CHEVIN TECHNOLOGY

Development of 10Gb Ethernet applications in FPGAs

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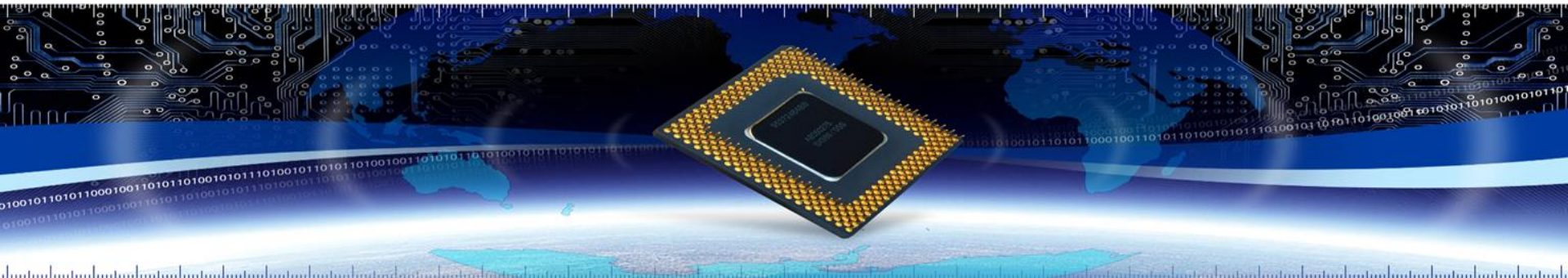
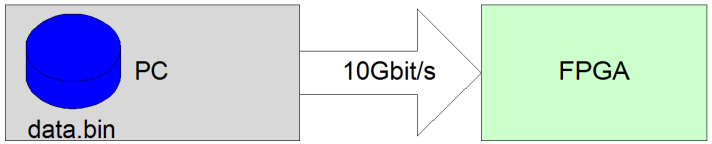
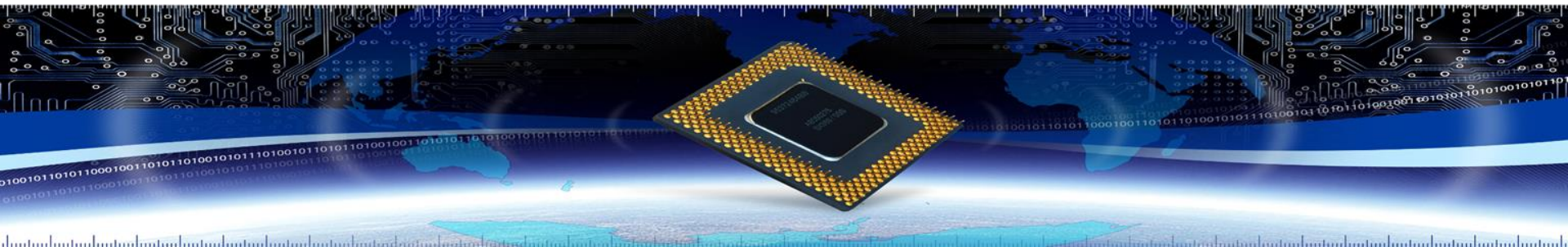


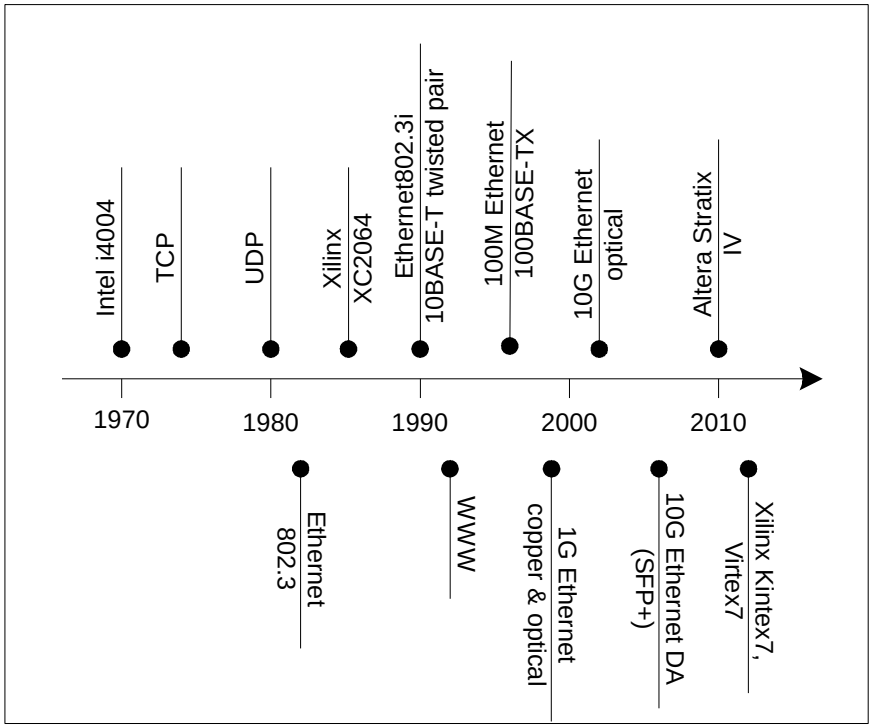
The Objective: Move large amounts of data quickly and reliably from PC to FPGA



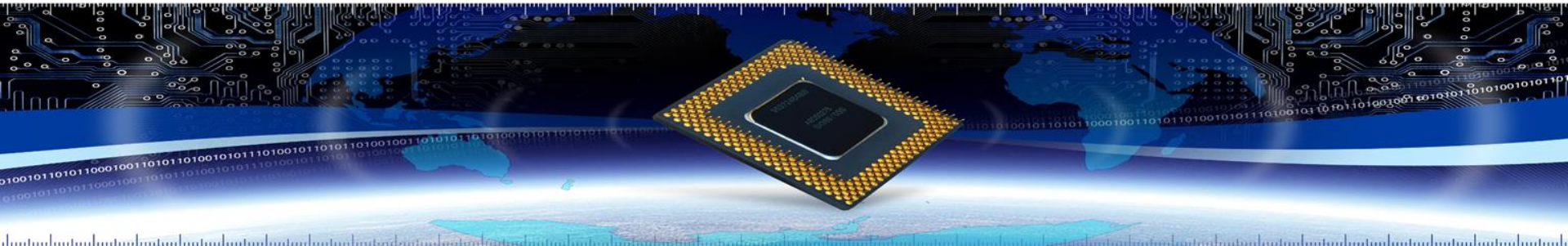
- Candidate protocols
  - DVI, HD-SDI — High data rates but not ultra-reliable, not error free
  - USB, SATA — Reliable but not very high throughput, short range
  - PCI — Reliable, high throughput, short range
  - Ethernet — (TCP/UDP) High throughput, long range



10 Gigabit Ethernet

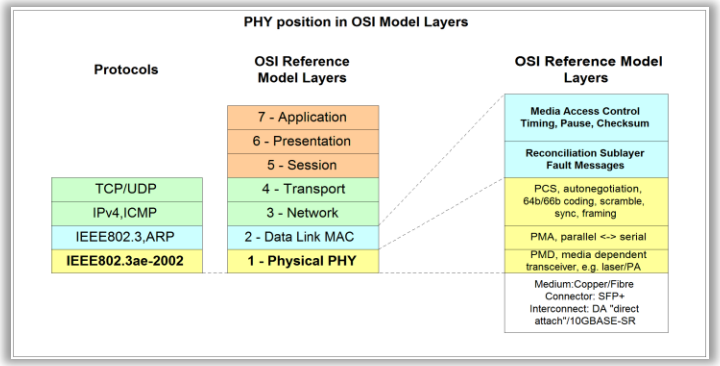


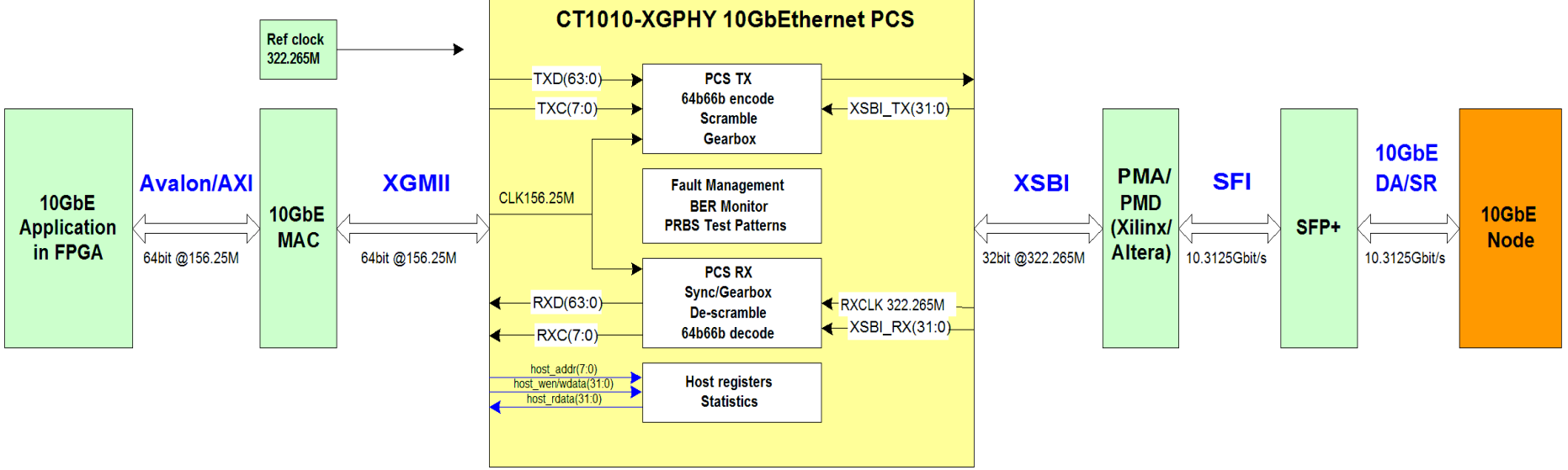
UPPER LAYERS	7	**Application Layer** ✓ Message format, Human-Machine Interfaces
UPPER LAYERS	6	**Presentation Layer** ✓ Coding into 1s and 0s; encryption, compression
UPPER LAYERS	5	**Session Layer** ✓ Authentication, permissions, session restoration
TRANSPORT SERVICE	4	**Transport Layer** ✓ End-to-end error control
TRANSPORT SERVICE	3	**Network Layer** ✓ Network addressing; routing or switching
TRANSPORT SERVICE	2	**Data Link Layer** ✓ Error detection, flow control on physical link
TRANSPORT SERVICE	1	**Physical Layer** ✓ Bit stream: physical medium, method of representing bits



The PHY Layer 1

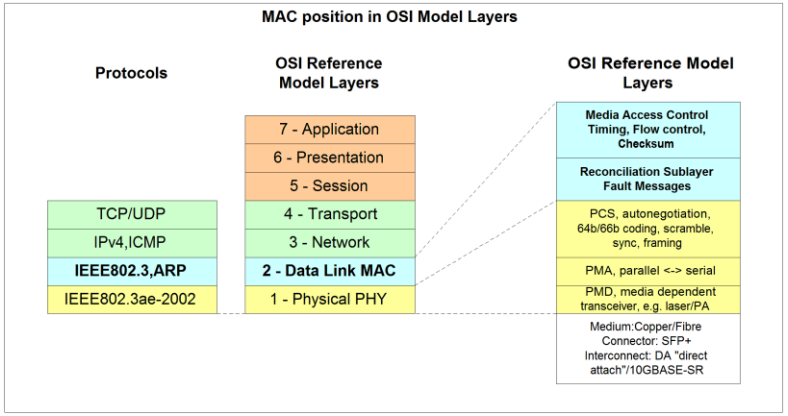
- IEEE802.3ae-2002
- XGMII –10G Media Independent Interface, 32bit @312.5MHz.
- 64B66B Encoding & Scrambling - EMI reduction
- Gearbox - 10Gbps <-> 10.3125Gbps
- Clock Rate adaptation - handle +/-100ppm difference
- PMA – Parallel<->Serial, CDR, Gigabit transceivers

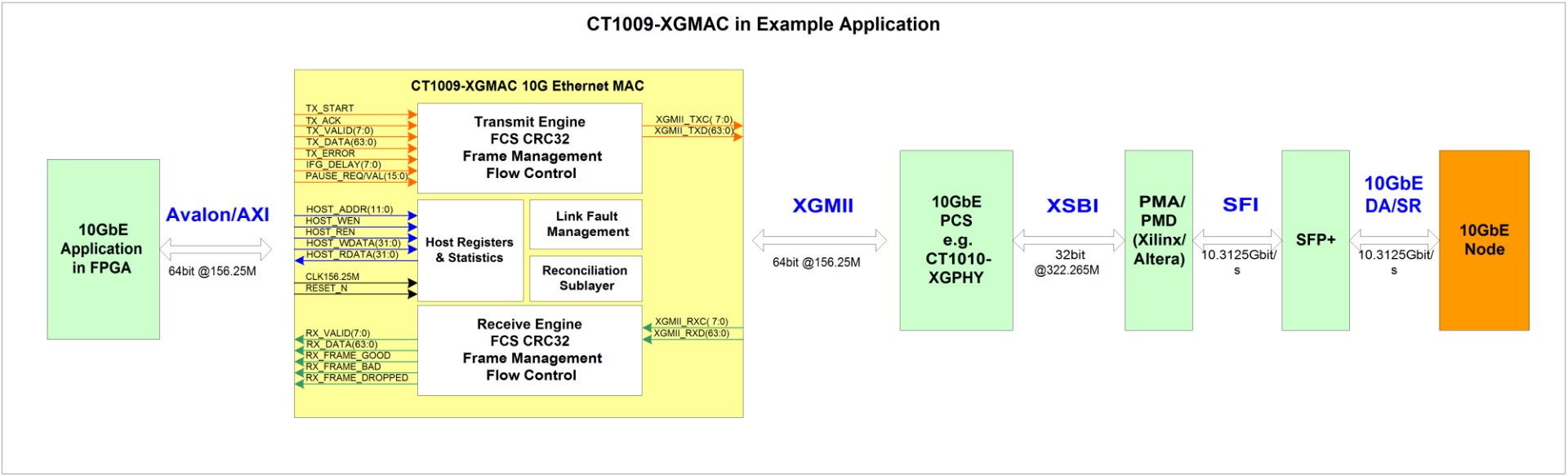




The MAC Layer 2

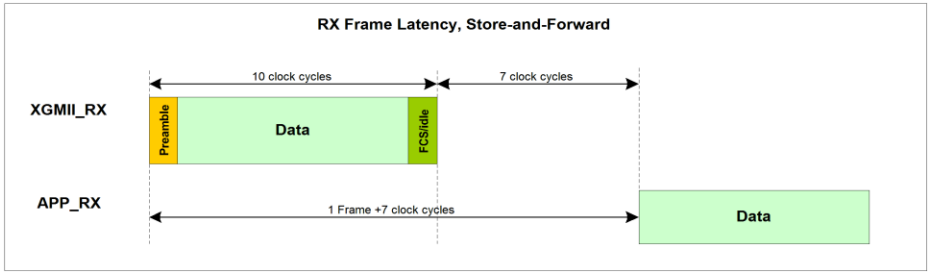
- XGMII –10G Media Independent Interface, use any PHY, 32bit @312.5MHz
- XAUI/XGXS "XGMII extension Sub-layer" between MAC /PHY, e.g. an external IC, backplane.
- XAUI rate 4 pairs @ 3.125GHz each way. 8b/10b
- Application – Streaming Interface (user specified, e.g. Avalon,AMBA,other)

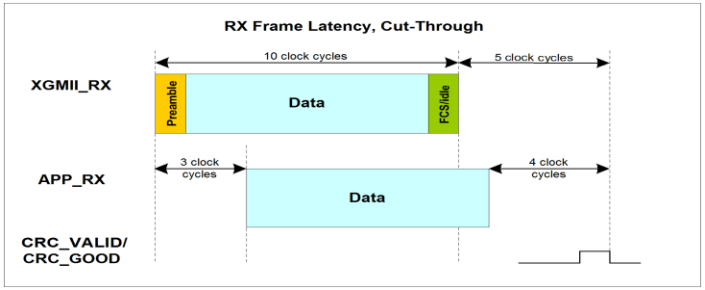


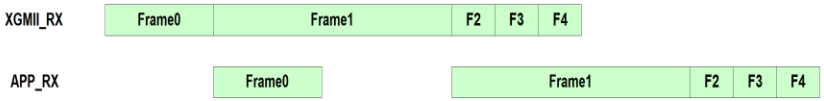


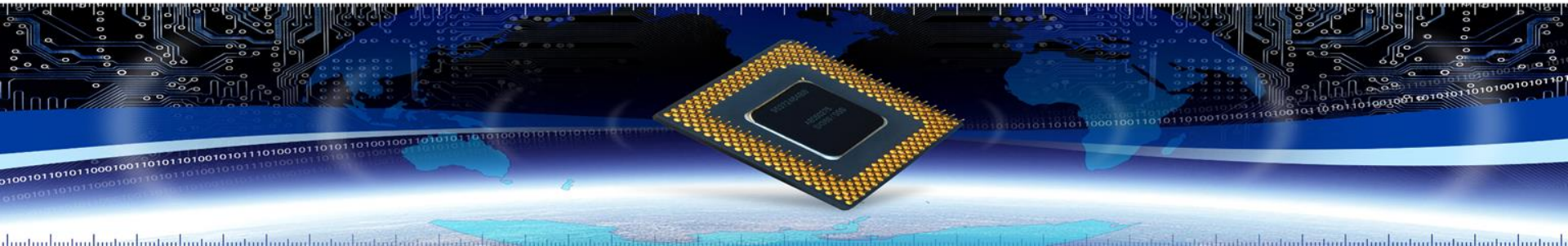
Store&Forward vs Cut-through

- Store-and Forward. No bad frames leave the MAC. Variable and longer latency
- Cut-through. Fixed and shortest latency. Possible “clean-up” required at App



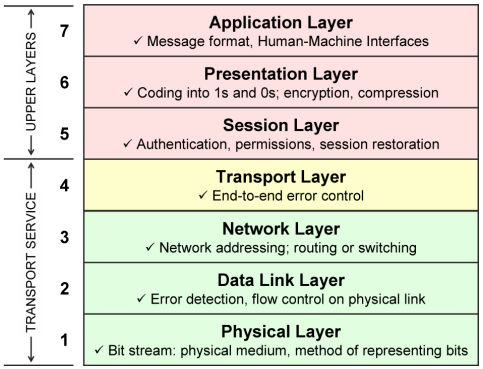


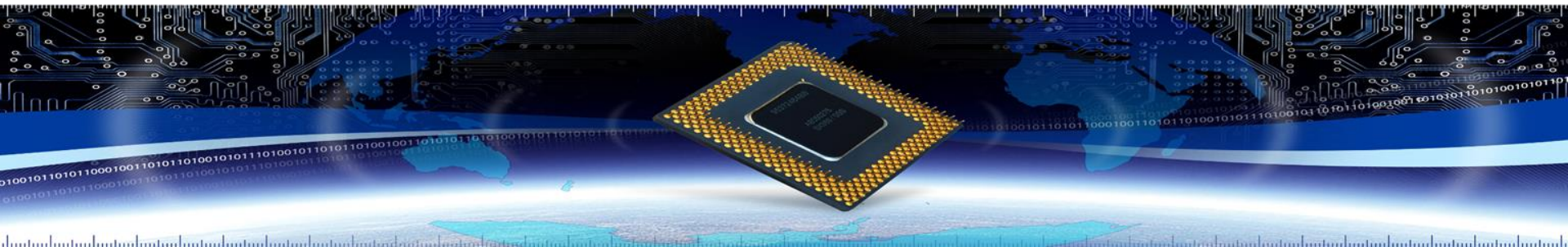




Transport Layer 4 Protocols

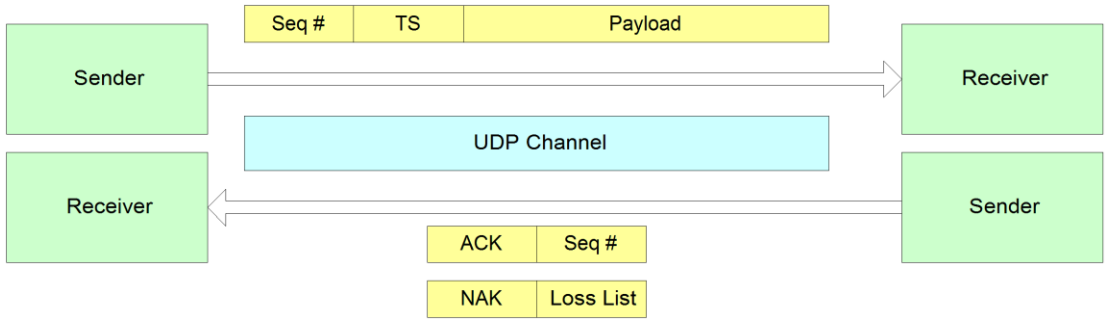
- TCP connection oriented
  - “Stream of bytes” between applications over sockets
  - Guaranteed delivery
  - Correct Order
  - Server and Client roles
  - Complex protocol, 1GHz CPU resources for each 1Gbps TCP traffic
  - Point-to-point only
- UDP connection-less
  - “message oriented” frames between applications over sockets
  - Uncertain delivery - “Send and forget”
  - No re-ordering
  - UDP message remains intact
  - Simple protocol, no sequence number, no ACK
  - Broadcast/Multicast/Unicast



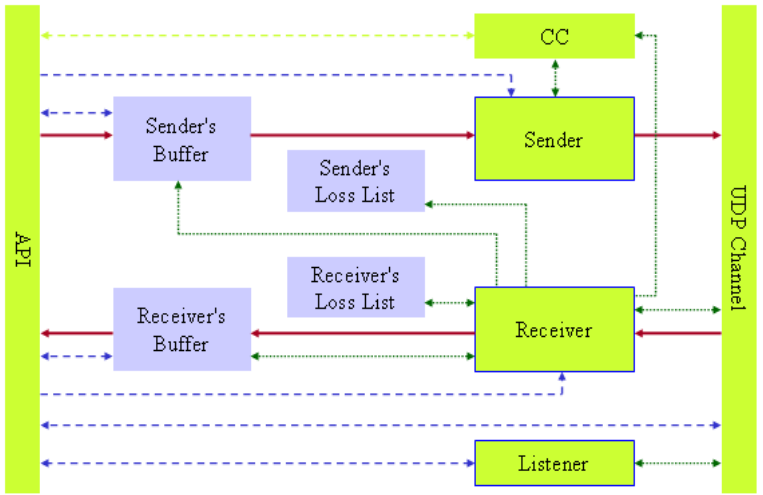


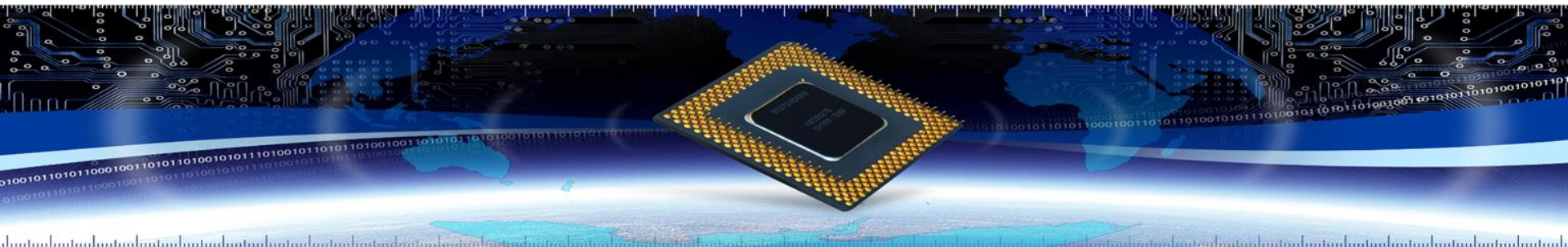
The UDT Protocol Layer 5

- UDT4 (UDP based Transfer Protocol) Yunhong Gu, University of Illinois at Chicago 2007
- Light weight – UDP with Sequence numbers
- Sliding Receive Window
- Lost packets are sent individually



- Identical nodes maintain Loss list
- Congestion Control

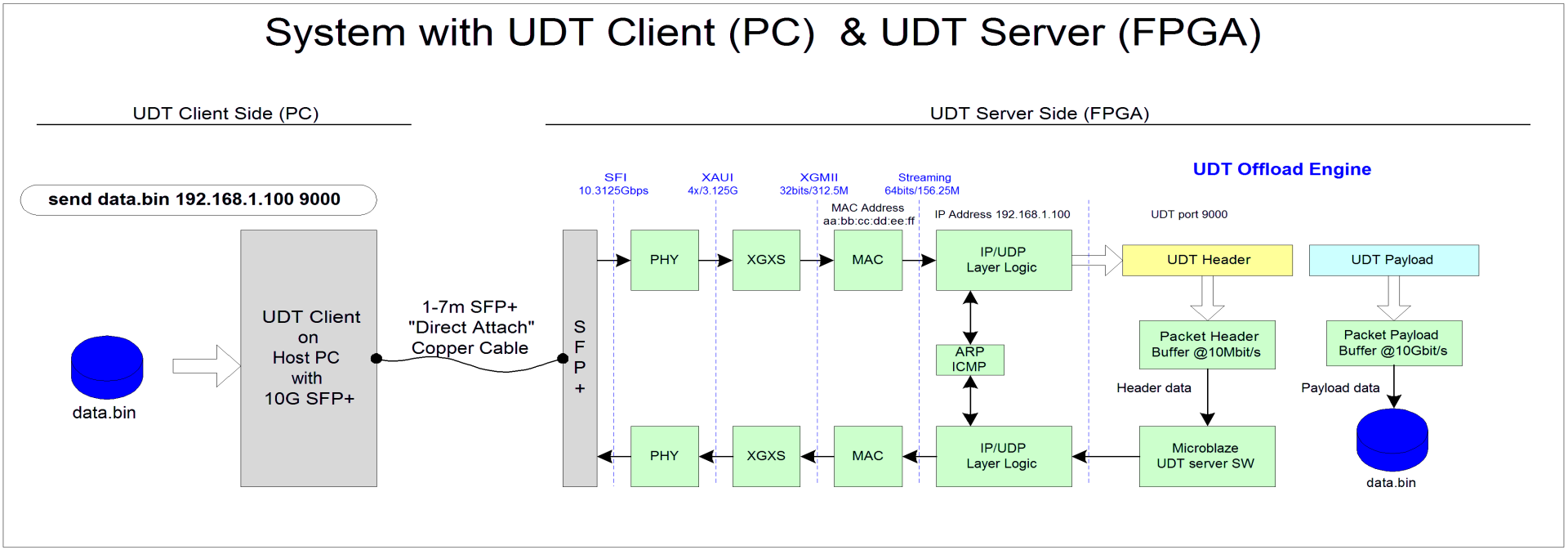




UDT Server in FPGA

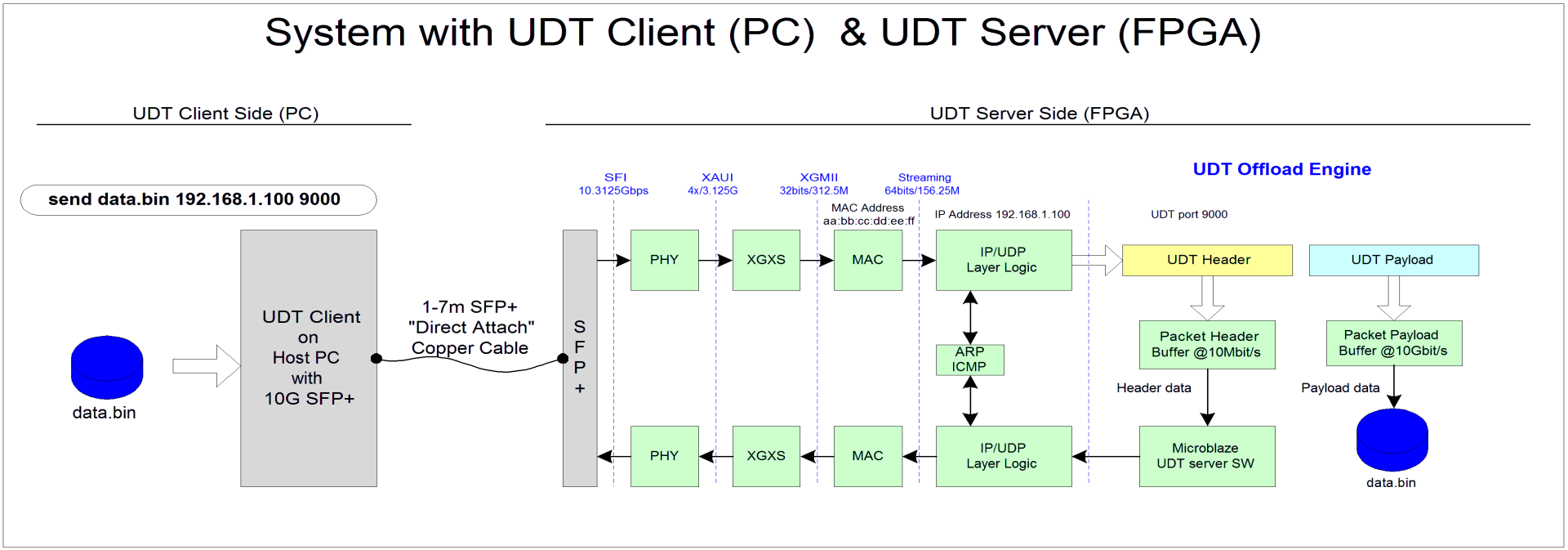
Offload Engine Tasks

- Separate UDT Payload from UDT header – process separately CPU / RTL
- Move UDT Header to Buffer - Microblaze CPU processes UDT protocol Header
- Move UDT Payload to Buffer - RTL processes UDT protocol Payload
- Microblaze CPU sends response – ACK, maintains & sends loss list, etc



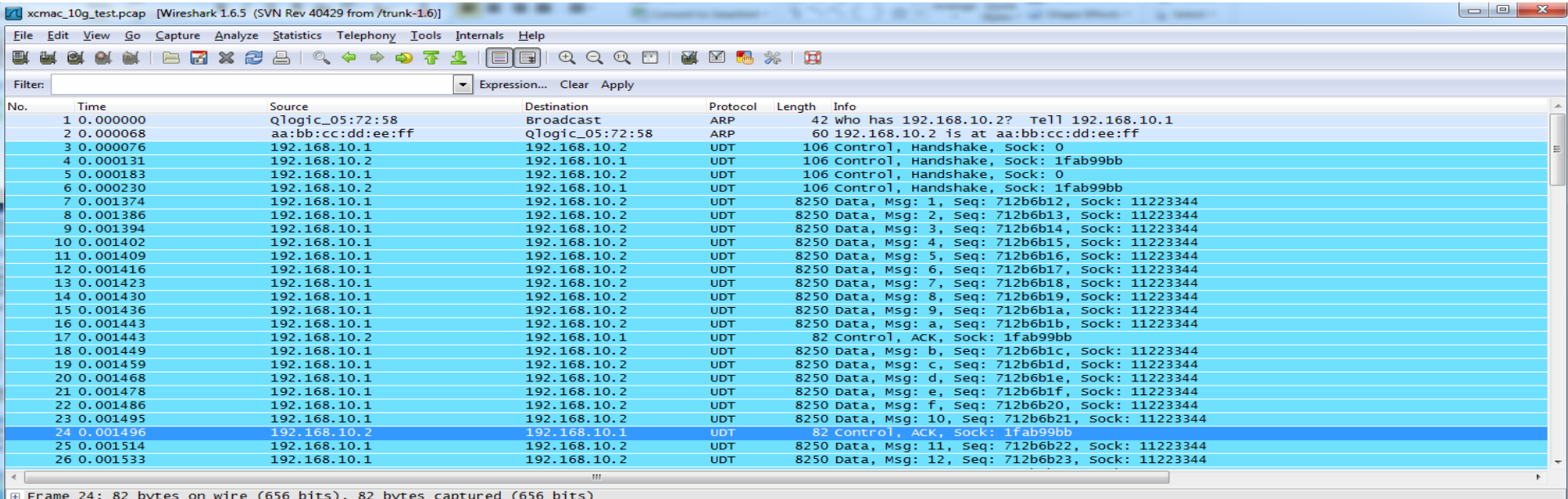
Verification using Simulation

- Simulation - Modelsim
- Vector tools
  - pcap2sim("xgmac_10g_test.pcap",[1,(3..25)],“vector.bin")
  - sim2pcap(“sim_result.bin" ,”sim_result.pcap”)
- Unit Tests
  - MAC/IP Address
  - PING, ARP
  - Filtering, UDT server



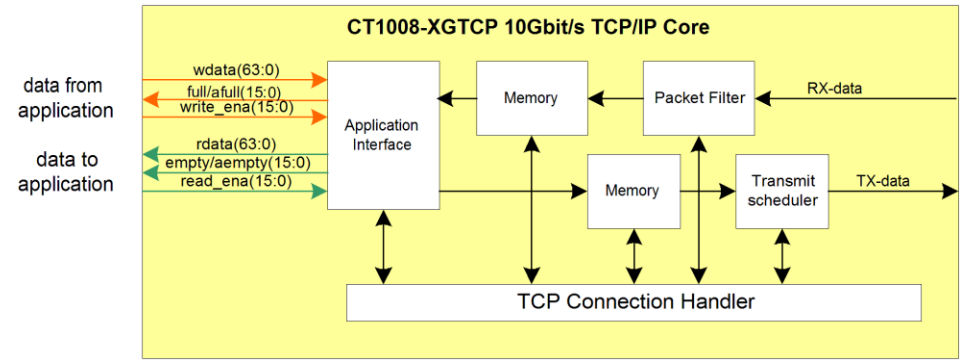
Verification on Hardware

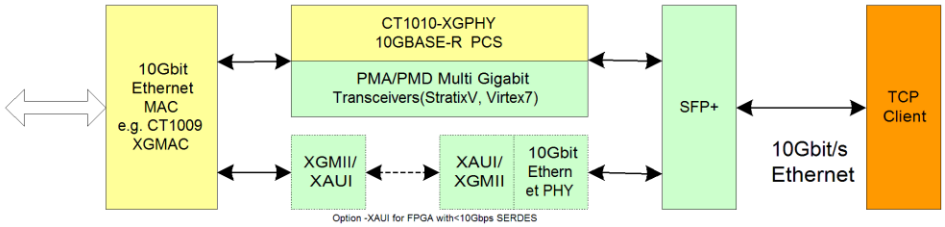
- Traffic Analysis – Wireshark
- Send something to the FPGA
  - > send.exe filename 192.168.1.102 9000
- Unit tests verify data is sent correctly to FPGA
  - Rate >9.5Gbit/s, error-free
  - Errors, bit errors, dropped packets
  - Flow Control
  - “Soak test”, check DDR3 memory content

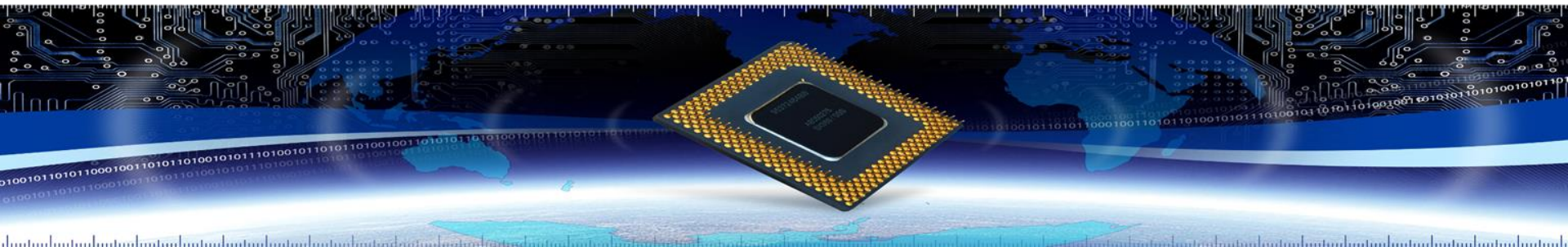


Designing for 10G in FPGA

- PHY – XGPHY - new possibilities in FPGA with SERDES > 10G (StratixV, Virtex7). XAUI option for slower SERDES FPGAs.
- MAC – XGMAC - easy to integrate, lean on resources, low-latency
- IP/TCP – XGTCP – easy to integrate, lean, optimised for few connections
- IP/UDP – UDT Server – easy to integrate, optimised for high bandwidth & distance







Thank You

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