

MMP Tool for Capacity & Gain Analysis

IEEE P802.3bn EPoC PHY Task Force

John Ulm

julm@motorola.com

Phoenix, AZ

Jan 23-25, 2013

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

- Profile Traffic Capacity
 - Listed as % of total unicast capacity for each profile
- Multicast/Broadcast Capacity
 - Listed as % of total capacity
 - Assumed that all Multicast & Broadcast traffic on LCD profile

MMP Tool Input – Shortened Codeword

- FEC Codeword size
 - E.g. 16,200 bits for DVB C2
- Scheduling Interval
 - Max time to service all profiles: e.g. 150us
- Max Shortened Codewords
 - Worse case # of shortened codewords per scheduling interval
- Tool assumes typical overhead is $\frac{1}{2}$ 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: { 8, 10, 11, 12 }
- Traffic capacity
 - Modem distribution for profiles A-D: { 2.5%, 24.5%, 64%, 9%}
 - Taken from earlier Dave Urban material
 - Note: profile A consisted of 2.4% in 512-QAM & 0.1% in 256-QAM bin
 - Multicast capacity: 0%
- Shortened Codeword
 - FEC codeword size = 16,200 bits
 - 150us scheduling interval
 - Max 4 shortened codewords per interval

MMP Tool Example – Six Cases

1. 256-QAM Profile A (LCD)
 - Base line starting point
2. 512-QAM Profile A (LCD)
 - E.g. drop or fix 0.1% modems in 256-QAM bin; bump LCD to 512-QAM
 - 512-QAM LDPC \approx 256-QAM J.83
3. 1024-QAM Profile A (LCD)
 - “excellent” plant, bump lower 2.5% up to 1024-QAM for new LCD
4. 512-QAM Profile A (LCD) + 15% Multicast
 - Estimate based on 250Mbps IP Video traffic (e.g. 50 HD streams)
5. 512-QAM Profile A (LCD) + 15% Multicast + Micro-reflections
 - Example how impairments might impact MMP gain; details to follow
6. 48MHz wide channel with Case 5 inputs
 - Shows additional impact from shortened codeword

MMP Tool Example – Results

Case:	MMP Gain	MMP Capacity	Single Profile Capacity (LCD)
1. 256-QAM LCD	32.3%	1697 Mbps	1283 Mbps
2. 512-QAM LCD	18.1%	1704 Mbps	1443 Mbps
3. 1K-QAM LCD	6.6%	1709 Mbps	1603 Mbps
4. 512-QAM LCD + 15% Multicast	14.7%	1655 Mbps	1443 Mbps
5. Case 4 + Micro-reflection	10.3%	1591 Mbps	1443 Mbps
6. Case 5 + 48MHz channel	5.7%	355 Mbps	335 Mbps

MMP Tool – More on Micro-reflections

Case:	Micro-reflection	MMP Gain	MMP Capacity	Single Profile Capacity (LCD)
4. 512-QAM LCD + 15% Multicast	>0.5us	14.7%	1655 Mbps	1443 Mbps
5.a. Case 4 + 3us CP (15%)	3us	14.5%	1440 Mbps	1258 Mbps
5.b. Case 4 + 0.5us CP (2.5%)	3us	10.3%	1591 Mbps	1443 Mbps

- Add 3us micro-reflection impairment to plant
 - Conventional Wisdom: use 3us CP, take ~15% hit across all profiles
 - Alternate approach to achieve higher capacities: use 0.5us CP
 - Cancels part of micro-reflection; remainder adds to ISI SNR
 - ISI SNR impact is greater on higher modulation orders (e.g. 5% loss per 6dB)
 - Observation: MMP capacity with 3us CP \approx SMP capacity with 0.5us CP

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