MIMO and 802.11n

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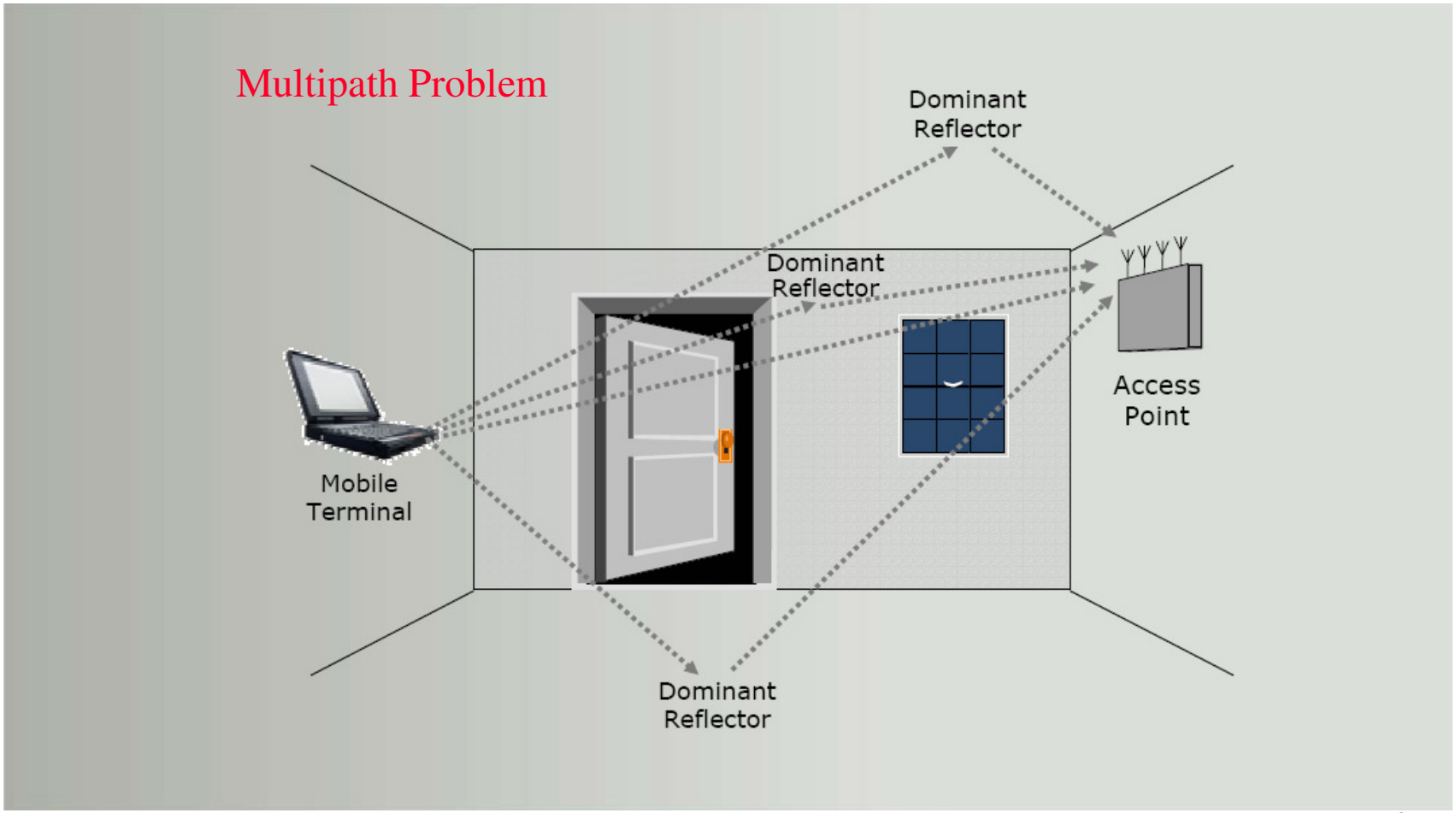
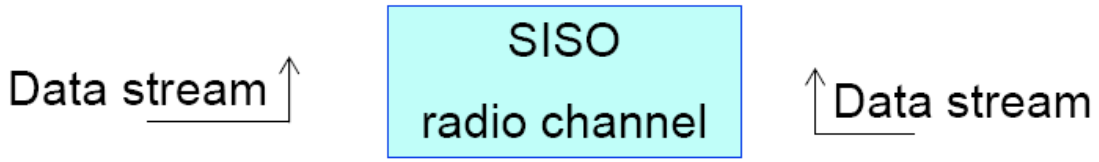
Outline

- MIMO Brief
- 802.11 mechanism
- 802.11n requirements
- 802.11n enhancements
  - PHY key features
  - MAC Details
- Summary

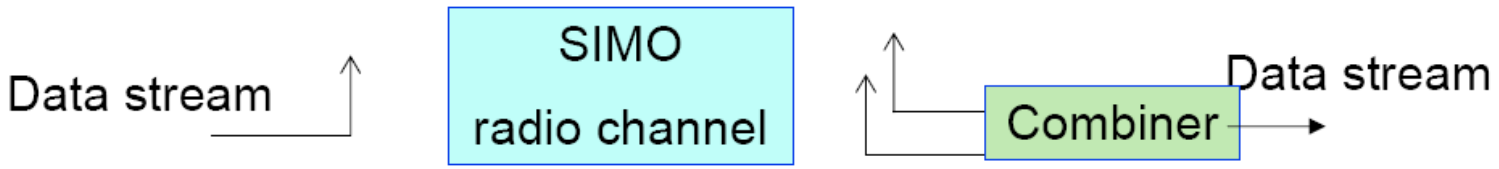
MIMO Brief


Multipath Problem
Dominant Reflector
Dominant Reflector
Access Point
Mobile Terminal
Dominant Reflector

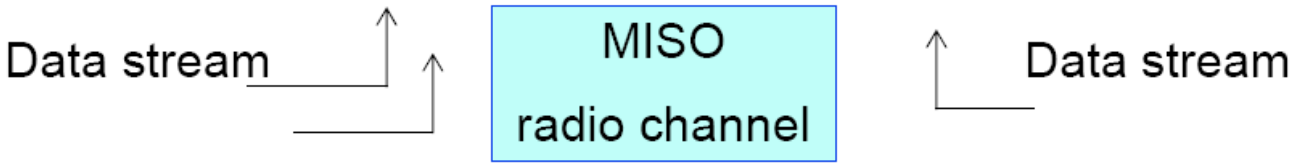
MIMO Brief



Single-Input, Single-Output channel suffers from fading



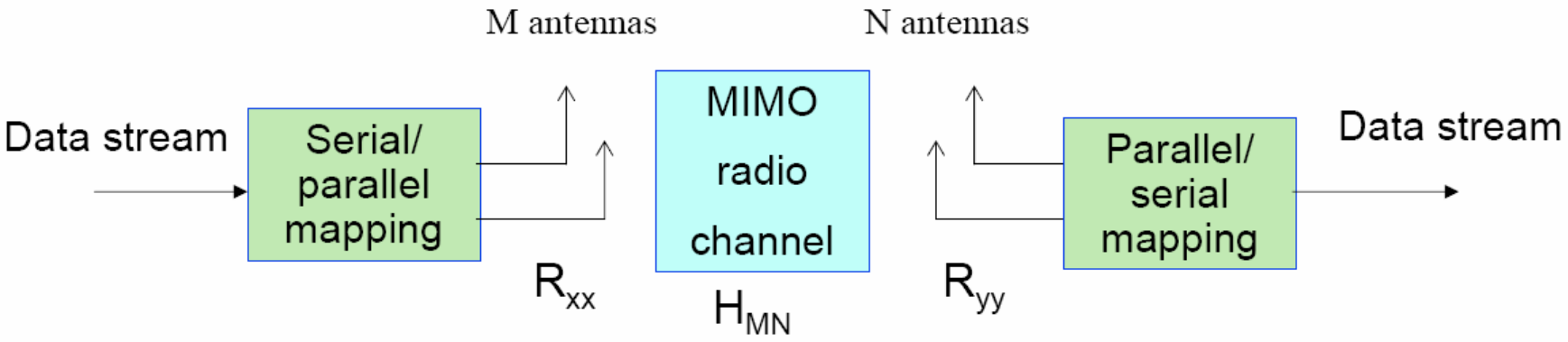
Single-Input, Multiple-Output channel : Rx diversity



Multiple-Input, Single-Output channel : Tx diversity

MIMO Brief

- What's MIMO (Multiple-Input, Multiple-Output)?
  - Mapping of a data stream to multiple parallel data streams and de-mapping multiple received data streams into a single data streams
  - Sending signals on multiple Tx antenna at the same carrier frequency
    - Coding across the antenna
      - Space-Time Coding (STC) =>increases range / robustness
    - Transmitting independent streams of data
      - Space Division Multiplexing (SDM) => increases throughput

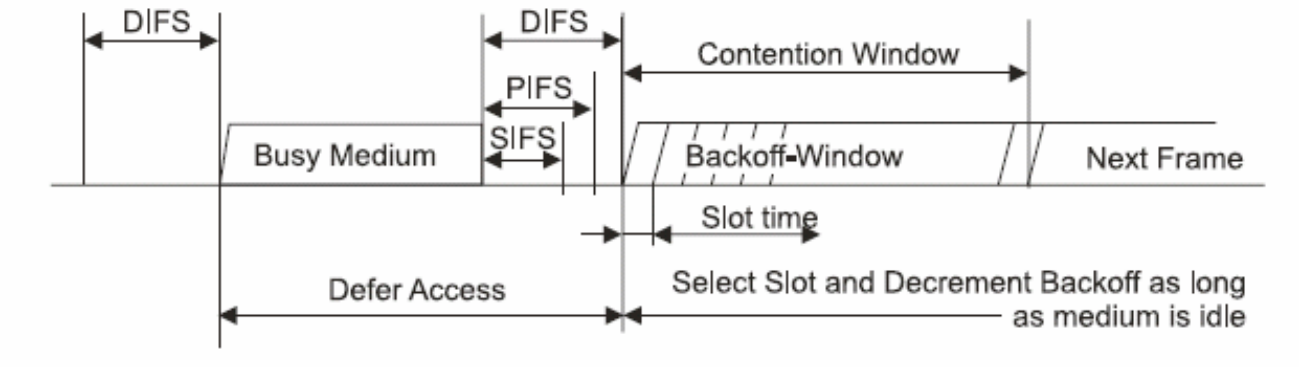


MIMO Brief

- Advantage of Multiple Antennas
  - Resistively to fading (signal quality)
  - Increased coverage
  - Increased capacity
  - Increased data rate
  - Improved spectral efficiency
  - Reduced power consumption
  - Reduced cost of wireless network

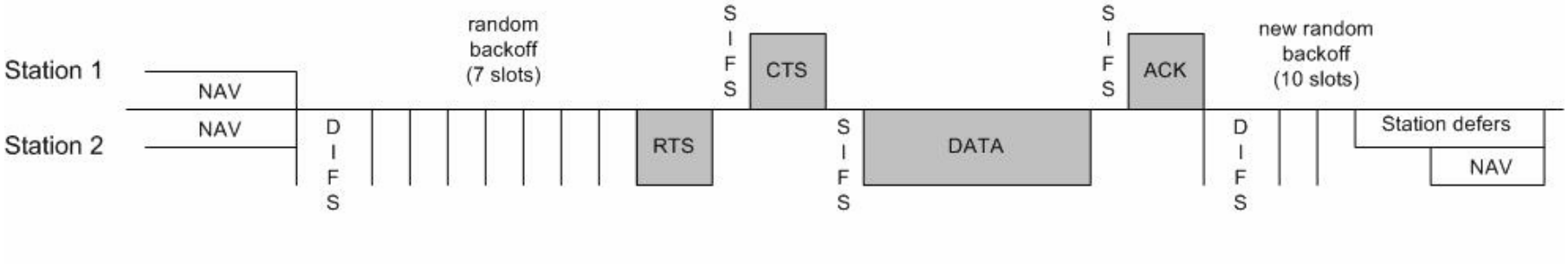
802.11 Mechanism

- Interframe Space (IFS)
  - Short Interframe Space (SIFS)
  - PCF Interframe Space (PIFS)
  - DCF Interframe Space (DIFS)
  - Extended interframe space (EIFS)



802.11 Mechanism

- DCF operation



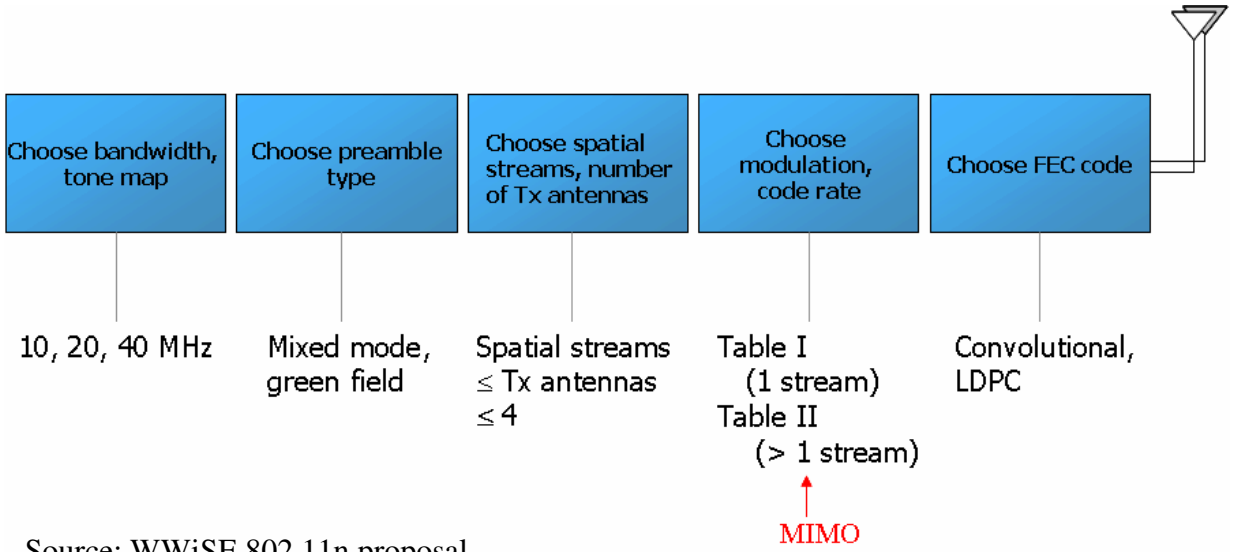
CSMA/CA degrades the transmission efficiency (30~50 %)

802.11n Requirements

- MAC layer throughput > 100Mbps
- Support 20MHz Channel
- Support 5GHz Band
- Backward compatible with 802.11g (if support 2.4GHz Band) and 802.11a
- Support 802.11e (QoS)
- Spectral Efficiency >= 3 bps / Hz
- Control of support for legacy STA from 802.11n AP

PHY key features

- Enhancement to OFDM PHY
  - Enable 2X2 MIMO operation in 20 MHz => 100 Mbps
  - Up to 4X4 MIMO => 200 ↑ Mbps
- Bandwidth extension option
  - Using double channel (40 MHz) to achieve higher data rate



Source: WWiSE 802.11n proposal

MAC Enhancement
MSDU Aggregation

- Aggregation of multiple frames => improve system efficiency
- A-MSDU is aggregated with multiple MSDU
  - separated by a sub-frame header
- Only aggregate with other frame of the same address type
- Should not aggregate MSDUs of different values of priority

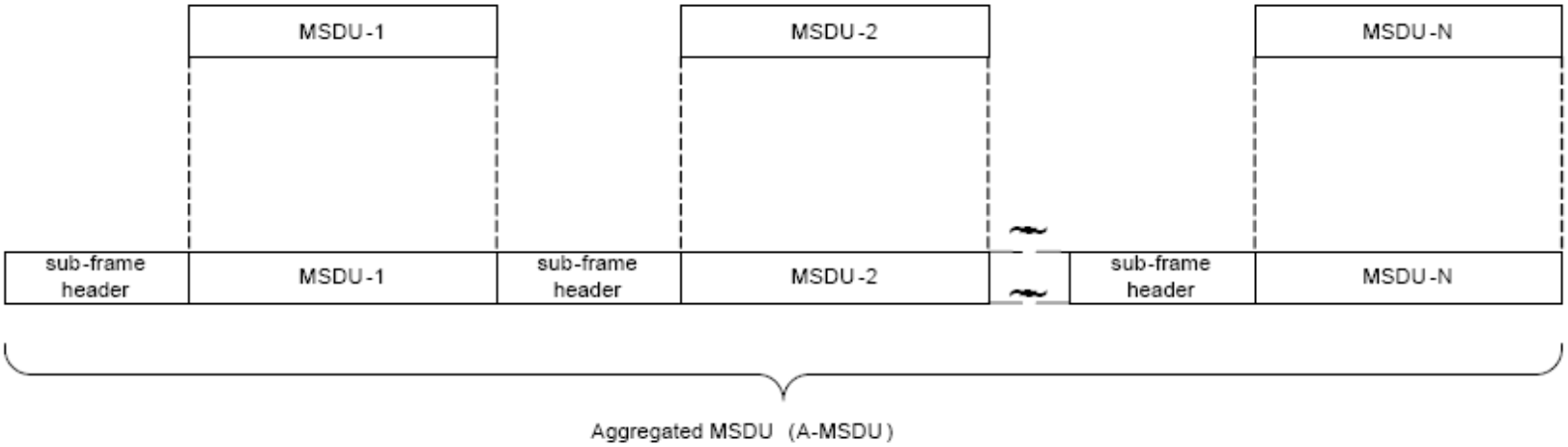


Figure 001n – Formation of an A-MSDU

MAC Enhancement
HTP Burst Transmission

- One single medium access for one High Throughput PHY (HTP) burst transmission
- Permits frames to be sent to different destination addresses
- Using the same rate group for a HTP burst
- The MAC may utilize ZIFS or RIFS and/or construct the PHY to aggregate multiple frames into a single A-PPDU
  - Frames can be aggregated into a single A-PPDU, or separated by ZIFS (If they are at the same TXPWR_LEVEL)
  - A frame that uses a different TXPWR_LEVEL may use RIFS

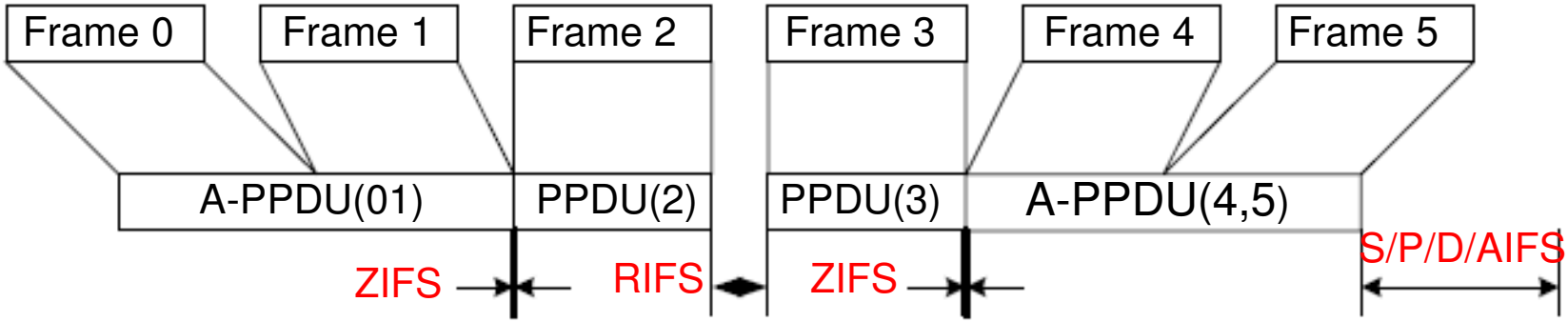


Figure 003n – HTP Burst transmission

MAC Enhancement
Interframe Space

- ZIFS and RIFS are defined for use between frames in a HTP burst transmission
- IFS
  - ZIFS : Zero Interframe Space
  - RIFS : Reduced Interframe Space
  - SIFS : Short Interframe Space
  - PIFS : PCF Interframe Space
  - DIFS : DCF Interframe Space
  - AIFS : Arbitration Interframe Space (used for QoS)
  - EIFS : Extended Interframe Space

MAC Enhancement
Block ACK

- Transmission between two Q-STAs without intervening ACK frames
- Improve the channel efficiency by aggregating several acknowledgements into one frame
- Each of frames shall have the ACK policy subfield in the QoS Control set to “Block Acknowledge”

- Immediate Block ACK
  - Suitable for high-bandwidth, low latency traffic
- Delayed Block ACK
  - Suitable for applications that tolerate moderate latency

MAC Enhancement
40 MHz Channel Pairs

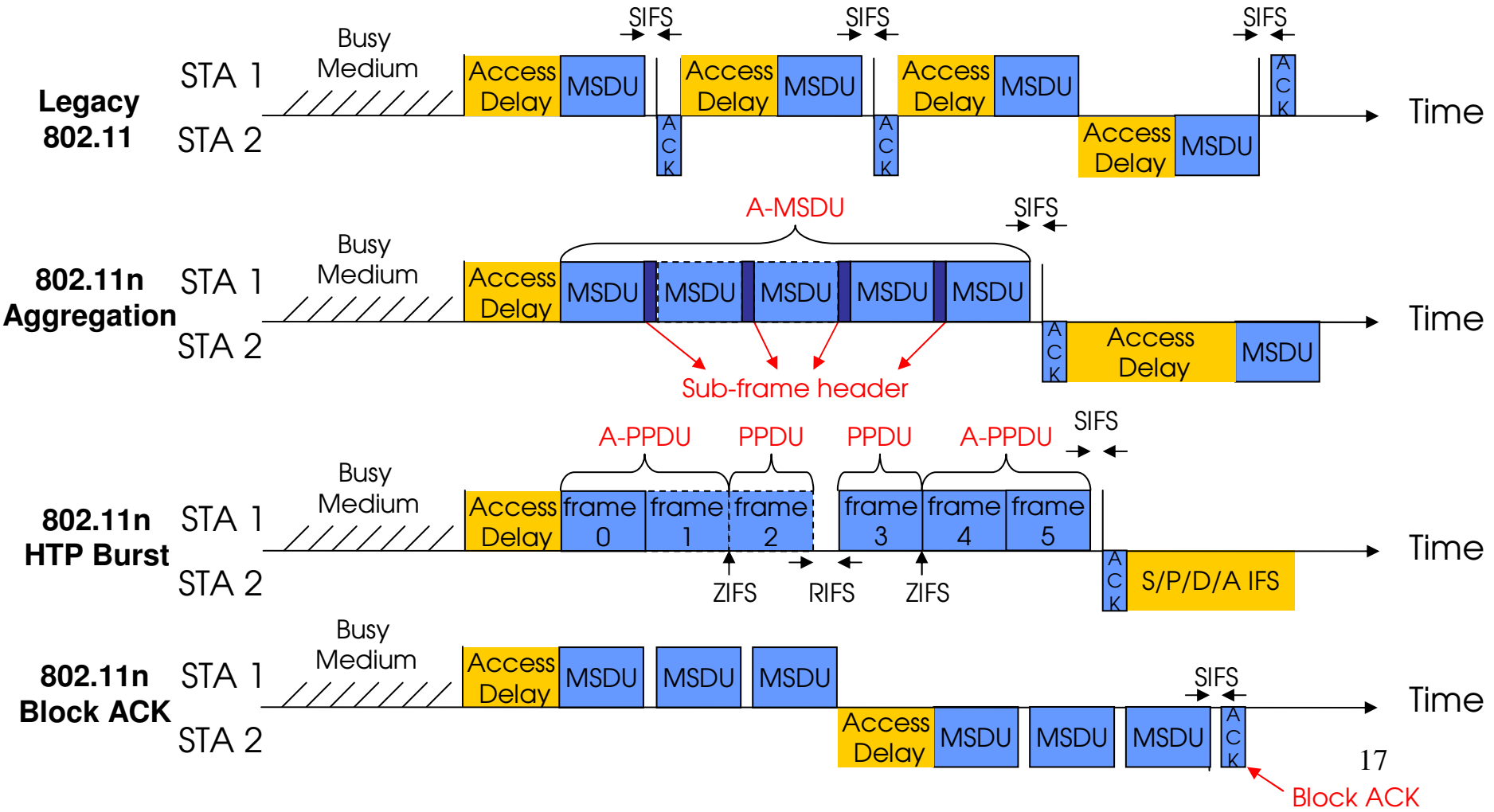
- Goal
  - Utilize a 40 MHz channel pair to achieve lower frame durations

- Mechanism
  - Only be used when the STA has joined or started an Infrastructure BSS
  - Channel Set IE in AP's Beacon frames is used to indicate the operation on a 40 MHz channel
  - A STA shall not send a 20 MHz transmission to STA of a BSS on the secondary channel of the BSS directly
  - A STA shall not change the transmission time of frame due to CSMA/CA on the second channel
    - May change the transmission rate or modulation
  - A STA shall not join a BSS on its secondary channel
  - STAs do not need to consider the Carrier Sense state of the secondary channel before transmitting

MAC Enhancement
40 MHz Channel Pairs

- Issues
  - Collision with 20 MHz transmissions from overlapping BSS in the secondary channel is greatly increasing
  - The STA shall not initiate a frame sequence in 40MHz transmissions if there is a significant evidence of collisions on the secondary channel
    - The algorithm of determining significant evidence of collisions is implementation dependant

802.11 and 802.11n Comparison



Summary

- MIMO is the main technique to enhance the PHY data rate of 802.11n
  - 2X2: 108Mbps (54Mbps X2)
  - 4X4: 216Mbps (54Mbps X4)

- 802.11n increases transmission efficiency of MAC layer by
  - MSDU aggregation
  - HTP burst transmission
  - Block ACK
  - 40 MHz Channel Pairs

} 30~50% => 70%