ACCELERANT NETWORKS

The Leader In Backplane Communication Systems

Outline

- Communication Trends
- Obstacles
- Our Approach
- Adaptation
  - Dispersion
  - Reflection
  - Crosstalk
- Conclusions

Communication Trends

- Next generation systems demand up to 10 times growth in data (e.g. 1 Gigabit to 10 Gigabit Ethernet)
- Increased demand for bandwidth worldwide
- Significant speed advances in connectivity
  - Optical networks
  - Copper based networks
- Data bottlenecks at the switches and routers
  - More specifically the internal backplane

➢ Demand for higher speed backplane transceivers

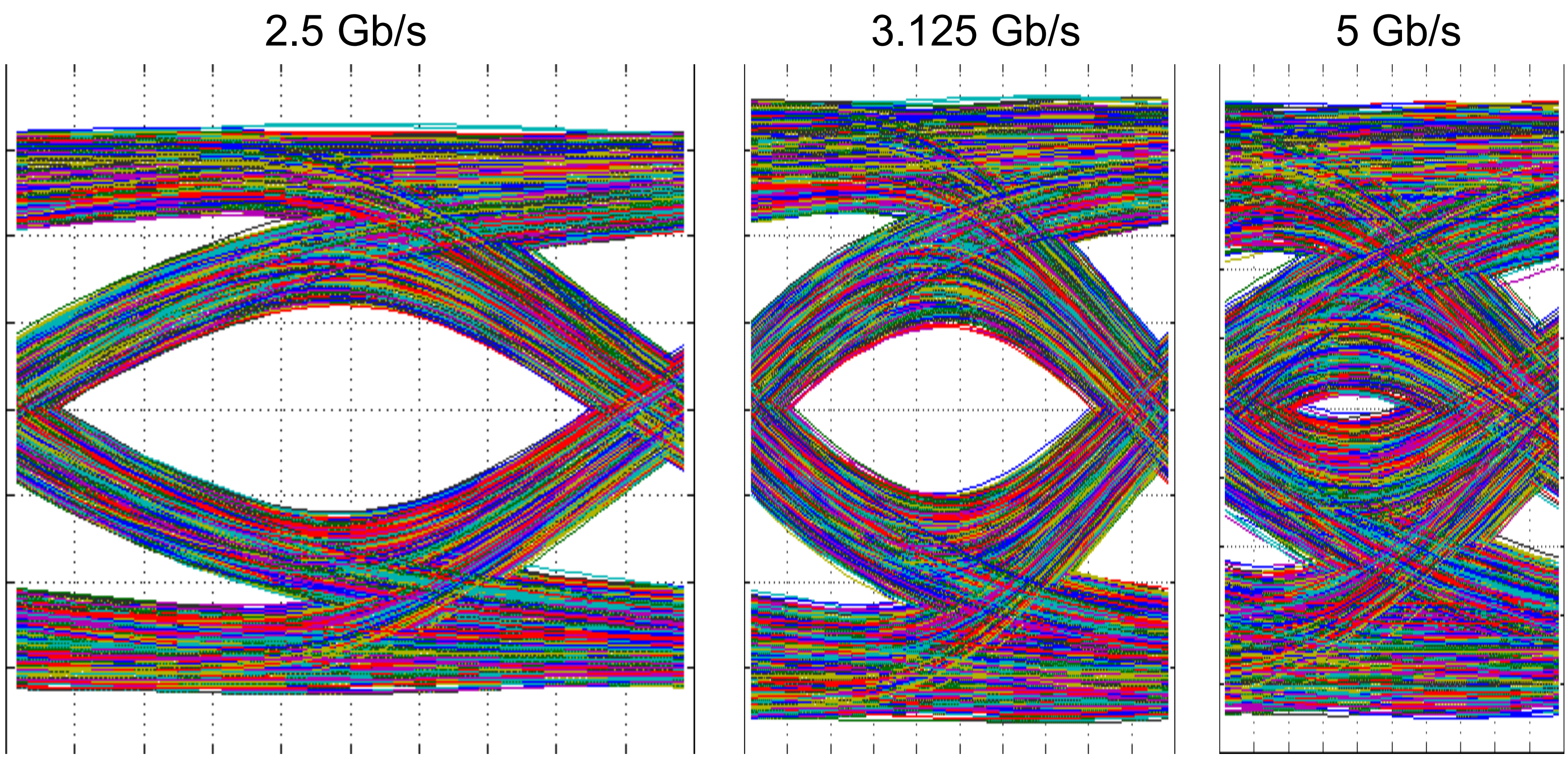
Obstacles at Higher Speeds

- More sensitive to dielectric and skin effect loss
  - Dispersion => adjacent symbol ISI
- More sensitive to signal termination
  - Reflection => distant symbol ISI
- Most sensitive to interferer coupling
  - The signal to crosstalk ratio decreases with frequency

…Every Channel can be Different

The Problem
Qualitative Observations

- Simulated Eye Diagrams (34 in. FR4)



Our Approach

- Iteratively/simultaneously attack the problem at circuit and system levels
- Design the system to make a solution that is easier to implement and robust

Understanding the Problem

- Developed a proprietary simulation methodology to:
  - Permit rapid evaluation of transceiver topologies
    - Line codes
    - Convergence algorithms
    - Coupled with widely varying channel conditions
  - Include second order effects of the physical channel and the resultant system/circuit design
  - Accurately move from both virtual and measured channels to the system/circuit design environment

Measurement Methodology

- Channel measurements from prototypes, production systems and in-house test boards
- Dozens of differential 2-port S-parameter measurements of real boards
  - Different connectors
  - Different lengths
  - Different board owners (customers and connector vendors)
  - Different material and board topologies
- Crosstalk transfer functions from neighboring pairs measured in the same way
  - Near end
  - Far end

Design Techniques

- Four-level signaling to reduce line rate
- Scrambling to eliminate transmitted tones
- Dynamically configurable adaptive transmit equalizer to mitigate near and far ISI
  - Equalization depends on received signal
- Adaptive transmit power control to mitigate Crosstalk
  - Transmit power depends on received signal

Enabling Adaptation

- Want Rx-side to communicate with Tx-side
  - Cannot interrupt user data stream
- Communication overhead already exists
  - Coding normally used to DC balance the line
  - Trade deterministic DC balance for statistical balance
- Enables communication channel back to the transmitter
  - Auto-negotiation for initial blind convergence
  - Zero-overhead back-channel link

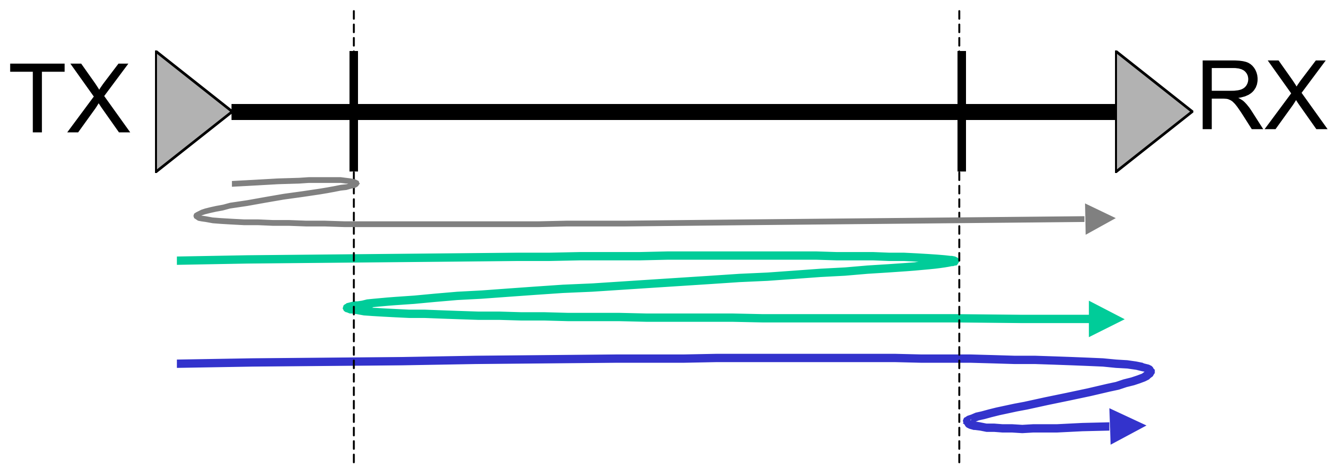
ACCELERANT NETWORKS

Adaptation for Dispersion

- Backplane channel has a low-pass characteristic
  - Causes attenuation and dispersion
- Adaptively pre-distort the transmit signal to counter low-pass
  - Want flat response over frequency for all channels

Reflection Challenges

- Reflections from non-ideal connectors and from non-ideal transmitters and receivers
- Reflections take at least 3 trips through part of the wire vs. 1 trip for signal
- Signal to signal reflection ratio improved for longer traces
- Reflections addressed through equalization



ACCELERANT NETWORKS

Adaptation for Reflection

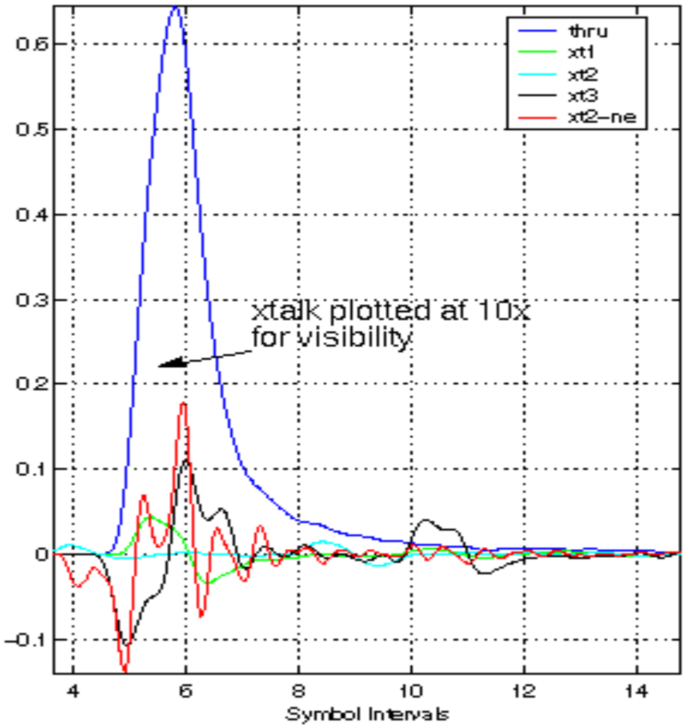
- Impedance variations compromise signal integrity
  - Connectors, vias, and package parasitics
  - Causes reflections
- ISI from non-adjacent symbols
  - Depends on physical proximity of discontinuity
- Sufficiently long FIR filter can cancel reflections
  - Implement as a sparse filter
  - Identify dominant reflection source
  - Adjust magnitude to minimize reflection

➢ Roving compensation tap

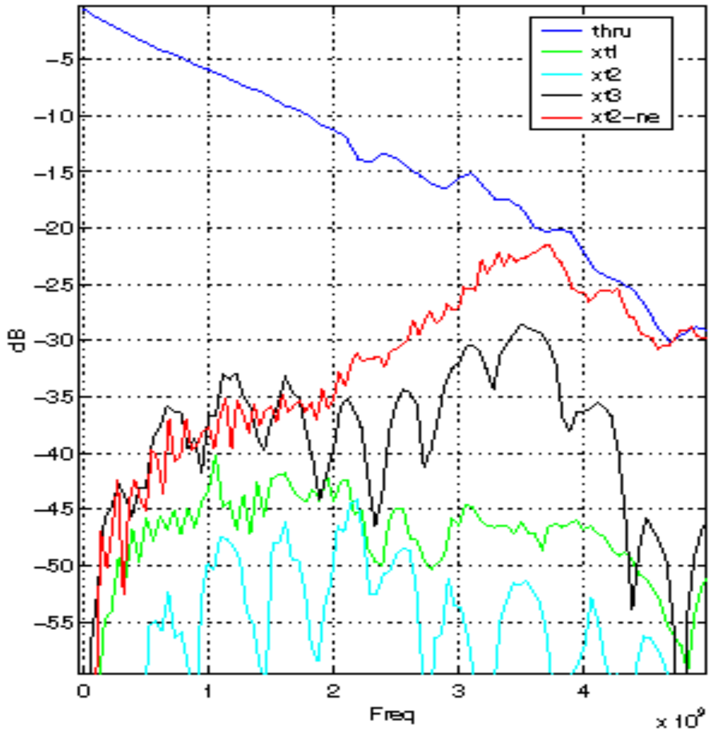
Crosstalk Study

- Transmission with Crosstalk

Pulse Response



Frequency Response



Measured

Typical Backplane Including Connectors

Adaptation for Crosstalk

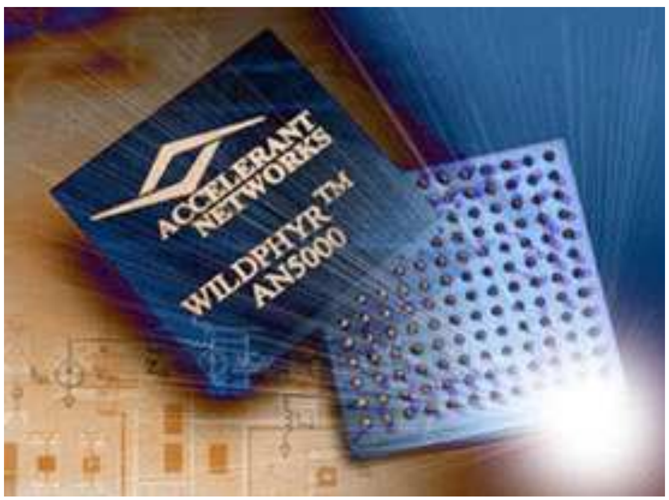
- Coupling from other transceivers
  - Similar to ISI but impractical to cancel
- Level the playing field
  - No dominant aggressor or victim
- Adaptively adjust transmit level
  - Results in equal receive amplitude independent of trace length
- Crosstalk sensitivity reduced
  - Adaptive transmit levels
  - Reduced frequency
  - Margin from codebook

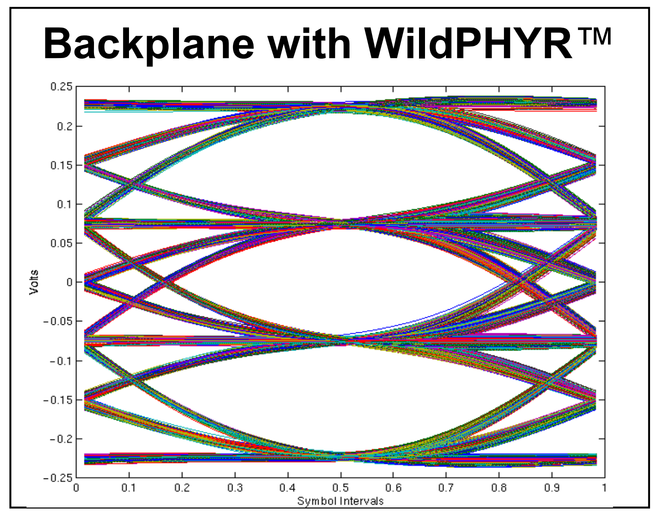
WildPHYR™ Implementation

- Set the speed evolution path on a new track
  - Use multi-level analog signaling to run at lower frequency
    - Trade speed for complexity
    - Push speed again
- Aggressive adaptive equalization
  - Compensates for line/board impairments
  - Compensates for trace and length variations
- Process technology
  - **0.25u CMOS**
    - Driven by DSP complexity, integration
    - Mixed signal compatibility

WildPHYR™ (The Chip)

- The first practical demonstration of WildPHYR™ technology
- Implementation of 5Gb/s digital signal processing in CMOS
- Fast multi-level analog signaling transceiver realized
- Self configurable adaptive equalization AT SPEED
- Backplane specific DSP enables virtually error-free transmission
- In-system channel evaluation, analysis and configuration





Simulated