Addressing Real World Copper Cabling Challenges for IP Convergence
Addressing
REAL WORLD COPPER CABLING CHALLENGES

Copper cable is a staple in any networking system, and it is here to stay. However, it is constantly being put to the test in a changing landscape. Due to its high electrical conductivity and relatively low cost, copper has become the signal-carrying medium of choice. Now carrying voice and data communications, signaling, video and power for many applications, twisted-pair copper cables have evolved and addressed many performance challenges.

Twisted-pair copper cables provide a solid foundation on which to build technological advancements for the 100 meter (328 feet) horizontal channels in enterprise networks. However, network designers and end-users are assured that the installed base of twisted-pair copper cable standardized nearly two decades ago can perform in today’s real-world environments and support many new applications. With expanding bandwidths, added power and connectivity to networked devices via Internet protocol (IP), twisted-pair cable is being pushed to its operational and electrical signal-carrying limits. Inhibitors such as crosstalk, static, heat and electrical noise can affect transmission line properties and cause dropped data packets, ultimately affecting the performance of an application.

Copper cabling standards developed by the Telecommunications Industry Association (TIA) and the International Organization for Standardization (ISO) have evolved significantly since the early 1990s. The main purpose of these standards is to create a uniform approach to cable management, interconnects, and interconnects and alternating current power cables (AC) to facilitate the installation and operation of telecommunications networks in real-world environments.

The TIA/EIA-568-C.2 standard includes environmental classifications that describe areas in which the cable can be placed and address factors that may inhibit performance. These classifications are predetermined by factors such as M/C—mechanical, I for ingress, C for climate and E for electromagnetic. The standard provides guidelines for areas (e.g., office buildings) as well as industrial environments, and it provides different levels.
AGENDA

- IP Convergence
- Network Trends
- Cabling Challenges
- Real World Testing
IP Convergence
Yesterday...
... Proprietary Cabling

- Video Coax Cable
- Video and Power (18/2)
- HDMI
- Access control

Multi purpose – Coax, power, data
Multi-system Closet
Today – IP Convergence

IP VOICE with PoE

More IP & PoE Devices

Data Cloud

Computing

IP Video

Conferencing

Smart Devices

HVAC/BAS

IP LED

IP Cameras

W.A.P.

IP TV

Download

Bicsi
How things have changed,...... and stayed the same

Cable used to be only for **DATA**

Then the **same** cable was used for **VOICE**
  - VoIP

Then the **same** cable was used for **POWER**
  - PoE (15W), PoE+ (30W), PoE++ (≈ 60W)

  - Ethernet cable for IP applications
Structured Cabling TR
Network Trends
Today’s IT Managers...

“We need help achieving maximum ROI from our converging network today, and into the future.”

• Today’s business environment is ultra competitive
• IP Convergence is only going to grow
• Our IT infrastructure will need to support emerging applications
Major Trends in IT Networks

Emerging Applications

- IP HVAC
- IP Intercom
- IP LED
- Cloud Computing
- IP TV

Three GROWING cabling trends to consider:

- VoIP (VOICE or Audio)
- BANDWIDTH (DATA)
- PoE (POWER)
VoIP Trend

IP Desktop Phone Unit Shipments (millions)

Source: Frost and Sullivan Analysis 2011
Global IP traffic by Month*:

- Will grow from 44 exabytes in 2012, to 121 exabytes in 2017
- Business IP traffic expected to be 18% of total
  - 21.8 Exabytes = 5.4 billion DVDs worth of information

<table>
<thead>
<tr>
<th>Name</th>
<th>Numerical</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kilobyte</td>
<td>1000</td>
<td>Thousand Bytes</td>
</tr>
<tr>
<td>Megabyte</td>
<td>$1000^2$</td>
<td>Million Bytes</td>
</tr>
<tr>
<td>Gigabyte</td>
<td>$1000^3$</td>
<td>Billion Bytes</td>
</tr>
<tr>
<td>Terabyte</td>
<td>$1000^4$</td>
<td>Trillion Bytes</td>
</tr>
<tr>
<td>Petabyte</td>
<td>$1000^5$</td>
<td>Quadrillion Bytes</td>
</tr>
<tr>
<td>Exabyte</td>
<td>$1000^6$</td>
<td>Quintillion Bytes</td>
</tr>
<tr>
<td>Zettabyte</td>
<td>$1000^7$</td>
<td>Sextillion Bytes</td>
</tr>
<tr>
<td>Yottabyte</td>
<td>$1000^8$</td>
<td>Septillion Bytes</td>
</tr>
</tbody>
</table>

*Source: Cisco VNI Forecast 5/29/13*
Data Trend (Bandwidth)

What about compression technology?

- VOICE and DATA traffic are typically compressed
- Needed to reduce bandwidth consumed
- File size can be reduced to 10% of original

Think about consequence of frame errors with compression; they can be much more damaging.
PoE++ Trend

225% Growth by 2018

PoE started @ ≈ 15W
PoE + increased ≈ 30W
PoE++ considering ≈ 60W+
## PoE++ Trend & Markets

<table>
<thead>
<tr>
<th>System</th>
<th>Market</th>
<th>Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nurse Call Systems</td>
<td>Healthcare</td>
<td>30-50W</td>
</tr>
<tr>
<td>Point of Sale</td>
<td>Retail</td>
<td>30-60W</td>
</tr>
<tr>
<td>IP Turrets (Trading Floor Phones)</td>
<td>Financial/Retail</td>
<td>45W</td>
</tr>
<tr>
<td>Lighting, HVAC, Access Control</td>
<td>Building Management</td>
<td>40-50W</td>
</tr>
<tr>
<td>IP Cameras (PTZ, Heaters)</td>
<td>Security</td>
<td>30-60W</td>
</tr>
<tr>
<td>Video Conferencing</td>
<td>Hospitality</td>
<td>45-60W</td>
</tr>
<tr>
<td>Motor Control Unit, Drives</td>
<td>Industrial</td>
<td>&gt;30W</td>
</tr>
</tbody>
</table>

Source: IEEE 802.3; Four Pair Power over Ethernet; Call for Interest March 2013
Cabling Challenges
Voice and Data Protocol Differences

**Voice**
- UDP protocol because time sensitive
- UDP does not retransmit traffic if errors
- Any VoIP traffic lost... is lost forever

**Data**
- TCP/IP protocols, not as time sensitive
- Frames with errors are retransmitted
- Network can become very sluggish
VOICE is sensitive to noise and heat, interferes with clarity resulting in broken and choppy voice and dropped calls.
DATA is sensitive to noise and heat, interferes with network speed.
POWER is both **noisy**, and generates **heat**
Cable Challenges

- **Noise**
  - Internal PoE
  - External EFTs from Power Sources

- **Heat**
  - Internal PoE
  - External from Plenum Spaces

- **Power**
  - Is both noisy and generates heat
    - Remember this?

Protect VOICE and DATA from noise and heat while delivering power and make sure it all works here.
Cabling Standards

• Provides basic guidelines for pathways, cabling & connectivity
• Provides a reference of common design practices
• Defines minimum requirements for cable and connectivity performance
Min. Compliant ≠ Max. Performance

But everything was designed to work on 5e, right?

Yes, **VOICE** was designed for 5e
Yes, **DATA** was designed for 5e
Yes, **POWER** was designed for 5e

But, how well do they work simultaneously?
Min. Compliant ≠ Max. Performance

But everything was designed to work on 5e, right?

Yes, **VOICE** was designed for 5e
Yes, **DATA** was designed for 5e
Yes, **POWER** was designed for 5e

But, how well do they work simultaneously?

And do they work well here?
But everything was designed to work on 5e, right?

Yes, **VOICE** was designed for 5e

Yes, **DATA** was designed for 5e

Yes, **POWER** was designed for 5e

Remember, CAT 5e was ratified in 1999, CAT 6 2002

But, how well do they work simultaneously?

And do they work well here?
The Limit = The Weakest Link

Your network is only as strong as the weakest link

The standards represent the minimum

• Testing in a laboratory
• Focus has been on data only, and done many years ago
• What about simultaneous operation in the real world?
Standard Testing Approach

100 meter, (4) connector channel running data only
Real World ≠ Lab

There is a **BIG** difference with working
Here, in the real world  **AND**  Here, in a lab with A/C

**VOICE, DATA, POWER**
- Temps in plenum easily reach 120°F+
- Multiple sources of EFTs
- Rigors of installation

**DATA Only**
- Temps stay constant 68°F
- EFTs are eliminated
- One cable handled carefully
Real World Testing:

• New Real World Test Set-up
• Data/Frame Error Rate
• VoIP
• IPTV
New Real World Test Set-up

100 meter, (4) connector channel running VOICE, DATA, POWER under stress (75°C and 250V EFT) for one (1) hour.

- Multiple CAT 5e (min); one CAT 6 (min); multiple CAT 6-e & CAT 6-E
Frame Error Rate (FER)

- As number of errors increases, so do the “re-transmits”
  - Network becomes sluggish, receiver unable to process information
- Converging Applications
  - If UDP – dropped frames lost forever (VoIP, IP Cameras, etc)
  - If TCP/IP – Data or video can become painfully slow or “time out”

Frame Error Rate Measurement

1 Byte = 8 Bits
1,518 X 8 = 12,144 bits
Frame Error Test Results

Frame Errors in One (1) Hour

Frame errors represent:

- CAT 5e (Sample 1)
- CAT 5e (Sample 2)
- CAT 6
- CAT 6-e (Sample 1)
- CAT 6-e (Sample 2)
- CAT 6-e (Sample 3)
- CAT 6-E (Sample 1)
- CAT 6-E (Sample 2)
- CAT 6-E (Sample 3)

Frame Errors
Mean Opinion Score (MOS)

- Common test used to test quality of VoIP calls
- Measures packet loss, latency, jitter (based on users perceptions)
- Scoring (1 = worst and 5 = best)
  - 3.6 is generally considered minimally acceptable

<table>
<thead>
<tr>
<th>MOS</th>
<th>Expected User Satisfaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.34 - 5.00</td>
<td>Very Satisfied</td>
</tr>
<tr>
<td>4.03 - 4.34</td>
<td>Satisfied</td>
</tr>
<tr>
<td>3.60 - 4.03</td>
<td>Some Users Dissatisfied</td>
</tr>
<tr>
<td>3.10 - 3.60</td>
<td>Many Users Dissatisfied</td>
</tr>
<tr>
<td>2.58 - 3.10</td>
<td>Nearly All Users Dissatisfied</td>
</tr>
<tr>
<td>&lt; 2.58</td>
<td>All Users Dissatisfied</td>
</tr>
</tbody>
</table>

Software used for MOS scoring

- Exfo, Fluke, Empirix

Sample Software report
VoIP MOS Test Results

3.60 = Minimally acceptable
IPTV Expansion

• IPTV = multimedia services such as television/video/audio/text/graphics/data delivered over IP based networks

• Central control management

• Customized content can be edited and transmitted
Media Loss Rate (MLR) and IPTV

- MLR is defined as the number of lost or out of order packets over a specified time frame.
  - Any packet error will adversely affect video quality
    - RTP (Real Time Protocol): Like UDP, no re-transmit
  - Maximum acceptable MLR should be zero
  - Service Level Agreements (SLA) are sometimes negotiated to a MLR equivalent to two (2) errors per hour

Some information on slide referenced from; Understanding and Interpreting MDI Values; Agilent Technologies;
A Visible Impact

Media Loss Rate (MLR)

Snapshot of MLR = 0

Snapshot of MLR > 0

MLR images courtesy of Agilent Technologies; Scalable IPTV testing;
IPTV MLR Test Results

Media Loss Rate for Video IPTV over 1 hour

Standard Definition IPTV

<table>
<thead>
<tr>
<th>CAT 5e (Sample 1)</th>
<th>CAT 5e (Sample 2)</th>
<th>CAT 6-e (Sample 1)</th>
<th>CAT 6-e (Sample 2)</th>
<th>CAT 6-e (Sample 3)</th>
<th>CAT 6-E (Sample 1)</th>
<th>CAT 6-E (Sample 2)</th>
<th>CAT 6-E (Sample 3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.7</td>
<td>7.1</td>
<td>7.0</td>
<td>21.0</td>
<td>14.2</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

MLR Max Avg. Limit = 2 frame errors per hour

Results represent averages over multiple tests

MLR image courtesy of Agilent Technologies; Scalable IPTV testing;
Why Cable Matters

Is your invested and installed cable capable of:

• Minimizing effects of heat?
• Minimizing effects of noise?
• Minimizing effects of outside disturbers?
• Protecting voice, data and video traffic?
What Matters in Cable Production

• Helical cable concentricity

• Precise twist technology with inline adjustment

• Premium materials

• Cable UL Ratings

• Inline test procedures
Prepare for IP Convergence

• Standards provide installation guidelines
• Invest in a high-grade cable for IP applications
• Ask for real world test results
• Know the environment and cable properties
Contact:
Stephen Cherry, RCDD
tel. (613) 371-5230
stephen.cherry@nexans.com