MMP Tool for Capacity & Gain Analysis

IEEE P802.3bn EPoC PHY Task Force

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MMP Ad Hoc

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MMP Tool – Motivation & Scope

- Primary Motivation: provide a common tool to the TF for analyzing the gain from Multiple Modulation Profiles (MMP)
- Include comprehensive set of known factors that impact MMP:
  - OFDM parameters: e.g. channel width, modulations, FEC, CP
  - Profile Traffic distribution, including Multicast/Broadcast
  - Shortened Last Codeword
  - Micro-reflections
- Continue to update tool as TF learns more

- What this presentation does NOT try to do:
  - Provide a suggestion or recommendation for inputs
    - Example provided is meant *to illustrate tool capabilities* and provoke additional group discussion on input requirements for MMP evaluation

MMP Tool Input – OFDM Parameters

- Channel Width
  - I.e. 24-192MHz less overhead (e.g. 7MHz for pilots, guard bands, etc.)
- Modulation per Profile
  - Average bit loading per profile: e.g. 8 bits (256-QAM) to 12 bits (4K-QAM)
    - If profile carries a mix, then use average: e.g. 10.5 for 1K- & 2K-QAM
- FEC Overhead
  - FEC Rate per profile: e.g. 0.889 for DVB C2 8/9 code
- Cyclic Prefix (CP) Overhead
  - CP across all profiles: e.g. 2.5% for 0.5us CP with 20us symbol time
- Other PHY Overhead
  - Hooks to show additional degradation per profile
    - E.g. micro-reflection impacts, detailed later

MMP Tool Input – Traffic Distribution [revised]

- Profile Traffic Capacity
  - Listed as a weight of total unicast capacity for each profile
  - Unicast traffic is proportionally shared based on profile weight
- Multicast/Broadcast Capacity
  - Listed as either:
    - % of total capacity
    - or Multicast/Broadcast capacity in Mbps
  - Assumed that all Multicast & Broadcast traffic on LCD profile

MMP Tool Input – Shortened Codeword [revised]

- FEC Codeword size
  - E.g. 16,200 bits for DVB C2
- Scheduling Interval
  - Max time to service all profiles: e.g. 160us
- Max Shortened Codewords
  - Worse case # of shortened codewords per scheduling interval
    - Nominally # of active profiles, e.g. 4
  - Gate messages forcing profile changes (see boyd_01a_0113)
    - Input Effective Upstream MAC data rate (0=no impact), Avg Xmit length

- Tool assumes typical overhead is ½ worse case
  - Quick sampling shows it is close to Qualcomm analysis

MMP Tool Example – Initial Inputs

- OFDM parameters
  - 192MHz channel with 7MHz overhead; FEC rate = 0.889; CP = 2.5%
  - Profile A-D Modulations: { 9, 10, 11, 12 }
- Traffic capacity
  - Modem distribution for profiles A-D: { 1%, 10%, 73%, 16%}
    - Taken from newer Dave Urban material (6M MTA)
  - Multicast capacity: 10%
- Shortened Codeword
  - FEC codeword size = 16,200 bits
  - 160us scheduling interval
  - Max 4 shortened codewords per interval

MMP Tool Example – MTA Distribution

1. 512-QAM Profile A (LCD)
   - Base line starting point
2. 1024-QAM Profile A (LCD)
   - E.g. drop or fix 1% modems in 512-QAM bin; bump LCD to 1024-QAM
3. 1024-QAM Profile A (LCD)
   - Remove 3dB margin: {1% 1K-, 10% 2K-, 89% 4K-QAM}
4. 2048-QAM Profile A (LCD)
   - Remove 3dB margin, fix 1%: {11% 2K-, 89% 4K-QAM}

MMP Tool Example – MTA Distribution

Case:	MMP Gain	MMP Capacity	Single Profile Capacity (LCD)
1. 512-QAM LCD	18.0%	1703 Mbps	1443 Mbps
2. 1024-QAM LCD Without 1%	8.3%	1737 Mbps	1603 Mbps
3. 1024-QAM LCD No 3dB Margin	15.6%	1853 Mbps	1603 Mbps
4. 2048-QAM LCD No 3dB, 1%	6.7%	1881 Mbps	1764 Mbps

MMP Gain – Impact of Gates?

- The more I dug, the more I found I could not model gate impact
  - Need a detailed proposal on how gates are handled
  - Interesting issues arise:
    - How does the PHY even identify Gate message?
    - If found, could you deliver Gate over LCD to prevent shortened code?
- How often might we see Gate messages?
  - Frequency of Gates a function of upstream bandwidth, burst length
  - 1Gbps upstream with 1KB bursts means 5 gates per 40us interval
  - 25% to 60% might be in existing DS profile; 40% to 75% outside profile
  - 400Mbps upstream: 2 gates per 40us for 1KB bursts
    - Reasonable bandwidth assuming 42-85MHz
    - Symmetric service when paired with 48MHz downstream
    - [comment from Ed on call: impact may NOT be linear; you may have frequent polling intervals for low latency, increasing gate frequency.]

MMP Tool Example Cases

1. 512-QAM Profile A (LCD), 160us Schedule Interval
   - Base line starting point
2. 512-QAM Profile A (LCD), 80us Schedule Interval
   - Reduce Schedule Interval from 160us to 80us
3. 512-QAM Profile A (LCD), 40us Schedule Interval
   - Reduce Schedule Interval down to 40us
4. 512-QAM Profile A (LCD), 48MHz, 160us
   - Reduce bandwidth from 192MHz down to 48MHz
5. 512-QAM Profile A (LCD), 48MHz, 80us
   - Reduce Schedule Interval from 160us to 80us
6. 512-QAM Profile A (LCD), 48MHz, 40us
   - Reduce Schedule Interval down to 40us

MMP Tool Example – Shortened Code Impact

Case:	MMP Gain	MMP Capacity	Single Profile Capacity (LCD)
1. 512-QAM LCD 160us interval	18.0%	1703 Mbps	1443 Mbps
2. 512-QAM LCD 80us interval	16.7%	1684 Mbps	1443 Mbps
3. 512-QAM LCD 40us interval	14.1%	1647 Mbps	1443 Mbps
4. 512-QAM LCD 48MHz, 160us	13.5%	363 Mbps	320 Mbps
5. 512-QAM LCD 48MHz, 80us	8.1%	346 Mbps	320 Mbps
6. 512-QAM LCD 48MHz, 40us	-1.3%	316 Mbps	320 Mbps

MMP Tool – Summary

- Inputs & results described for a comprehensive tool to analyze the gain from Multiple Modulation Profiles (MMP)
  - Tool is work in progress and will continue to be upgraded as other factors are uncovered
- Example of a single distribution shows that gains can vary significantly based on inputs: e.g. 32.3% => 5.7%
- RF Impairments and other factors may impact profiles unevenly causing MMP gain impact
- Next steps:
  - TF needs to agree on reasonable set of inputs for evaluating MMP gain
  - Leverage channel model work to understand what factors influence profile bit-loading