COMMENTS ON CHANNEL MODELS

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DRAFT OBJECTIVE ON OPERATING MODEL

- **Approved draft objective: "Define required plant configurations and conditions within an overall coaxial network operating model."**
- **The Task Force (TF) will be obligated to satisfy this objective**
- **Also known as a "Channel Model"**
- **Why is a channel model needed?**
  - Simulation is much easier and broader reaching than actual testing
  - Access to live cable plant is revealing, however:
    - Logistically difficult
    - Not representative of all systems or considerations
      - Can evaluate that plant "today" but not "tomorrow"
    - Requires complete system to put under test
    - Allows cable operators to evaluate existing plant for suitability

COMMENTS ON CHANNEL MODEL

- **What comprises a Channel Model?**
  - Collection of information and characteristics about actual coaxial distribution networks
    - Can be organized as text, lists, tables, parameter sets, etc.
    - As an example of structure, see SCTE-40
      - Informational reference: *www.scte.org/documents/pdf/standards/SCTE_40_2011.pdf*
      - NOTE: EPoC TF will decide on content
  - Can be supplemented with guidelines defining interrelationship of elements in the model process rules: e.g., block or flow diagrams
    - These are very useful
    - Defines signal and noise paths
    - Provides element sequencing: parallelism, concatenation, etc.

USES

- **Uses for a Channel Model?**
  - Facilitates repeatable (confirmable) simulations for evaluation purposes
    - Operates in conjunction with performance goals: information rate, error rates, etc.
    - Essential for evaluation of modulation and error correction selection
    - Example evaluation process:
      1. Select a set of parameter values for one or more scenarios from the Channel Model
         - Characterized by a specific impulse response and specific parameter values for the parameters comprising the channel model
      2. Simulate the Tx and Rx for each scenario
      3. Evaluate results as compared to performance goals and objectives
         - Information rate, error rate, traffic mix, etc.
      4. Determine if additional scenarios are needed, repeat as necessary
    - Performance in the scenarios are evaluated, not the Channel Model itself
  - Permits cable operators to evaluate/test cable plant
    - Ties back to real world

THREE TIERS TO A CHANNEL MODEL

- **802.3 EPoC is unique among many technology standards in that the majority of coaxial cable networks are owned and managed by a small number of operators**
- **For success of the standard, it is essential for operators to "buy in" to the adopted channel model**
- **The most efficient approach would be for operators to contribute Channel Model information, segregated into three tiers, that is representative of their needs:**
  - Tier 1: Parameters and impairments
  - Tier 2: Different gradations of fidelity and impairments. For example, different ranges of parameter values and impairment levels:
    - Typical versus minimum/maximum
    - High SNR and low amplitude variation versus lower SNR and more amplitude variation
    - Etc.
  - Tier 3: For each gradation, one or more scenarios is defined for evaluation purposes

WHAT GOES IN TO CREATING A CHANNEL MODEL?

- **Sources of Channel Model information include:**
  - Manufacturing industry contributes component information
  - Cable Industry contributes engineering and environment models
    - Configuration and use of components
    - Technical details on impairments
    - Include any regional differences (North America, Chinese, European, etc.)
  - Frameworks from the past: e.g. 802.14 archives, SPIE, etc. (for Tier 1)
- **Cable operators will have to indicate that the model is "sufficiently representative" of their (private) target cable networks**
- **TF consensus will approve**
  - Made available to all TF members, maintained, updated, etc.
  - Make the Scenarios the "common meeting ground" for all evaluations

WHEN DO WE NEED A CHANNEL MODEL?

- **Prior to making "key" PHY technology selections**
  - Reviewing performance from simulations is key part of evaluation process
  - Different folks should get the same answer when evaluating a contribution
  - Aids in deciding options, for example:
    - frequencies,
    - channel sizes,
    - capacities,
    - modulation types,
    - error correction options,
    - etc.

ELEMENTS OF A CHANNEL MODEL

FACTORS INFLUENCING A CHANNEL MODEL AND EVALUATIONS

- **Frequency and Service Plan**
  - Pass bands, channel plans, other services, channel assumptions
- **Coaxial Plant Information**
  - Topologies, all equipment in signal path, signal level management, CNR/SNR, etc.
  - Essentially an engineering plan of a portion of a sample network
- **Impairments**
  - Noise and distortion sources, environmental changes, etc.
- **Block Diagram**
  - Avoids ambiguities on where things are in simulation process path
- **System Service Requirements**
  - Customer distribution, services, capacities, delay, delay variation, error rate, etc.

FREQUENCY AND SERVICE PLAN

- **Cable Network frequency and pass band configuration**
  - Downstream
  - Upstream
  - Active
  - Passive
- **Other services**
  - Channels, modulation type, power levels
- **EPoC provisioning**
  - Frequency, channel sizes, power levels
  - Contiguous, non-contiguous spectrum allocation
- **Change and evolution friendly?**
  - “Today” select a channel modulation, frequency, bandwidth, etc.
  - “Tomorrow” will require changing spectral occupancy and widening bandwidth.
  - Must study future approaches: ranges in flexibility, channel bonding, etc.

COAXIAL PLANT INFORMATION

- **Topologies**
  - Node + 0 passive, cable operator plant
    - Also, Node + 0 passive, MDU distribution (if different)
  - Node + N active, N = 3, 5, ?
  - Node + 0 passive isolated segment of a Node + N active legacy network
  - Single and multiple branches in the above toplogies
- **Operational**
  - Signal power levels, managed noise floor level(s), reference points
- **All equipment in signal path**
  - Amplifiers, cable, taps, splitters, couplers, filters, diplexers, etc.
  - Actual manufacturers specs or agreed-to equivalents
- **Business versus Residential**
  - Population sizes, how and where customers are connected
- **Regional Differences**
  - Can different regions share the same model or are there differences?
    - For example: North America, China, etc.
    - Not just RF spectrum allocation differences: active and passive equipment characteristics, impairments, power levels, etc.

IMPAIRMENTS

- **Most types of well-known interference**
  - Wideband, narrowband, burst noise
  - Impulse noise
  - Micro-reflections
  - Ingress
  - Hum
  - Phase noise
  - Effects from other services and equipment on same cable
    - CSO
    - CTB
    - CIN
    - Spurious emissions
    - Thermal noise power
  - Attenuation

BLOCK DIAGRAM

- **Example (not a proposal)**

- From: Kolze, T., “Upstream HFC channel modeling and physical layer design”, SPIE 2917 240, June, 1996, http://spiedigitallibrary.org/proceedings/resource/2/psisdg/2917/1/240_1

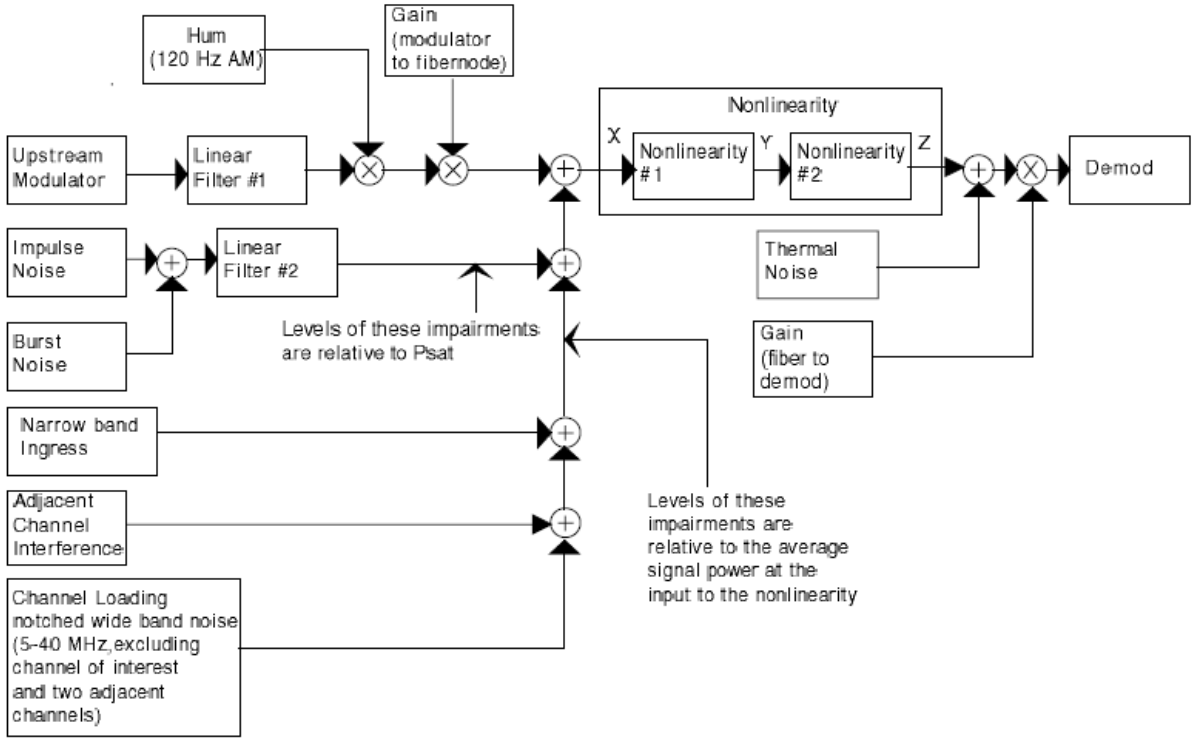

Figure 1. Upstream HFC Impairment Model Block Diagram

SYSTEM SERVICE REQUIREMENTS

- **Customer distribution**
  - Business
  - Residential
- **Types of service**
  - Population sizes
  - Capacities
  - Delay, delay variation
  - Error rate
- **Traffic mix**
  - Lightly loaded and heavily loaded systems, while system is providing required services
  - Suggest a small set of anonymous EPON traffic samples from existing cable operator deployments
  - Why? Error protection versus data burst length considerations, maximum supported data burst size, PHY data framing considerations, etc.

OBSERVATIONS

CHANNEL MODEL OBSERVATIONS

- **Grinding simulations from the "ground up" starting with the engineering / topology plan takes a lot of time and work for each simulation**
  - E.g., too many variables to document, control, agree to each time
  - One approach would be for operators to agree on several baseline topologies for active and passive cable plant and select several representative gradations of parameter sets.
  - For each gradation produce one or more scenarios
    - Everyone uses the same scenarios (vectors) in their simulations
    - Guided by the Channel Model and Block Diagram
- **Typical and "Worst Case"**
  - Often only nominal equipment performance factors are considered
    - Even in a "typical" system, some components will deviate from nominal performance
  - Evaluations should consider "worst case" (e.g. minimum/maximum) equipment performance in some fashion
  - Better assurance of operating under most conditions

CHANNEL MODEL OBSERVATIONS

continued

- **Modeling should focus on cable operator plant and avoid effects of subscriber premises wiring**
  - For high performance objectives identified in the PAR and Objectives, we need a gateway at the service provider subscriber demarcation point
  - No engineering standard “baseline” for subscriber premises wiring
    - Unbounded variability, more so with in-home networking and impairments
  - Significantly adds effort, number, and complication to simulation studies
- **Recommendation: best to proceed assuming CNU Tx and Rx will be isolated from the subscriber environment**
  - Point of Entry “Gateway” model with defined network interface
  - Likely needed for assuring Gb/s performance
  - Likely needed to avoid interfering with existing subscriber “in home” equipment
  - Avoids frequency duplicative use collision problems; e.g. satellite, MOCA, HomePlugAV, etc.
    - Cable operator is in control of their spectrum to the subscriber demarcation point
    - And: “what happens in the home stays in the home”

SUMMARY

- **Having a channel model is fundamentally necessary**
  - It may be more than one scenario, e.g. a limited set of point scenarios representing different configurations
    - E.g. active vs. passive, business vs. residential, NA vs. China, etc.
- **Our cable operator participants must "validate" the model if our standard is to be successful**
- **Considering the complexity of the factors involved in the developing the Channel Model (i.e., pages 9 - 14) it would be appropriate and most efficient for the operators to characterize and validate the Channel Model for the Task Force**
- **Common analysis basis for evaluating aspects of contributions prior to making technical selection**

Thank you

THREE TIER PICTURE VIEW

- **Ideally, cable operators would generate sufficient representative required point scenarios for evaluation and selection**
  - i.e. a required “base set”
- **Evaluation using other scenarios is optional**