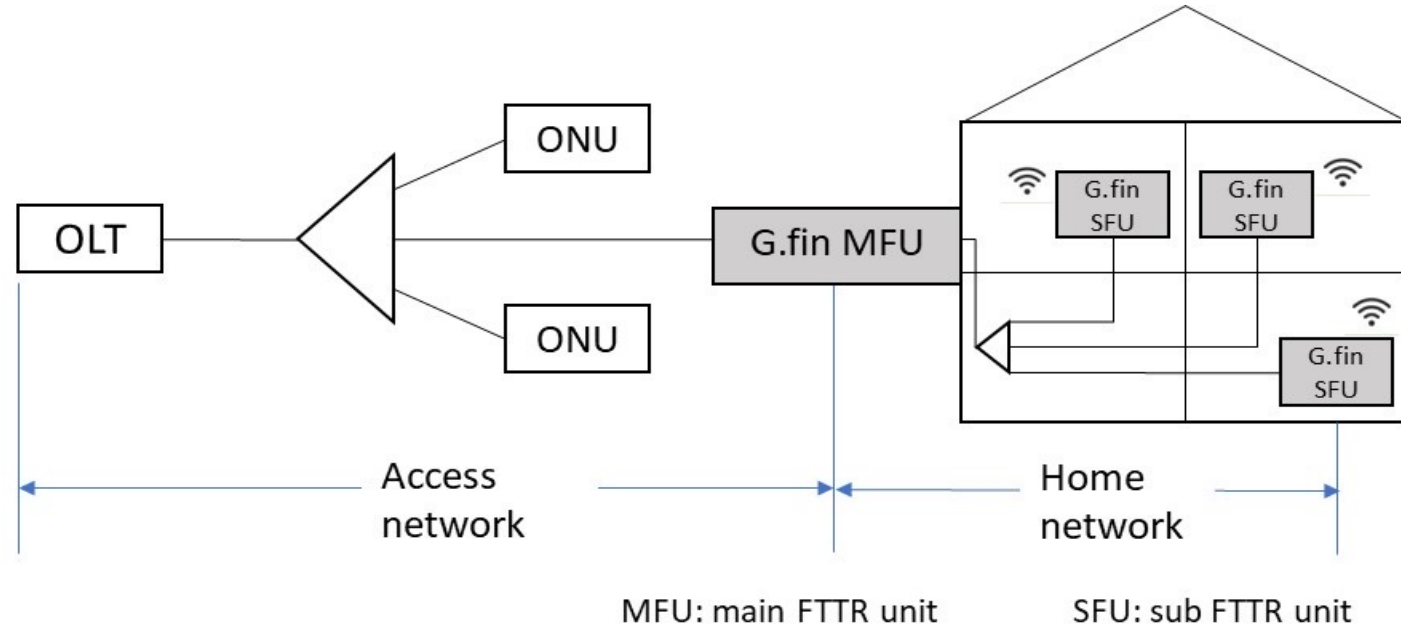


Supporting FTTR with Multi-AP Coordination

Yuanqiu Luo, Andy Shen, Frank Effenberger

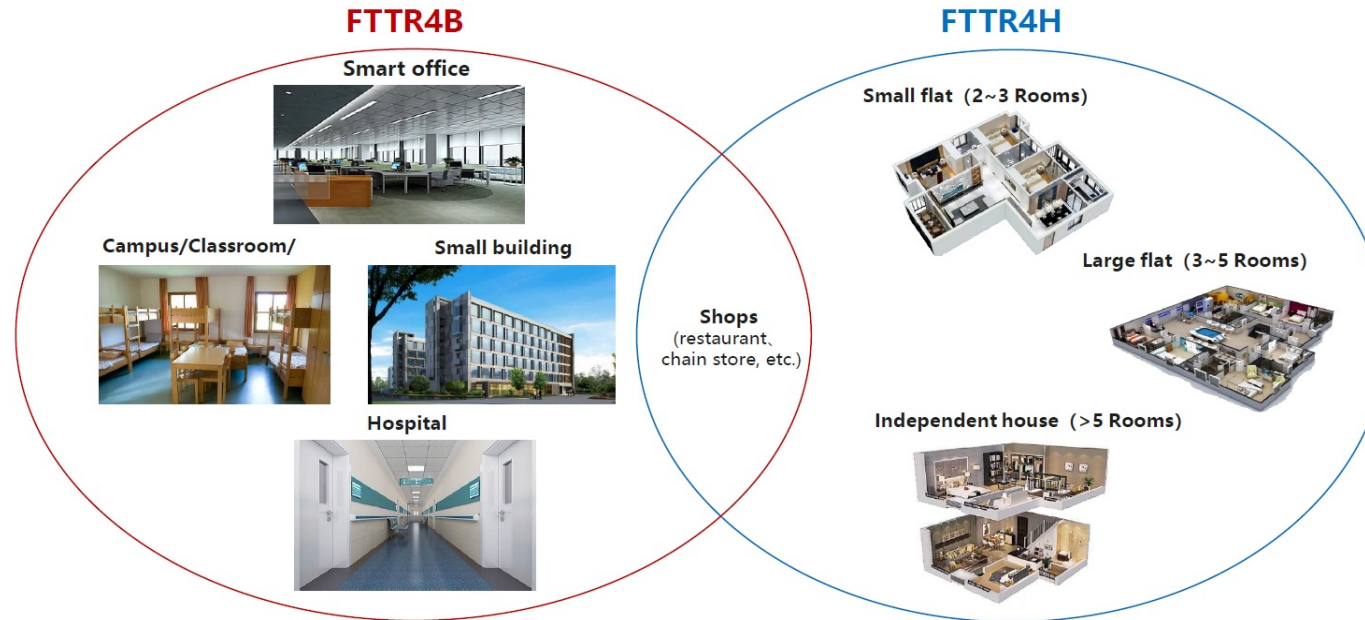
Futurewei Technologies, USA

FTTR



- Fiber to the room (FTTR) promotes fiber deployment from last mile to last meter
- Fiber systems are employed for both access and home networks
- Its use cases, architectures, and enabling technologies are under active study by ITU-T, ETSI, CCSA, and BBF

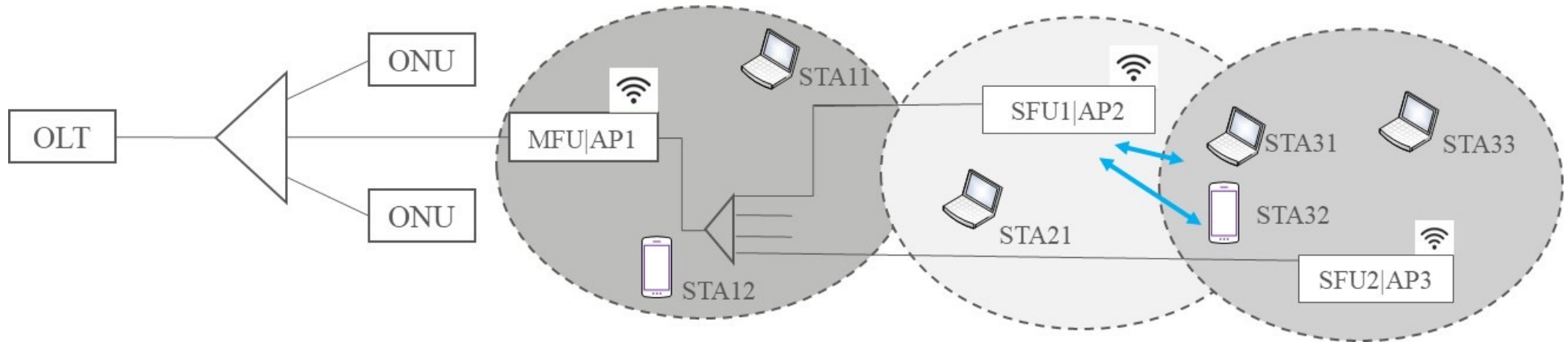
FTTR Applications



- FTTR4B supports small/medium sized enterprises (SME), FTTR4H connects rooms in a house [1]
- In both applications, multiple Wi-Fi access points (APs) are installed at a single facility to provide highspeed broadband access
- Coordination among APs will significantly reduce the interference and further enhance user experience

[1] "To open a formal recommendation for use case collection over FTTR", ITU-T SG15 Q18, Q18/15-C2 (210722) , 2021

Multi-AP Coordination



- Multiple APs are widely introduced to improve performance in Wi-Fi environments
- Wi-Fi AP market is projected to grow at 32.3% CAGR between 2022-2027 [2]
- Multi-AP coordination is a key feature of Wi-Fi 8
- It attracts many contributions in Wi-Fi 8 discussion

[2] "Gigabit Wi-Fi Access Point Market Outlook – 2022-2027", Future Market Insights

Multi-AP Coordination in Wi-Fi 8

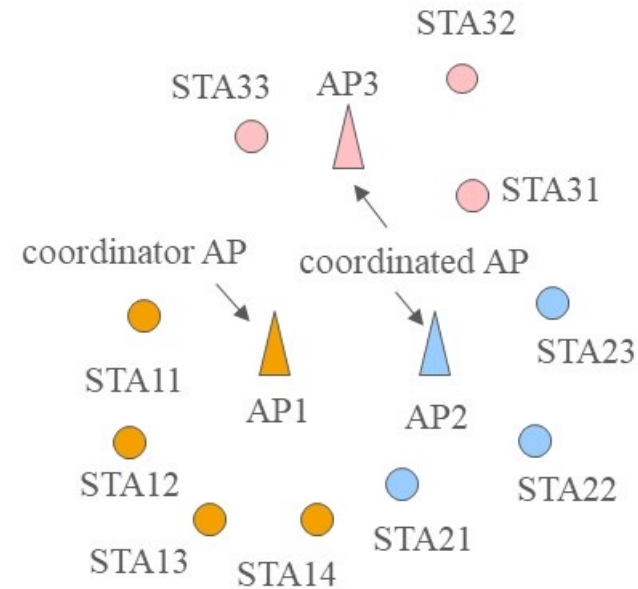
- Wi-Fi 8 has considered several improvements of WLAN [3], such as
 - Increased reliability of WLAN connectivity
 - Increased manageability and mobility support
 - Lower latencies
 - Throughput enhancements
 - Increased performance in congested environments
- Multi-AP coordination has been studied as a main solution to satisfy the above requirements, there are four methods [4]
 - Coordinated OFDMA
 - Coordinated spatial reuse
 - Coordinated beamforming
 - Joint transmission

[3] “Thoughts on Next Gen WLAN”, IEEE802.11-22/694r0

[4] “Follow-up on TWT based Multi-AP Coordination”, IEEE802.11-23/293r0

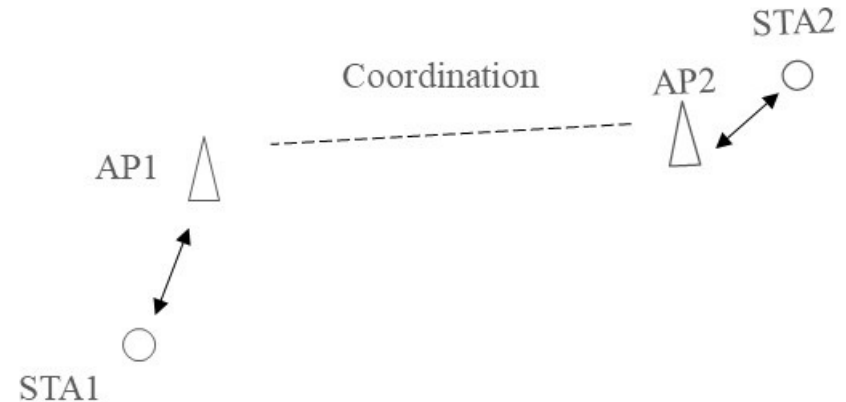
Coordinated OFDMA

- In coordinated OFDMA multiple APs schedule OFDMA transmission [5,6]
- One AP is the coordinator AP, the others are coordinated APs
- Coordinated OFDMA operation is conducted in two stages
 - C-OFDMA announcement stage
 - C-OFDMA transmission stage



Coordinated Spatial Reuse

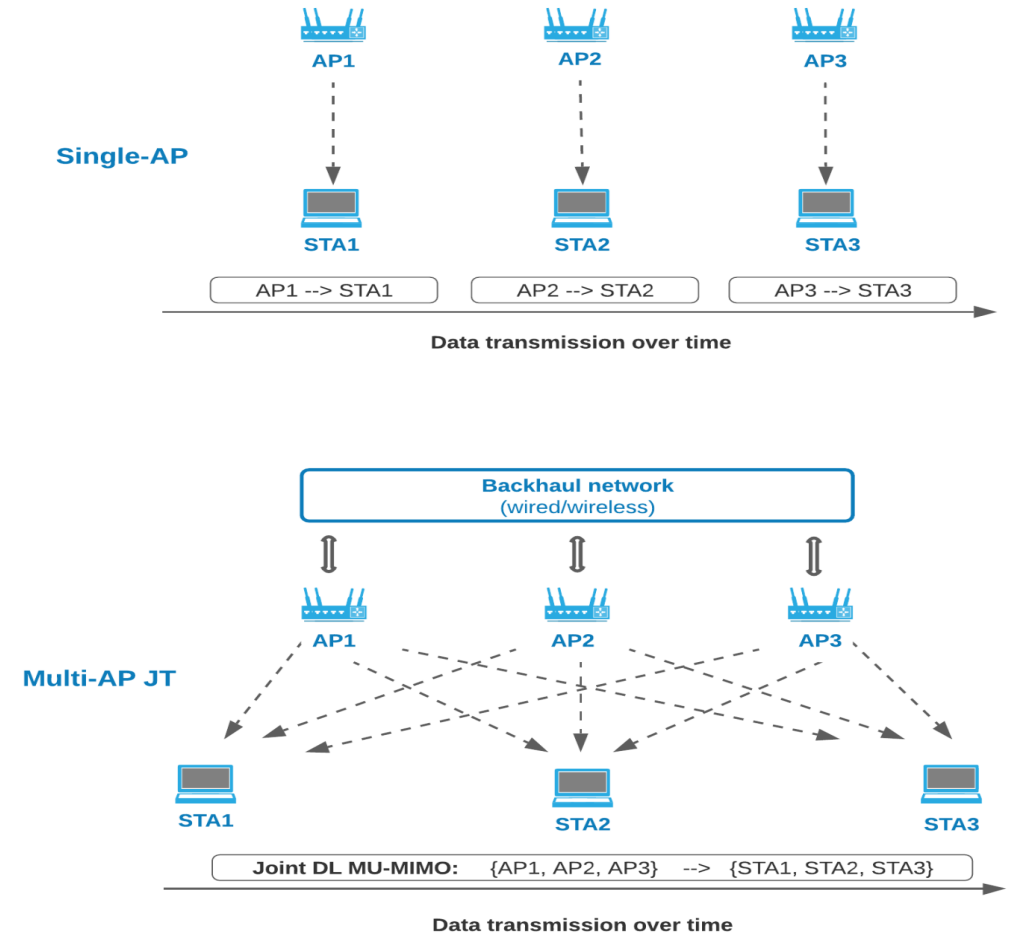
- Spatial reuse allows APs to use the same resource unit (e.g., subcarriers) to communicate with different STAs simultaneously [7]
- The STAs in spatial reuse are far enough, and signals in the same resource unit to other STAs don't impact the performance too much
- AP coordination is needed when spatial reuse is implemented to multiple AP scenarios



[7] "AP Coordination in EHT", IEEE802.11-19/0801r0

Joint Transmission

- Multiple distributed APs jointly work as one coordinated AP [8,9]
- More antennas
- Higher MU-MIMO gain
- Signal coming from multiple locations improves robustness, coverage, and reliability

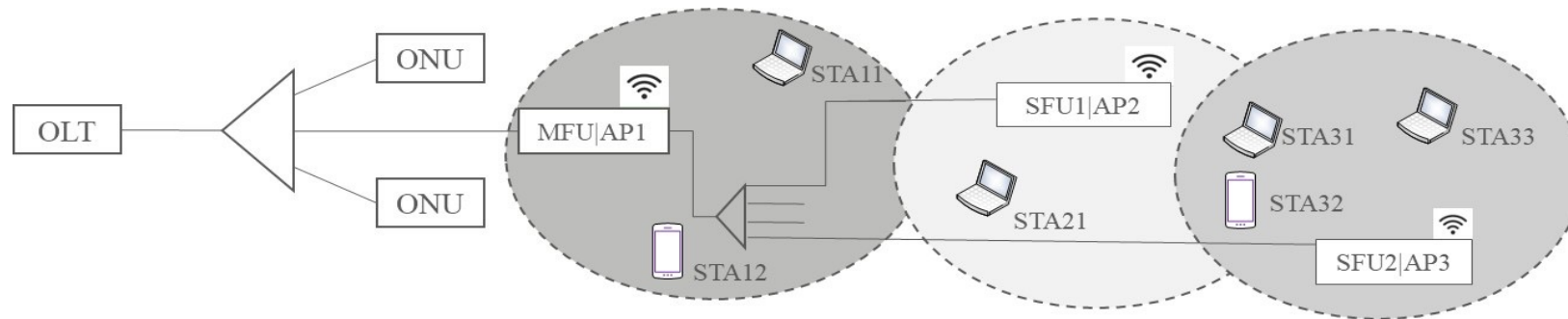


Challenges to Wi-Fi Multi-AP Coordination

- Multi-AP coordination requires information sharing between APs
 - “The more you share, the more you get”
 - This means extra heavy load on the backhaul link
 - Wireless channel can be used for it, resulting in throughput reduction
- Multi-AP coordination requires tight synchronization between APs
 - Air interface suffers from various noise and interference
 - Frequency sync is more stringent than phase and time
 - Tight synchronization is challenging
- It also needs to decide which AP is the coordinator
 - How to select the best coordinator AP is an open issue

[10] “Joint Transmissions: Backhaul and Gain State Issues”, IEEE802.11-19/1089r0
[11] “Performance of JT with wireless Backhaul” IEEE 802.11-19/1909

FTTR with Multi-AP Coordination



- FTTR provides a fiber backhaul link for AP coordination
 - No need to use wireless channels for coordination
 - Information sharing among APs can be done
- MFU is the best candidate of coordinator AP
 - It has direct fiber connections to all other APs
 - It coordinates SFUs
- MFU provides a good base clock for synchronization
 - It runs on the same clock as the OLT
 - FTTR clock signal can be used for multiple AP synchronization
 - And such synchronization info is transmitted in fiber

Summary

- Multi-AP coordination improves “FTTR + Wi-Fi” solution to a higher level with desired features
 - Reliability
 - Throughput
 - User mobility
- Air interface presents challenges to support multi-AP coordination
 - Extra traffic load
 - Tight synchronization
- Using FTTR fiber link as backhaul facilitates such coordination