Response to the Technical Feasibility CSD

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Supporters

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- Rick Rabinovich — Alcatel Lucent
- Faro Chang — Alpha Networks
- Scott Kipp — Brocade
- Melody Chiang — Accton
- Yong Kim — Broadcom
- Will Bliss — Broadcom
- Bob Wagner — Panduit
- Brad Booth — Chair IEEE Std 802.3an-2006
- Jon Lewis — Dell
- Maurice Lee — Delta Electronics
- Jack Weng — Delta Electronics
- Andreas Dreher — Hirschmann / Belden
- Stephan Kehrer — Hirschmann / Belden
- Likseng Lim — Delta Networks

- Zhuangyan Zhuang — Huawei
- Roy Shiyong Fu — Huawei
- Alon Regev — Ixia
- Jeremy Chiu — Kennixa
- Wei George — Kennixa
- Keith Abercromby — Keysight
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- Hyung-Jin Park — Korea Telecom
- Farid Hamidy — Pulse
- Mingwei Li — Ruijie Networks
- Yongxin Ye — Ruijie Networks
- Weisen Cheng — ZTE
- Dong Woo Kim — Dasan Networks
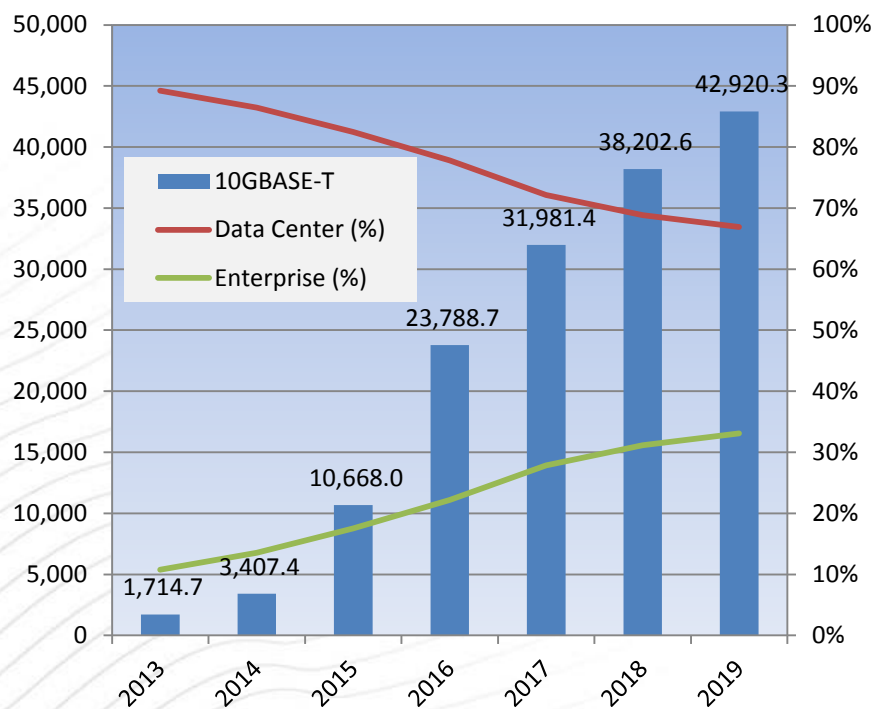- Subong Lee — Ubiquoss

Introduction

- This presentation is given in support of the Technical Feasibility CSD.

- We examine the feasibility of scaling the 10GBASE-T Physical layer to operate at 2.5/5G.

10GBASE-T Market – Significant Growth

- 10GBase-T market doubled in 2014 (from 2013)

- Expected to grow to >40M by 2019

- 1/3 of all ports will be shipped for the enterprise by 2019

10GBase-T Forecast ('000 Ports)

Legend:
- 10GBASE-T
- Data Center (%)
- Enterprise (%)

Data labels: 1,714.7 · 3,407.4 · 10,668.0 · 23,788.7 · 31,981.4 · 38,202.6 · 42,920.3

Years: 2013, 2014, 2015, 2016, 2017, 2018, 2019

Source: Dell'Oro Feb'15

10GBASE-T Standard

- Hockey stick growth in Enterprise & Data Center environments

- 10GBASE-T operates successfully in Enterprise & Data Center environments

- Use and knowledge of 10GBASE-T is widely disseminated:
  - 10GBASE-T standard was approved in June 2006.
  - Three generations in the field: 65nm, 40nm and 28nm.
  - Multi-vendor interoperability well established.

- Due to 10GBASE-T's success, an amendment to IEEE Std 802.3 (802.3bq) is under way for:
  - 25G
  - 40G

- Scaling the 10GBASE-T standard is a fast and sure path to a 2.5/5GBASE-T standard.

10GBASE-T Modulation and Coding

- ## DSQ-128 and (2048,1723) LDPC
  - 10GBASE-T is a performance optimized transmission standard less than 2.5dB from Shannon capacity
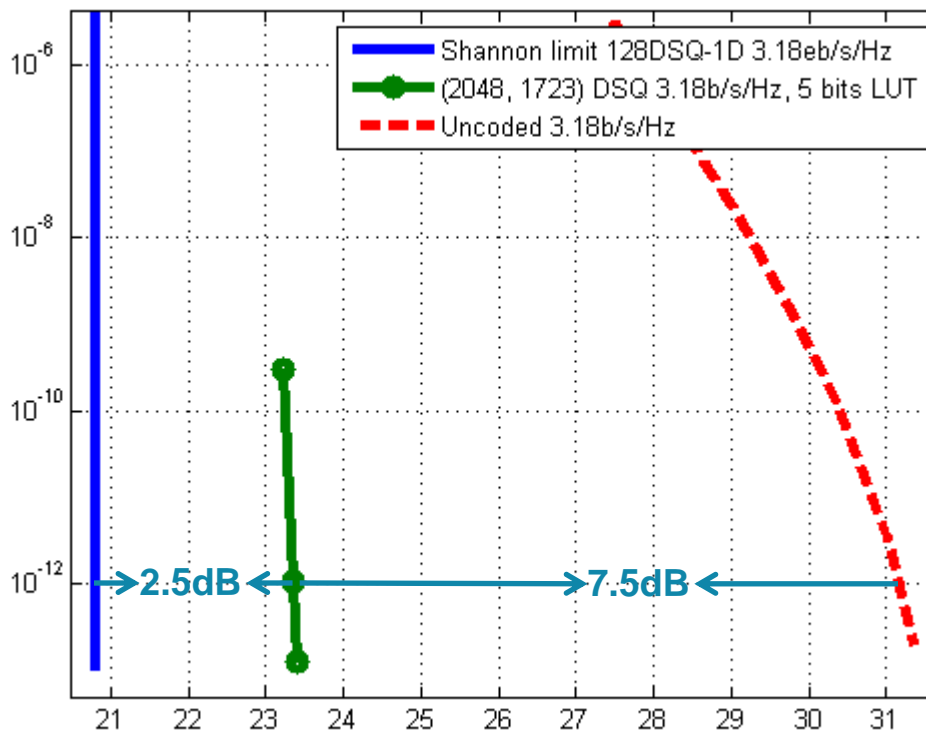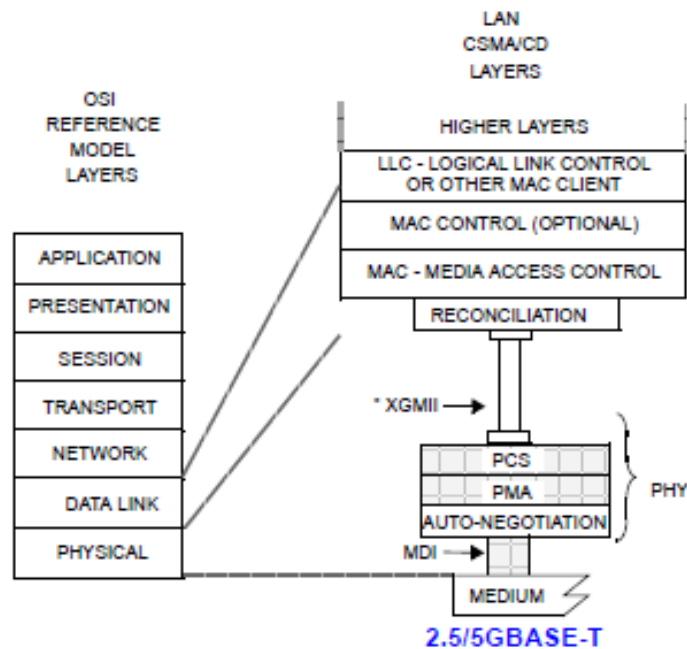
Figure xx-1--Type 2.5/5GBASE-T PHY relationship to the ISO Open Systems Inter-connection (OSI) reference model and the IEEE 802.3 CSMA/CD LAN model
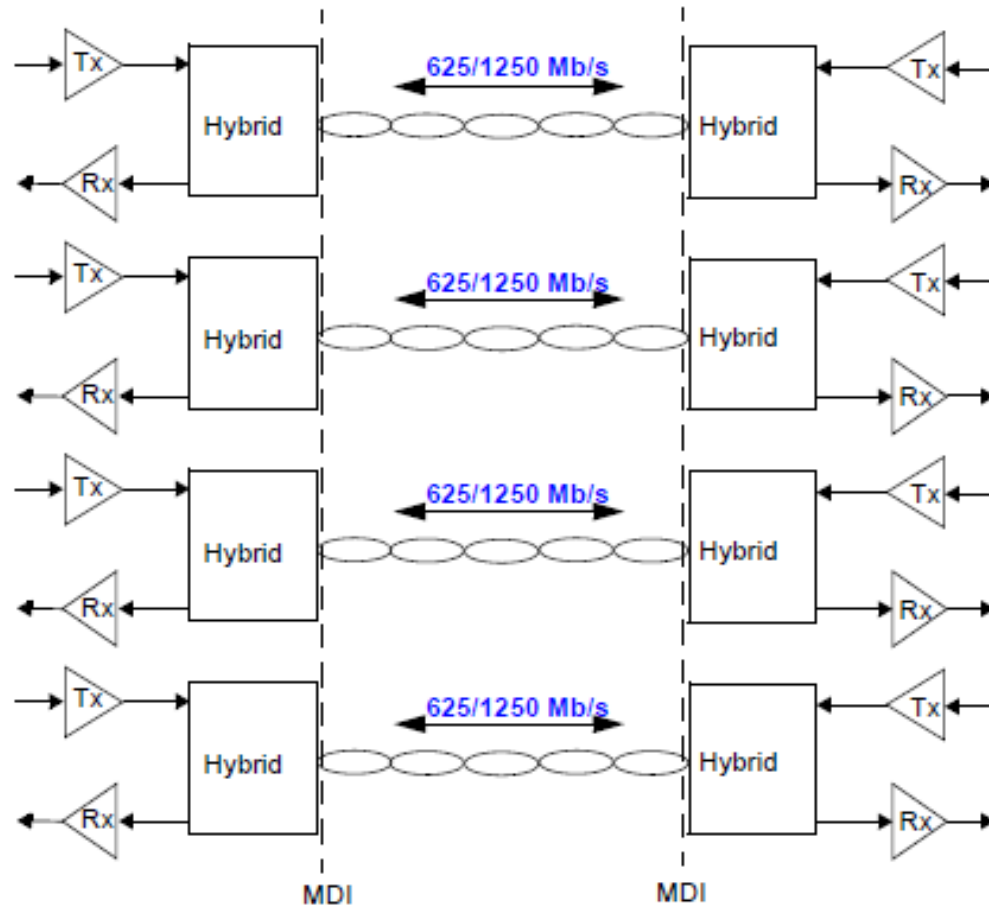
Figure xx-2--2.5/5GBASE-T topology

Potential 2.5/5GBASE-T Technical Approach

- Scale frequencies:
  - ½ for 5G
  - ¼ for 2.5G

- Use industry-wide 10GBASE-T compatible start-up sequence.

- Preserve industry accepted implementation delay.

- Reuse TX specifications with 3dB (5G) and 6dB (2.5G) higher TX-PSD:
  - Additional protection against cross-talk
  - Maintains EMC characteristics

- DSQ-128 signaling on four twisted pairs.
  - 3.125bits per symbol needed for
    - 200MBd for 2.5G
    - 400MBd for 5G
  - 3.5bits per symbol
  - Guarantees sufficient SNR for the timing loop by avoiding false decisions
  - Efficient 12dB constellation partitioning

- Near Shannon capacity (2048/1723) LDPC code

- For 10GBASE-T, this approach was extensively analyzed in the 802.3 standards committee and found to provide the best performance

- **ALL BITS ARE PROTECTED:**
  - Some bits protected by LDPC code
  - Some bits protected by Euclidean Distance
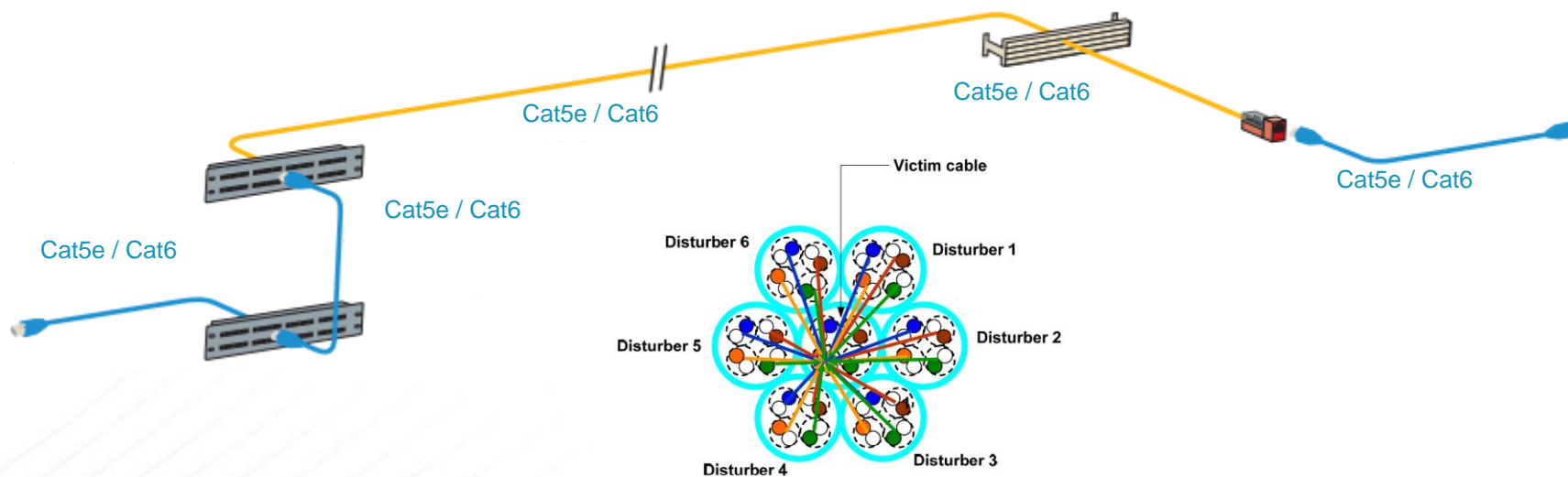 - Uncoded is NOT synonymous with unprotected
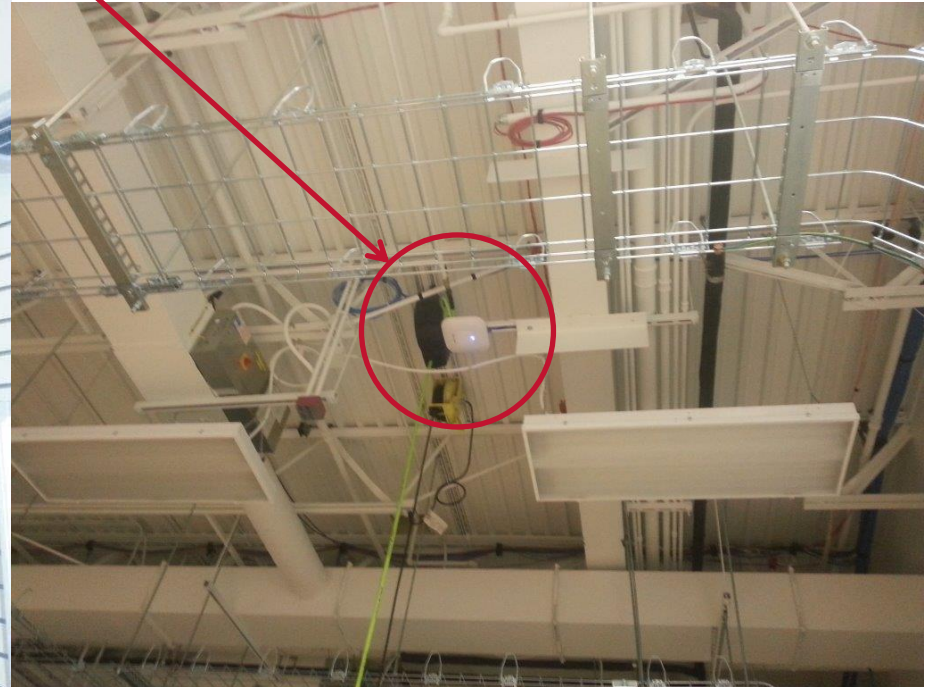
From C. DiMinico: NGEABT Use Case Ad Hoc

Error-free Test Results

Cat5e / Cat6 Channel

Cat5e / Cat6

Cat5e / Cat6

Cat5e / Cat6

Cat5e / Cat6

Cat5e / Cat6

Victim cable

Disturber 6

Disturber 1

Disturber 5

Disturber 2

Disturber 4

Disturber 3

Rate	Cable type	Configuration	Aggressor rate	Aggressors length (m)	Victim length (m)
2.5G	Cat5e	6-a-1 (4 segments)	2.5G	100	≥100
5G	Cat5e	6-a-1 (4 segments)	1G	100	≥100
5G	Cat6	6-a-1 (4 segments)	5G	100	≥100

2.5/5GBASE-T Technical Feasibility Summary

- Leverage proven 10GBASE-T Technology
  - Robust DSQ-128 Modulation
  - High-performance LDPC coding

- Provide excellent performance
  - Error-free operation over 100m of Cat5e & Cat6 at 2.5Gb/s & 5Gb/s
  - Robust against alien noise sources (24/7 problem)
  - Robust against impulsive noise sources (infrequent)

- Straightforward implementation
  - Re-use of 10GBASE-T blocks accelerates multi-vendor implementation
  - Minimal hardware changes

- Support fast-track standardization
  - Leverage successful 10GBASE-T standardization
  - Enable direct path to IEEE standardization