EEE P802.11  
Wireless LANs

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
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# Abstract

This document describes the simulation scenarios for the 11ax TG.

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# Revisions

|  |  |  |
| --- | --- | --- |
| **Revisions of document 13/1001** | | |
| **Revision** | **Comments** | **Date** |
| *R0* | Initial draft template | Aug 28th |
| *R1* |  | Sept 15th 2013 |
| *R2* | Made it consistent with document 1000r2 | Sept 16th 2013 |
| *R3* | Included Scenario 1 from 1081r0  Included Scenario 2 from 722r2  Included Scenario 3 and 4 from 1248r0; scenario 3 likely compatible with documents 722 and 1079.  Included concept from 1176r0  Added References  Updated co-authors | Oct 4th 2013 |
| *R4* | Minor corrections | Oct 4th 2013 |
| *R5* | Added description for scenario 4a (Simone (Qualcomm), Ron (Broadcom))  Tentative addition of contributions related to traffic models; more discussion is needed:   * Added video traffic models from #1335 (Guoqing Li, Intel) * Table for traffic models (Bill, Sony) * Management Traffic profile and % of unassociated users (Reza, Cisco) * Application activity intervals (Huai-Rong, Samsung)   Indicated that legacy STAs can be present (Various)  Indicated that legacy APs can be present in scenario 1(Liwen, Marvell)  Indication of antenna height (Wookbong, LG)  RTS Thresholds (Liwen, Marvell)  Primary channel location (Liwen (Marvell), Klaus (Nokia))  Clarified that all BSSs are either all at 2.4GHz, or all at 5GHz (Liwen, Marvell)  Some changes on traffic model for Residential Scenario (Klaus, Nokia)  Initial indications of channel model (various, Joseph, (InterDigital), Wookbong (LG); needs more discussion)  Clarification on non-HEW definition.  Other comments from Jason, David, Wookbong, Thomas | Nov 14th 2013 |
| *R6* | Modified the number of APs in scenario 2 (Filip (Ericsson))  Add description of the interference scenario for Scenario 2 (David (Huawei))  Added considerations on feedback from WFA |  |
| *R7* | Editorials corrections and accepted all track changes to ease identification of future changes (Wookbong) | Mar 2014 |
| *R8* | Update on the management traffic parameters (Reza)  Various updates (Yakun)  Addition of multicast traffic on Scenario 3 (Eisuke)  Updated Scenarion 1 with pathloss model and calibration parameters (Simone, 14/355r0)  Updates on Residential Scenario parameters (Jarkko, Klaus) | Mar 2014 |
| R9 | Updated Interfering scenario for scenario 2 which I missed in previous version (from Ross) | April 2014 |

|  |  |  |
| --- | --- | --- |
| **Revisions of document 14/0621** | | |
| **Revision** | **Comments** | **Date** |
| R0 | Cleanup, removal of old comments, resolution of (hopefully) non-controversial TBDs. To see all the comments, please refer to r9  Included comments from Jarkko: added a tentative set of common parameters upfront; removed several comments.  Included comments from Suhwook on the allocation of channels from 14/0625  Included VDI and Gaming in the traffic from doc 14/0594, 14/0595.  Removed Annex 2, which is now part of Evaluation Methodology document | May 2014 |
| R1 | Modified the pathloss for Scenario 1, based on 14/577r0 | May 2014 |
| R2 | Removed section on calibration scenarios: people need more time to review  Corrected pathloss formula for Scenario 1  Accepted all the changes to have a clean baseline | May 2014 |
| **R2 was accepted as baseline for the TG Simulation Scenario document on 5/14/14** | | |
| R3 | Added calibration scenarios for MAC simulator | May 2014 |
| R4 |  | May 2014 |
| **Chnaged document number to 14/0980 due to server issues** | | |
| R0 | Changes from contributions 896r0, 972r0, 967r5 | July 2014 |
| R1 | Corercted some typos  This version adopted via motion on 7/17/14 | July 2014 |
| R2 | Accepted earlier changes and updated authors list and | July 2014 |
| R3 | Added text for power save model from 1286r1, calibration from 1272r1; added a reference to a MAC calibration results report | September 2014 |
| R4 | Accepted | September 2014 |
| R5 | Corrected text in Test 2  Corrected figure in Test 3  1496r5  Updated revision number of calibration results | November 2014 |
| R6 | Modifictions to Test 1a based on 78r2  Modifications to Test 5 based on 172r1  Added Gaming traffic profile text from 61r6 | January 2015 |
|  | Modifications to Test 4 from 441r3  Modifications for distinction between shallow and deep sleep based on 304r2  Clarification on Beacon size 316r5 | March 2015 |

# Introduction

This document defines simulation scenarios to be used for

* Evaluation of performance of features proposed in HEW
* Generation of results for simulators calibration purpose.

Each scenario is defined by specifying

* Topology: AP/STAs positions, P2P STAs pair positions, obstructions , layout, propagation model
* Traffic model
  + UL: STA - AP traffic
  + DL: AP – STA traffic
  + P2P traffic (tethering, Soft-APs, TDLS)
  + ‘Idle’ management (generating management traffic such as probes/beacons)
* Power model
* List of PHY, MAC, Management parameters
  + We may want to fix the value of some parameters to limit the degrees of freedom, and for calibration
  + Optionally, some STAs may use legacy (11n/ac) operation parameters, if required to prove effectiveness of selected HEW solutions
* An interfering scenario (its performance optionally tracked)
  + Not managed or managed by a different entity than the one of the main scenario
  + Defined by its own Topology, Traffic model and parameters

Per each of above items, the scenario description defines a detailed list of parameters and corresponding values.

**Values not specified can be set to any value.**

**Values included in square brackets [] are default values to be used for calibration.**

**All other parameters values not included in [], are to be considered mandatory for performance evaluation.**

Simulation results should be presented together with the specification of the value used per each of the parameters in the tables.

# Notes on this version

This document builds on document 13/1001r9, which was developed during the HEW SG phase.

The document consolidates contributions on scenarios details from various authors and reflects the comments/submissions received. It is not a final version by any means and is subject to changes based on further discussion and feedback.

Major TBDs

* Traffic models
* Channel models an penetration losses per scenario
  + Not clear agreement on which channel models to be used in each scenario; some tentative included in the document
* Calibration scenarios;
* Some other topics under discussion refer to simulation methodology/parameters that can be common and fixed across all scenarios, hence they may be directly included in the Evaluation Methodology document or in an appendix of this documents
  + Rate adaptation model
  + Use of wrap around for scenarios 3 and 4?
    - Discussion is needed; Use of wrap around with CSMA may create artefacts
  + Is the ‘random’ position of STAs randomly generated by each simulation run, or are we going to have a file with common positions?
  + Several channel model and RF related parameters that are likely to be common and fixed across scenarios see #1383

# Scenarios summary

This document reports the initial agreement according to document 11-13/1000r2.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Scenario Name** | **Topology** | **Management** | **Channel Model** | **Homogeneity** | **~Traffic Model** |
| **1** | Residential | A - Apartment building  e.g. ~10m x 10m apartments in a multi-floor building  ~10s of STAs/AP, P2P pairs | Unmanaged | Indoor | Flat | Home |
| **2** | Enterprise | B - Dense small BSSs with clusters  e.g. ~10-20m inter AP distance,  ~100s of STAs/AP, P2P pairs | Managed | Indoor | Flat | Enterprise |
| **3** | Indoor Small BSS Hotspot | C - Dense small BSSs, uniform  e.g. ~10-20m inter AP distance  ~100s of STAs/AP, P2P pairs | Mobile |
| **4** | Outdoor Large BSS Hotspot | D - Large BSSs, uniform  e.g. 100-200m inter AP distance  ~100s of STAs/AP, P2P pairs | Managed | Outdoor | Flat | Mobile |
| **4a** | Outdoor Large BSS Hotspot  + Residential | D+A | Managed + Unmanaged | Hierarchical | Mobile + Home |

## Considerations on the feedback from WFA

Document 11-13/1443 includes feedback from WFA regarding prioritization of usage models.

Document 11-13/1456r1 shows a mapping between the prioritized usage models and the simulation scenarios in this document (as of r5).

The summary is copied here:

* **Mapping**
  + 1b Airport / train station 🡪 Scenario 3
  + 1e E-education 🡪 Scenario 2
  + 3a Dense apartment building 🡪 Scenario 1
  + 4b Pico-cell street deployment 🡪 Scenario 4
  + 2b Public transportation 🡪 ??
    - No good match with existing scenarios
* **Is usage model 2b relevant for HEW, in the opinion of the SG?**
  + Usage model 2b is essentially ‘single cell’, which is a departure from ‘Dense scenarios’ scope of HEW
    - High density of STAs but likely just 1 or few APs
  + Goal of simulation scenarios is to capture key issues, and for proof of solutions
  + If considered not relevant: our current simulation scenarios are enough
  + If considered relevant: we need to either add one more scenario, or fit it into an existing one (preferred)
    - E.g. can it fit as a special case of Scenario 2 or 3?

## Common Parameters for all simulation Scenarios

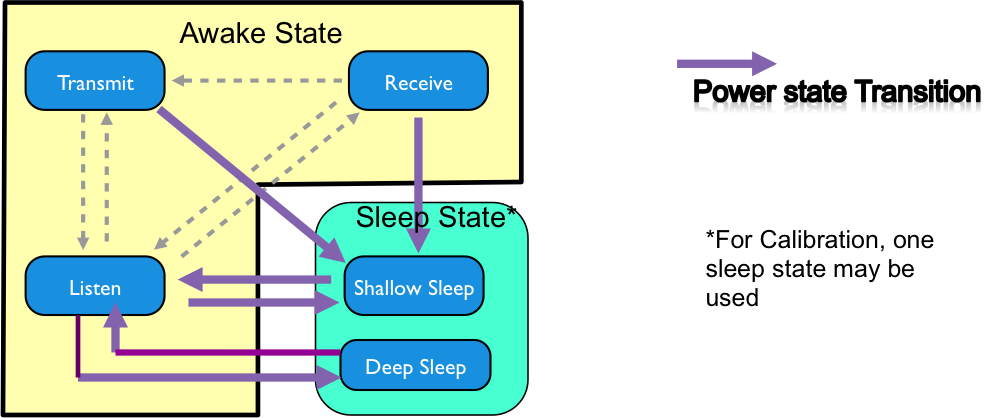
Each simulation scenario shall use the PHY and MAC parameters as defined below. If a scenario changes any value of these parameters, then the changed value is listed in the simulation scenario.

|  |  |
| --- | --- |
| **PHY parameters** | |
| BW | All BSSs either all at 2.4GHz, or all at 5GHz  [20MHz BSS at 2.4GHz, or 80 MHz BSS at 5GHz] |
| Data Preamble Type | [2.4GHz, 11n; 5GHz, 11ac] |
| STA TX Power | 15 dBm per antenna |
| AP TX Power | 20 dBm per antenna |
| P2P TX Power | 15 dBm per antenna |
| AP Number of TX antennas | All APs with [2] or all with 4 antennas |
| AP Number of RX antennas | All APs with [2] or all with 4 antennas |
| STA Number of TX antennas | All STAs with [1] or all with 2 antennas |
| STA Number of RX antennas | All HEW STAs with [1] or all with 2 antennas |
| AP antenna gain | +0dBi |
| STA antenna gain | -2dBi |
| Noise Figure | 7dB |
| Distance-based Path Loss | Computed on the basis of 3-D distance, with a minimum 3-D distance of 1 meter. Formulas shall be evaluated with carrier frequency equal to 2.4GHz for channels within the 2.4 GHz band, and with carrier frequency equal to 5GHz for channels within the 5 GHz band. |

|  |  |
| --- | --- |
| **MAC parameters** | |
| Access protocol parameters | [EDCA with default parameters] |
| Aggregation | [A-MPDU / max aggregation size / BA window size, No A-MSDU, with immediate BA] |
| Max number of retries | Max retries: 10 |
| RTS/CTS Threshold | [no RTS/CTS] |

## Power State Transitions and Power Consumption

## Following state transition is used for power modelling in simulations and performance evaluation



## Common Power Model Parameters for all simulation Scenarios

|  |  |
| --- | --- |
| **Power State parameters** | |
| Power State | Average Current Consumption (mA), Voltage = 1,1V,  Bandwidth = { 20 MHz }, Band = { 2.4 GHz, 5 GHz }, NSS = { 1 },  Number of TX/RX antennas = { 1 }, TX power per antenna = { 15 dBm } |
| Transmit | 280 mA |
| Receive | 100 mA |
| Listen | 50 mA |
| Shallow Sleep | 0.9 mA |
| Sleep | 0.003 mA |

Transmit power state is defined as the state when the STA is sending a PPDU.

Receive power state is defined as the state when the STA is receiving a PPDU.

Listen power state is defined as the state when the STA is performing CCA or actively looking for the presence of a PPDU.

Deep Sleep power state is defined as a sleep state with the least (non-zero) power consumed and the longest transition time to Listen state.

Shallow Sleep power state is defined as a sleep state when the STA consumes more power but transitions faster to Listen state when compared to the Deep Sleep power state.\*

\* For calibration purpose, only Shallow Sleep power state may be used for the sleep state (see Test 5).

|  |  |  |
| --- | --- | --- |
| **Power Transition parameters** | | |
| State Transitions | Transition Time (ms) | Average Power Consumption (mW) |
| Transmit ⬄ Listen | 0 | 0 |
| Receive ⬄ Listen | 0 | 0 |
| Receive Transmit | TRT | e.g., 209 mW (PRT=(280+100)\*1.1/2) |
| Transmit Shallow Sleep | TTS | e.g., 154.5 mW (PTS=(280+0.9)\*1.1/2) |
| Receive  Shallow Sleep | TRS | e.g., 55.5 mW (PRS=(100+0.9)\*1.1/2) |
| Listen ⬄ Shallow Sleep | TLS | e.g., 28 mW (PLS=(50+0.9)\*1.1/2) |
| Shallow Sleep Listen | 0.5 ms (TSL) |
| Listen  Deep Sleep | TDS | e.g., 0.5 mW (PDS=(0.9+0.003)\*1.1/2) |
| Deep Sleep Listen | 3 ms (TSD) |

|  |  |  |  |
| --- | --- | --- | --- |
| Power Save Mechanism parameters | | | |
| Mechanism | Parameter | Definition/Values | Pick one value from the Suggested Set of Simulation Values \*\* |
| Power save mode (PSM) | Beacon Interval (BI) | 100 TU | 100 TU |
| DTIM | Integer in unit of BI | { 1, 3 } |
| PSM timeout | Length of time before STA goes to sleep | { 50, 100, 200 } ms |
| Pre-Target Beacon Transmission Time (TBTT) | Length of time before a STA wakes before Beacon | { 0 } ms |
| Beacon timeout | Length of time after TBTT | { 5 } ms |
| Power save polling (PSP) | Beacon Interval | 100 TU | 100 TU |
| DTIM | Integer in unit of BI | { 1, 3 } |
| Pre-Target Beacon Transmission Time (TBTT) | Length of time before a STA wakes before Beacon | { 0 } ms |
| Beacon timeout | Length of time after TBTT | { 5 } ms |
| Unscheduled automatic power save delivery (U-APSD) | Beacon Interval | 100 TU | 100 TU |
| DTIM | Integer in unit of BI | { 1, 3 } |
| Max SP Length | Indicate the maximum number of buffered MSDUs, A-MSDUs, and MMPDUs that AP may deliver per SP | { 2, 4, 6, ∞ } |
| AC | Access Category | All ACs are both delivery and trigger enabled |
| Pre-Target Beacon Transmission Time (TBTT) | Length of time before a STA wakes before Beacon | { 0 } ms |
| Beacon timeout | Length of time after TBTT | { 5 } ms |

\*\* Simulation results presented should clearly indicated what values are used in the generating the simulation results

# 1 - Residential Scenario

(Initial version from documents 11-13/1081r0**,** 786)

|  |  |
| --- | --- |
| **Topology** | |
| Figure 1 - Residential building layout | |
| **Parameter** | **Value** |
| Environment description | Multi-floor building   * 5 floors, 3 m height in each floor * 2x10 apartments in each floor * Apartment size:10m x 10m x 3m |
| APs location | In each apartment, place AP in random xy-locations (uniform distribution) at z = 1.5 m above the floor level of the apartment. |
| AP Type | M APs in the building  AP\_1 to AP\_M1: HEW AP\_{M1+1} to AP\_M: non-HEW  M = Number of Apartments = 100  M1 = [100]  Non-HEW = 11b/g/n in 2.4GHz  Non-HEW = 11ac in 5GHz |
| STAs location | In each apartment, place STAs in random xy-locations (uniform distribution) at z = 1.5m above the floor level of the apartment |
| Number of STA  and STAs type | N STAs in each apartment STA\_1 to STA\_N1: HEW STA\_{N1 +1} to STA\_N: non-HEW  N = [2] or N = 10  N1 = [N]  Non-HEW = 11b/g (TBD) in 2.4GHz  Non-HEW = 11ac (TBD) in 5GHz |
| Channel Model  And Penetration Losses | Fading model  TGac channel model D NLOS for all the links. |
| Pathloss model  PL(d) = 40.05 + 20\*log10(fc/2.4) + 20\*log10(min(d,5)) + (d>5) \* 35\*log10(d/5) + 18.3\*F^((F+2)/(F+1)-0.46) + 5\*W  d = max(3D distance [m], 1)  fc = frequency [GHz]  F = number of floors traversed  W = number of walls traversed in x-direction plus number of walls traversed in y-direction |
| Shadowing  Log-normal with 5 dB standard deviation, iid across all links |
|  | |
| **PHY parameters** | |
| MCS | [use MCS0 for all transmissions] or  [use MCS7 for all transmissions] |
| GI | Short |
| AP #of TX antennas | All HEW APs with [2] or all with 4 |
| AP #of RX antennas | All HEW APs with [2] or all with 4 |
| STA #of TX antennas | All HEW STAs with [1] or all with 2 |
| STA #of RX antennas | All HEW STAs with [1] or all with 2 |
|  | |
| **MAC parameters** | |
| Access protocol parameters | [EDCA with default parameters according to traffic class] |
| Center frequency, BSS BW and primary channels | Operating channel:  2.4GHz: random assignment of 3 20MHz non-overlapping channels 5GHz: random assignment of [3] or 5 80MHz non-overlapping channels, with random selection of primary channel per operating channel |
| Aggregation | [A-MPDU / 64 MPDU aggregation size / BA window size, No A-MSDU, with immediate BA] |
| Max # of retries | Max retries: 10 |
| RTS/CTS Threshold | [No RTS/CTS] |
| Association | X% of STAs in an apartment are associated to the AP in the apartment; 100-X% of the STAs are not associated  [X=100] |
| Management | Each AP is independently managed |

**Traffic model**

**For Calibration:**

* Use full buffer traffic
* Downlink only or Uplink only
* BE class

**For performance tests:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Traffic model (Per each apartment) - TBD** | | | | | |
| **#** | **Source/Sink** | **Name** | **Traffic definition** | **Flow specific parameters** | **AC** |
| **Downlink** | | | | | |
| D1 | AP/STA1 | Buffered video streaming |  | 200Mbps/N (4k video 20Mbps for N=10); | VI |
| … |  |  |  |  | VI |
| DN | AP/STA\_N | Buffered video streaming |  | 200Mbps/N (4k video 20Mbps for N=10); | VI |
| **Uplink** | | | | | |
| U1 | STA1/AP |  |  | 1.5Mpbs |  |
|  |  |  |  |  |  |
| UN | STA\_N/AP |  |  | 1.5Mpbs |  |
| **P2P (optional)** | | | | | |
| P1 | STA\_{N1+1}/STA\_{N1+2} | Buffered video streaming |  | 10Mbps | VI |
|  |  |  |  |  |  |
|  | STA\_{N-1}/STA\_{N} | Buffered video streaming |  | 10Mbps |  |
| **Idle Management (optional** | | | | | |
| M1 | AP1 | Beacon | TX | 80 octets long Beacon frame is transmitted every 100ms |  |
| M2-M | All unassociated STAs | Probe Req |  | TBD |  |

# 2 – Enterprise Scenario

(Initial version form the Wireless Office scenario in 11/722r2)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Parameter** | | **Value** | | |
|  | | | | |
| **Topology** | | | | |
| Figure 2 - BSSs within the building floor | | | | |
|  | | | | |
| Toplogy_dense.png  Figure 3 - STAs clusters (cubicle) and AP positions within a BSS    Figure 4 - STAs within a cluster | | | | |
| Topology Description | | Office floor configuration   * 1. 8 offices (see Figure 2)   2. 64 cubicles per office (see Figure 3)   3. Each cubicle has 4 STAs (see Figure 4)   STA1: laptop  STA2: monitor  STA3: smartphone or tablet  STA4: Hard disk | | |
| APs location | | 4 APs per office  Installed on the ceiling at:  AP1: (x=5,y=5,z=3)  AP2: (x=15,y=5,z=3)  AP3: (x=5,y=15,z=3)  AP4: (x=15,y=15,z=3)  From the left-bottom of each office location. | | |
| AP Type | | HEW | | |
| STAs location | | Placed randomly in a cubicle (x,y) z=1 | | |
| Number of STAs  and STAs type | | N STAs in each cubicle. STA\_1 to STA\_{N1}: HEW STA\_{N1+1} to STA\_{N} : non-HEW N = 4  N1 = [4]  Non-HEW = 11b/g/n (TBD) in 2.4GHz  Non-HEW = 11ac (TBD) in 5GHz | | |
| Channel Model  And Penetration Losses | Fading model  TGac channel model D NLOS for all the links. | | | |
| Pathloss model  PL(d) = 40.05 + 20\*log10(fc/2.4) + 20\*log10(min(d,10)) + (d>10) \* 35\*log10(d/10) + 7\*W  d = max(3D-distance [m], 1)  fc = frequency [GHz]  W = number of office walls traversed in x-direction plus number of office walls traversed in y-direction  Shadowing  Log-normal with 5 dB standard deviation, iid across all links | | | |
|  | |  | | |
|  | | | | |
| **PHY parameters** | | | | |
| MCS | | | [use MCS0 for all transmissions] or  [use MCS7 for all transmissions] | |
| GI | | | Short | |
| AP #of TX antennas | | | 4 | |
| AP #of RX antennas | | | 4 | |
| STA #of TX antennas | | | All STAs with [1], or all STAs with 2 | |
| STA #of RX antennas | | | All STAs with [1], or all STAs with 2 | |
|  | | | | |
| **MAC parameters** | | | | |
| Access protocol parameters | | | | [EDCA with default EDCA Parameters set] |
| Center frequency, BSS BW and primary channels | | | | Channel allocation  5GHz:  Four 80 MHz channels (Ch1, Ch2, Ch3, Ch4)  The channel distribution can be:  Ch1: BSS 4k-3  Ch2: BSS 4k-2  Ch3: BSS 4k-1  Ch4: BSS 4k  k=1~8, is the office index.  APs on same 80MHz channel uses the same primary channel  2.4GHz:  Ch1: BSS 1  Ch2: BSS 2  Ch3: BSS 3 and 4  Repeat same allocation for all offices |
| Aggregation | | | | [A-MPDU / max aggregation size / BA window size, No A-MSDU, with immediate BA] |
| Max # of retries | | | | 10 |
| RTS/CTS Threshold | | | | [no RTS/CTS] |
| Association | | | | X% of STAs associate with the AP based on highest RSSI in the same office; 100-X% of STAs are not associated.  [X=100] |
| Management | | | | It is allowed to assume that all APs belong to the same management entity |
| **Parameters for P2P (if different from above)** | | | | |
| Primary channels | | | | Channel allocation  5 GHz  All P2P group use one 80 MHz channel which is Channel 1 of HEW’s parameter with random selection of primary channel per operating channel  2.4 GHz  Random assignment in 4 channels of HEW’s parameter |

**Traffic model**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Traffic model (Per each cubicle)** | | | | | |
| **#** | **Source/Sink** | **Name** | **Traffic definition** | **Flow specific parameters** | **AC** |
| **Downlink** | | | | | |
| D1 | AP/STA1 | Web browsing, Local file transfer | T1 |  | VI |
| D2 | AP/STA3 | Web browsing, Local file transfer | T3 |  | BE |
| **Uplink** | | | | | |
| U1 | STA1/AP | Web browsing, Local file transfer |  |  |  |
| U2 | STA3/AP | Web browsing, Local file transfer |  |  |  |
| **P2P** | | | | | |
| P1 | STA1/STA2 | Lightly compressed video |  |  |  |
| P2 | STA1/STA4 | Hard disk file transfer |  |  |  |
| **Idle / Management** | | | | | |
| M1 | AP | Beacon |  |  |  |
| M2 | STAs | Probes |  |  |  |

## Interfering scenario for scenario 2

All surveys and observations so far have led to the same conclusion that most enterprises in the world are made up of micro, small or medium sizes. The results of the surveys also indicate that small enterprises consist of a single office/room whereby medium enterprises consist of 2 to 4 offices. Hence, a mixed office scenario that contains multiple BSSs belonging to different ESSs is proposed. These ESSs are managed independently. (Reference: 14/0051r0).

**Interference models:**

Based on the mixed enterprise topology, two kinds of interferences are considered either in a combined or separate way:

* Interference between APs belonging to different managed ESS due to the presence of multiple operators (multiple small and medium enterprises).
* Interference with unmanaged networks (P2P links).

1. Interference between APs belonging to different managed ESS due to the presence of multiple operators (multiple small and medium enterprises). Use the model of scenario 2 with the following differences.

Different offices can be managed by a different entities, as indicated in Figure 5, where each color represents a management entity (note that office 1 (BSS1-4) and office 2 (BSS5-8) have same management entity)

BSS 9-12

BSS13-16

BSS 5-8

BSS 1-4

20 m

20 m

BSS 25-28

BSS 29-32

BSS 21-24

BSS 17-20

1

2

4

3

Figure 5- Scenario 2 with different management entities

1. Interference with unmanaged networks (P2P links). Use the model of scenario 3 with the following differences.

A number of additional P2P STAs

|  |  |
| --- | --- |
| STAs location | (NP2P /2) P2P pairs with STAs placed 0.5m apart.  The P2P pairs are placed in a random location within an office. |
| Number of STAs  and STAs type | P2P STAs:  NP2P STAs in an office, with MP2P STAs HEW.  STA\_{64N+1} to STA\_{64N+MP2P}: HEW STA\_{64N+ MP2P+1} to STA\_{64N+NP2P}: non-HEW  (NP2P = TBD, MP2P = TBD) ,  with N STAs in a cubic as described in scenario 2, and 64 cubics per office.  Non-HEW = 11b/g/n (TBD) in 2.4GHz  Non-HEW = 11n/ac (TBD) in 5GHz |



# 3 - Indoor Small BSSs Scenario

(From document 1248r0)

This scenario has the objective to capture the issues and be representative of real-world deployments with high density of APs and STAs that are highlighted by the first category of usage models described in [5]:

* In such environments, the infrastructure network (ESS) is planned. For simulation complexity simplifications, a hexagonal BSS layout is considered with a frequency reuse pattern.
* In such environments, the “traffic condition” described in the usage model document mentions:
  + interference between APs belonging to the same managed ESS due to high density deployment: *this OBSS interference is captured in this scenario*
    - *note that this OBSS interference is touching STAs in high SNR conditions (close to their serving APs, while in outdoor large BSS scenario, the OBSS interference will be touching STAs in low SNR conditions (for from their serving APs)*
  + Interference with unmanaged networks (P2P links): *this OBSS interference is captured in this scenario by the definition of interfering networks, defined here as random unmanaged short-range P2P links, representative of Soft APs and tethering*
  + Interference with unmanaged stand-alone APs: *this OBSS interference is currently not captured in this scenario, but in the hierarchical indoor/outdoor scenario*
  + Interference between APs belonging to different managed ESS due to the presence of multiple operators: *this OBSS interference is currently not captured in this scenario, but in the outdoor large BSS scenario*
* Other important real-world conditions representative of such environments are captured in this scenario, [20]:
  + Existence of unassociated clients, with regular probe request broadcasts.

Different frequency reuse pattern can be defined (1, 3 and/or more).

Frequency reuse 3 is more realistic in a scenario with such high density of AP and we should use it as the default setting.

It is representative of the majority of planned deployments which apply frequency reuse higher than 1 and where STAs are located closer from their serving APs (good SNR conditions) than from neighboring APs on the same channel.

It is regular

Reuse 1 should however also be considered, to capture the fact that some regions have very low available bandwidth and are forced to apply frequency reuse 1 deployments. (But this reuse 1 case is very difficult seeing the huge overlap between neighboring APs due to high density of APs).

Note that frequency reuse 1 is more suited to scenario 4 either to represent:

A single operator deployment in a region where available bandwidth is low (the lower density of APs in large outdoor makes it more realistic)

An overlap between 3 operators, each applying a frequency reuse 3: this is equivalent to a single deployment with reuse 1.

In order to focus this scenario on the issues related to high density, the channel model is considered as a large indoor model (TGn F). *Note that robustness to outdoor channel models, which is also a requirement for some usage models in category 1 (like outdoor stadiums), is captured in the outdoor large BSS scenario.*

It is important to define a proportion (TBD %) of legacy devices in the scenario that won’t implement the proposed solution under evaluationto ensure that the solution will keep its efficiency in real deployments (some solutions may be sensitive to the presence of legacy devices while other won’t).

These legacy devices shall simply keep the baseline default parameters and shall not implement the proposed solution under evaluation. Those devices can be:

* STAs connected to the planned network
* APs and STAs part of the interfering network

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Value** | | |
|  | | | |
| **Topology (A)** | | | |
| Figure 6 - BSSs layout  BSS  BSS  BSS  BSS  BSS  BSS  BSS  BSS  BSS  BSS  BSS  BS  BSS  BSS  BSS  BSS  BSS  BSS  BSS  Figure 7 - Layout of BSSs using the same channel in case frequency reuse 3 is used | | | |
| Environment description | BSSs are placed in a regular and symmetric grid as in Figure 6 for frequency reuse 1 and Figure 7 for frequency reuse 3.  Each hexagon in Figures 6 and 7 has the following configuration:  Radius (R): 10 meters  Inter BSS distance (ICD): 2\*h meters  h=sqrt(R2-R2/4) | | |
| APs location | AP is placed at the center of the hexagon, with 3m antenna height | | |
| AP Type | HEW | | |
| STAs location | STA antenna height 1.5m.  Reuse 1:  STAs are placed randomly (uniform distribution) within the 19 cell area. STA identifies AP from which it receives the highest power (based on distance-based pathloss and shadowing). STA associates to corresponding AP if the AP does not yet have N1 STAs associated to it; if AP already has N1 STAs associated to it then this STA is removed from the simulation. This process is repeated, with iid dropping of STAs within the 19 cell area, until each of the 19 APs has exactly N1 STAs associated to it.  Reuse 3:  STAs are placed randomly (uniform distribution) within the 61 cell area that covers the reuse 3 pattern in Figure 7. STA identifies which (of the 61) APs from which it receives the highest power (based on distance-based pathloss and shadowing). If the corresponding AP is one of the 19 co-channel APs shown in Figure 7 and if the AP does not yet have N1 STAs associated to it, then STA associates to it; else STA is removed from the simulation. This process is repeated until each of the 19 co-channel APs has exactly N1 STAs associated to it.  If Y >0 or Z> 0, where Y and Z are the percentage of STAs that associate with the 2nd /3rd strongest AP’s respectively (see below for specification of Y, Z, and X; percentage of STAs that associate with strongest AP), then the above procedure should be performed three times: first to load each AP with N1\*X/100 STAs that have associated with the strongest AP, then to load with N1\*Y/100 STA’s that have associated to the 2n d strongest AP, and a third time to load with N1\*Z/100 STA’s that have associated to the 3rd strongest AP. This procedure guarantees each AP has the same number of associated STAs that have identified it as the strongest, 2nd strongest, and 3rd strongest AP (e.g., if X = 50, Y = 25, Z =25, then each AP will have 20/10/10 associated STAs for which that AP is the 1st/2nd/3rd strongest respectively.). | | |
| Number of STA and STAs type | N STAs per AP.  STA\_1 to STA\_{N1}: HEW STA\_{N1+1} to STA\_{N} : non-HEW N = [30] or 40  N1 = [N]  Non-HEW = 11b/g/n (TBD) in 2.4GHz  Non-HEW = 11ac (TBD) in 5GHz | | |
| Channel Model | | Fading model  TGac channel model D NLOS for all the links. |
| Pathloss model  PL(d) = 40.05 + 20\*log10(fc/2.4) + 20\*log10(min(d,10)) + (d>10) \* 35\*log10(d/10)  d = max(3D-distance [m], 1)  fc = frequency [GHz]  Shadowing  Log-normal with 5 dB standard deviation, iid across all links |
|  |  | | |
|  | | | |
| **PHY parameters** | | | |
| MCS | [use MCS0 for all transmissions] or  [use MCS7 for all transmissions] | | |
| GI | Short | | |
| AP #of TX antennas | All APs with [2] or all APs with 4 | | |
| AP #of RX antennas | All APs with [2] or all APs with 4 | | |
| STA #of TX antennas | All STAs with [1] or all STAs with 2 | | |
| STA #of RX antennas | All STAs with [1] or all STAs with 2 | | |
|  | | | |
| **MAC parameters** | | | |
| Access protocol parameters | [EDCA with default EDCA Parameters set] | | |
| Primary channels | All BSSs either all at 2.4GHz, or all at 5GHz  2.4GHz:  20MHz BSS with reuse 3  5GHz:  80 MHz BSS  [Reuse 3] or reuse 1  Per each 80MHz use same primary channel across BSSs | | |
| Aggregation | [A-MPDU / max aggregation size / BA window size, No A-MSDU, with immediate BA] | | |
| Max # of retries | 10 | | |
| RTS/CTS Threshold | [no RTS/CTS] | | |
| Association | X% of STAs are associated with the strongest AP, Y% of STAs are associated with the second-strongest AP, and Z% of STAs associate with the third-strongest AP. Z% of STAs are not associated. Association is based on RSSI, i.e., received power as determined by path loss, shadowing, and any penetration loss (but not multipath). Detailed distribution to be decided.  [X=100,Y=0,Z=0] | | |
| Management | It is allowed to assume that all APs belong to the same management entity | | |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Traffic model (per each BSS) - TBD** | | | | | |
| **#** | **Source/Sink** | **Name** | **Traffic definition** | **Flow specific parameters** | **AC** |
| **Downlink** | | | | | |
| D1 | AP/STA1 to AP/STA10 | Highly compressed video (streaming) | T2 |  |  |
| D2 | AP/STA11 to AP/STA20 | Web browsing | T4 |  |  |
| D3 | AP/STA21 to AP/STA30 | Local file transfer | T3 |  |  |
| D4 | AP/STA31 to  AP/STA 70 | Multicast Video Streaming | T8 |  |  |
|  |  |  |  |  |  |
| **Uplink** | | | | | |
| U1 | STA1/AP to STA10/AP | Highly compressed video (streaming) – UL TCP ACKs… |  |  |  |
| U2 | STA11/AP to STA20/AP | Web browsing: – UL TCP ACKs… |  |  |  |
| U3 | STA21/AP to STA30/AP | Local file transfer | T3 |  |  |
| U4 | STA/AP31 to  STA/AP 70 | - | - |  |  |
|  |  |  |  |  |  |
| **P2P** | | | | | |
| P1 | NONE (see interfering scenarios) |  |  |  |  |
| **Idle / Management** | | | | | |
| M1 | AP | Beacon | TX |  |  |
| M2 | STA36 to STA TBD | Probe Req. | TY |  |  |

## Interfering Scenario for Scenario 3

This scenario introduces and overlay of unmanaged P2P networks on top of Scenario 3.

|  |  |  |
| --- | --- | --- |
| **Parameter** | | **Value** |
|  | | |
| **Topology** | | |
| BSS  BSS  BSS  BSS  BSS  BSS  BSS  Figure 8 - BSSs layout, with interfering P2P links | | |
| Topology Description | Starting from Scenario 3 topology, add K P2P pairs of STAs within each hexagon | |
| APs location |  | |
| AP Type | HEW | |
| STAs location | STAs pairs randomly placed in the simulation area  Per each pair, STAs are placed 0.5m apart | |
| Number of STA and STAs type | STA\_1 to STA\_{K1}: HEW STA\_{K1+1} to STA\_{K} : non-HEW K = 4  K1 = [4] | |
| Channel Model | TBD | |
| Penetration Losses | None | |
|  | | |
| **PHY parameters: Same as main scenario**  **Except for the following ones** | | |
| STA TX Power | 15dBm | |
|  | | |
| **MAC parameters: same as main scenario**  **Except for the following ones** | | |
| Primary channels | P2P on same channel as the BSS corresponding to the same hexagon | |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Traffic model for interfering scenario** | | | | | |
| **#** | **Source/Sink** | **Name** | **Traffic definition** | **Flow specific parameters** | **AC** |
| **Downlink** | | | | | |
| 1 | STA\_1 to STA\_2 | Highly compressed video (streaming) | T2 |  |  |
| 2 |  |  |  |  |  |
| 3 | STA\_n to STA\_{n+1} | Local file transfer | T3 |  |  |
| **Idle / Management** | | | | | |
| M1 | STA\_{2n} | Beacon | TX |  |  |

# 4 - Outdoor Large BSS Scenario

This scenario has the objective to capture the issues (and be representative of) real-world outdoor deployments with a high separation between APs (BSS edge with low SNR) with high density of STAs that are highlighted by the forth category of usage models described in []:

* In such environments, the infrastructure network (ESS) is planned. For simulation complexity simplifications, a hexagonal BSS layout is considered with a frequency reuse pattern. This frequency reuse pattern is defined and fixed, as part of the parameters that can’t be modified in this scenario. *(Note that BSS channel allocation can be evaluated in simulation scenarios where there are not planned networks (ESS), as in the residential one.)*
* In such environments, the “traffic condition” described in the usage model document mentions:
  + interference between APs belonging to the same managed ESS due to high density deployment: *this OBSS interference is captured in this scenario even if it is low as the distance between APs is high*
  + Interference with unmanaged networks (P2P links): *this OBSS interference is currently not captured in this scenario, but in the scenario 3.*
  + Interference with unmanaged stand-alone APs: *this OBSS interference is currently not captured in this scenario, but in the hierarchical indoor/outdoor scenario 4a*
  + Interference between APs belonging to different managed ESS due to the presence of multiple operators: *this OBSS interference is captured in this scenario, by an overlap of 3 operators, using relatively similar grid but channel selection offset*

Reuse factor, TBD

We should consider a hexagonal deployment using frequency reuse 1.

Such a frequency reuse 1 scenario is representative of:

A single operator deployment in a region where available bandwidth is low and forces frequency reuse 1 deployments (the lower density of APs in large outdoor makes it more realistic)

An overlap between 3 operators, each applying a frequency reuse 3: in case of close location of this is equivalent to a single operator deployment with reuse 1.

As the inter-site distance is high, the overlap between neighboring cells is close to minimum sensitivity (low SNR)

* *this enables to capture the issue of outdoor performance in low SNR conditions*
* *this enables to capture the issue of fairness between users spread on the full coverage of each AP*
* *this enables to capture OBSS interference touching STAs in low SNR conditions (far from their serving APs), while in dense hotspot scenario, the OBSS interference is touching STAs in high SNR conditions (close to their serving APs)*

It is important to define a proportion (TBD %) of legacy devices in the scenario that won’t implement the proposed solution under evaluationto ensure that the solution will keep its efficiency in real deployments (some solutions may be sensitive to the presence of legacy devices while other won’t).

These legacy devices shall simply keep the baseline default parameters and shall not implement the proposed solution under evaluation. Those devices can be:

* STAs connected to the planned network
* APs and STAs part of the interfering network

|  |  |  |
| --- | --- | --- |
| **Parameter** | | **Value** |
|  | | |
| **Topology (A)** | | |
| Figure 9 – BSSs layout | | |
| Environment description | Outdoor street deployment  BSS layout configuration  Define a 19 hexagonal grid as in Figure 9  With ICD = 130m  h=sqrt(R2-R2/4)/2 | |
| APs location | Place APs on the center of each hexagon  Antenna height 10 m. | |
| AP Type | HEW | |
| STAs location | .  STA antenna height 1.5 m.  STAs are placed randomly (uniform distribution) within the 19 cell area, at a minimum X-Y distance of 10 m from every AP. STA identifies AP from which it receives the highest power (based on distance-based pathloss and shadowing). STA associates to corresponding AP if the AP does not yet have N1 STAs associated to it; if AP already has N1 STAs associated to it then this STA is removed from the simulation. This process is repeated until each of the 19 APs has exactly N1 STAs associated to it.  If Y >0 or Z> 0, where Y and Z are the percentage of STAs that associate with the 2nd /3rd strongest AP’s respectively (see below for specification of Y, Z, and X; percentage of STAs that associate with strongest AP), then the above procedure should be performed three times: first to load each AP with N1\*X/100 STAs that have associated with the strongest AP, then to load with N1\*Y/100 STA’s that have associated to the 2n d strongest AP, and a third time to load with N1\*Z/100 STA’s that have associated to the 3rd strongest AP. This procedure guarantees each AP has the same number of associated STAs that have identified it as the strongest, 2nd strongest, and 3rd strongest AP (e.g., if X = 50, Y = 25, Z =25, then each AP will have 20/10/10 associated STAs for which that AP is the 1st/2nd/3rd strongest respectively.). | |
| Number of STA and STAs type | N STAs per AP.  STA\_1 to STA\_{N1}: HEW STA\_{N1+1} to STA\_{N} : non-HEW (N= 50 - 100 TBD, N1 = TBD)  Non-HEW = 11b/g/n (TBD) in 2.4GHz  Non-HEW = 11ac (TBD) in 5GHz  N=50  [N1=50] | |
| Channel Model | [UMi] or UMa  The following equations from ITU-UMi model [4] are to be used for computing the path loss for each drop in an outdoor scenario  LOS Links  where the effective antenna height parameters are given by  and  and  NLOS Links  Modify height parameters as follows depending on the link   * + = 1.5m for the STA; = 10m for AP in the AP🡨🡪 STA links   + = 1.5m for STA🡨🡪 STA links   + m for AP 🡨🡪 AP links   In the above equations, the variable d is defined as:  d = max(3D-distance [m], 1)  TBD Note: In case of UMi channel model, M.2135-1 defines that 50% of user are indoor users, but since indoor users can be served by indoor AP, we can change the percentage of users are indoor; need to decide which percentage | |
| Penetration Losses | None | |
|  | | |
| **PHY parameters** | | |
| MCS | [use MCS0 for all transmissions] or  [use MCS7 for all transmissions] | |
| GI | Long | |
| AP #of TX antennas | All APs with [2] or all APs with 4 | |
| AP #of RX antennas | All APs with [2] or all APs with 4 | |
| STA #of TX antennas | All STAs with [1] or all STAs with 2 | |
| STA #of RX antennas | All STAs with [1] or all STAs with 2 | |
|  | | |
| **MAC parameters** | | |
| Access protocol parameters | [EDCA with default EDCA Parameters set] | |
| Center frequency, BW and  primary channels | Frequency reuse 1 is used.  5GHz  all BSSs are using the same 80MHz channel  [Same Primary channel]  2.4GHz  All BSSs are 20MHz BSS on same channel | |
| Aggregation | [A-MPDU / max aggregation size / BA window size, No A-MSDU, with immediate BA] | |
| Max # of retries | 10 | |
| RTS/CTS Threshold | [no RTS/CTS] | |
| Association | X% of STAs are associated with the strongest AP, Y% of STAs are associated with the second-strongest AP, and Z% of STAs are associated with the third-strongest AP. Z% of STAs are not associated. Detailed distribution to be decided.  [X=100, Y=0,Z=0] | |
| Management | It is allowed to assume that all APs belong to the same management entity | |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Traffic model (Per each BSS) - TBD** | | | | | |
| **#** | **Source/Sink** | **Name** | **Traffic definition** | **Flow specific parameters** | **AC** |
| **Downlink** | | | | | |
| D1 | AP/STA1 to AP/STA10 | Highly compressed video (streaming) | T2 |  |  |
| D2 | AP/STA11 to AP/STA20 | Web browsing | T4 |  |  |
| D3 | AP/STA21 to AP/STA25 | Local file transfer | T3 |  |  |
| … | … |  |  |  |  |
| DN | AP/STAN |  |  |  |  |
| **Uplink** | | | | | |
| U1 | AP/STA1 to AP/STA10 | Highly compressed video (streaming) – UL TCP ACKs… |  |  |  |
| U2 | AP/STA11 to AP/STA20 | Web browsing: – UL TCP ACKs… |  |  |  |
| U3 | STA26/AP to STA30/AP | Local file transfer | T3 |  |  |
| … | … |  |  |  |  |
| UN | STAN/AP |  |  |  |  |
| **P2P** | | | | | |
| P1 | STA1/AP |  |  |  |  |
| P2 | STA2/AP |  |  |  |  |
| P3 | STA3/AP |  |  |  |  |
| … | … |  |  |  |  |
| PN | STAN/AP |  |  |  |  |
| **Idle Management** | | | | | |
| M1 | AP1 | Beacon | TX |  |  |
| M2 | STA2 | Probe Req. | TY |  |  |
| M3 | STA3 |  |  |  |  |
| … | … |  |  |  |  |
| MN | STAN |  |  |  |  |

# 4a- Outdoor Large BSS + Residential Scenario

|  |  |  |
| --- | --- | --- |
| **Parameter** | | **Value** |
|  | | |
| **Topology (A)** | | |
| Figure 10 –Layout of large BSSs with residential buildings | | |
| Environment description | This scenario consists of an overlay of the following   * Scenario 4, with the exception that only 7 cells are included out of the 19 * A Residential building per each BSS, which center is placed in a random uniform position within a radius of ICD/2 around the AP; the Residential building topology is as defined in Scenario 1, with the exception that the number of floors is set to 1. | |
| APs location | See Scenario 1 and 4. | |
| AP Type | See Scenario 1 and 4. | |
| STAs location | See Scenario 1 and 4. | |
| Number of STA and STAs type | See Scenario 1 and 4. | |
| Channel Model | See Scenario 1 and 4  {indoor/outdoor??} | |
| Penetration Losses | See Scenario 1 and 4. | |
|  | | |
| **PHY parameters** | | |
| Same parameters as defined for the STAs in Scenario 1 and Scenario 4. | | |
|  | | |
| **MAC parameters** | | |
| All parameters except the ones listed in this table are same as in Scenario 1 and Scenario 4 | | |
| Association | STAs defined by Scenario 1, associate as defined by Scenario 1  STAs defined by Scenario 4:  80% associate as defined by Scenario 4  20% associate with strongest AP from a Residential building | |
| Management | It is allowed to assume that all outdoor APs belong to the same management entity. Each indoor AP belongs to a different management entity | |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Traffic model (Per each BSS) - TBD** | | | | | |
| **#** | **Source/Sink** | **Name** | **Traffic definition** | **Flow specific parameters** | **AC** |
| **Downlink** | | | | | |
| Traffic model for STAs defined by Scenario 1, is defined by Scenario 1 | | | | | |
| Traffic model for STAs defined by Scenario 2, is defined by Scenario 2 | | | | | |

# Scenarios for calibration of MAC simulator

The applicability of each test in this section is TBD.

## Common parameters

|  |  |
| --- | --- |
| **PHY Parameter** | **SUGGESTED VALUES** |
| GI: | [long] |
| Data Preamble: | [11ac] |
| BW | 20 Mhz |

The following parameters are common to the MAC tests unless otherwise stated.

|  |  |
| --- | --- |
| **Parameter** | **SUGGESTED VALUES** |
| Aggregation | A-MPDU  max aggregation size =64  No A-MSDU  immediate BA  (aggregation is assumed to be ON) |
|  |  |
| Max number of retries | 10 |
| Rate adaptation | Fixed MCS |
| EDCA parameters | Default params for best effort (CWmin=15)  AIFSN=3 |

The follwing parameters are common to the traffic model unless otherwise stated.

Transpot protocol- UDP

Traffic model: full buffer

## Test 1a: MAC overhead w/out RTS/CTS

Goal:

designed to verify whether the simulator can correctly handle the basic frame exchange procedure, including AIFS+backoff procedure and A-MPDU+SIFS+BA sequence. Also to make sure the overheads are computed correctly.

Assumptions:

Assumption is that PER is 0

Parameters:

MSDU length:[0:500:2000Bytes]

2 MPDU limit

RTS/CTS off

Data MCS = [0,8] ( to clarify, run a sweep over MSDU length once for MCS 0, and once for MCS 8.

Block ACK MCS=0 (non-HT format)

AIFS=DIFS=34us



Output metric:

(1) MAC layer Throughput

(2) Time trace of transmitting/Receiving event

CP1 ( check point 1) start of A-MPDU

CP2 end of A-MPDU

CP3 start of Block ACK

CP4 end of Block ACK

CP5 start of A-MPDU

|  |  |  |  |
| --- | --- | --- | --- |
| Test Items | Check points | Standard definition | Matching? |
| A-MPDU duration | Tcp2-Tcp1= | ceil((FrameLength\*8)/rate/OFDMsymbolduration) \* OFDMsymbolduration + PHY Header |  |
| SIFS | Tcp3-Tcp2=16 us | 16 us |  |
| Block ACK duration | Tcp4-Tcp3= | ceil((ACKFrameLength\*8)/rate/OFDMsymbolduration) \* OFDMsymbolduration + PHY Header |  |
| Defer & backoff duration | Tcp5-Tcp4= | DIFS(34 us)+backoff (CWmin)  =34us+n\*9us |  |

Tcp is the timestamp related with the corresponding simulation event on the check point (CP)

The following is an example calcultation of TPUT when the MSDU size is 1508, and MCS =0

* Number of MPDUs in AMPDU= 2
* Bytes per MPDU: 1538
  + Bytes from application laye:1472
  + The MSDU size is 1508
    - 28-bytes UDP/IP header and 8 byte LLC packet header
    - So total of 36 bytes are to added to the application packet, making 1508 byte of MSDU size
  + MAC header 30 bytes
  + FC=2;Duration=2;Addr1=6;Addr2=6;Addr3=6;SeqContrl=2;QoSCntrl=2; FCS=4
    - Note: Assuming HT control field is not used
  + MPDU delimiter 4 bytes in each AMPDU subframe
  + 2 bytes padding in first MPDU
* Bytes per PSDU: 2\*(1538+4+2)=3088B
* Each PSDU is appended with:
  + Tail bits 6 bits
  + Service Field 2 Bytes
* Total bits per PPDU without preamble (i.e, data field in PPDU): 3088\*8+6=24726 bits
* Duration of PPDU w/out preamble= ceil(24726/26)\*4us =3.804ms
* Duration of PPDU w/ preamble= 3.844ms
* Duration of Block ACK 68 us
* Expected time waiting for the Medium = 110.5 us (SIFS+AIFSN\*slotTime+CW/2\*slotTime=16+3\*9+15/2\*9)
* Expected TPUT= 1472\*8\*2/(3.844ms+68us+16us+110.5us) =5.83Mbps
* (Note this is application layer tput)

Note: in some simulators, there may be management frame exchanges such as ABBBA request/response and the corresponding ACKs before application data transmission, which may slightly affect the simulation results.

## Test 1b: MAC overhead w RTS/CTS

Goal:

This test case is designed to further verify whether the simulator can correctly handle the frame exchange procedure with RTS/CTS protection based on test1a. It also tests whether the correct overhead computation with RTS /CTS.

Assumptions:

Assumption is that PER is 0

Parameters:

MSDU length:[0:500:2000Bytes]

2 MPDU limit

RTS/CTS ON

Data MCS = [0,8] ( to clarify, run a sweep over MSDU length once for MCS 0, and once for MCS 8.

RTS/CTS MCS=0

ACK MCS=0

AIFS=DIFS=34us

Output metric:

1. MAC layer Throughput
2. Time trace of transmitting/Receiving event



CP1 ( check point 1) : start of RTS

CP2 : end of RTS

CP3: start of CTS

CP4: end of CTS

CP5: start of A-MPDU

CP6: end of A-MPDU

|  |  |  |  |
| --- | --- | --- | --- |
| Test Items | Check points | Standard definition | Matching? |
| RTS duration | Tcp2-Tcp1= | ceil((RTSFrameLength\*8)/rate/OFDMsymbolduration) \* OFDMsymbolduration + PHY Header |  |
| CTS duration | Tcp4-Tcp3= | ceil((CTSFrameLength\*8)/rate/OFDMsymbolduration) \* OFDMsymbolduration + PHY Header |  |
| Frame duration | Tcp6-Tcp5= | ceil((FrameLength\*8)/rate/OFDMsymbolduration) \* OFDMsymbolduration + PHY Header |  |

The following is an example TPUT calculation when MSDU size is 1508, and MCS =0

* Number of MPDUs in AMPDU= 2
* Bytes per MPDU:
  + Bytes from application layer:1472
  + L4 header: 36 bytes
  + MAC header 30 bytes
  + FC=2;Duration=2;Addr1=6;Addr2=6;Addr3=6;SeqContrl=2;QoSCntrl=2; FCS=4
  + MPDU delimiter 4 bytes
  + 2 bytes padding
* Bytes per AMPDU
  + Tail bits < 1 bytes
  + Service Field 2 Bytes
* Total Bytes per AMPDU: 3091
* Duration of PPDU w/out preamble= 3091/6.5e6=3.804ms
* Duration of PPDU w/ preamble= 3.844ms
* Duration of ACK 68 us
* Duration of RTS 52 us
* Duration of CTS 44 us
* SIFS= 16us
* Expected time waiting for the Medium = 100.5 us (CWmin =15)
* Expected TPUT= 1472\*8\*2/(3.844ms+68us+16us+100.5us + 52us+44us+2\*16us) (Note this is application layer TPUT)

## Test 2a: Deferral Test 1

(AP1 and STA2 are essentially co-located)

Goal:

This test case is designed to verify whether the simulator can correctly handle deferral procedure after collision happens without hidden nodes. It also checks whether deferral because of energy levels is happening correctly.

Assumptions:

All devices are within energy detect range of each other.

When AP1 and AP2 start to transmit on the same slot, both packets are lost (PER= 100%). Otherwise packets get through 100%. PER=0 %

Note:

AP1 and AP2 should defer to each other.

The only packet loss is due to collisions when backoffs end at same time

Parameters:

MSDU length:[0:500:2000Bytes]

2 MPDU limit

RTS/CTS [ OFF, ON]

Data MCS = [0]

RTS/CTS MCS=0

ACK MCS=0

AIFS=DIFS=34us

CWmax=1023

Outputs:

MAC tput.

## Test 2b: Deferral Test 2

Goal:

This test case is designed to verify whether the simulator can correctly handle deferral procedure after collision happens with the existing of hidden nodes.

Assumptions:

AP1 and AP2 can not hear each other ; i.e they are not within Preamble detection range of each .

* + Interference Assumptions:
    - If any part of an MPDU sees interference, that MPDU should fail
    - If any part of a data preamble sees interference, all MPDUs should fail
    - If an MPDU, or data premable sees no interference, it should pass
    - If an ACK overlaps with the transmission of an OBSS AP, the PER on the ACK should be 0. (i.e. the ACK should pass)
  + Backoff
    - If no ACK is received, the transmitter should double it’s CW.
    - If an ACK is received, the transmitter should reset its CW
    - If no MPDUs are decoded, no ACK should be sent.
    - After 10 missing ACKS, the CW should be reset.
  + PER definition
    - PER= 1-Acked data MPDUs/Total data MPDUs sent
      * ( TPUT can be computed from number of successfully ACKed MPDUs and the total time)

ACKed data MPDUs are measured by the transmitters

Parameters:

MSDU length:[1500Bytes]

RTS/CTS [ OFF]

Data MCS = [0,8]

ACK MCS=0

AIFS=DIFS=34us

CWmax=1023

2MPDU limit

Outputs:

MAC tput.

## Test 3: NAV deferral

Same as test 2b, but with RTS/CTS on.

ACK MCS=0

RTS/CTS MCS=0

AIFS=DIFS=34us

CWmax=1023

2MPDU limit

Goal: This test is designed to test whether NAV deferral is happening properly.

## Test 4: Deferral Test for 20 and 40MHz BSSs

(AP1 and STA2 are essentially co-located)

Assumptions:

All devices are within energy detect range of each other.

Data PPDU is transmitted in VHT format, while RTS and CTS PPDUs are transmitted in non-HT duplicate format.

When AP1 and AP2 start to transmit on the same slot, both packets are lost (PER= 100%). Otherwise packets get through 100%. PER=0 %

A non-HT duplicate PPDU can be successfully received by a STA if there is no other signal appearing in the STA’s primary channel within the PPDU duration.

If RTSs transmitted by AP1 and AP2 collide, AP1 obtains a TXOP only in primary channel. The AP2 does not obtain TXOP.

Note:

AP1 and AP2 should defer to each other.

The only packet loss is due to collisions when backoffs periods of AP1 and AP2 end at the same time

Parameters:

MSDU length:[ 2000Bytes]

RTS/CTS [ OFF, ON]

MCS = [0]

Procedure:

AP1 sends traffic to STA1 on a 40MHz channel with a full buffer continuously.. All other setting is the same as test case 2a.

AP2 sends traffic to STA2 on a 20MHz channel staing at t1, which is located at the secondary channel of BSS1.

The traffic is based on the Poisson distribution with following parameters.

* + MSDU length at 2000Bytes.
  + Let lambda, for example, to be 100 ( in the unit of 1/second)
    - The mean inter-arrival time is 1/100 second.

The long time average data rate for the largest MSDU size is 2000\*8/(1/100)=1.6Mbps

1.6 Mbps is non-full buffer traffic since it is lower than the 20MHz BSS MCS0 rate

**Implementing Traffic Generator**

For vendor with proprietary simulator, Poisson distribution traffic generator is a vendor specific implementation.

**How to determine the simulation time for a simulator**

* Each simulator calibrates its running time
  + Step 1: Activating the 20MHz BSS only and monitoring how long it will take for the throughput of the 20MHz BSS to be stabilized. Recording the time, ***t***.
  + The throughput of the 20MHz BSS shall corresponding to the mean “inter arrival time”.
* Step 2: Run the OBSS MAC calibration case for at least time ***t***.

If any packet is transmitted at the overlapping time with another one and on the overlapping channel, both transmissions are considered failure(PER = 1).

Measure the throughput of AP1, AP2, STA1 and STA2. Also measure the percentage of time of the each of the bandwidth specific Power states of the APs. Listen state is not bandwidth specific whereas Receive and Transmit states are bandwidth specific.

Outputs:

MAC tput.

Percentages of time of the each of the bandwidth specific Power states of AP. The results are obtained for both AP1 and AP2.

The following example shows how occupations on 20MHz and 40MHz are calculated for AP1 in case when AP1 transmits once using 20MHz and once using 40MHz.



## Test 5: Power Save Mechanism Test

Goal:

This test case is intended to verify the baseline power save mechanism implemented in MAC system simulator

Assumptions:

* PER = 0

PSM test:

Figure 11 – Example of the frameflow in PSM scenario and non-AP STA Power States.

•MSDU length: 1500 bytes with CWmin=15 downlink every 200 ms

•RTS/CTS [ OFF ]

•AIFS=DIFS=34us

•MCS = [ 0 ]

•No A-MPDU aggregation

•Beacon is 80 octets long Beacon frame (as defined in the Traffic model)

•When a STA in PS mode wakes for DTIM Beacon and detects that the TIM bit corresponding to its AID is set to 0, STA returns to Shallow Sleep state. STA remains in Shallow Sleep state until the next DTIM Beacon.

•DTIM = [ 3 ]

•PSM timeout = [ 100 ] ms

**PSP test:**

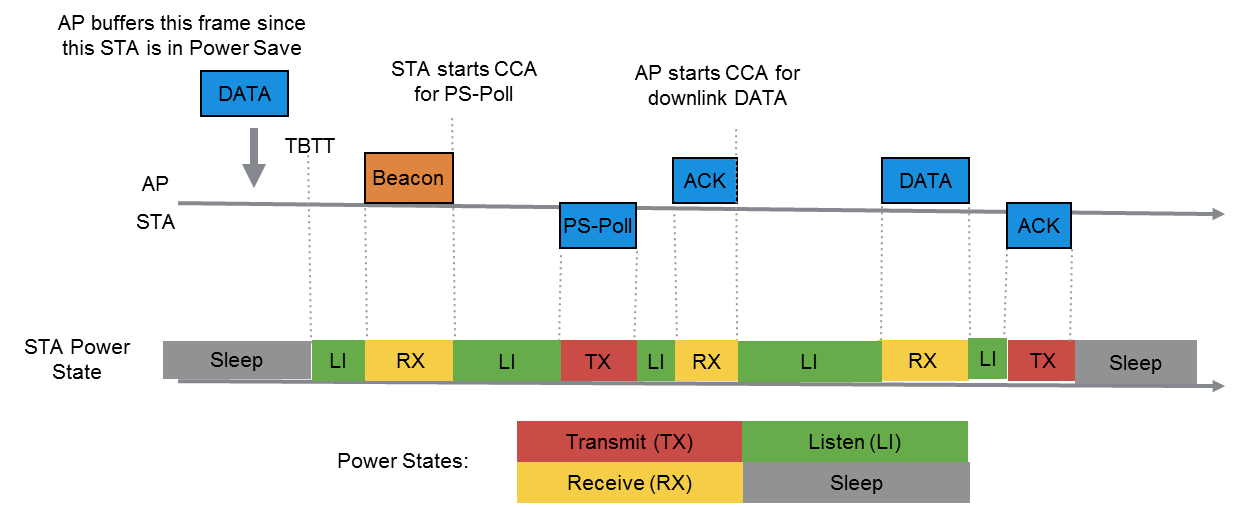


Figure 12 – Example of the frameflow in PSP scenario and non-AP STA Power States.

MSDU length: 1500 bytes with CWmin=15 downlink every 200 ms

•RTS/CTS [ OFF ]

•AIFS=DIFS=34us

•MCS = [ 0 ]

•No A-MPDU aggregation

Beacon is 80 octets long Beacon frame (as defined in the Traffic model)

•When a STA in PS mode wakes for DTIM Beacon and detects that the TIM bit corresponding to its AID is set to 0, STA returns to Shallow Sleep state. STA remains in Shallow Sleep state until the next DTIM Beacon.

•DTIM = [ 3 ]

**U-APSD test**



Figure 13 – Example of the frameflow and backoff in U-APSD scenario and non-AP STA Power fStates.

* MSDU length:  120 bytes with CWmin=15  (once every 40 ms) for both uplink and downlink

Power save test parameters

* AIFS=DIFS=34us
* RTS/CTS [ OFF ]
* MCS = [ 0 ]
* Beacon is not transmitted in U-APSD test
* Max SP Length = [ 4 ]
* ProbeDelay = 100µs

A STA that is changing from Doze to Awake in order to transmit shall perform CCA until a frame sequence is detected by which it can correctly set its NAV, or until a period of time equal to the ProbeDelay has transpired. If no valid NAV has been set during the period of ProbeDelay, the STA shall perform the Basic Access procedure as defined in 9.3.4.2 (Basic access) immediately after ProbeDelay’s transpiration.

Output:

* MAC throughput
* Table (breakdown) of percentage of time spent in each power state during the course of the simulation

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | STA (%) | | | | AP (%) | | | |
|  | Listen | RX | TX | Shallow Sleep | Listen | RX | TX | Shallow Sleep |
| < Power Save Mechanism > On |  |  |  |  |  |  |  |  |
| < Power Save Mechanism > Off |  |  |  |  |  |  |  |  |

* Pie chart (breakdown) of energy consumed in each power state during the course of the simulation

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | STA (Watt) | | | | AP (Watt) | | | |
|  | Listen | RX | TX | Shallow Sleep | Listen | RX | TX | Shallow Sleep |
| < Power Save Mechanism > On |  |  |  |  |  |  |  |  |
| < Power Save Mechanism > Off |  |  |  |  |  |  |  |  |

**Calibration results**

The initial calibration report is provided in contribution 14/1192r6

# Annex 1 - Reference traffic profiles per scenario

**Reference traffic profile for Scenario 1**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Traffic Model #** | **Traffic model name** | **Description** | **Application traffic**  **(Forward / Backward)** | **Application Load (Mbps)**  **(Forward / Backward)** | **A-MPDU Size (B)**  **(Forward / Backward)** | **Baseline Power Save Mechansim** |
| T1 | Local file transfer | FTP/TCP transfer of large file within local network | FTP file transfer  / FTP TCP ACK | Full buffer /  0.1 | Max A-MPDU / 64 |  |
| T2 | Lightly compressed video |  |  |  |  |  |
| T3 | Internet streaming video/audio |  |  |  |  |  |
| T4 | 4k video streaming |  |  |  |  |  |
| T5 | Online game server | Moderate UDP traffic load with short large bursts periodically during game synchronization | UDP packets | 2.4Mbps |  |  |
| T6 | Management: Beacon |  |  |  |  |  |
| T7 | Management: Probe requests |  |  |  |  |  |
| T8 | Gaming | Small UDP traffic load with short large bursts periodically during game synchronization | UDP packets | 54 Kbps |  |  |
| T9 | VoIP |  |  |  |  |  |

**Reference traffic profile for Scenario 2**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Traffic Model #** | **Traffic model name** | **Description** | **Application traffic**  **(Forward / Backward)** | **Application Load (Mbps)**  **(Forward / Backward)** | **A-MPDU Size (B)**  **(Forward / Backward)** | **Baseline Power Save Mechansim** |
| T1 | Local file transfer | FTP/TCP transfer of large file within local network | FTP file transfer  / FTP TCP ACK | Full buffer /  0.1 | Max A-MPDU / 64 |  |
| T2 | Lightly compressed video |  |  |  |  |  |
| T3 | Internet streaming video/audio |  |  |  |  |  |
| T4 | 4k video streaming |  |  |  |  |  |
| T5 | Online game server | Moderate UDP traffic load with short large bursts periodically during game synchronization | UDP packets | 2.4Mbps |  |  |
| T6 | Management: Beacon |  |  |  |  |  |
| T7 | Management: Probe requests |  |  |  |  |  |
| T8 | Virtual desktop infrastructure | Small UDP traffic load with short large bursts periodically during game synchronization | UDP packets | 54 Kbps |  |  |
| T9 | VoIP |  |  |  |  |  |

**Reference traffic profile for Scenario 3**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Traffic Model #** | **Traffic model name** | **Description** | **Application traffic**  **(Forward / Backward)** | **Application Load (Mbps)**  **(Forward / Backward)** | **A-MPDU Size (B)**  **(Forward / Backward)** | **Baseline Power Save Mechansim** |
| T1 | Local file transfer | FTP/TCP transfer of large file within local network | FTP file transfer  / FTP TCP ACK | Full buffer /  0.1 | Max A-MPDU / 64 |  |
| T2 | Lightly compressed video |  |  |  |  |  |
| T3 | Internet streaming video/audio |  |  |  |  |  |
| T4 | 4k video streaming |  |  |  |  |  |
| T5 | Online game server | Moderate UDP traffic load with short large bursts periodically during game synchronization | UDP packets | 2.4Mbps |  |  |
| T6 | Management: Beacon |  |  |  |  |  |
| T7 | Management: Probe requests |  |  |  |  |  |
| T8 | Multicast Video Streaming | UDP/IP transfer of compressed video streaming | UDP packet transfer/Nothing | 3-6Mbps/Nothing |  |  |
| T8 | Gaming | Small UDP traffic load with short large bursts periodically during game synchronization | UDP packets | 54 Kbps |  |  |
| T9 | VoIP |  |  |  |  |  |

**Reference traffic profile for Scenario 4**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Traffic Model #** | **Traffic model name** | **Description** | **Application traffic**  **(Forward / Backward)** | **Application Load (Mbps)**  **(Forward / Backward)** | **A-MPDU Size (B)**  **(Forward / Backward)** | **Baseline Power Save Mechansim** |
| T1 | Local file transfer | FTP/TCP transfer of large file within local network | FTP file transfer  / FTP TCP ACK | Full buffer /  0.1 | Max A-MPDU / 64 |  |
| T2 | Lightly compressed video |  |  |  |  |  |
| T3 | Internet streaming video/audio |  |  |  |  |  |
| T4 | 4k video streaming |  |  |  |  |  |
| T5 | Online game server | Moderate UDP traffic load with short large bursts periodically during game synchronization | UDP packets | 2.4Mbps |  |  |
| T6 | Management: Beacon |  |  |  |  |  |
| T7 | Management: Probe requests |  |  |  |  |  |
| T8 | Gaming | Small UDP traffic load with short large bursts periodically during game synchronization | UDP packets | 54 Kbps |  |  |
| T9 | VoIP |  |  |  |  |  |

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# Annex 3 - Templates

|  |  |  |
| --- | --- | --- |
| **Parameter** | | **Value** |
|  | | |
| **Topology** | | |
| Figures | | |
| Environment description |  | |
| APs location |  | |
| AP Type |  | |
| STAs location |  | |
| Number of STA and STAs type |  | |
| Channel Model |  | |
| Penetration Losses |  | |
|  | | |
| **PHY parameters** | | |
| Center frequency and BW |  | |
| MCS |  | |
| GI |  | |
| Data Preamble: |  | |
| STA TX power |  | |
| AP TX Power |  | |
| AP #of TX antennas |  | |
| AP #of RX antennas |  | |
| STA #of TX antennas |  | |
| STA #of RX antennas |  | |
|  | | |
| **MAC parameters** | | |
| Access protocol parameters |  | |
| Primary channels |  | |
| Aggregation |  | |
| Max # of retries |  | |
| RTS/CTS Threshold |  | |
| Association |  | |

**Traffic model**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Traffic model (Per each apartment) - TBD** | | | | | |
| **#** | **Source/Sink** | **Name** | **Traffic definition** | **Flow specific parameters** | **AC** |
| **Downlink** | | | | | |
| D1 | AP/STA1 | 4k Video | T1 |  | VI |
| D2 | AP/STA2 | Local file transfer | T3 |  | BE |
| D3 | AP/STA3 | … |  |  |  |
| … | … |  |  |  |  |
| DN | AP/STAN |  |  |  |  |
| **Uplink** | | | | | |
| U1 | STA1/AP |  |  |  |  |
| U2 | STA2/AP |  |  |  |  |
| U3 | STA3/AP |  |  |  |  |
| … | … |  |  |  |  |
| UN | STAN/AP |  |  |  |  |
| **P2P** | | | | | |
| P1 | STA1/AP |  |  |  |  |
| P2 | STA2/AP |  |  |  |  |
| P3 | STA3/AP |  |  |  |  |
| … | … |  |  |  |  |
| PN | STAN/AP |  |  |  |  |
| **Idle Management** | | | | | |
| M1 | AP1 | Beacon | TX |  |  |
| M2 | STA2 | Probe Req. | TY |  |  |
| M3 | STA3 |  |  |  |  |
| … | … |  |  |  |  |
| MN | STAN |  |  |  |  |

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