Broad Market Potential of 100GE Transceivers

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Outline

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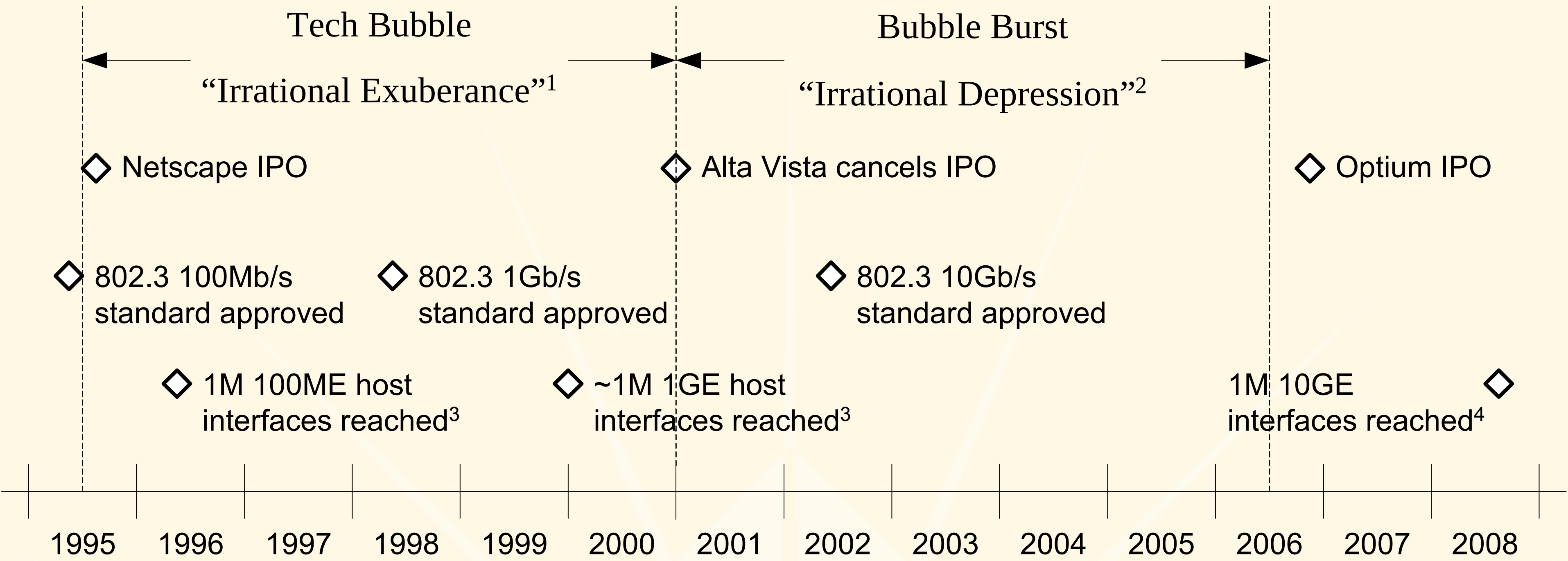
Broad Market Potential in the Data Center

- "[Server system throughput roadmap implies 100Gbps in 2014]" "100Gbps will not be usable by servers until 2015."
  Sun Microsystems: Shimon Muller, et.al., HSSG presentation, Jan.'07
- "Due to technology economics, it will take 100 GigE 5+ years, after standard adoption, to begin ramping up in the enterprise." "100GigE ramp-up in the data center will likely not occur until 2015."
  IBM: Renato J Recio, Chief Engineer, eSystem Networks, Feb.'07
- "One can expect higher volume 100GE server adoption to start in 2012. This is when process technology improvements will lead to high volume extreme multi-core / processing power per server that will be many times what it is today."
  HP: Michael Krause, HP Fellow Engineer, Enterprise Storage & Servers, Feb.'07
- Given this Broad Market Potential, what is the right timing for a 100GE standard?
  1. Adopt 100GE after 2010, with the assumption that a quick ramp-up to high volume can take place, similar to 100ME and 1GE.
  2. Adopt 100GE before 2010 (i.e. start working on the standard now,) with the assumption that it will take many years and several iterations to mature 100GE technology to be able to support ramp-up to high volume.
- Past technology trends suggest that early standard adoption will lead to the soonest availability of low cost 100GE.

Economic Trends



[1] Alan Greenspan, Federal Reserve Bank Chairman

[2] Eli Noam, Columbia University Professor

[3] Shimon Muller, et.al., "HSSG Speeds and Feeds Reality Check," Jan., 2007, IEEE

[4] Christian Urricariet, Finisar Product Marketing Forecast, Feb., 2007

10GE Standard Observations

- Comparisons of relative adoption rates of past standards, should include underlying economic trends, as the timing of these standards is not the only factor determining the rate of new IT spending.
- The choice of 4 x 2.5G (3.3G) interface for Gen1 10GE, which required a SerDes function to match Optical I/O to MAC I/O rate, was not in itself problematic. Transponder complexity was due to including the PCS function.
  - Conclusion: Put the PCS in the MAC.
- The 10GE-SR 300m reach on OM3 drove the link budget at the expense of VCSEL yield, adversely impacting cost.
  - Conclusion: Balance reach goals and OSA manufacturing yield by providing large optical link budget margin.
- The 10GE-LR (10km) and 10GE-ER (40km) standards are different technologies (although typically photo-receivers are responsive to both 1310nm and 1550nm.)
  - Conclusion: If possible, define the 40km reach to use incremental technology with respect to the 10km reach.
- There have been many 10GE MSA Transceiver form factors.
  - Conclusion: If possible, define only one form factor per I/O type. This implies that there should have been three 10GE types: one for XAUI, one for XFI, and one for SFI.

Wire Datacom Technology Trend

ITU standard	V.22 (1980)[1]	V.32 (1984)
bit rate	1200bps	9600bps
Baud	600Bd	2400Bd
bits/symbol	2 bits/symbol 4 state QAM (or QPSK)	4 bits/symbol 16 state QAM
channels	1ch (unidirectional, split-band, i.e. FDM, over 1 wire pair)	1ch (bidirectional, full-band over 1 wire pair)
signal processing	Fixed Equalization	Echo Cancellation, Adaptive Equalization, and Error Correction

[1] An intermediate 2400bps standard, V22*bis,* uses 16 state QAM modulation.

Wire Datacom Technology Trend, cont.

IEEE standard	100BASE-TX (1995)	1000BASE-T (1999)[1]
bit rate	100Mbps	1000Mbps
Baud	125MBd	125MBd
bits/symbol	1 bit/symbol 3 state PAM (MLT3)	~2 bits/symbol 5 state PAM
channels	1ch (unidirectional over one wire pair per direction)	4ch (bidirectional over four wire pairs)
signal processing	4B/5B encoding	Echo Cancellation, Adaptive Equalization, and Error Correction

[1] The optical 1GE standard was adopted in 1998.

Wire Datacom Technology Observations

- By the time the 1000BASE-T standard was written, there was over 20 years of industry experience with DSP based wire communication, including solutions, analysis, measurements, and hardware/software approaches.
- Despite 1000BASE-T being a very difficult problem, the standard defined an excellent solution (as demonstrated by high volume shipments,) with the accumulated commercial experience being one of the reasons.
- Typically, new technology is first deployed into the high end of a market, at lower volumes and higher costs. Over time, progressively higher volumes are reached with follow on iterations.
- 100G has so far followed past technology trends. The first Transceiver, Infinera 10x10G line card, was introduced into the very top of the market; DWDM.
- To date, there is limited commercial experience with low cost, high volume 100G technologies, like complex optics integration and high speed packaging.

Conclusion: It will take multiple 100G technology iterations before low cost, high volume products are available.

40G Technology comparison to 100GE Proposals

Reach	40G alternative	100GE IEEE 802.3 HSSG alternative
100m OM3 MMF	QSFP MSA 4x10G option 850nm array	proposed 10x10G (or 12x10G) 850nm array
2km SMF	(OC768) STM256 ITU G.693 code 1x40G 1550nm	possible future standard optimized for PIC losses
10km SMF	proposed STM256 ITU G.959.1 code 1x40G[1] 1310nm	proposed 4x25G 1310nm (or others)
40km SMF	proposed STM256 ITU G.959.1 code 1x40G 1310nm (or 20km)	proposed 4x25G 1310nm (or others)
> 40km / DWDM	possible future ITU standard (DPSK, DQPSK) 1550nm	possible future standard 2x50G (DQPSK) 1550nm

[1] Another 10km 40G alternative is proposed ITU G.695 code 4x10G 1310nm, with one possible implementation defined by X40 MSA.

40G Technology Observations

- There are a number of 40G Transceiver alternatives and standards that are available, or will be available. If possible, these should be taken advantage of for 40G applications.
- The mainstream short reach (40km and less) 40G technology is serial, which requires low complexity optics in high speed packaging.

  Conclusion: 40G technology development will benefit low cost 100GE technology development in the area of high speed packaging.

Discussion

- There is Broad Market Potential for 100GE Transceivers in the data center.
- Low cost 100GE Transceivers will require new optics integration and high speed packaging technologies to address high volume markets.
- Past trends suggest that new technologies require multiple iterations before they can address high volume markets.
- High end markets are ideal for introduction of new technologies, such as 100GE Transceivers, as they support higher costs at lower volumes.
- Timely availability of low cost 100GE Transceivers for high volume data center applications is enabled by early completion of a 100GE standard.