

# **Interleaved Trellis Coded Modulation & Decoding**

---

Keshab K. Parhi and Yongru Gu  
Department of Electrical and Computer Engineering  
University of Minnesota  
Minneapolis, MN 55455

July - 2003 (IEEE-802.3)

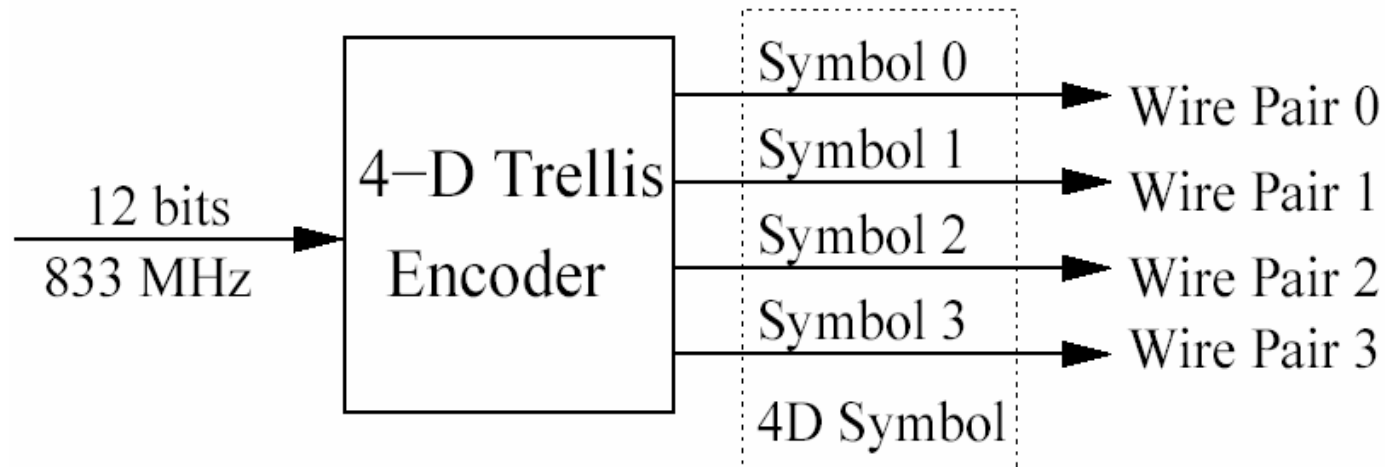
# Coding & Modulation Scheme

---

- PAM-10
- 4D, 8-state trellis code
- 12 bits per 4D symbol
- 833 Mbaud

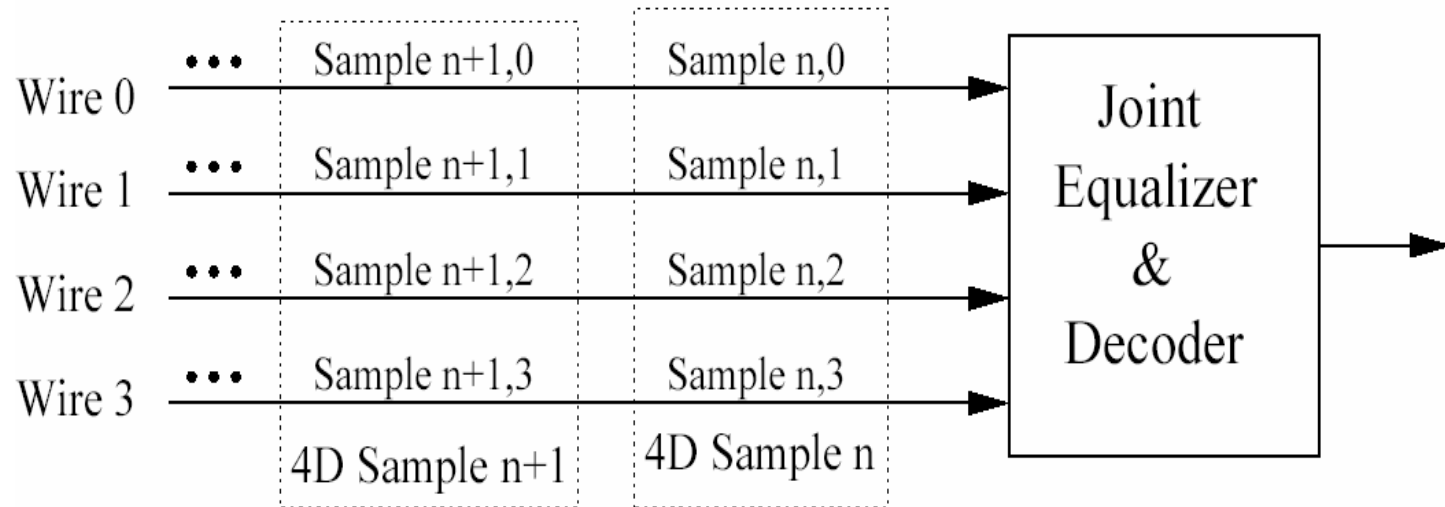
# Traditional Trellis Encoding Scheme

---



**4D spatial symbol:** 4 1D-symbols simultaneously transmitted over four different wire pairs (one dimension per pair)

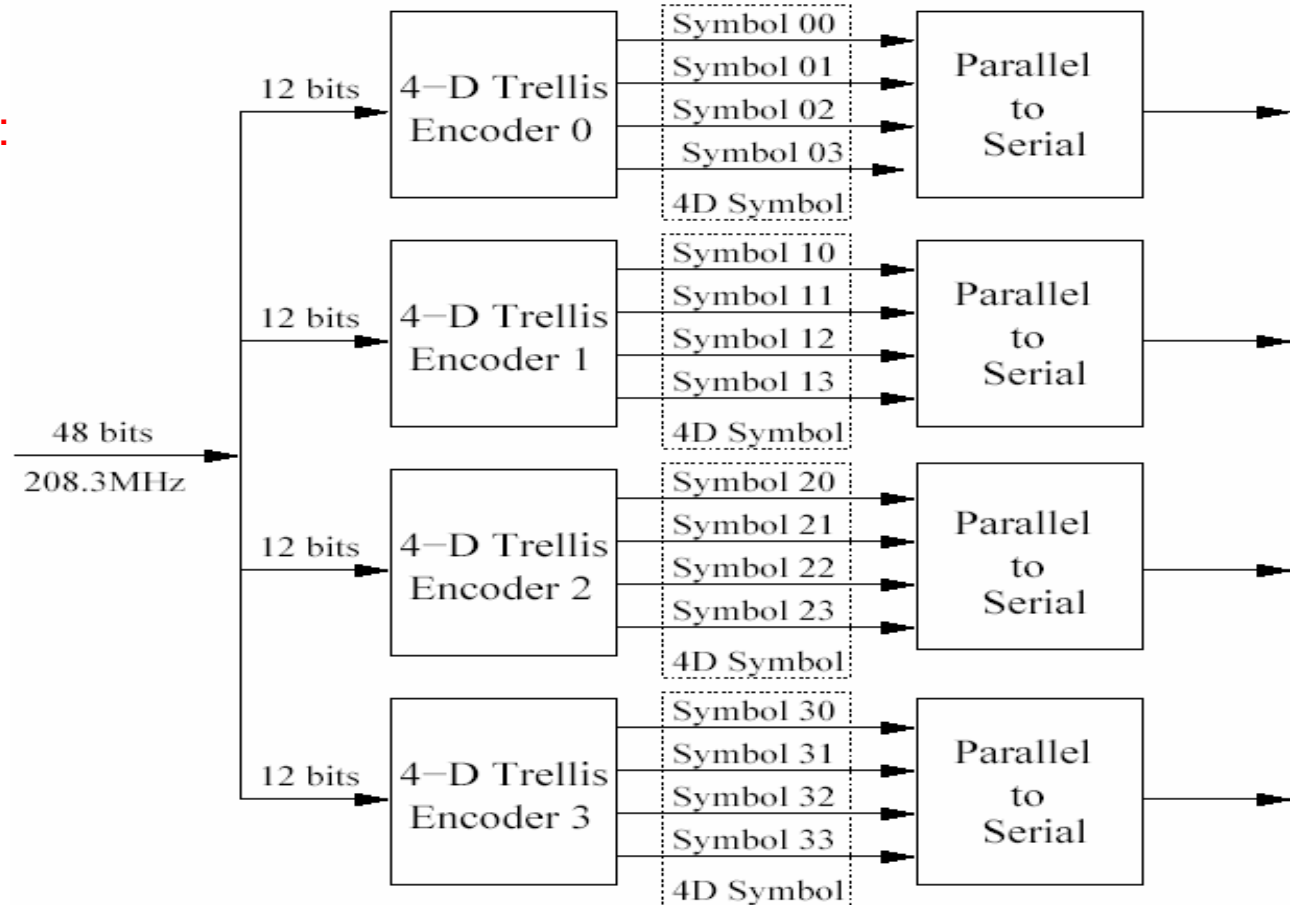
# Traditional Decoding Scheme



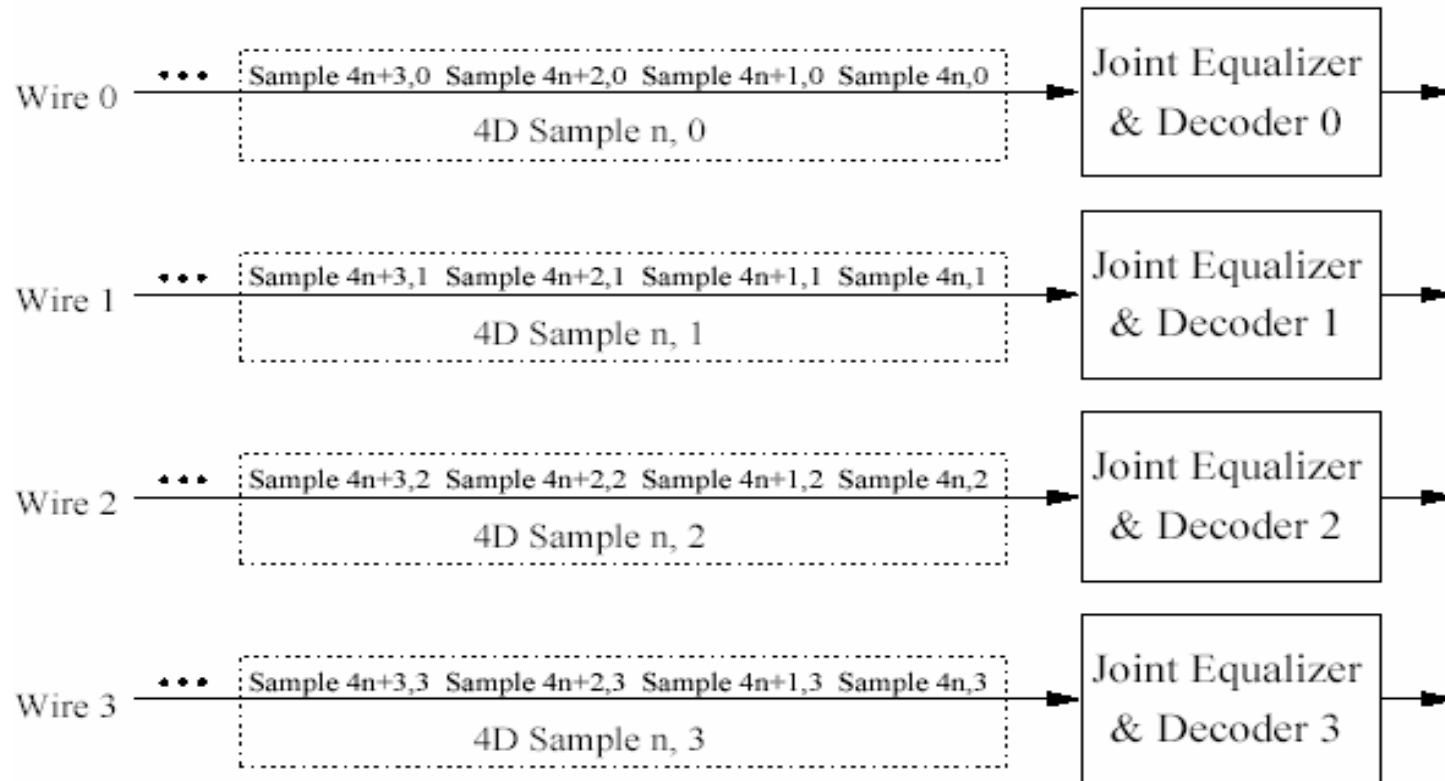
Required Decoding Speed for the Decoder: 833MHz  
(Clock Speed Hard to Achieve Due to Long Loop Critical Path)

# Proposed Interleaved Trellis Encoding Scheme

4D temporal  
symbol per wire:  
4 consecutive  
1D-symbols  
transmitted  
over the same  
wire pair



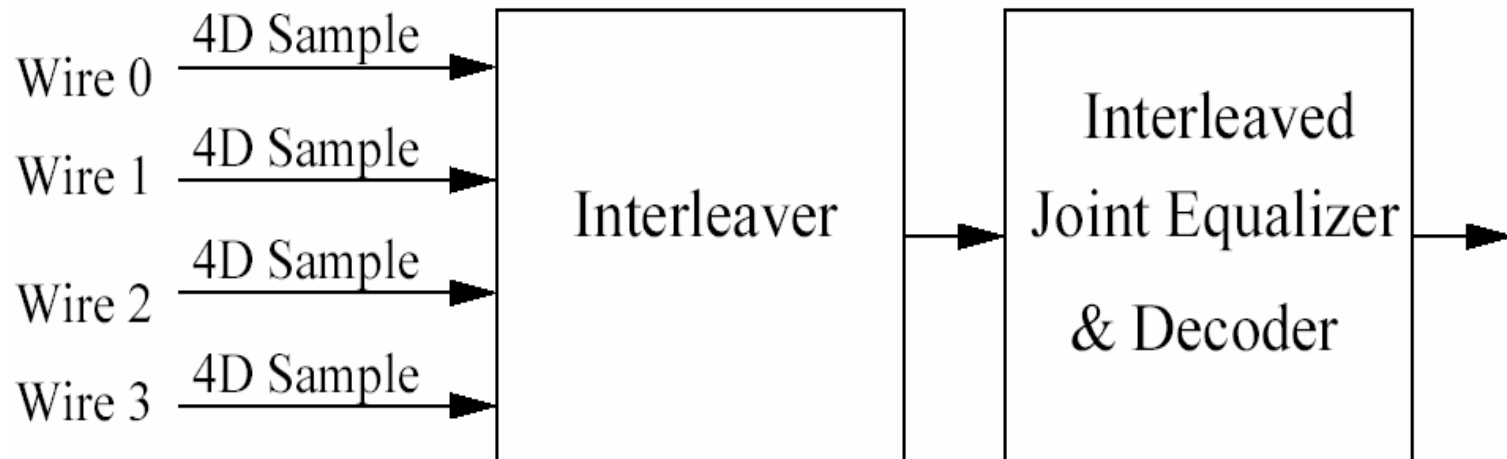
# Interleaved Trellis Decoding Scheme



Required Decoding Speed for Each Decoder:  
208.3MHz (critical path can be 4 times longer)

# Interleaved Trellis Decoder

---



- 1) Low hardware overhead: 1 decoder instead of 4 (Time Multiplexing or folding)
- 2) Each delay in the decoder is replaced by four delays. The critical path is reduced by a factor of 4 after path balancing by retiming.
- 3) Clock speed increased by factor 4 to 833 MHz with 1/4-th critical path of traditional non-interleaved decoder.

## **Decoder Complexity Reduction**

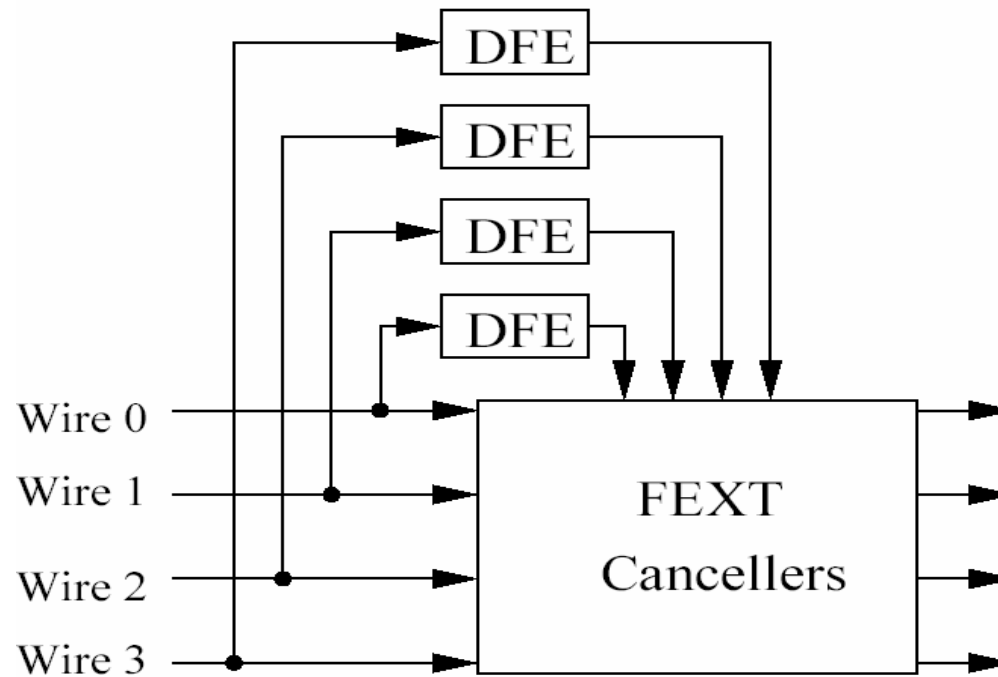
---

- Dependence among temporal 4 1-D samples due to ISI increases Branch Metric Complexity which Increases Loop Critical Path
- Achievable Speedup may be 3 instead of 4!
- Current work is in progress for complexity reduction



# FEXT Cancellation

---



# Conclusion

---

- Interleaved Trellis Coded Modulation by temporal interleaving
- Reduction of Critical Path by a Factor of 4 makes Decoder Design Easier!
- Proposed Idea is similar to PAM-5 10 Gbps Optical Receiver Proposal for IEEE 802.3-ab ([http://grouper.ieee.org/groups/802/3/ae/public/mar00/agazzi\\_1\\_0300.pdf](http://grouper.ieee.org/groups/802/3/ae/public/mar00/agazzi_1_0300.pdf)) (Interleaving exploited for 4 wires instead of 1 cable; Interleaved joint equalizer and decoder instead of parallel)