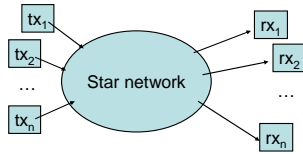


Demonstration of Uncoordinated Multiple Access in Optical Communications

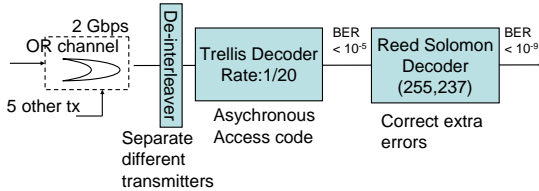
H. Chan, A. Vila Casado, J. Basak, M. Griot, W. Weng, R. Wesel, B. Jalali, E. Yablonovitch, I. Verbaunghede*

* Also with K.U.Leuven

Optical System and Code Design



Uncoordinated access: transmitters can transmit at any time using an interleaver chosen from a family, without informing anyone except the desired receiver



OR Channel (non-coherent combination)

- Output 0 if all users transmit 0
- Output 1 if one or more users transmit 1

Directional Hamming Distance

$d_D(c_1, c_2)$, for codewords c_1 and c_2

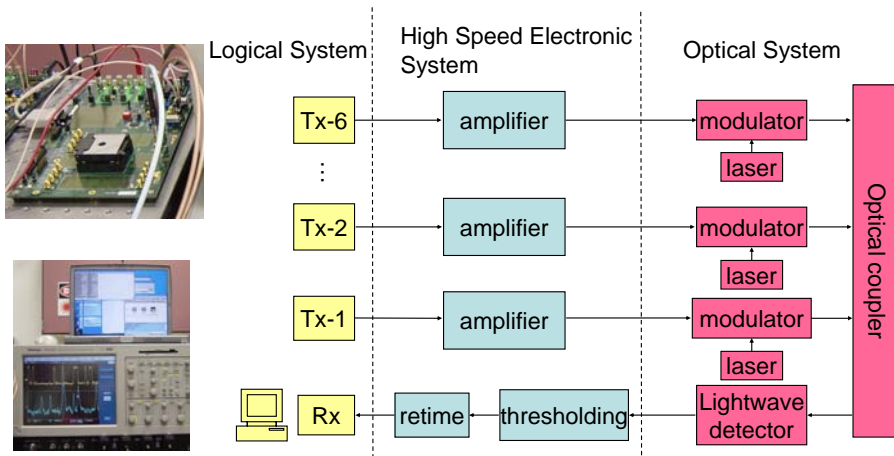
Number of ones that needs to be added to c_1 , so that all the ones of c_2 are ones in the received word

Trellis Code Design

For a given rate and average ones density find a set of codewords that will:

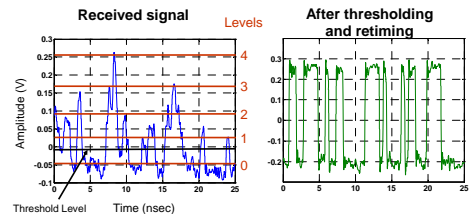
- Maximize the distance between branches splitting from a state.
- Maximize the distance between branches merging to a state.

System Implementation



Optical Receiver

- Lightwave detector converts optical signal to multilevel electrical signal
- Threshold level of flip flop converts to two level signal output
- Variable delay line matches clock phase to that of desired transmitter.

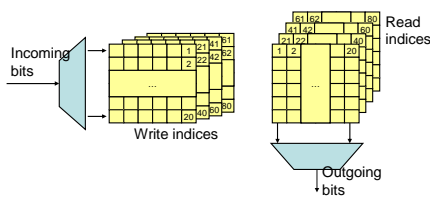


Logic Implementation

Channel coding implemented on VirtexII-Pro FPGAs

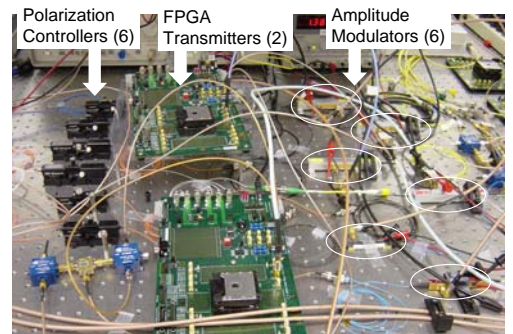
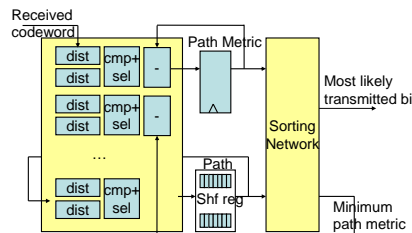
Interleaver:

- 1600 bit interleaver
- Use novel random write-by-row, read-by-column scheme



Trellis code:

- 64 state parallel Viterbi decoding
- Heavily pipelined



Results

Channel rate	1.2 Gbps * 6 = 7.2 Gbps		
Data Rate	60Mbps * 6 = 360 Mbps		
Users	Bits tested	Errors Found	Measured BER
1	1.5e+11	0	< 6.4e-12
2	4.6e+10	0	< 2.2e-11
3	1.2e+9	0	< 8.3e-10

Successfully demonstrated for up to 3 simultaneous users with combined channel rate of 3.6 Gbps

Reference:
"Interleaver Division Multiple Access on the OR Multiple Access Channel", Information Theory and Applications Workshop 2006.

Code Design

- Non-Linear Trellis code design for the Z channel
- Interleaver Division Multiple Access design for uncoordinated access

FPGA Logic Design

- Codeword based interleaver design
- Parallel and pipelined Viterbi Decoder
- Serial Reed Solomon Decoder RS(255,237)

Electrical / Optical Design

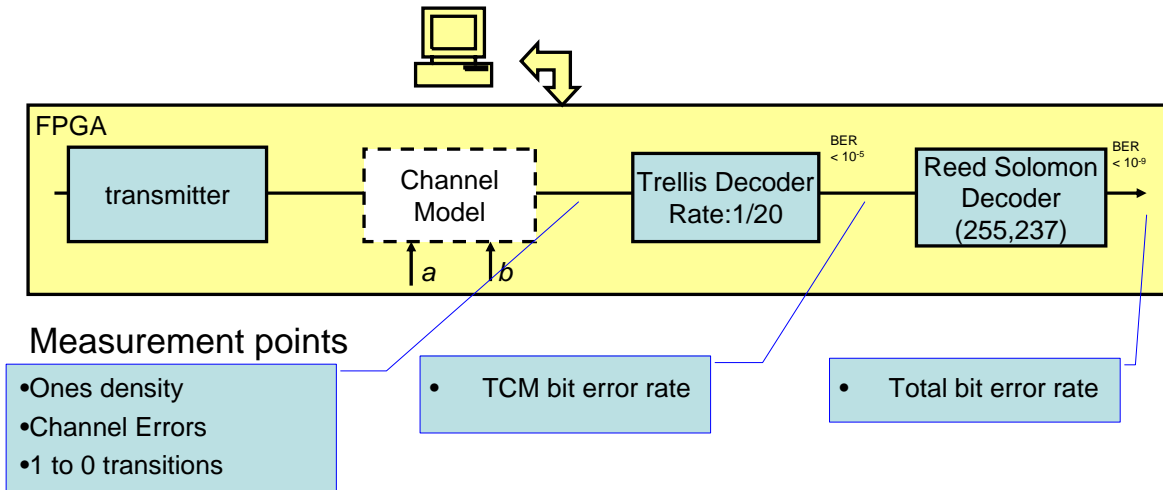
- Six continuous wave lasers at 1550 nm wavelength spaced at least 4GHz apart
- Signals are intensity modulated with MZM modulators

Sponsored by Space and Naval Warfare Systems Center – San Diego (N66001-02-1-8938)

Uncoordinated Multiple Access Simulation System

H. Chan, A. Vila Casado, J. Basak, M. Griot, W. Weng, R. Wesel, B. Jalali, E. Yablonovitch, I. Verbaauwhede*
 * Also with K.U.Leuven

FPGA Channel Simulator



Simulation

- Random data is generated and encoded
- The signal passes through a parameterizable channel model
- Probes are placed at different point of the receiver to see how the codes react to changes in the channel

Channel model

a and b simulate the degradation of the transmitted signal due to interference from other transmitters

a – non-coherent combination
 Probability that a 0 bit turns into 1

b – coherent combination
 Probability that a 1 bit turns into 0

Simulation Interface

