Cable Dynamics: an End User Perspective

IEEE P802.3bq 40GBASE-T Task Force

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Channel Modeling ad hoc
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Abstract

- Mechanical movement of a physical link can result a time-varying channel response, which in turn can affect the Ethernet physical layer performance. This presentation discusses cases where such movement exists during network operation, the user's expected result, and a call for additional information.

Goals

- Minimize PHY power consumption and complexity by bounding the time-varying nature of the channel
- Define testable limits to cable movement in a live network
- Define cable performance under those conditions of movement

Background

During 10GBASE-T Product development

- Undesirable performance impacts noted when patch cord moved
    - Most likely observed during a BER test
- Developers found no relevant standards for
    - Cable movement during operation
    - Channel performance during movement
    - Link performance during movement
- Evaluators and customers created ad hoc tests & performance criteria
    - Coined the term “cable dynamics”
    - Developers responded by tweaking firmware until desired performance was achieved

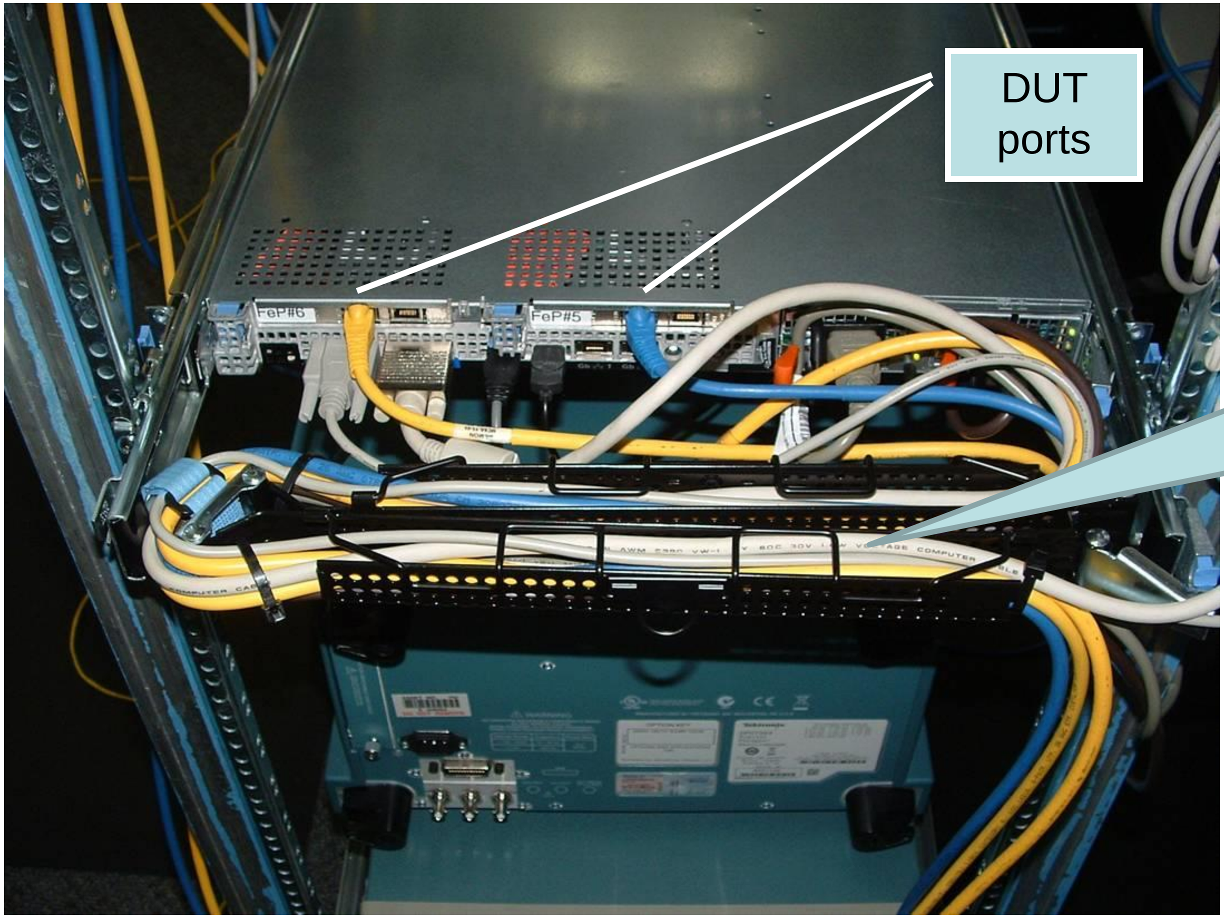
Similar problem has received some study in optical communication

- Example from 10GBASE-LRM - http://grouper.ieee.org/groups/802/3/aq/public/nov04/king_1_1104.pdf

Typical field cases

- Operator manipulates flexible patch cord
  - Move a cord aside to access another port
  - Stow excess cable
  - Excess cordage dropped onto floor
- Equipment moveable in operation
  - Rack-mount equipment on slide rails
    - Rack server hardware includes cable management arm (CMA, see picture)

Cable Dynamics CMA & cable routing



DUT ports

Hinged arm swings when server slides out

Ad Hoc Tests circa 2009

- Manual shake or twist of cable
    - difficult to control & characterize
- Operation of server slide rails
    - Slide server in & out of rack while in operation

Details in backup

Expected Performance

- In the presence of “normal” in-use cable manipulation, user expects
  - – No loss of link
  - – Maintains BER target (1E-12)

Request for input

- Related to twisted pair patch cords & equipment cords,
- Does the cabling community have specifications, data, recommendations, folklore for
  - Cable movement during operation
    - What is acceptable deflection, bend radius, angle and rate
      - » Conditions under which PHY performance should be maintained
    - What is excessive deflection, bend radius, angle and rate
      - » Where performance should not matter
  - Channel performance during movement
    - Limit change in channel performance during acceptable deflection case

backup

- Description of the ad hoc tests

User Oriented Ad Hoc Cable Dynamics Tests

- The flexible patch cord elements of structured cabling implementations may be subject to movement (cable dynamics) during normal use. Intel has defined two tests that are intended to evaluate a 10GBASE-T PHY implementation's robustness/immunity to these movements.
- Based on the expected installations, two tests, described in two parts of this procedure, are defined.
  - Part 1 is intended to simulate movement of the “equipment area” (EA) segment during normal server maintenance operations. This test is derived from customer-specific requirements and focuses on cable flexion (bending).
  - Part 2 is intended to simulate flexible patch cord movement in either the “cross-connect” (cables between patch panels) (XC) or “work area” (WA) (connection to a system without cable management features) segments of the channel. This test is an internal Intel requirement and focuses on cable rotation (twisting).

Part 1: Equipment area (EA) cable dynamics test

- Objective: Test that normal and worst-case movement of server cable management solutions (sometimes known as a Cable Management Arm, or CMA) won't interfere with or affect networking traffic as defined by no long time-to-link (TTL), no link drops, and no excessive errors introduced during system movement.
- Equipment:

(1) Rack server with a 10GBASE-T Device Under Test (DUT) and cable management arm attached at the rear of the system. The channel EA flexible patch cord and all other cables should be installed and routed in the CMA according to the manufacturer's recommendations.

(2) 2nd system with a 10GBASE-T link partner (LP). Both the DUT and LP should have the ability to indicate link status and provide statistical counter data.

Part 1 continued

- Procedure
  - Step 1
    - Connect a 100 meter CAT6a "4-connector" channel to the DUT at the "equipment area" (EA) end of the channel and the LP at the "work area" end of the channel.
    - Expected result: Cable connected and linked successfully with <7s TTL.
  - Step 2
    - Run a 500M packet (~15 minutes) test first. Run the test with the server fully retracted in the rack (normal use position) to make sure everything works normally.
    - Expected result: Test runs normally with no link drop and BER < 1E-12.
  - Step 3
    - Start extending and retracting the server (sliding it in and out of the rack) using various speeds and strengths w/ any cable stays or retention mechanisms connected. Restart another 500M packet (~15 minutes minimum) test.
    - Expected result: Cable connected and linked successfully with <7s TTL. No link drop and no errors > TBD during the test.
    - *Editorial note: The original customer test procedure specifies 0 errors; I'm not sure this is realistic for very aggressive movement. Final BER criteria is open at this time. Minimum acceptable is no link drop.*
  - Step 4
    - Repeat the same test using a 55 meter CAT6 4-connector channel.
    - Expected result: Cable connected and linked successfully with <7s TTL. No link drop and no errors > TBD during the test.

Part 2: Cross-connect/Work area (XC/WA) cable dynamics test:

- Objective: Test that normal and worst-case movement of free-standing or loose patch cables won't interfere with or affect networking traffic as defined by no long time-to-link (TTL), no link drops, and no excessive errors introduced during system movement.
- Equipment:

(1) Host system with a 10GBASE-T DUT. No *(limited?, minimal?)* cable management practices should be employed on this system.

(2) Rack server with a 10GBASE-T LP and cable management arm attached at the rear of the system. The channel equipment area flexible patch cord and all other cables should be installed and routed in the CMA according to the manufacturer's recommendations. This system remains stationary with the server fully retracted during this part of the test. Both the DUT and LP should have the ability to indicate link status and provide statistical counter data.

Part 2 continued

- Procedure:
  - Step 1
    - Procedure: Connect a 100 meter CAT6a "4-connector" channel to the DUT at the "work area“ (WA) end of the channel and the LP at the "equipment area" (EA) end of the channel.
    - Expected result: Cable connected and linked successfully with <7s TTL.
  - Step 2
    - Procedure: Run a 500M packet (~15 minutes) test first. Run the test with no movement of either the WA or XC patch cables to make sure everything works normally.
    - Expected result: Test runs normally with no link drop and BER < 1E-12.
  - Step 3a (work area)
    - Make sure the RJ45 connection at the DUT is immobilized to eliminate false failures due to intermittent connections. Grasp the patch cord with the thumb and fingers at a distance of approximately 2 feet from the DUT. Rotate the WA patch cable with a rolling motion between the thumb and fingers at various speeds and strengths. Restart another 500M packet (~15 minutes minimum) test.
    - The cable rotation should be performed as follows:
      - Approximately 90 degrees clockwise and return to start, 10x
      - Approximately 90 degrees counterclockwise and return to start, 10x
      - Alternating approx. 90 degrees clockwise and 90 degrees counterclockwise w.r.t. start, 10x
        - » Center, right, center, left center = 1x (rotating thru center for a 180 rotation)
    - Repeat this sequence throughout the test.
    - Expected result: Cable connected and linked successfully with <7s TTL. No link drop and no errors > TBD during the test.

Part 2 continued

- Procedure (continued):
  - Step 3b (cross connect)
    - Make sure the RJ45 connections at the patch panels are immobilized to eliminate false failures due to intermittent connections. Grasp the XC patch cord with the thumb and fingers at a distance of approximately 2 feet from the patch panel. Rotate the patch cable with a rolling motion between the thumb and fingers at various speeds and strengths. Restart another 500M packet (~15 minutes minimum) test.
    - The cable rotation should be performed as follows:
      - Approximately 90 degrees clockwise and return to start, 10x
      - Approximately 90 degrees counterclockwise and return to start, 10x
      - Alternating approx. 90 degrees clockwise and 90 degrees counterclockwise w.r.t. start, 10x
        - » Center, right, center, left center = 1x (rotating thru center for a 180 rotation)
    - Repeat this sequence throughout the test.
        - » Note: 3a (WA) and 3b (XC) may be alternated during a single 15 minute test.
        - » *EDITORIAL COMMENT TO REMOVE: If you are listening to music during a test with a slow partner (~30 minutes test time), it's a bit easier to rotate in sets of 8x and "twist to the beat" (unless you like to listen to Dave Brubeck's Take Five" for 30 minutes).*
        - » *EDITORIAL COMMENT: Cable can rotate during CMA slide – add that as well?*
    - Expected result: Cable connected and linked successfully with <7s TTL. No link drop and no errors > TBD during the test.
  - Step 4
    - Repeat the same test using a 55 meter CAT6 4-connector channel.
    - Expected result: Cable connected and linked successfully with <7s TTL. No link drop and no errors > TBD during the test.

Thank You!

Four Connector Topology (Example #1)