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

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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
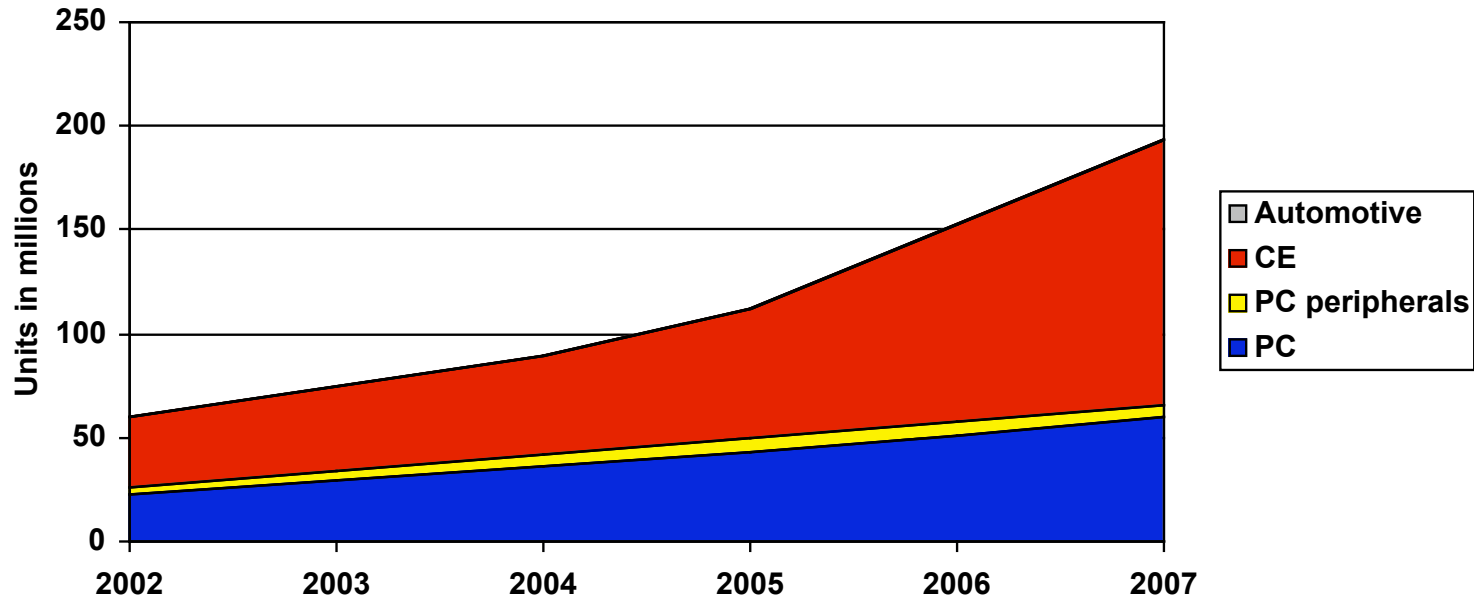
	2002	2003	2004	2005	2006	2007
PC	22.67	29.61	36.36	43.49	51.01	59.47
PC peripherals	3.84	4.41	5.31	6.06	6.85	5.94
CE	33.51	40.99	48.04	62.47	94.35	127.71
Automotive	0.00	0.01	0.04	0.10	0.40	0.75
Total	**60.02**	**75.02**	**89.75**	**112.12**	**152.61**	**193.87**

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!