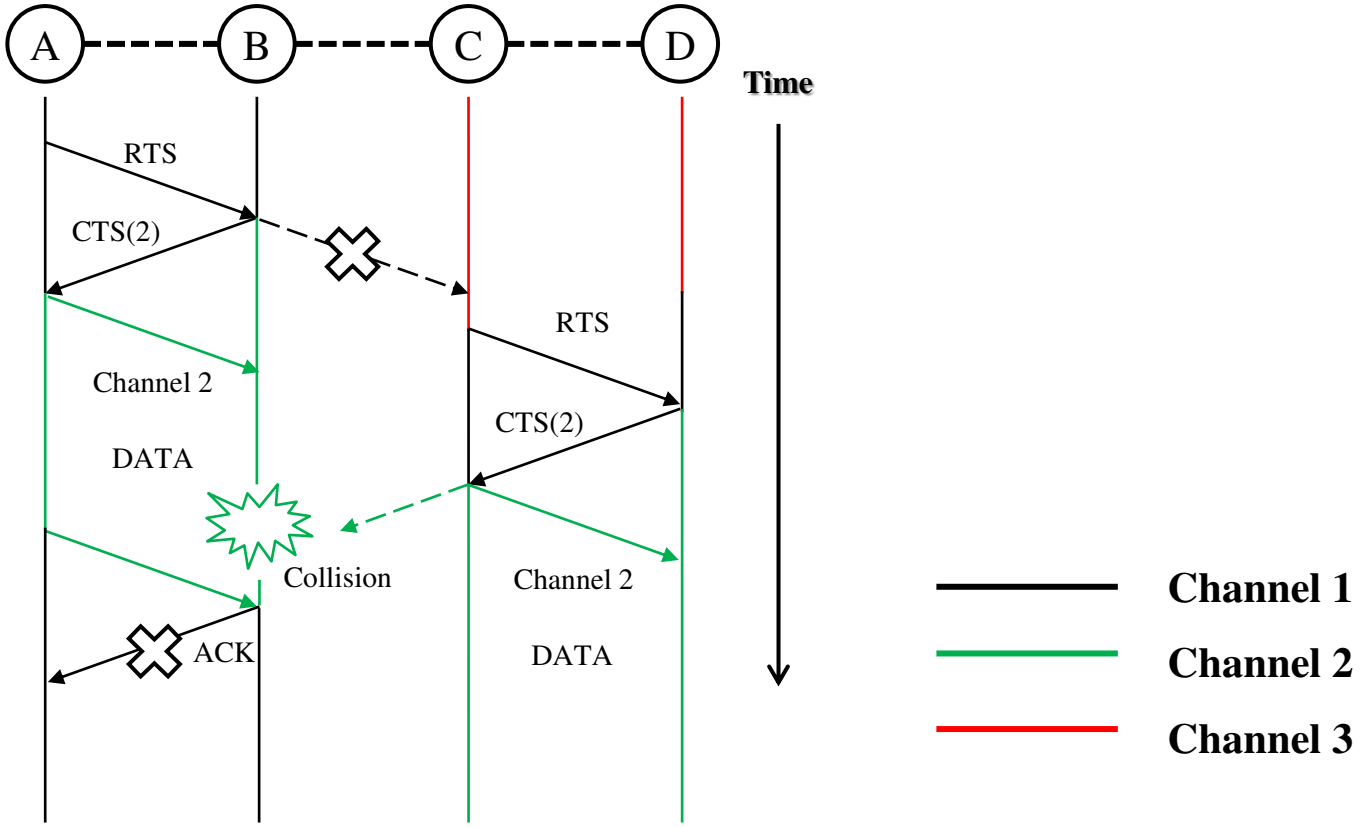


Challenges for multi-channel MAC protocols

- **Multi-channel hidden terminal problem**
- **Missing receiver problem**
- **Broadcast support problem**
- **Channel switching delay problem**

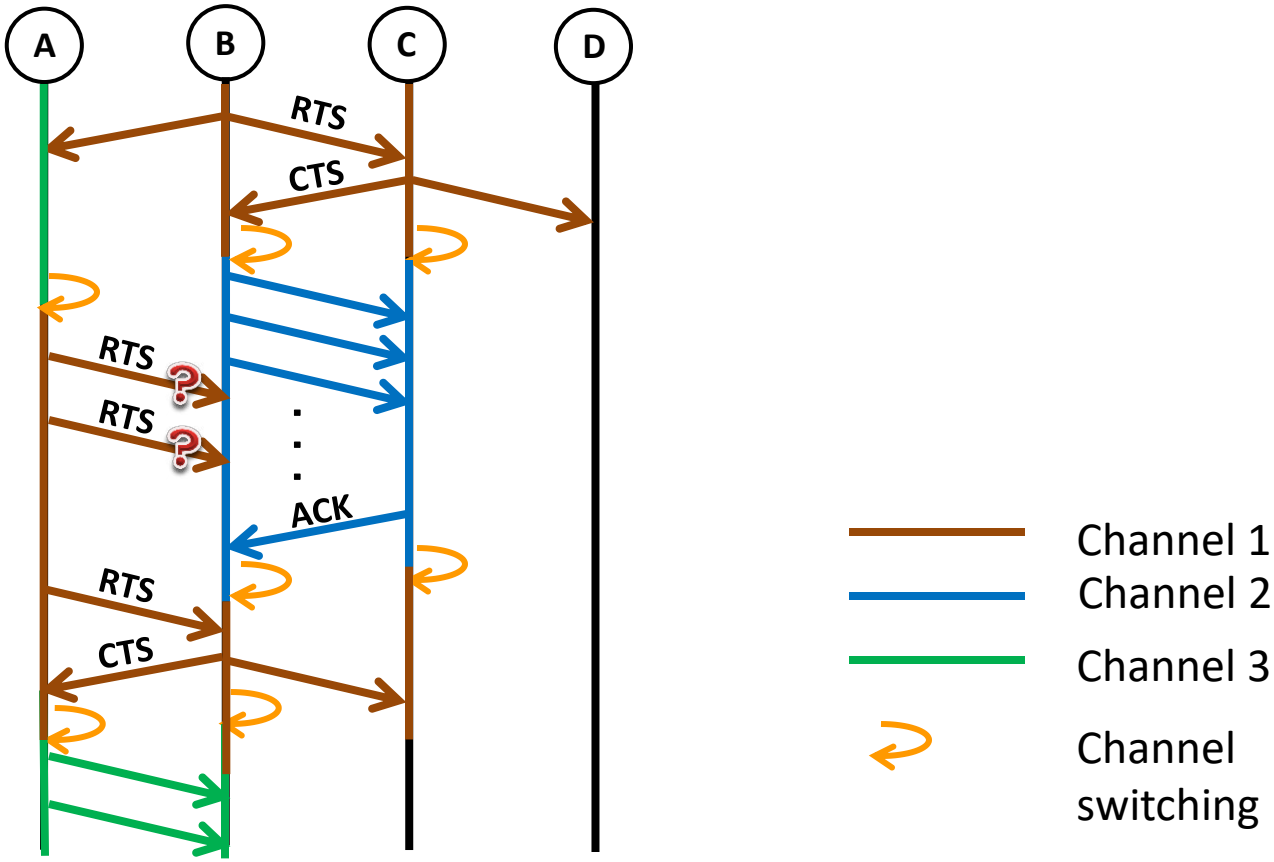
• Multi-channel Hidden Terminal Problem

- **Channel 1** is the common **control channel**

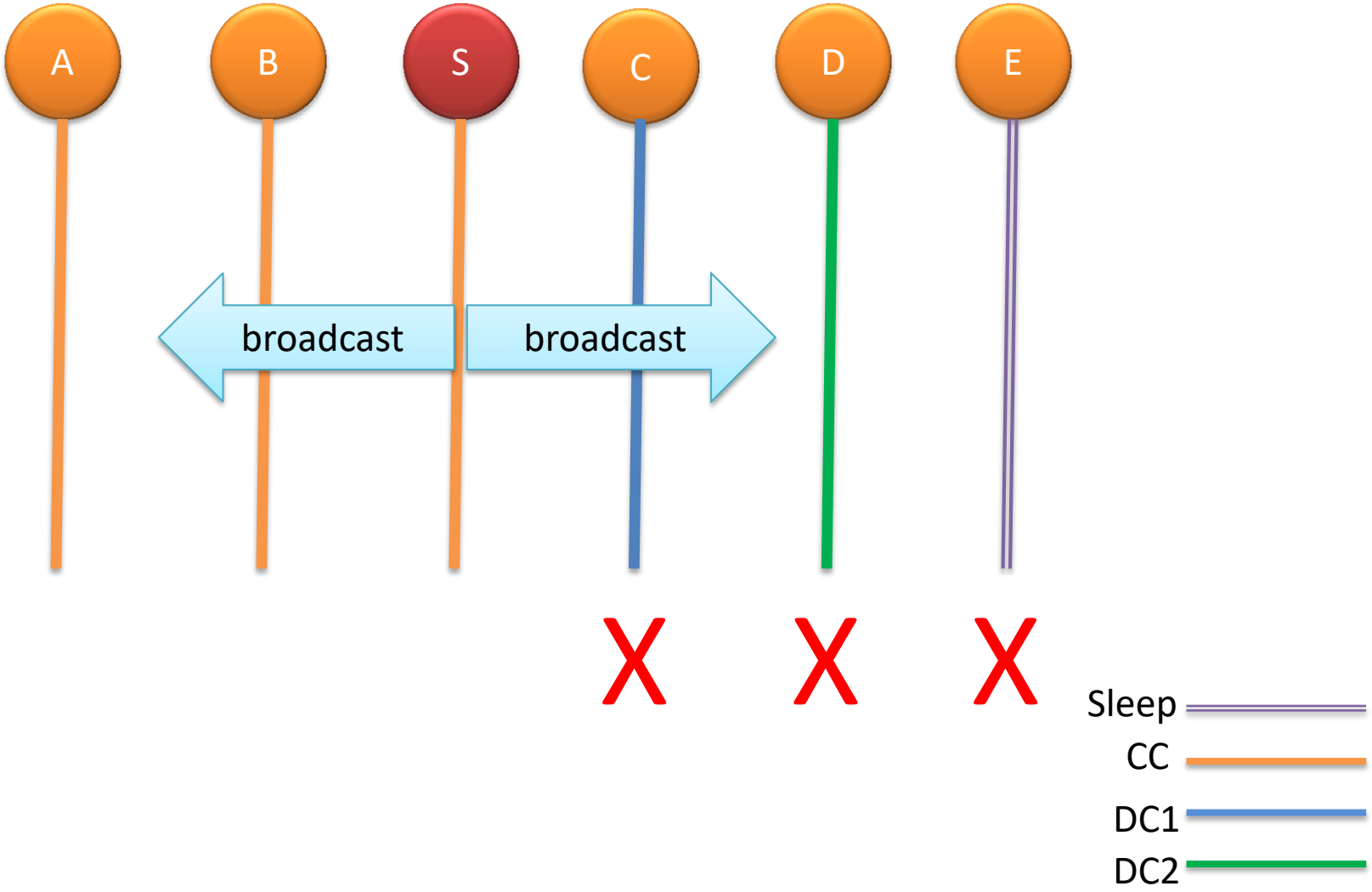


Multi-channel Missing Receiver problem

- **Channel 1** is the common **control channel**



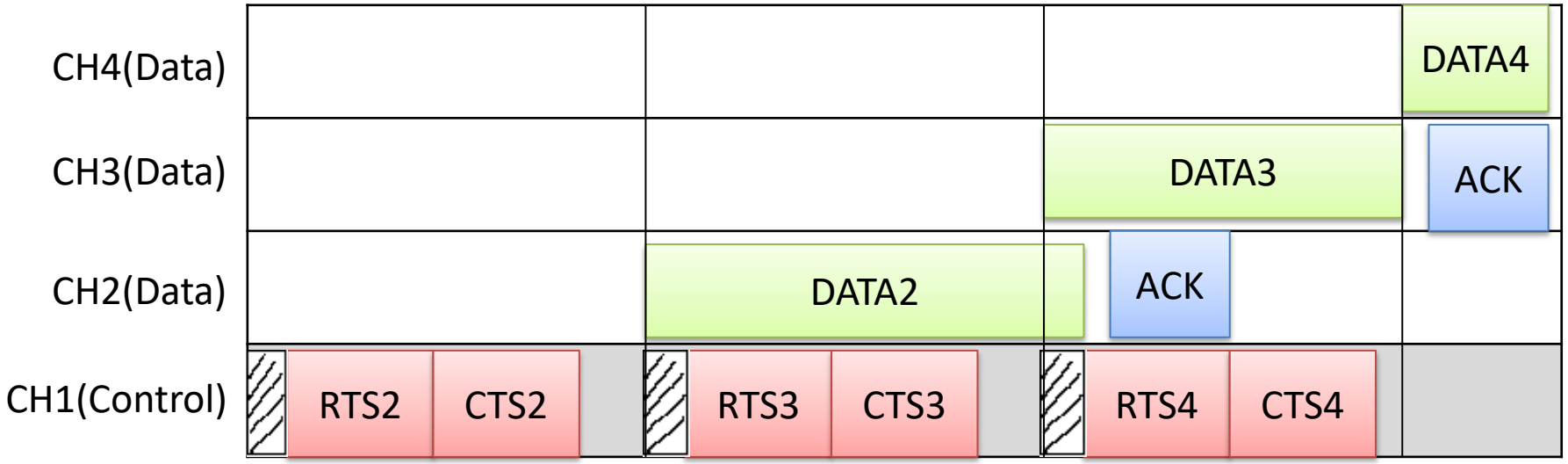
Broadcast support problem



Channel switching delay problem

- Switching amongst channels may take considerable time
- Hence may increase delay and degrade throughput.

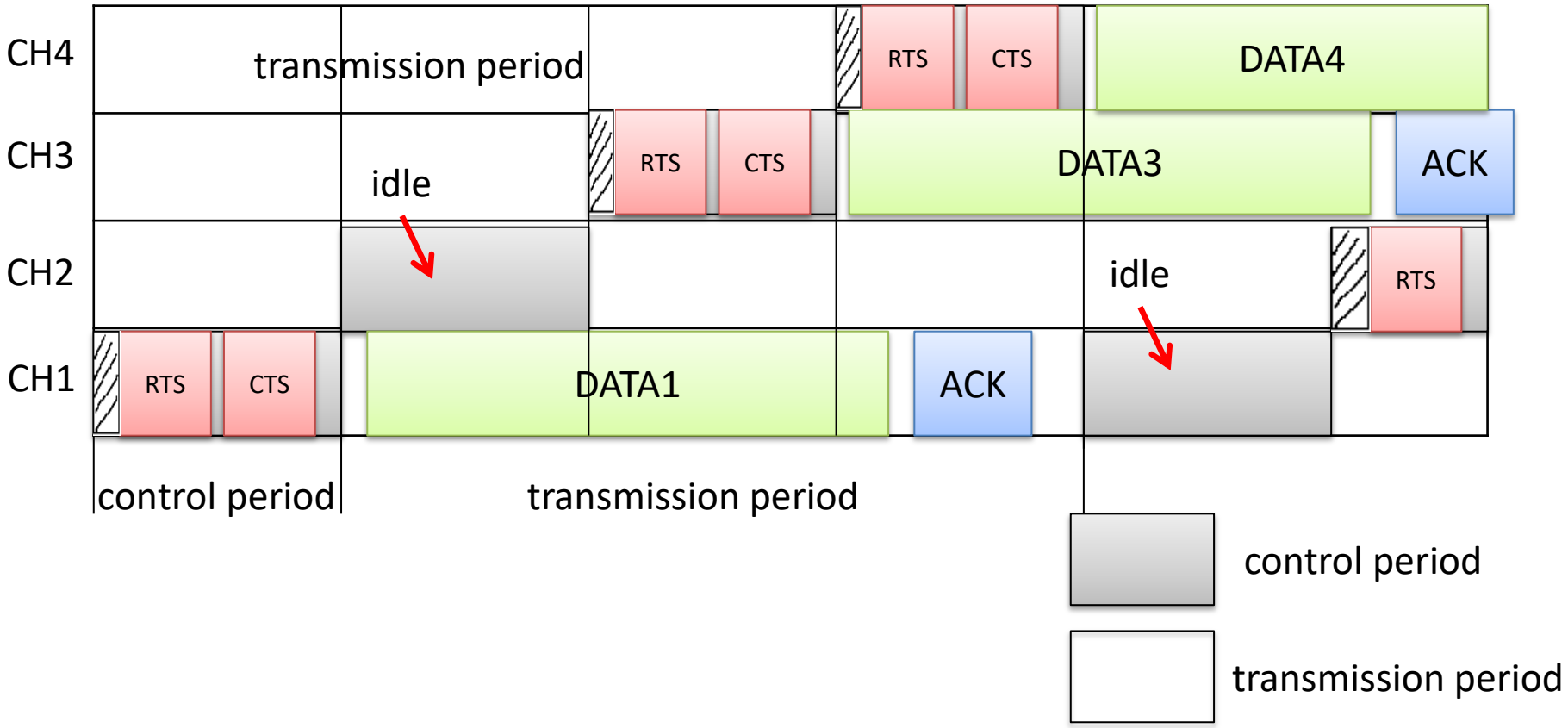
Dedicated control channel approach



Dedicated control channel approach

- Advantage:
  - it does not require time synchronization
- Disadvantage:
  - requires a dedicated control channel

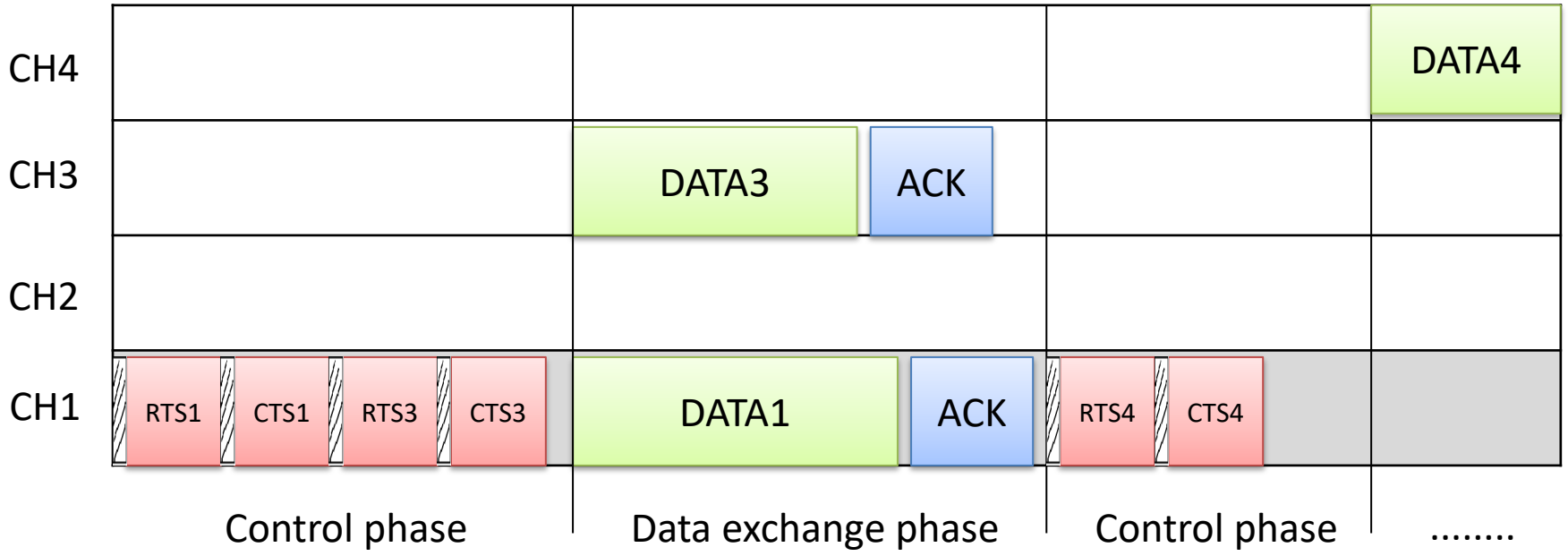
Channel hopping approach



Channel hopping approach

- Advantage:
  - Only one transceiver per node
  - can use all the channels for data transmission
- Disadvantage:
  - Need time synchronization

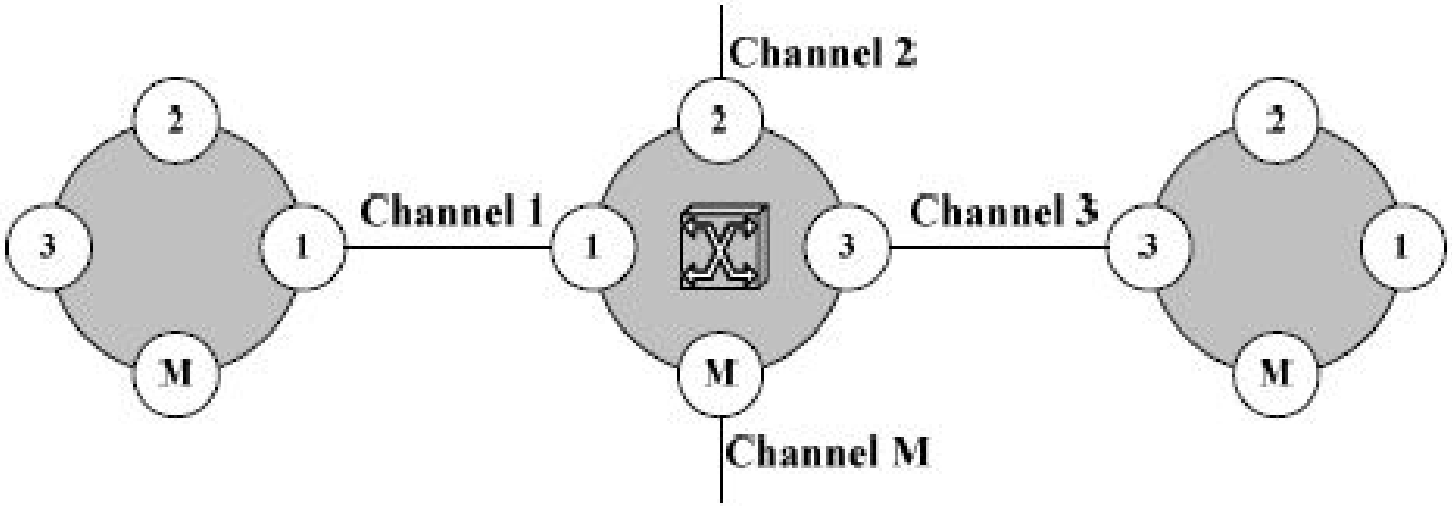
Time division approach



Time division approach

- Advantage:
  - Only one radio per node
- Disadvantage:
  - Need time synchronization
  - Waste other channels In control phase

Multiple transceivers approach

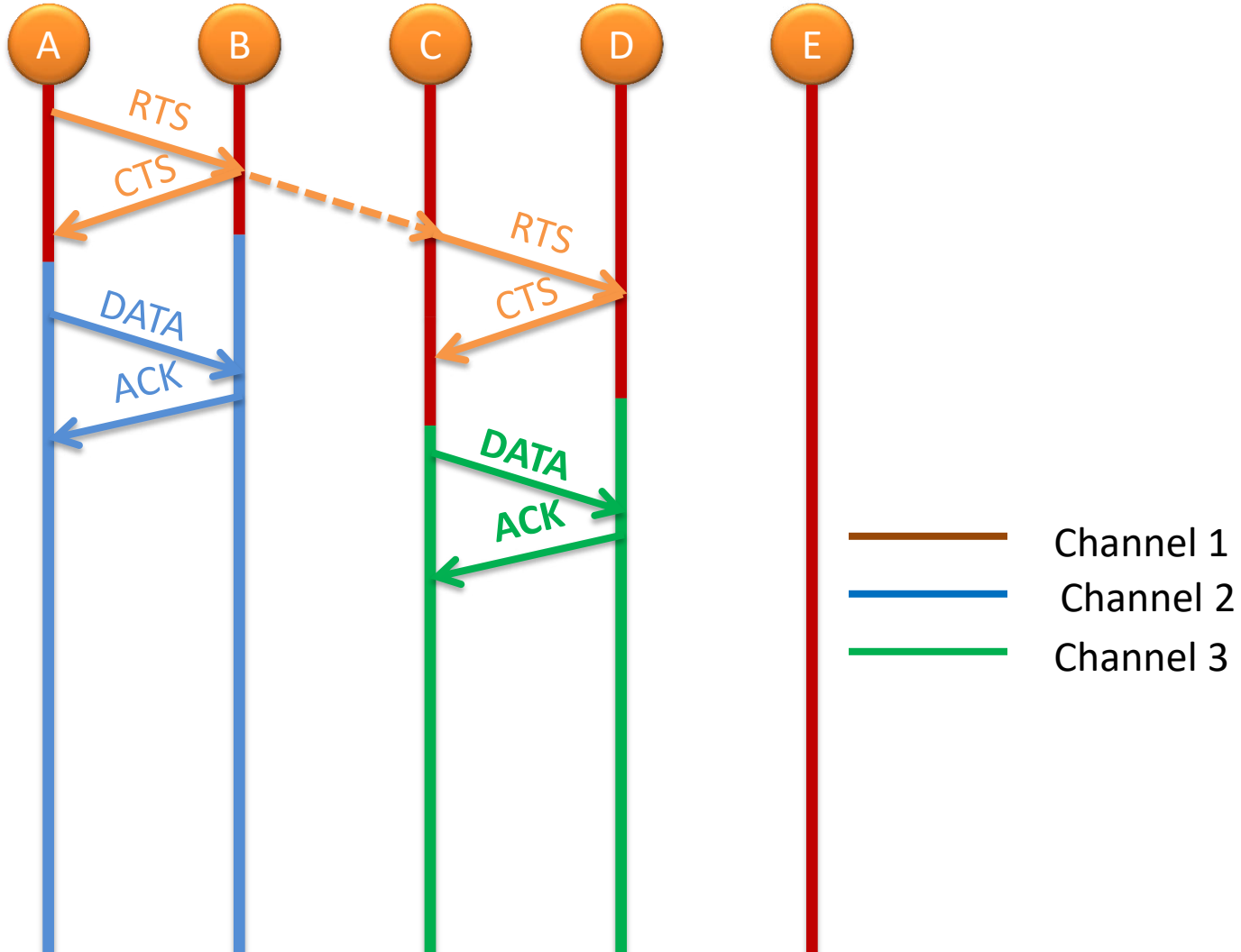


Multiple transceivers approach

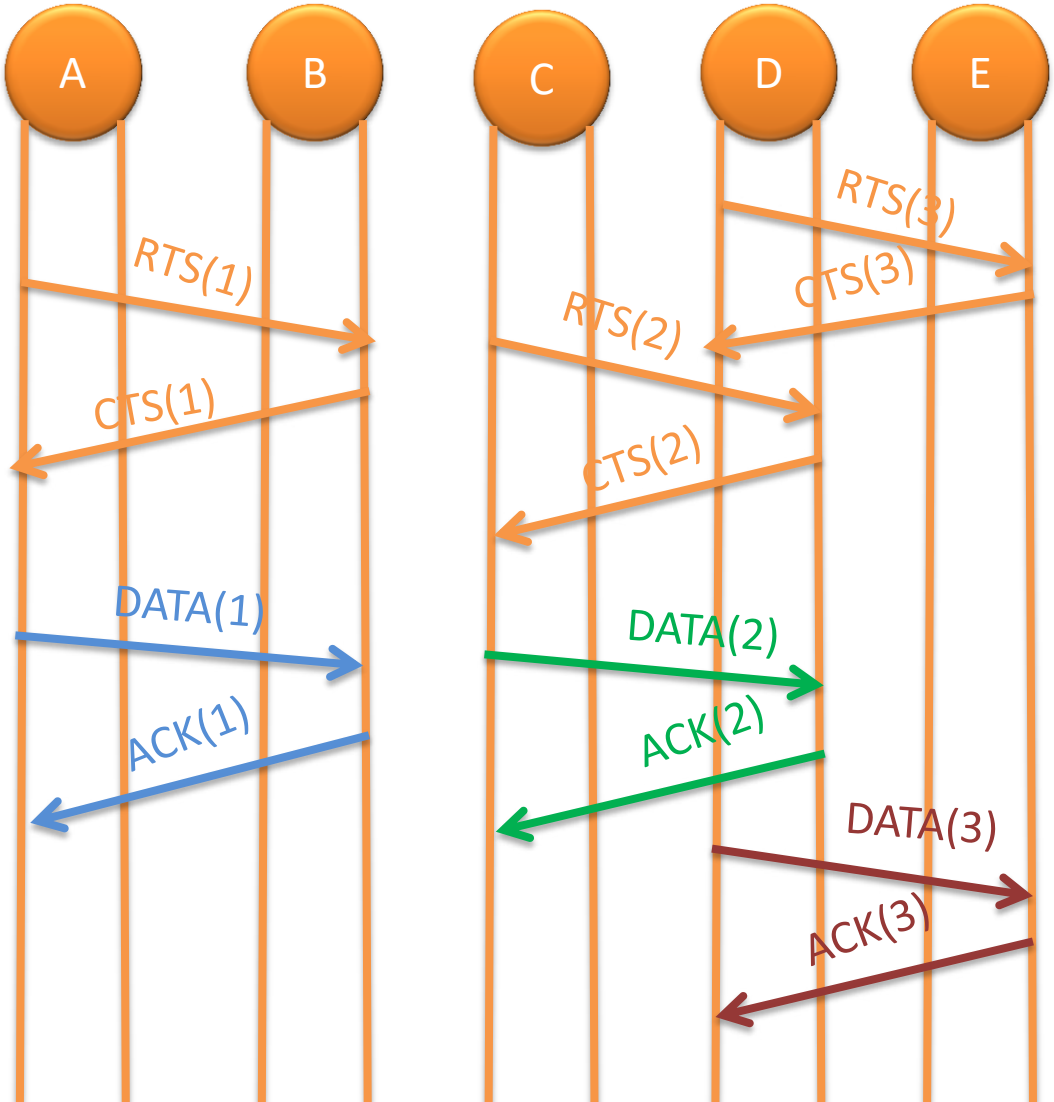
- Advantage:
  - can receive packets on all channels the same time
- Disadvantage:
  - increases the energy consumption
  - High Hardware cost

Multi Channel Single Transceiver

- **Channel 1** is the common **control channel**



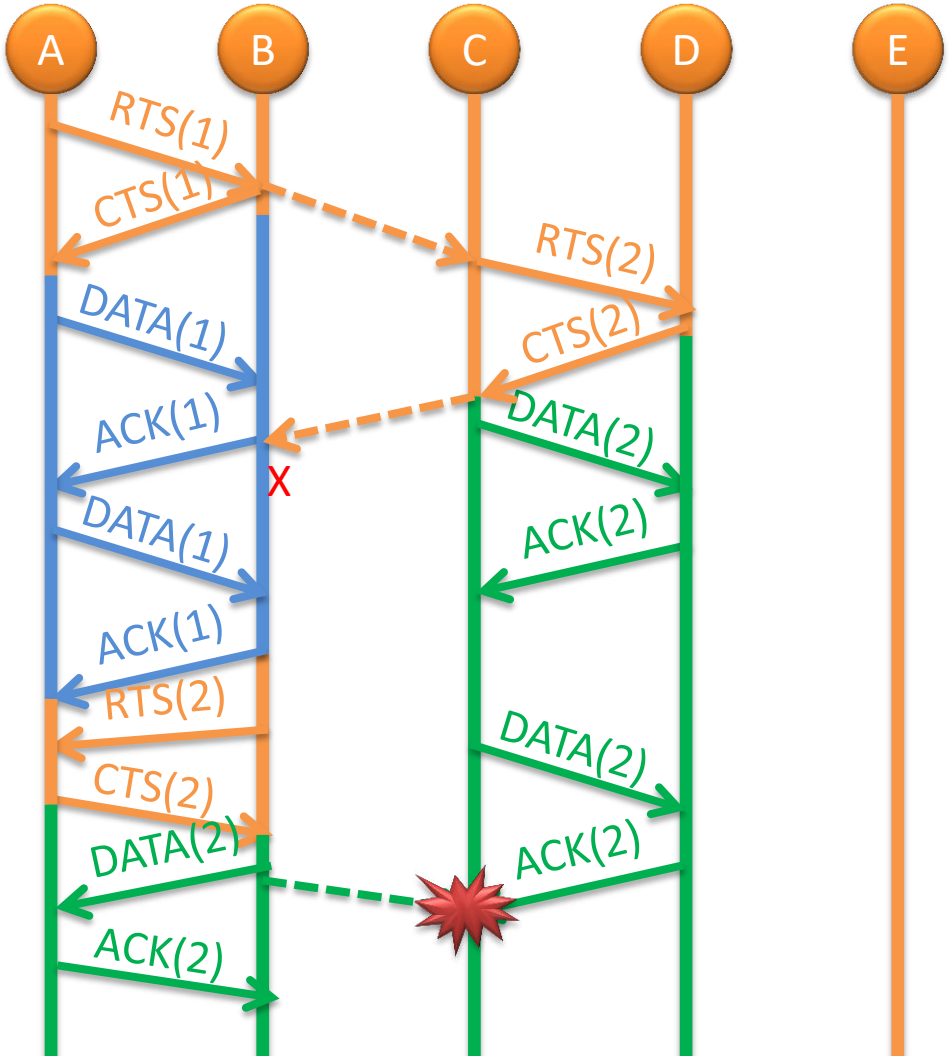
Multi Channel Two Transceiver

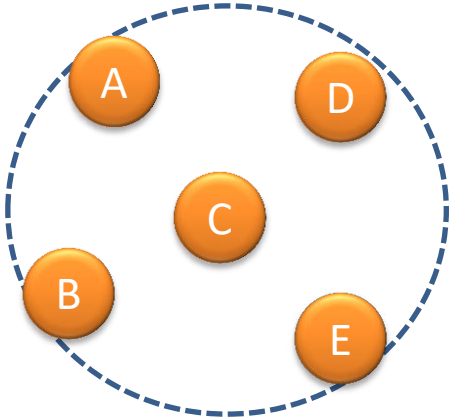


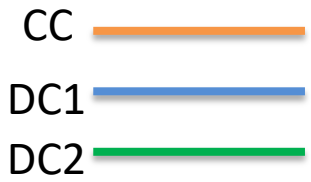
Triple hidden terminals(THT)

- Multi channel hidden
- Sleep hidden terminal
- Multi hop hidden

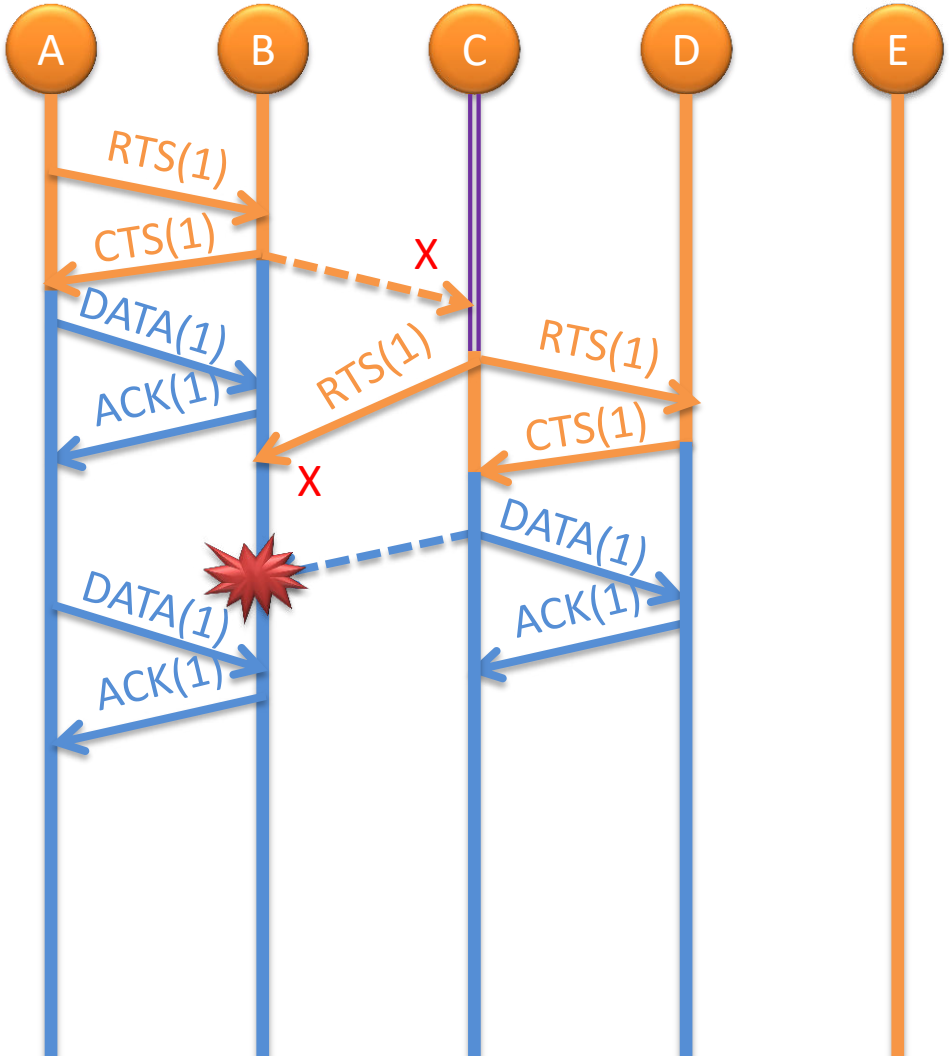
Multi Channel Single Hop Hidden Terminal Problem

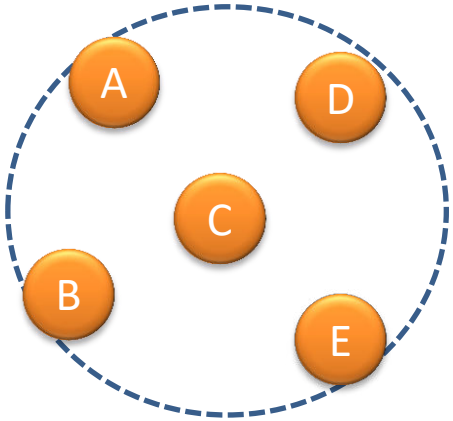






Multi Channel Single Hop Hidden Terminal Problem due to Sleep State





Sleep

CC

DC1

DC2