IEEE 1394 Tutorial
Agenda

- 1394 History and Market
- Technical Summary of 1394
- 1394c: 1394/802.3 coexistence
- 1394/802.15.3 cooperation
- Future cooperation
IEEE 1394 History and Market Summary

Michael Johannes Teener
Chair P1394c WG
mike@teener.com
Agenda

• History

• Current market

• Developing markets
Prehistory: 1986-87

- IEEE Study Group started September 1986
  - Too many different serial busses …
  - IEEE Working Group approved December 1986
  - First paper, "Reducing the Tower of Babel", January 1987
- Basic design set by January 1987
  - Cable (10m) and backplane environments
  - 2 Mbaud/sec base rate, 8 Mbaud/sec optional high-speed rate
  - Bit-serial arbitration, 4B5B data encoding
  - Guaranteed latency
  - Read/write/lock transactions with 32-bit address space
  - Cost for silicon/connector/cable of < $15
- Draft 1.0, November 1987
System support begins: 1988-91

- Apple starts full scale development
  - Isochronous data a requirement for digital sound
  - Data rates of 12.288 and 49.152 Mbaud/sec, 4B5B optical interface
- IBM and Apple want a better SCSI
  - Data rates up to 49 Mbaud/sec, 196 MBaud/sec growth
  - Apple works on optical interface, invents LVDS instead
    - separate clock, drops 4B5B encoding
- Higher layers become robust
  - 64-bit addressing adopted
  - DMA control for disk drives
- Actual implementations!
  - Xilinx-based 12.288 Mbaud system
  - 49.152 Mbaud cable transceiver fabbed
Cross-platform: 1992

- Physical layer solidifies
  - hierarchical arbitration, full bit repeating at PHY
  - Apple designs 98.302 MBit/sec PHY
  - TI builds first test chips
  - Connector based on Nintendo Gameboy
- Return of encoding?
  - DC-Balanced code of 8B10B may be needed at 192 Mbit/sec
  - SGS-Thompson proposes Data-Strobe encoding, allows 393Mbit/sec using same cable/transceiver
- Higher layer improvements
  - simplified isochronous arbitration (no ordering)
  - SCSI-3 Serial Bus Protocol (SBP) effort starts
- Jerry Marazas of IBM takes over as chair
  - Thank you Jerry!
It works, it works! 1993

• TI delivers “draft 6” PHY
  ... and it works!
  – NCR (->ATT->Symbios->LSI) announces intention to build P1394 IC’s

• Comdex demos
  – IBM/Maxtor/Adaptec
  – Apple/IBM/Western Digital
  – Apple and TI win “Most Significant Technology” award

• Standardization finishes
  – Final connector wars over
  – Bus management closure
**Becoming reality: 1994-1997**

- IEEE 1394-1995
  - Official standard after two ballots
- First products
  - Sony DV camcorders in 1995, many others by 1997
  - Sony machine vision cameras
- PC OEMs show interest
  - 1394 “truth session” at fall 1995 Comdex
- Open HCI definition
  - Standard programming model for PC link interface
  - Wintel/Apple/Sun work together!
- New standards efforts
  - P1394b: gigabit/long distance
  - P1394.1: bridging
  - P1212r: reality check
Accelerating growth: 1998-2002

• Patent pool established
  – $0.25/end user system (regardless of the number of ports or internal nodes)

• PCs from Apple, Compaq, NEC, Sony with 1394 on the motherboard
  – Apple and Sony commit 100%
    • iMovie, the first killer application
  – Disk drives! Printers!

• Consumer electronics expands
  – DVB, EIA, FCC specify 1394 for standard digital video interface
    • First 1394 DTVs from Mitsubishi and Sony in US
    • DTV/STB/VCR/PVR in Japan
  – Audio products from Pioneer, Philips, Yamaha

• 1394b finished
  – 786 Mbit/sec PHYs from TI, “FireWire 800”
    • 5m STP cable, 100m GOF shipping
  – 98 Mbit/sec cat5, 100m networks from TI
  – 1573 Mbit/sec PHY specified

• IP 1394 implemented
  – Windows 98/XP, Mac OS 10.3
Latest developments

- p1394 revision
  - combine 1394/1394a/1394b plus errata and enhancements (perhaps 1394c)
  - 3146 Mbit/sec PHY definition
- p1394c
  - 796 Mbit/sec cat5 100m network using 1000baseT PHY technology
  - negotiation to allow either 802.3 or 1394 protocols
- 802.15.3 Protocol Adaption Layer
  - Allows any PAN that uses the 802.15.3 MAC to carry 1394 protocols transparently
Current market and projections

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source: In-Stat-MDR report IN030582MI, May 2003
Market notes

• Other, smaller markets not included
  – Industrial vision/sensors/robots
  – Professional audio and video equipment
  – Aerospace

• Automotive numbers are probably too conservative

• PC peripherals are probably quite conservative unless “external PCI Express” becomes reality
Market trends

• Consumer audio and video gear are naturals for 1394 and greatest long term growth
  – DV, MPEG, uncompressed A/V uses continue to expand
  – Automotive is interesting subset
• PCs want to connect to CE gear, so 1394 will continue in consumer PCs and those used for content creation
• PC peripherals will continue to grow, but more modestly
  – Low overhead, adequate power sourcing, extra performance keeps market niche open w/r/t USB
Possibilities for the future

- Wireless shows signs of being unifying force for protocols
  - 802.15.3/WiMedia support for 1394 PAL as well as traditional IP networking
  - 802.11e work partially completed
    - same basic approach as for UWB

- Process should be continued for wired networks
  - Ethernet in some form could provide backbone for 1394 local clusters
  - but only if similar QOS is provided
    - hence, my interest in “residential Ethernet”
Thank you!