IEEE P802.11  
Wireless LANs

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| HEW SG Evaluation Methodology | | | | |
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**ABSTRACT**

This document describes the evaluation methodology for HEW SG to develop the scope of the High Efficiency WLAN project and for performance comparisons in TG.

# Contributors

This will grow to reflect those providing explicit contributions / review comments of this document.

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# Revision History

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| --- | --- | --- |
| **Revision** | **Comments** | **Date** |
| *R0* | Initial draft |  |

# Introduction

The evaluation methodology defines PHY performance and a limited set of simulation scenarios.

# PHY Performance

## PHY channel model

Channel models defined in 802.11n channel model document [2] shall be used. Some modifications to 802.11n channel model are described in [3].

For outdoor, outdoor-to-indoor, indoor-to-outdoor usage scenarios, channel models defined in [11] shall be used.

## PHY impairments

PHY impairments are updated from ones desribed in 802.11n comparison criteria document [1].

***Note: Some of the PHY impairments may need to be reviewed.***

Table 1. PHY impairments

|  |  |  |  |
| --- | --- | --- | --- |
| **Number** | **Name** | **Definition** | **Comments** |
| IM1 | PA non-linearity | Simulation should be run at an oversampling rate of at least 2x.  To perform convolution of the 2x oversampled transmit waveform with the channel, the channel may be resampled by rounding each channel tap time value to the nearest integer multiple of a sample interval of the oversampled transmit waveform.  Use RAPP power amplifier model as specified in document 00/294 with p = 3. Calculate backoff as the output power backoff from full saturation:  PA Backoff = ­10 log10(Average TX Power/Psat).  Total maximum TX power shall be limited to no more than   * Outdoor AP: 30 dBm * Indoor AP: 17 dBm * Non-AP STA for indoor and outdoor: 17 dBm.   Disclose: (a) EIRP and how it was calculated, (b) PA Backoff, and (c) Psat per PA.  Note: the intent of this IM is to allow different proposals to choose different output power operating points.  Note: the value Psat = 25dBm is recommended.  Note: Average TX Power is referenced to Psat. | Added comments for higher sampling rate for channel |
| IM2 | Carrier frequency offset | Single-user simulations for all comparisons except Offset Compensation shall be run using a fixed carrier frequency offset of –13.675 ppm at the receiver, relative to the transmitter. The symbol clock shall have the same relative offset as the carrier frequency offset. Simulations shall include timing acquisition on a per-packet basis.  Downlink multi-user simulations for all comparisons except offset compensation shall be run using a fixed carrier frequency offset selected from the array [*N(1) ,N(2),……,N(16)* ], relative to the transmitter, where *N(j)* corresponds to the frequency offset of the *j*-th client and is randomly chosen from [-20,20] ppm with a uniform distribution.  Uplink multi-user simulations for all comparisons except offset compensation shall be run using a fixed carrier frequency offset selected from the array [*N(1) ,N(2),……,N(16)* ], relative to the receiver, where *N(j)* corresponds to the frequency offset of the *j*-th client and is randomly chosen from [-2,2] KHz with a uniform distribution. | Added a set of possible offsets to be used for several STAs. 802.11n specified a single offset of -13.67 ppm |
| IM3 | Phase noise | The phase noise will be specified with a pole-zero model.    PSD(0) = -100 dBc/Hz  pole frequency *fp* = 250 kHz  zero frequency *fz* = 7905.7 kHz  Note, this model results in PSD(infinity) = -130 dBc/Hz  Note, this impairment is modeled at both transmitter and receiver. | Unchanged from 802.11n |
| IM4 | Noise figure | Input referred total noise figure from antenna to output of the A/D will be 10dB. | Unchanged from 802.11n |
| IM5 | Antenna Configuration | The TGn antenna configuration at both ends of the radio link shall be a uniform linear array of isotropic antennas with separation of one-half wavelength, with an antenna coupling coefficient of zero.  The TGac antennas can be assumed to either be all vertically polarized or a mix of vertical and horizontal polarizations or dual polarization at ±45 degree, as specified in the TGac channel model addendum document [11] | Mix of vertically and horizontally polarized antennas or dual polarization at ±45 degree is also considered for TGac devices |
| IM6 | Fluoroscent Light Effects | The fluoroscent light effects specifed in the TGn Channel model shall not be considered for the simulation scenarios. |  |
| IM7 | Timing | Uplink Multi-user simulations shall be run using a fixed timing offset selected from the array [*N(1) ,N(2),……,N(16*) ], where *N(j)* corresponds to the time offset of the *j*-th client transmission with respect to a common time reference and is randomly chosen from [-100,100] ns  with a uniform distribution |  |

## PHY link level simulation (placeholder)

## Comparison criteria (placeholder)

# Traffic Models

***Note: Most of the traffic models are from TGad evaluation methodology document [11-09/0296r16].***

1. **Lightly compressed video [8]**
   1. Parameters
      1. Slice inter-arrival time (IAT) = 1/4080 seconds
      2. µ = 15.798 Kbytes
      3. σ = 1.350 Kbytes
      4. b = 515 Mbps
   2. Algorithm for each video source – Input: target bit rate in Mbps (p); Output: slice size in Kbytes (L)
      1. At each IAT, generate a slice size L with the following distribution: Normal(µ\*(p/b), σ\*(p/b))
         1. If L > 92.160 Kbytes, set L = 92.160 Kbytes
2. **Internet streaming video/audio (e.g. Youtube)**
   1. Internet video/audio streaming model [10]



* 1. Parameters
     1. Protocol: TCP
     2. Encoding rate (RE) = TBD (e.g. 2-2.9 Mbps[9])
     3. Average rate during steady state (R) = RE × accumulation ratio (e.g. 1.25)
     4. Buffering phase parameters
        1. Buffering time (TB) = TBD
     5. Steady state phase parameters
        1. Block size (B) = TBD
        2. Cycle duration (TC) = Block size (B)/Average rate during steady state (R)
  2. Algorithm: After each video streaming session the new requests for videos are generated by the user (mean of TBD seconds, exponential distribution)

1. **Local file transfer [8]**
   1. protocol: TCP (Reno)
   2. offered load: infinite
   3. MSDU sizes: 64 bytes for TCP connection establishment (3-way handshake) and 1500 bytes for payload data.
   4. Algorithm: at the start of simulation, generate a TCP connection establishment with the following TCP parameter configuration (as appropriate for the simulation platform):

|  |  |
| --- | --- |
| **TCP Model Parameters** | |
| MSS | Ethernet (1500) |
| Receive Buffer (bytes) | 65535 |
| Receive Buffer Adjustment | None |
| Delayed ACK Mechanism | Segment/Clock based |
| Maximum ACK Delay (sec) | 0.05 |
| Slow-Start Initial Count (MSS) | 1 |
| Fast Retransmit | Enabled |
| Duplicate ACK Threshold | 3 |
| Fast Recovery | Reno |
| Window Scaling | Enabled |
| Selective ACK (SACK) | Disabled |
| ECN Capability | Disabled |
| Segment Send Threshold | Byte Boundary |
| Active Connection Threshold | Unlimited |
| Karn's Algorithm | Enabled |
| Nagle Algorithm | Disabled |
| Initial Sequence Number | Auto Complete |
| Initial RTO (sec) | 3.0 |
| Min RTO (sec) | 1.0 |
| Max RTO (sec) | 64.0 |
| RTT Gain | 0.125 |
| Deviation gain | 0.25 |
| RTT Deviation Coefficient | 4.0 |
| Timer Granularity | 0.5 |

1. **Web browsing [8]**
   1. Protocol: HTTP (version 1.0 or above)
   2. MSDU sizes: 350 bytes for HTTP requests and 1500 bytes for payload data
   3. Algorithm: After each reading time the new requests for pages are generated by the user (mean of 31 seconds), generate a HTTP request with the following parameters enlisted below. The parsing time is the time taken by the HTTP page to fill in all subpage requests which appear from the master page. After going through few of the subpages the user quits the session which is indicated by the last packet of the session. This is shown in the following figure.

Reading Time

First Packet of Session

Last Packet of Session

Reading Time

Parsing Time

|  |  |  |  |
| --- | --- | --- | --- |
| **Component** | **Distribution** | **Parameters** | **PDF** |
| Main  object  size (SM) | Truncated Lognormal | Mean = 10710 bytes  SD = 25032 bytes  Min = 100 bytes  Max = 2 Mbytes (before truncation) | if x>max or x<min, discard and generate a new value for x |
| Embedded object size (SE) | Truncated Lognormal | Mean = 7758 bytes  SD = 126168 bytes  Min = 50 bytes  Max = 2 Mbytes (before truncation) | f x>max or x<min, discard and generate a new value for x |
| Number of embedded objects per page (Nd) | Truncated Pareto | Mean = 5.64  Max. = 53 (before truncation) | Subtract k from the generated random value to obtain Nd  if x>max, discard and regenerate a new value for x |
| Reading time (Dpc) | Exponential | Mean = 30 sec | λ = 0.033 |
| Parsing time (Tp) | Exponential | Mean = 0.13 sec |  |

1. **Hard disk file transfer [8]**
   1. Transaction Model
      1. A transaction consists of a READ request from host to drive for a specific block of data
      2. Followed by the data transfer from drive to host



* 1. Algorithm
     1. Compute sequence of inter-arrival times
     2. Compute corresponding sequence of transaction data sizes
  2. Parameters
     1. READ request is a short (256B) packet sent from host to drive
     2. fixed 1ms delay between receipt of READ request and data offered
     3. Compute sequence of inter-arrival times of transaction requests with following discrete random variable distribution



* + 1. Compute corresponding sequence of transaction data sizes with following discrete random variable distribution



# System Evaluation

Simulation scenarios for system evaluation are summarized as:

Table 2. Simulation scenarios

|  |  |  |
| --- | --- | --- |
| Scenario  Number | Purpose | Note |
| 1 | Wireless office |  |
| 2 | Residential/apartment building |  |
| 3 | Hotspot (outdoor and indoor) |  |
| 4 | Stadium (outdoor and indoor) |  |

## AP and STA configuration

### Configurations

1. AP STA
   1. Number of antennas: 2-4 (TBR)
   2. Indoor maximum Tx power: 17dBm
   3. Outdoor maximum Tx power: 30 dBm
2. Non-AP STA
   1. Small form factor STAs (i.e. smartphone or tablet)
      1. Number of antennas: 1-2 (TBR)
   2. Larger form factor STAs (i.e. laptop or display or HDD)
      1. Number of antennas: 2-4 (TBR)
   3. Maximum Tx power: 17dBm

## Wireless office scenario

### Single BSS scenario

1. Office floor configuration (see Figure 1)
   1. 64 cubicles
   2. Each cubicle has 4 STAs
      1. Placed randomly in a cubicle (x,y,z=1)
      2. STA1: laptop
      3. STA2: monitor
      4. STA3: smartphone or tablet
      5. STA4: Hard disk
      6. Keyboard/mouse (TBR)
   3. AP is located at the center of the office
      1. Installed on the ceiling at (x=10,y=10,z=3)
2. Traffic
   1. Traffic from STA1 to STA2:
      1. Lightly compressed video
   2. Traffic between STA1 and AP:
      1. Web browsing, Local file transter
   3. Traffic between STA3 and AP:
      1. Web browsing, Local file transter
   4. Traffic between STA1 and STA4
      1. Hard disk file transfer
3. PHY Channel for each link
   1. TGn channel model D



Figure 1 Illustration of a cubile office configuration



Figure 2 Illustration of an office floor layout (each square represents a cubicle office shown in Figure 1).

### Multiple BSS scenario

1. Office floor configuration
   1. Eight BSSs (see Figure 3)
   2. Each BSS has the same configuration as described in the single BSS scenario (see Figure 2).
2. Frequency reuse
   1. Single management domain
      1. Four 80 MHz channels (Ch1, Ch2, Ch3, Ch4)
         1. Ch1: BSS1, BSS5
         2. Ch2: BSS2, BSS6
         3. Ch3: BSS3, BSS7
         4. Ch4: BSS4, BSS8
   2. Multiple management domain
      1. Random channel selection



Figure 3 Illustration of a large office floor with multiple BSSs (each BSS has the configuration shown in Figure 2)

## Residential/apartment building scenario

### Single apartment configuration

1. Apartment size and STAs configuration
   1. Size: 10 m x 10 m
   2. An apartment has 5 STAs and 1 AP
      1. STAs and AP are placed in the apartment randomly (x,y,z=1)
      2. STA1 and STA2: laptop
         1. Maximum TX power: 17 dBm
      3. STA3 and STA4: smartphone or tablet
         1. Maximum TX power: 17 dBm
      4. STA5: display
         1. Maximum TX power: 17 dBm
      5. AP
         1. Maximum TX power: 17 dBm
2. Traffic
   1. Traffic from STA1 to STA5 (local video streaming):
      1. Lightly compressed video
   2. Traffic between STA2 and AP:
      1. Local file transfer, Web browsing
   3. Traffic between STA3 and AP:
      1. Internet streaming video/audio
   4. Traffic between STA4 and AP:
      1. Local file transfer, Web browsing
3. PHY channel for each link
   1. TGn channel model B
   2. Floor attenuation TBD



Figure 4 Illustration of an apartment configuration

### Apartment building scenario

1. Building configuration
   1. n x m x 2 apartments (n and m are TBD)
   2. Each apartment has the configuration shown in 4.2.1.
2. Frequency reuse
   1. Each apartment selects an operation channel randomly
      1. Four 80 MHz channels



Figure 5 Illustration of an apartment building

## Hotspot scenario

### Single hotspot configuration

1. Single cell configuration
   1. Cell radius: R meters
   2. Inter-cell distance (ICD): 2\*h meters
      1. h=sqrt(R2-R2/4)
   3. 30 STAs are placed randomly in a cell (x,y,z=1) meters.
      1. STA configuration
         1. Maximum TX power: 17 dBm
   4. AP is placed at the center of the cell.
      1. Outdoor:
         1. Location (x,y,z) = (0,0,10) meters
            1. The height of the AP is based on the urban micro-cell model defined in [ITU-R M.2135]
         2. TX power:
            1. Typical hotspot (i.e. ICD = 100-200 m) case

Maximum TX power = 30 dBm

* + - * 1. Dense hotspot (i.e. ICD=15-30m):

Maximum TX power = 17dBm

* + 1. Indoor:
       1. Location (x,y,z) = (0,0,4(?)) meters
          1. AP on the ceiling
       2. TX power:
          1. Typical hotspot (i.e. ICD = 100-200 m) case

Maximum TX power = 30 dBm

* + - * 1. Dense hotspot (i.e. ICD=15-30m):

Maximum TX power = 17dBm

1. Traffic
   1. Traffic between X% of STAs and AP
      1. Local file transfer, Web browsing
   2. Traffic between AP and Y % of STAs
      1. Internet streaming video/audio
   3. Traffic between Z% of STAs
      1. Local file transfer (social media)



Figure 6 Illustration of a single cell configuration

### Outdoor hotspot scenario

1. Cell layout configuration
   1. Planned deployment:
      1. 19 cells arranged as shown in Figure 7.
   2. Unplanned deployment:
      1. Place TBD cells randomly in TBD m2 area.
   3. Each cell has the configuration shown in 4.3.1 (single cell configuration) and Figure 6.
   4. Inter-cell distance (ICD) [11-13/486r0]
      1. Typical hotspot deployment: 100-200 meters
      2. Dense hotspot deployment: 15-30 meters
2. Frequency reuse
   1. Frequency reuse 4 (four 80 MHz channel bandwidth)
   2. Frequency reuse 9 (nine 40 MHz channel bandwidth)
3. PHY channel
   1. STA – AP:
      1. Winner B1[11]
   2. STA – STA:
      1. Winner B1[11]



Figure 7 Illustration of a cell layout for the outdoor hotspot scenario

### Indoor hotspot scenario

The indoor hotspot scenarios are same as the outdoor scenarios except the placement of the AP and the PHY channel model between STAs and IEEE TGn channel model E is used

## Stadium scenario

### Block configuration

1. Seating layout of a 10m x 10m block
   1. 100 STAs are placed randomly on a mxn grid in the10m x 10m square block as shown in Figure 8.
      1. Location of STA(m,n): (x=.5x(m-1)+.75, y=1.5x(n-1)+.75,z=0.5)
   2. A block has one AP
   3. STA configuration
      1. Smartphone or tablet
      2. Maximum TX power: 17 dBm
   4. AP configuration
      1. Maximum TX power: 17dBm
2. Traffic
   1. Traffic between X% of STAs and AP
      1. Local file transfer, Web browsing
   2. Traffic between AP and Y % of STAs
      1. Internet streaming video/audio
   3. Traffic between Z% of STAs
      1. Local file transfer (social media)



Figure 8 Seating layout of a block (10m x 10m) for the stadium scenario

### Outdoor stadium scenario

1. pxq block layout and AP placement of the outdoor stadium scenario
2. The stadium scenario consists of mxn blocks as shown in Figure 9.
3. Block (p, q) indicates a block at p-th column and q-th row.
4. Each block has the configuration shown in Figure 8.
5. AP placement in a block(p,q)
6. If m is an odd number, an AP is placed at (x=10p-5, y=10q-5, z=3(?)) meters
7. If m is an even number, an AP is placed at (x=10p-5, y=10(q-1), z=3(?)) meters
8. Frequency reuse
9. Frequency reuse 4 (four 80 MHz channel bandwidth)
10. Frequency reuse 9 (nine 40 MHz channel bandwidth)
11. PHY channel
12. Winner B1[11]



Figure 9 Illustration of the stadium scenario with pxq blocks

### Indoor stadium scenario

The indoor stadium scenario is same as the outdoor stadium scenario except the PHY channel model between STAs.

1. PHY channel: IEEE TGn channel model F

## Comparison criteria (placeholder)

# References

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