# Efficient and Fair Medium Sharing Enabled by a Common Preamble

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# Background - I

- Motivation for the presentation is to address the co-existence between 3GPP (NR) and IEEE (802.11 ax) for the 6 GHz band

- 802.11 ax based devices use CSMA like mechanism to access the wireless medium

- These devices contend for medium by performing continuous energy detection (ED) and preamble detection (PD)
- IEEE has defined these limits to be
  - ED = -62 dBm/20 MHz
  - PD = -82 dBm/20 MHz

# Background – II

- Harmonized standard EN 301 839 defines 5GHz co-existence which uses Listen-before-talk (LBT) mechanism

- LBT uses only energy detection (ED) to perform clear channel assessment (CCA)

- In EN 301 839 for 11a, 11n and 11ac
    - ED = -62 dBm/20 MHz

- In EN 301 839 for 11ax and LTE/NR
    - ED = -72 dBm/20 MHz

- There is no preamble detection (PD) described in current version (v2.1.1) of EN 301 839

# Need for Preamble

- Drawback of using ED only is that any signal received with power lower than ED limit is considered as noise and channel is assumed to be available for transmission

| 20 MHz | 802.11 [dBm] | LBT [dBm] | |
|---|---|---|---|
| Standards | all | 11ax, LTE/NR | 11a, ac, n |
| ED | -62 | -72 | -62 |
| PD | -82 | NA | NA |

- Wi-Fi signals can be detected with much lower thresholds than even the PD limit

- Using ED only in fact gives rise to interference and collisions which does not serve well for both 3GPP or IEEE nodes

# Common Preamble for Co-Existence

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- As mentioned before, using only ED gives rise to interference and collisions which does not serve well for both 3GPP or IEEE nodes

- Therefore we propose that 3GPP should consider adding a common preamble for LBT to enable packet detect between Wi-Fi and 3GPP devices

- **With the capability of PD, both, 3GPP and IEEE devices, can detect the channel usage in much better manner and thus can avoid the collisions and improve spectrum usage**

# Proposal for Common Preamble

- 3GPP does not have any preamble like structure
- All 802.11 devices have a legacy preamble (802.11a) which is used widely across globe
- EN 301 839 is planning to make 802.11a preamble decoding mandatory in upcoming version of EN 301 839 for applying a transmit power independent LBT threshold of -62 dBm (out of scope of this presentation)
- **Therefore, we propose to utilize the 802.11a based common preamble for preamble detection in 6 GHz for the following reasons**
  - Simple structure
  - Requires less computation
  - Has high x-correlation properties
  - Most of the operating devices has Wi-Fi + Cellular so Wi-Fi chips can be used to detect preamble and inform the status to cellular

# Simulations for Common Preamble

- To show the benefits of the 802.11a based common preamble we performed some simulations

- These are system level simulations to show the effect on overall system performance

- These simulations also show that how the resources are shared between 3GPP and IEEE devices

- The simulations are performed for the case when a Wi-Fi based STA (11ax) and a 3GPP based UE (NR) tries to share the medium by performing ED only and then using ED + PD

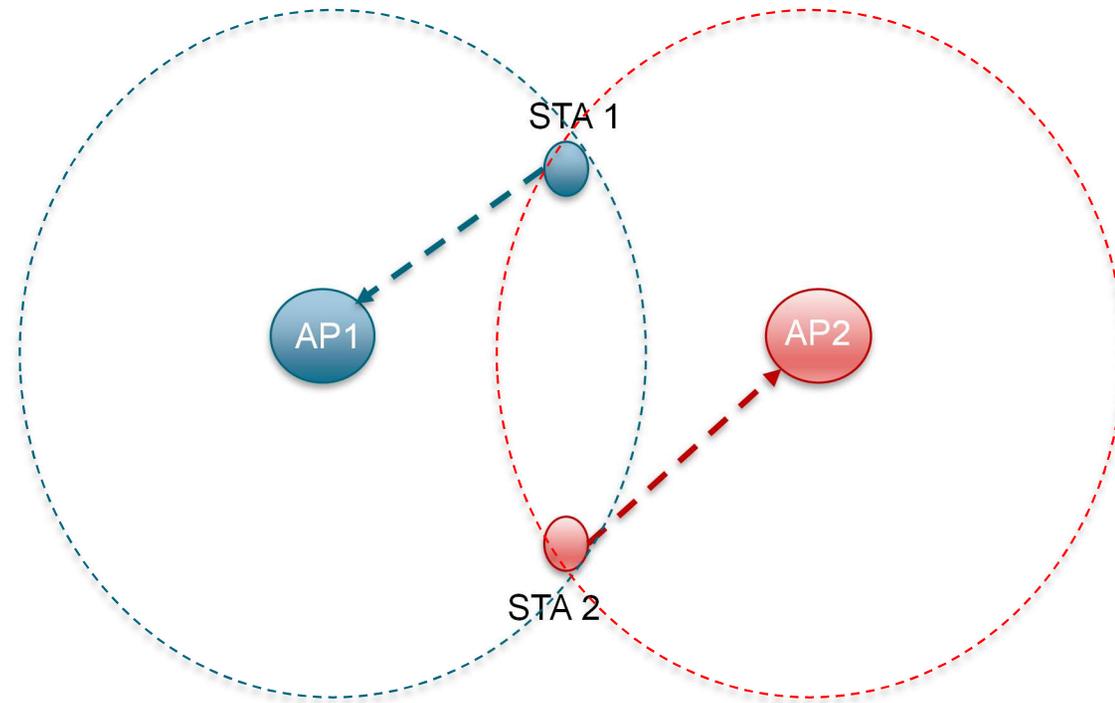- Next, we present the simulation scenario and details

# Simulation Scenario with 802.11a Common Preamble

- **Two Wi-Fi APs (11ax only)**
  - Operating BW = 20 MHz
  - Two Wi-Fi APs
  - Two STAs each associated to an AP
  - Both STAs contend for medium in UL direction
  - Both STAs use ED and PD Limits: -72 and -82 dBm respectively
  - Both STAs are equally distant from their own APs
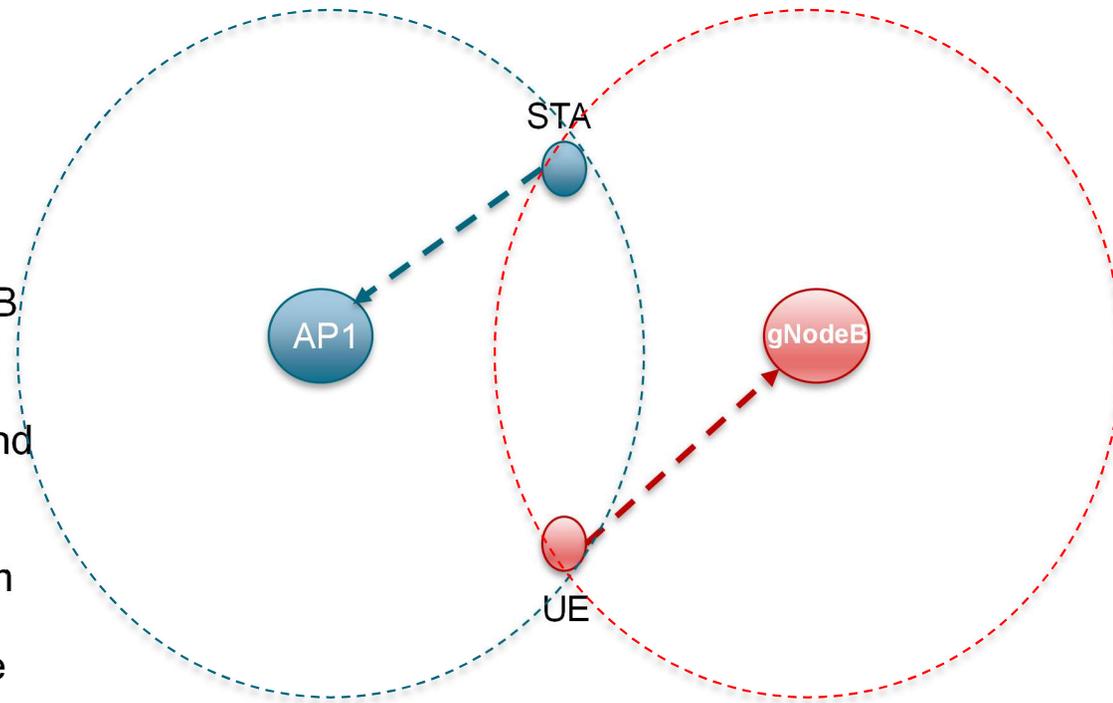  - Both STAs always have data to be transmitted, i.e., full buffer

# Simulation Scenario with 802.11a Common Preamble

- **Wi-Fi AP and gNodeB (11ax, NR) With ED Only**
  - Operating BW = 20 MHz
  - One Wi-Fi AP and One Cellular eNodeB
  - One STA associated to the AP
  - One UE connected to the cellular eNodeB
  - Both STA and UE contend for medium in UL direction
  - Wi-Fi STA uses ED and PD Limits: -72 and -82 dBm respectively
  - Cellular UE uses ED only with -72 dBm
  - Both STA and UE are equally distant from its AP and eNodeB
  - Both STA and UE always have data to be transmitted, i.e., full buffer

# Simulation Scenario with 802.11a Common Preamble

- **Wi-Fi AP and gNodeB (11ax, NR)**
  <span style="color:red">**With ED and PD**</span>
  - Operating BW = 20 MHz
  - One Wi-Fi AP and One Cellular eNodeB
  - One STA associated to the AP
  - One UE connected to the cellular eNodeB
  - Both STA and UE contend for medium in UL direction
  - <span style="color:red">Both Wi-Fi STA and Cellular UE use</span>
    - <span style="color:red">ED and PD Limits: -72 and -82 dBm respectively</span>
  - Both STA and UE are equally distant from its AP and eNodeB
  - Both STA and UE always have data to be transmitted, i.e., full buffer

# Simulation Scenario with 802.11a Common Preamble

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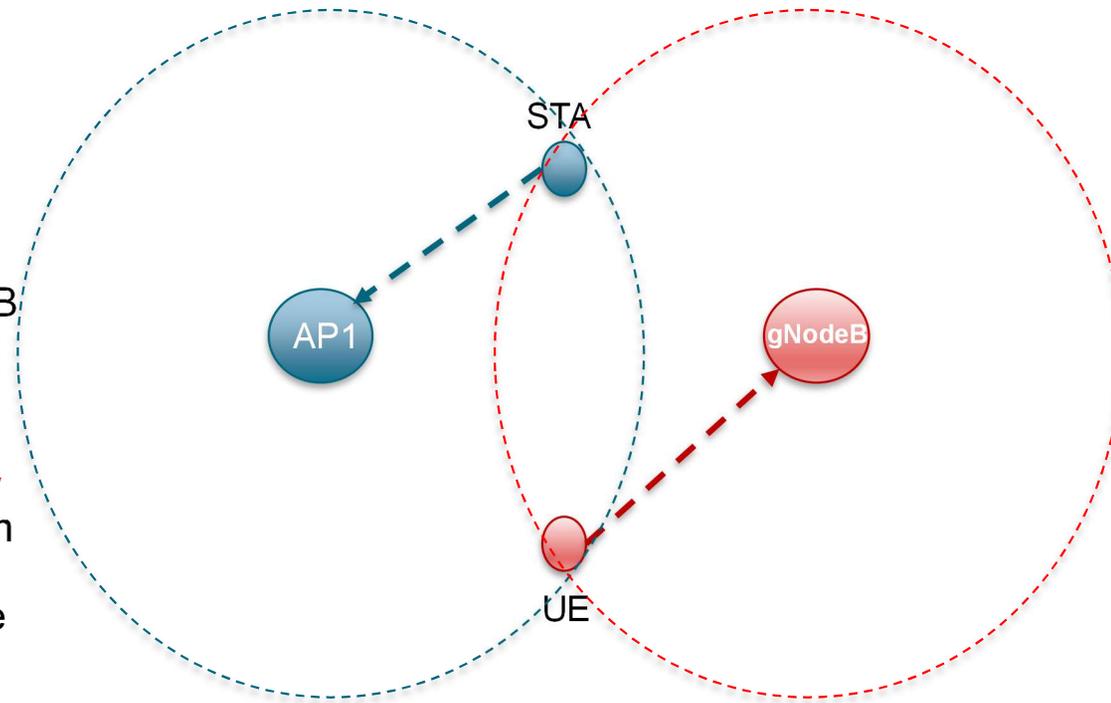
- **Position of interest**
  - Both STA and UE see power coming from each other less than -72 dBm but above -82 dBm
    - To see the effect when ED only is used, there are lots of collisions expected
    - The reason is that UE will not be able to detect that there is a Wi-Fi based signal on the medium so it will transmit, thus resulting in interference and collision
    - Similarly, Wi-Fi will not be able to detect that UE's signal is on the medium and it should defer for its duration, so it will also start transmission, thus resulting in interference and collision again
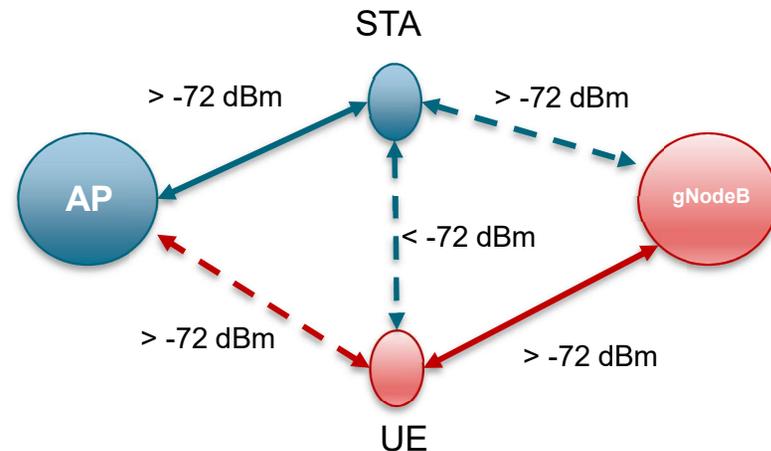
# Results

- ## Observations
  - Two APs scenario is serving as Base scenario
  - Base scenario has very small collisions and fair channel occupancy (is the time shared between both nodes)
  - In the second scenario with ED only,
    - Collisions go beyond 50 %
    - Channel occupancy goes bad
    - Overall throughput suffers due to collisions and interference
  - Second scenario with both ED and PD fixes the issue and the performance matches the Base scenario
  - Thus inclusion of common preamble helps the overall system

| | Two APs with ED and PD | AP and gNodeB with ED only | AP and gNodeB with ED and PD |
|---|---|---|---|
| **Collisions** | 9 % | 62 % | 9 % |
| **Channel Occupancy** | 49 – 51 % | 65 – 56 % | 49 – 51 % |
| **Overall Throughput** | 93 Mbps | 48 Mbps | 93 Mbps |

# Conclusion

- In this contribution we present the problem of not having a common preamble for co-existence of Wi-Fi and Cellular devices in 6 GHz band

- We propose to use 802.11a based common preamble for co-existence

- We performed simulations and showed the results highlighting the benefits of using the common preamble

- We conclude that use of a common preamble will help both 3GPP and IEEE nodes while improving the overall system performance and better spectrum usage

# Thanks and Questions?

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# EN 301 839 and Preamble

- **EN 301 839 in its current version (v2.1.1) does not have any PD.**
- **However, in the next version of EN 301 839, one of the expected update is**
  - Applying a transmit power independent LBT threshold of -62 dBm which requires using IEEE 802.11a preamble as secondary trigger
    - Hence, mandatory testing of IEEE 802.11a preamble conformance
    - Devices will defer for duration indicated in preamble's SIGNAL field
    - Device's sensitivity to preamble threshold is to be tested

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