What's new about 1394b?

Michael Johas Teener
CTO, Zayante, Inc.
269 Mt. Hermon Rd. STE 200
Scotts Valley, CA 95066
+1-831-461-4900

ZAYANTE

Agenda
Same familiar 1394, but with:

- **Higher speeds to 3.2 Gbit/sec**
  - new coding (8b10b + scrambling + control coding)
- **New arbitration (BOSS)**
  - overlapped, pipelined arbitration, hybrid bus operation for backwards compatibility
- **CE-friendly high speed connector w/backwards compatibility**
- **Longer distance to 100m per hop**
  - a “greener” standard with its emphasis on lower emissions
  - new media, but all compatible above the media dependent level
- **New integration model (PIL-FOP)**

ZAYANTE

But why improve 1394?

PC peripherals need higher speeds

- Disk head read rates continue to increase.
  - S400 on existing PCs and Macs is not enough: 1 Gbit/sec needed in 2001, growth path to over 2 Gbit needed in a few years.
- Imaging devices have higher and higher pixel densities and color depths

Home network needs high speed, low bit error, guaranteed latency

- CE devices already use 1394 for video and audio streams
  - Virtually all DTVs, STBs, VCRs, and DVDs will be 1394 by 2002.
- 6-20 Mbit/sec MPEG-2 streams for DTV
  - Very good error rate required (loss of I-frame disastrous)
- … and 1394 is also a dandy peer-to-peer IP network

ZAYANTE

First: what hasn't changed

Same ...

- point-to-point connection model
  - but now has loop healing
- logical bus model
- peer-peer operation
- user friendliness - plug and play
- transaction and addressing models
- asynchronous operation model (including fairness)
- isochronous operation model

IDENTICAL FUNCTIONALITY **above the link layer**

- existing software will work unchanged

Existing devices are all "home network ready"

ZAYANTE

What is 1394b, really?

Additional "Beta" mode of operation

- 1394a operation is called "Legacy" mode

1394b PHYs may have Legacy ports, Beta ports, or "Bilingual" ports

- Bilingual ports negotiate with attached peer for best mode of operation (Beta is MUCH better)

Beta mode yields higher speeds, longer distance, improved efficiency

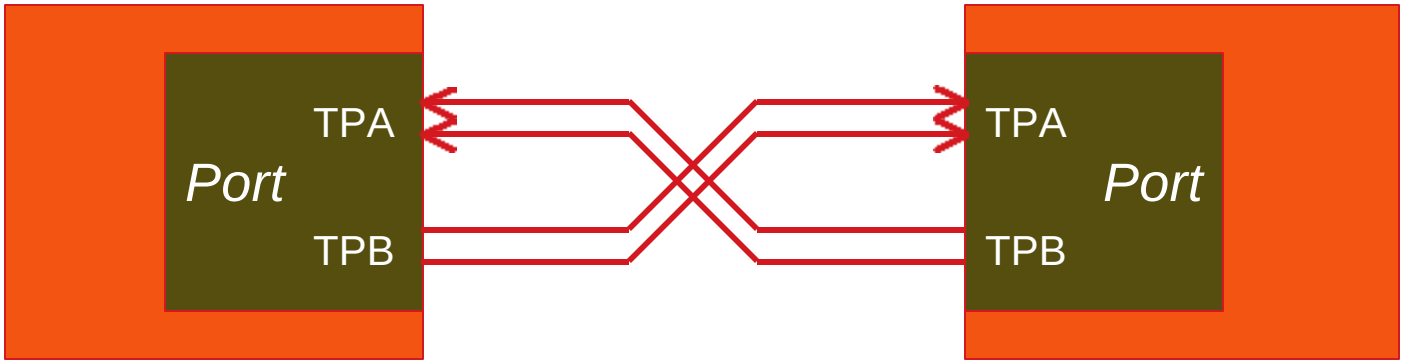
ZAYANTE

Beta mode: higher speeds

1394b specifies S800 and S1600 data transmission rates

- also future-proofs with media for S3200

- **Electrical spec still uses two twisted pairs**
- **Transmission is now continuous dual simplex**
  - one pair transmitting continuously in each direction
  - transmission speed never varies
  - simpler and more efficient than 1394-1995



ZAYANTE

Beta mode: signal encoding

Use only one scheme for data, arbitration and speed signaling

- **All signaling uses 10 bit symbols**
  - DC balanced code with bounded running disparity to combat "baseline wander"
  - limited run length for ease of clock recovery
- **Data and arbitration states use IBM's 8B10B encoding**
  - leveraged from Fibre Channel and Gigabit Ethernet
  - … but scrambled to minimize emissions

Control symbols use 10 bit codes

- all DC balanced with a Hamming distance of 2 from each other and from data for added robustness
- also scrambled

More Beta benefits

Simplifies analog design

- avoid common mode signaling, avoid bi-directional arbitration signaling

Robust error detection

- most single bit errors detected immediately, extra precautions taken to bound propagation
- control symbols duplicated for added robustness

Shorter start and end packet times

- no packet start-up latency

Same coding scheme for all media

- ideal for optical transmission
- leverage the benefit of high volume production for PHYs

The downside of Beta

Digital logic much more complex

- 2-3x more gates
- Clock recovery needed
  - Just like Ethernet, USB2

New "border" functionality needed

- For PHYs with Beta and Legacy ports
- Non-trivial design, need to preserve critical Legacy timings, subtle corner cases

Beta mode efficiency: BOSS arbitration

Legacy 1394 alternates between data transmission and arbitration

- arbitration depends on round-trip transmission time
- not scalable, so proportionately worse for higher speeds
- becomes much more significant with long distances

1394b uses overlapped pipelined arbitration

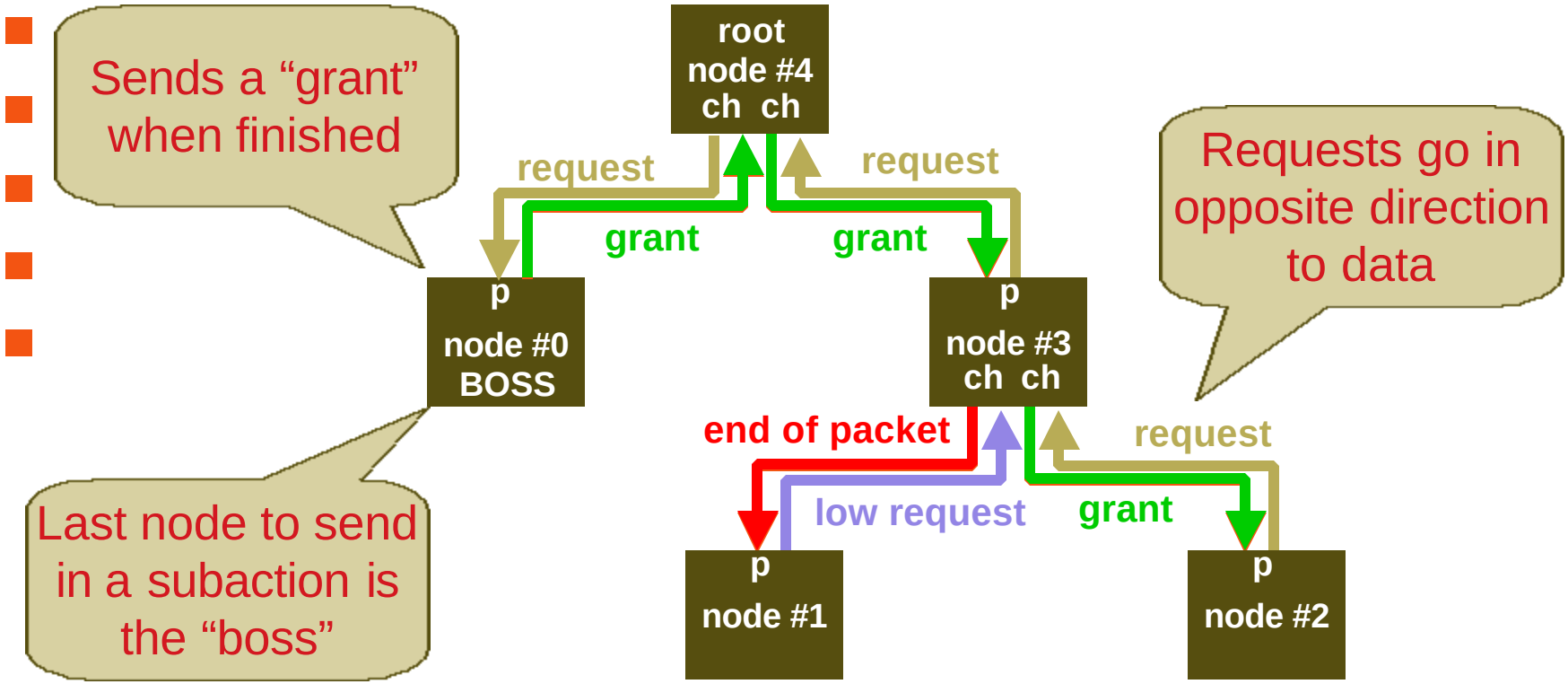
- scheme known as “BOSS”

The Boss is the currently transmitting node and decides who should transmit next

- explicit decision at the end of each subaction
- immediate decision saves the arbitration time

Overlapped arbitration

With BOSS, 1394b exploits the dual simplex property



ZAYANTE

Gaps are removed!

When the "BOSS" is finished transmitting, it knows where to send a grant

- The "end of packet" sequence includes an optional "Grant" symbol
- Each node repeating the end of packet sends the grant signal to the highest priority requestor.

Similar process removes the need for an "arbitration reset gap"

- A node can request the bus at the next fairness interval when it runs out of allocated opportunities in the current interval.
- BOSS transmits an arbitration reset symbol when only requests for the next interval are received.

Hybrid bus operation

1394b is fully backwards compatible

A port on a PHY may be implemented as

- a DS port,
  a Beta-mode only port
  a bi-lingual port

Connector keying ensures that incompatible connections cannot physically be made

A PHY may have any mix of ports operating in DS mode and Beta mode

A PHY may have a B link, a Legacy link or no link

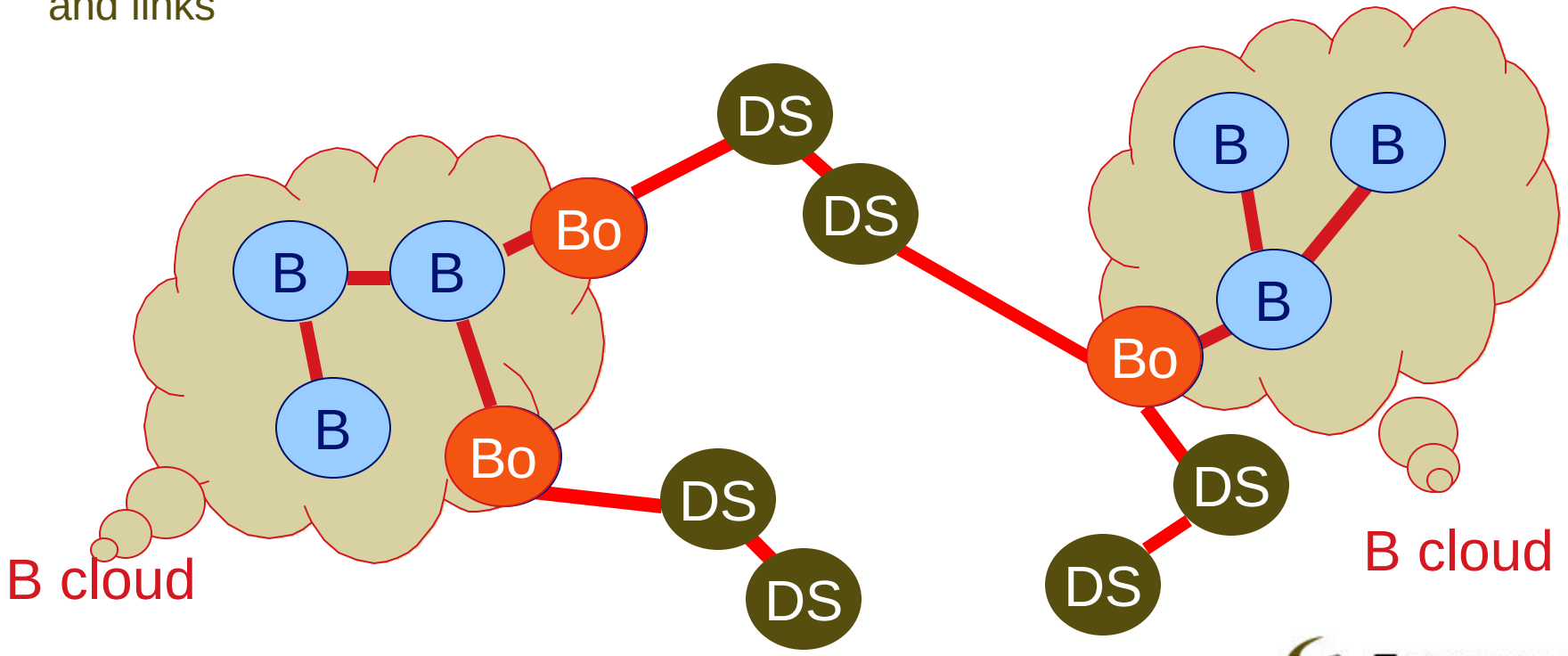
ZAYANTE

Hybrid bus operation - 2

A hybrid bus is one which contains DS (legacy) connections, and/or one or more Legacy link devices (as well as connections operating in Beta mode)

Devices communicating via Beta-mode connections group themselves into B clouds

- Border nodes connect between Legacy ports and links and 1394b Beta ports and links



ZAYANTE

Hybrid operation: summary

- **No restrictions on mixing Legacy nodes and 1394b nodes, beyond those inherent in the particular PHY chip implementation**
  - If the user can plug it together, then it works
- **Traffic within a B cloud can exploit full benefit of boss arbitration and more efficient packet formats**
  - And Beta-only nodes are significantly simpler
- **DS traffic operates as normal, with suitable gap times to ensure that all DS nodes can transmit each isochronous interval and in each fairness interval**
  - existence of more efficient Beta mode operation is totally transparent

ZAYANTE

Improved connector

New connector needed for higher data rates

- So let's make everything better
  - Much better shielding and signal isolation
- Designed for both CE and PC worlds
  - Only slightly larger than existing 4-ckt connector
  - Carries power to support PC peripherals

Keying to ensure compatibility

- Beta mode signaling is never used on a Legacy connector
- Simplifies backwards compatibility

Two variants

- Bi-lingual connector - accepts bi-lingual plug or Beta plug
- Beta connector - only accepts Beta plug

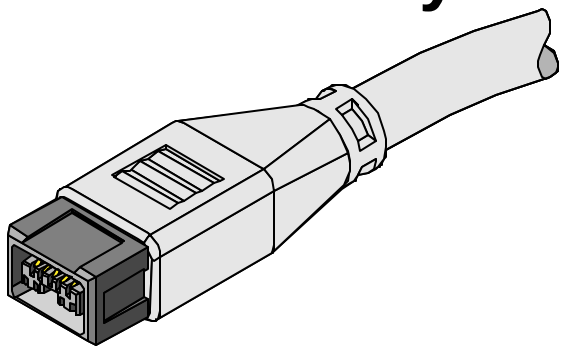
Bilingual and Beta connector plug and socket

9 pin

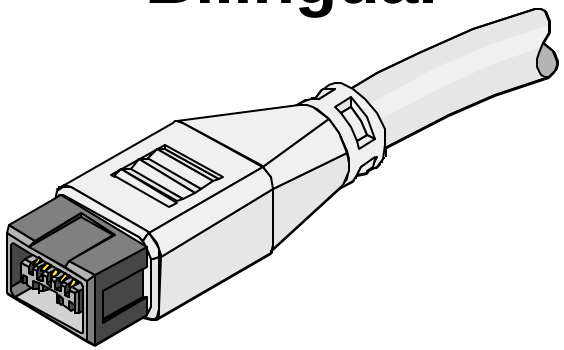
- includes power
- 2 extra pins for signal integrity
- one pin for reserved for future use

Small size - mating interface 8mm x 5 mm

Beta-only



Bilingual



ZAYANTE

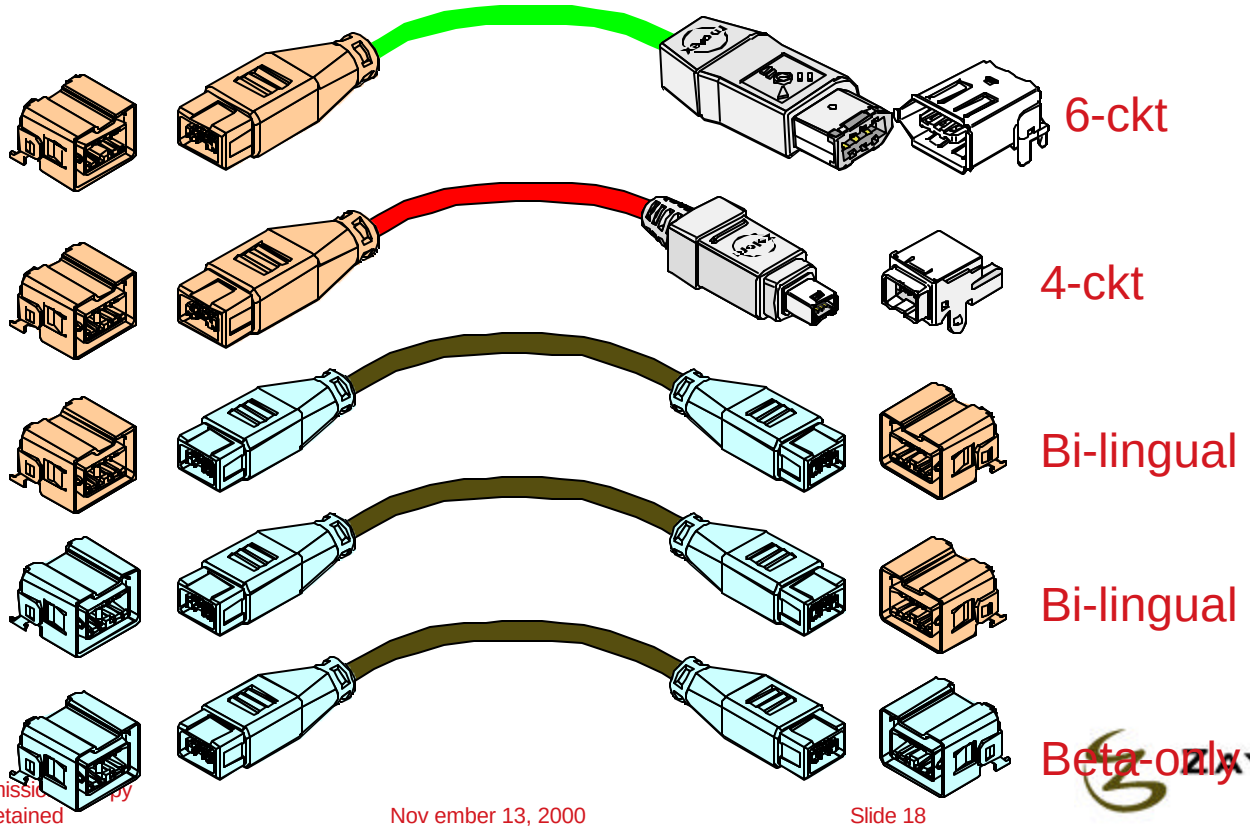
3 cable assemblies

Legacy mode cables (prevents DS to Beta-only connection)

Bilingual to 6-ckt DS (carries power)

Bilingual to 4-ckt DS (no power)

Beta mode cable **(also used for bilingual to Beta)**



ZAYANTE

Longer distance

General goal is 100m per hop

– input from VESA Home Network committee

Unfortunately, longer distance requires new media

– UPT-5 for S100

just like 100BASE-T Ethernet

– Plastic Optical Fiber (POF) for S200

S400 by 2001, S1600 by 2003

– Multi-mode glass fiber for higher speeds

road map from S400 all the way up to S3200

best for future-proof installations

ZAYANTE

Common properties

All media use the same encoding scheme

- optical media typically implemented with an optical transceiver integrated into the connector, with electrical connection to the PHY

Data and control symbols are scrambled using a side-stream scrambler before encoding

- saves 20dB on emissions
- preserves signal integrity properties of 8B10B
- essential for UTP-5
- a great help for system integration as well

Good news for UTP-5

Binary signaling, bounded running disparity and limited run length all help to simplify UTP analog

- substantially simpler than 100BASE-T, e.g. no adaptive thresholding
- less ISI for adaptive equalization to deal with
- overall signal integrity significantly better than Ethernet

1394b uses same RJ-45 connector

- but uses pairs on pins 1/2 and 7/8
  - minimizes cross-talk
  - best pins for signal integrity (pair 3/6 and 4/5 are much more problematic)

UTP-5: problem-free wiring

Polarity compensation

- a common wiring error is to connect the two wires in a twisted pair incorrectly - particularly in UTP building wiring
- 1394b detects this at scrambler synchronization time and automatically compensates

Pair-to-pair cross-over compensation

- building wiring is usually “straight-thru” - no crossover

  but Ethernet normally requires a crossover - results in two types of “patch cable”

- 1394b compensates for lack of crossover in UTP

  Result: no wiring problems, only a single type of patch cable needed

Plastic Optic Fiber

POF: 1000 µm plastic optic fiber

- suitable for S200 up to 50m
- improved version demonstrated at S400 for 100m

HPCF: 225 µm hard polymer clad fiber

- suitable for S200 up to 100m

Low cost, easy to install

Fiber alleviates emissions and interference problems

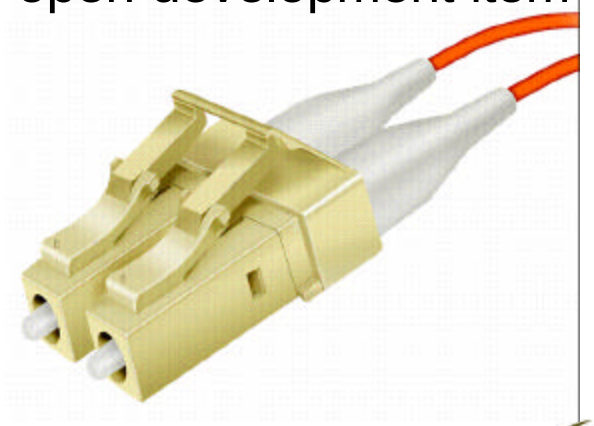
Currently use PN connector

- Japanese effort to define smaller, more friendly version

Glass fiber (MMF)

Leverage VCSEL (Vertical Cavity Surface Emitting Laser) technology

- **Leverage Fibre Channel and Gigabit Ethernet specifications**
- **50 micron multimode fiber (MMF)**
  - Media spec'd to S3200, transceiver spec'd to S1600
  - Transceiver @ S3200 is only open development item
- **LC connector**



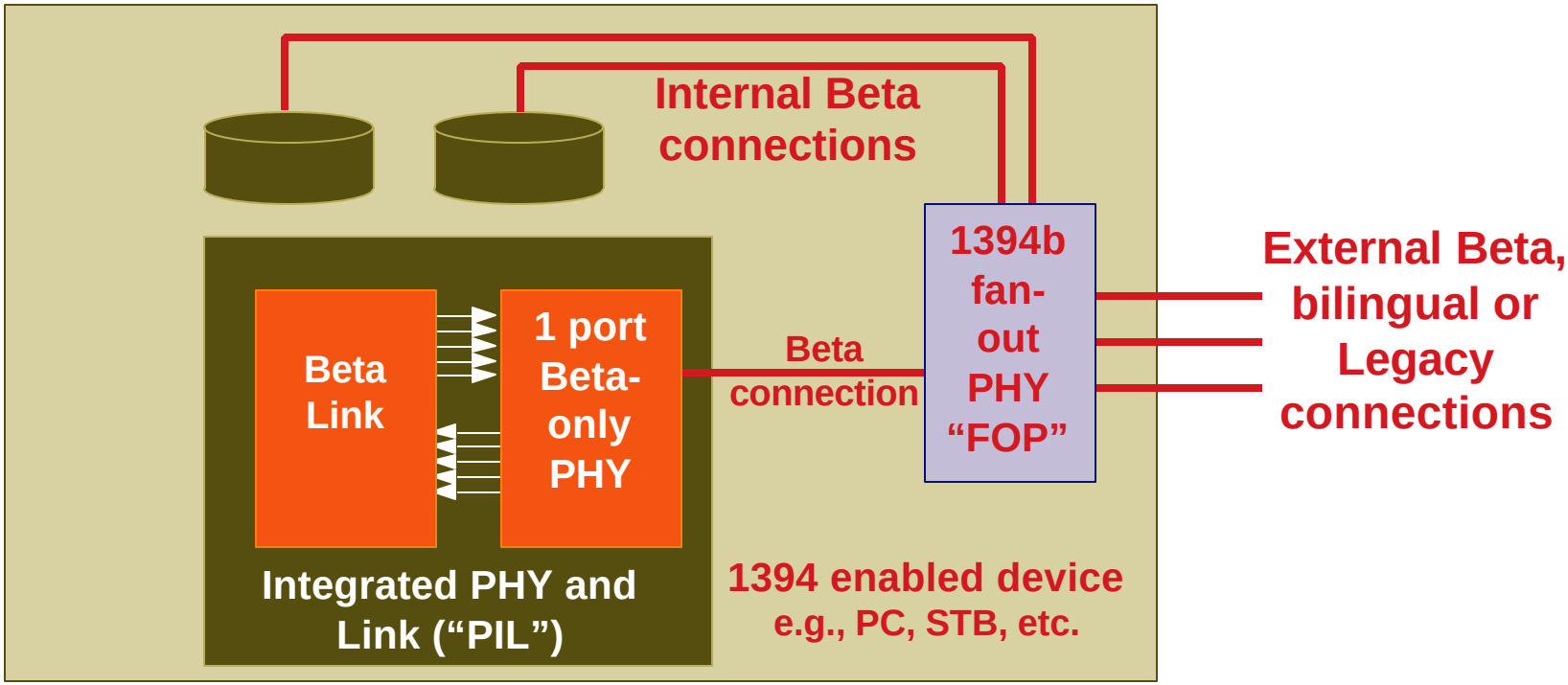
ZAYANTE

Media summary

	Reach	S100	S200	S400	S800	S1600	S3200
UTP-5	100m	✓					
POF/ HPCF	100m	✓	✓ fo	✓new	✓	✓	
50µm GOF	100m	1		✓	✓	✓	✓
STP (beta)	4.5m			✓	✓	✓	✓
STP (DS)	4.5m	✓	✓	✓			

ZAYANTE

New PC integration model



PC chipset vendor integrates "PIL" into chipset

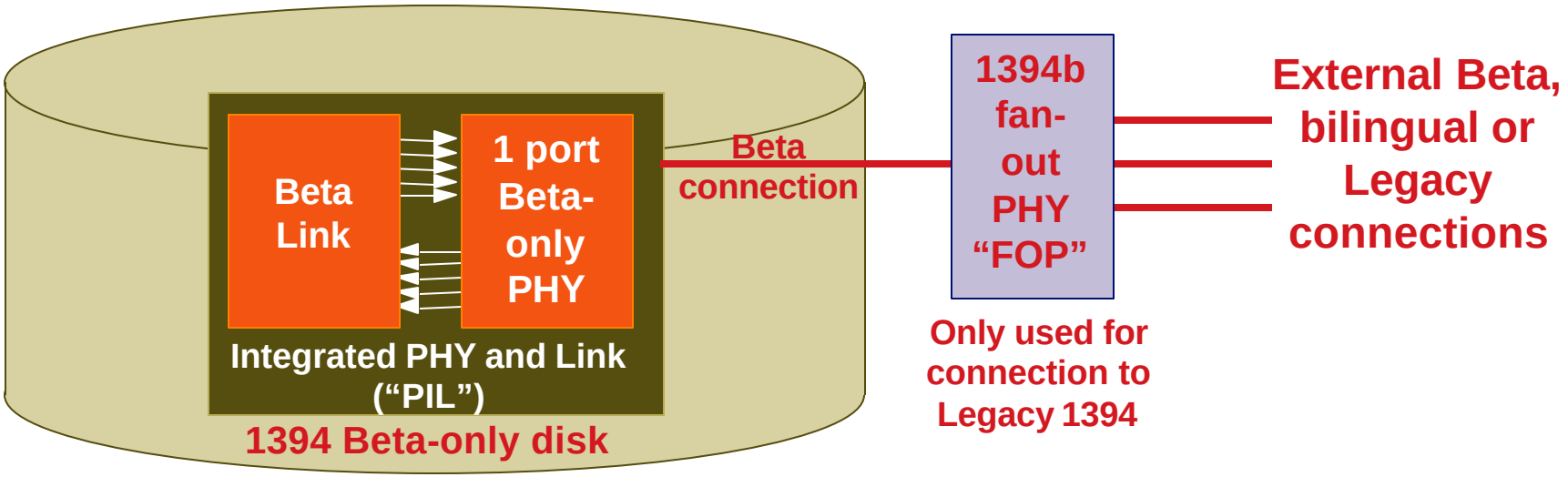
- PIL gate count relatively low (less than USB 2 controller)
- Fully enabled for 800 Mbit/sec and higher

PC OEM chooses "FOP" based on market requirements

- various choices of types and numbers of ports

ZAYANTE

1394b disks?



Absolutely! PIL-FOP model is ideal for storage OEM

Storage OEM uses PIL on disk

- High volume internal storage uses low gate count direct Beta interface
- External version use attached FOP for legacy interface or for RAID packaging

ZAYANTE

Conclusions

No change for software and applications

All existing 1394 devices are “home network ready”

- **Improvements:**
  - lower cost and more flexible for the PC OEM
  - even more efficient
  - up to 1.6 Gbits/sec
  - up to 100m
- **Fully backwards compatible**
- **Expect products this year**
  - product already available using intermediate drafts of 1394b
  - “NEC Termboy” S200, 100m repeater

Call to action!

Review 1394b specs ASAP

- Standard will go final early 2001
- Chipsets will appear by 2001, get your preferences known NOW!
  - You know how long it takes to roll a new version!
- Review mechanical and electrical requirements for connectors
  - Tooling for sockets is long lead time item

Plan on PIL-FOP interface model

- External ports must be bilingual
- Internal ports should be beta-capable

More information

Status

- First round ballot passed in April, 2000
- Ballot review committee formed, first meetings in June, 2000
- Second round ballot before end of 2000
- Final draft to be forwarded to IEEE Q1 2001

Implementations

- Lucent, NEC, Panasonic have prototype ICs announced or demonstrated.
- Zayante public commitment with multiple partners
- Omneon Video Networks demonstrated S800/300m network for professional video at NAB 2000

Internet email reflector

- “p1394b@zayante.com”, subscription information at http://www.zayante.com/p1394b

Documents

- http://www.zayante.com/p1394b

ZAYANTE