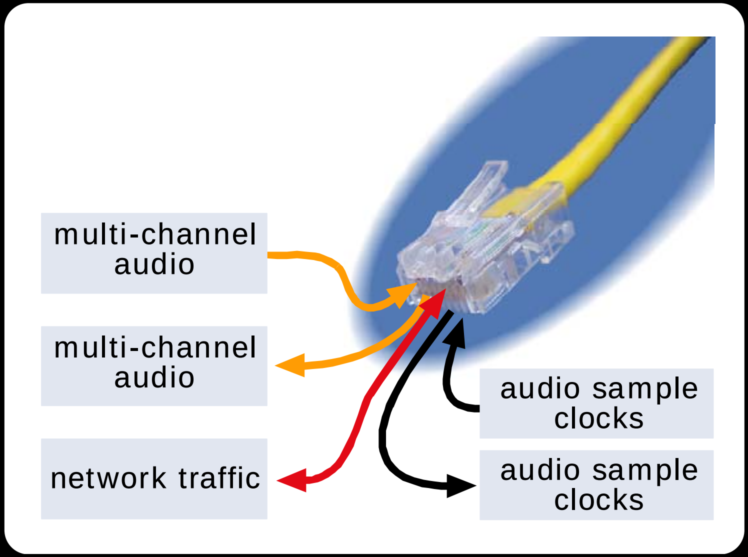
AES50-2005

High Resolution Multi-channel Audio Interconnection



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The Plan

- How it came to be
- The philosophy
- How it actually works
- What you can do with it
- Real-world progress, and the future

How it came to be

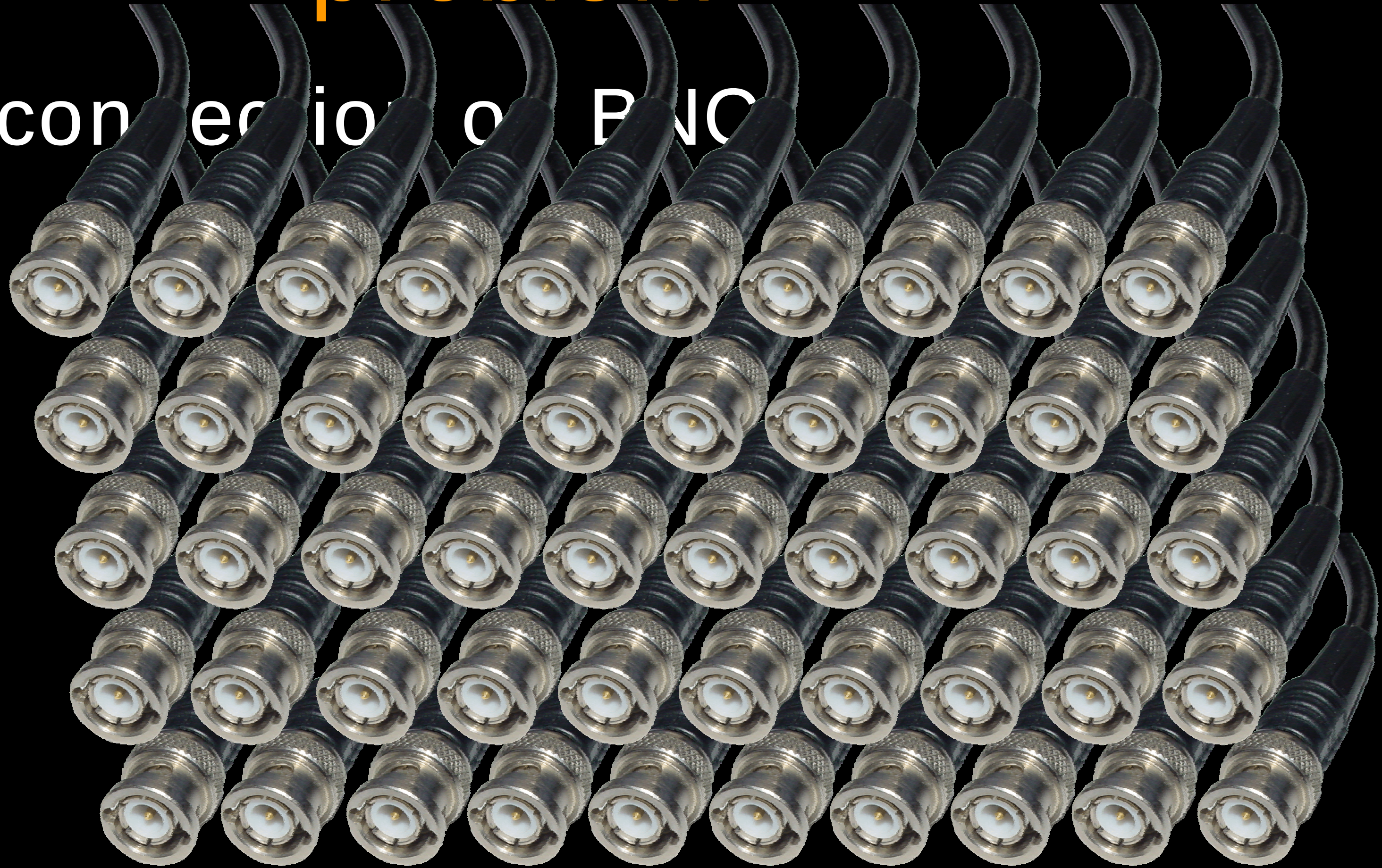
Rewind to early 2002...

The original engineering problem

- Super Audio CD pro-application engineering
- Direct Stream Digital (DSD):
  - 64x 44.1 kHz sample rate = 2.8224 MHz
  - 1-bit samples
  - Delta-sigma modulated

The original engineering problem

- DSD connection on BNC



Desired solution...

- Use one Cat-5 cable
- Full-duplex
- Suitable for pro-studio use
- Latency ~ 10s of microseconds
- DSD sample clock

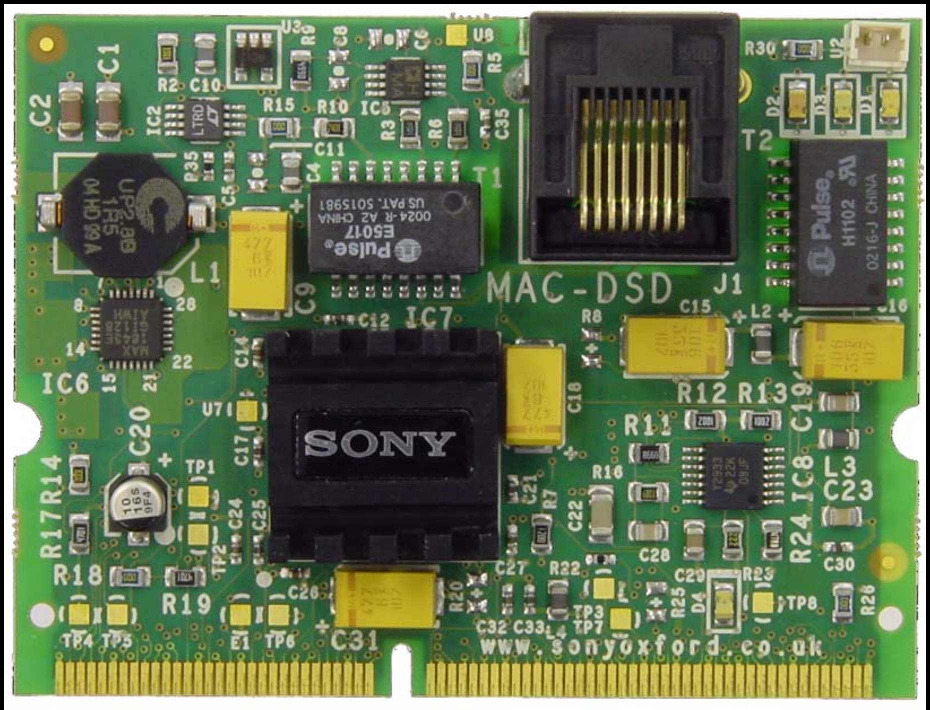
Enabling technology

- 100Base-TX (“Fast Ethernet”) physical layer

MAC-DSD

- **M**ulti-channel **A**udio **C**onnection for **D**irect **S**tream **D**igital
- Paper 5691 at 113th AES Convention (Los Angeles, fall 2002)

MAC-DSD



The move to PCM

- How to get around the political angle?

The move to PCM

- PCM spec:
  - Support all the high-res formats
  - Support wide sample-rate deviation
  - Phase alignment of word clock
  - Transparent to AES3

SuperMAC

- Super Multi-channel Audio Connection
- Paper 5878 at 115th AES (New York, fall 2003)

SuperMAC audio specs

- Latency = three 44.1/48 kHz sample periods
- 48 channel @ 44.1/48 kHz
- 24 channel @ 88.2/96 kHz
- 12 channel @ 176.4/192 kHz
- 6 channel @ 352.8/384 kHz
- 24 channel @ DSD

SuperMAC auxiliary data

- 5.6 Mbit/sec bitstream available

SuperMAC auxiliary data

Ethernet!

- bridged over the auxiliary data bitstream, alongside the audio

(higher audio layers not shown)

Auxiliary Data Frame Format
512-byte sotware-defined Ethernet frames

Audio Bitstream Formatting
DSD or PCM (sample sub-frame) encapsulation

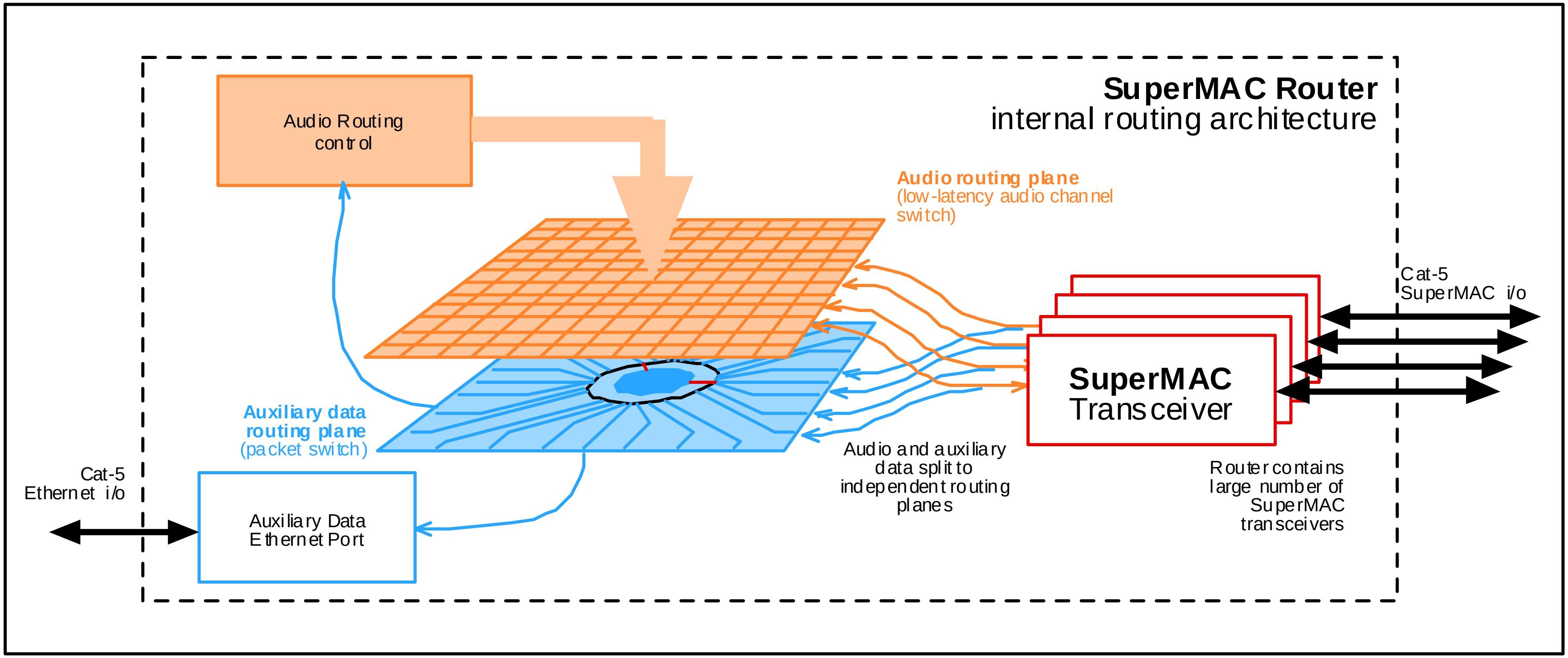
Auxiliary Data Bitstream Formatting
Demarcate 512-byte frames in contiguous 128fs bitstream

Payload encoding
26 64fs bitstreams, FEC-coded and interleaved

SuperMAC Frame Format
1448-byte frames, with defined headers for Ethernet MAC and protocol-specific identification, plus 1408-byte payload

PHY Interface Layer
Physical Layer device (MII) interface: physical layer frames prefixed only by preamble

SuperMAC Router



SuperMAC Router

AES Standardization

- Why an open standard?

AES Standardization

- Project X140 initiated in late 2003
- Published as AES50-2005 on July 17^{th}, 2005
- See also AES-R6-2005 if you want to understand the standard!

The philosophy

of AES50 technology

Optimization

- All these multi-channel audio over Cat-5 systems – they're basically the same, right?

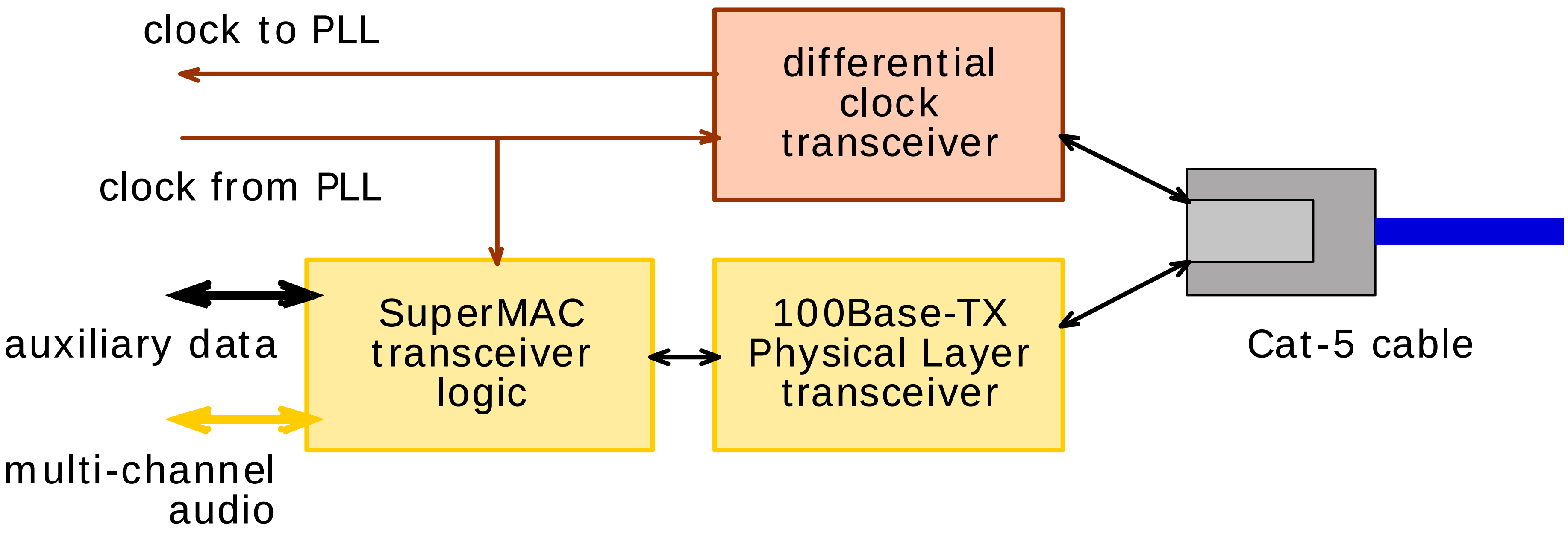
Dedicated Routers

- Ultra-low latency
- Totally consistent latency
- Single-channel granularity
- Non-blocking routing

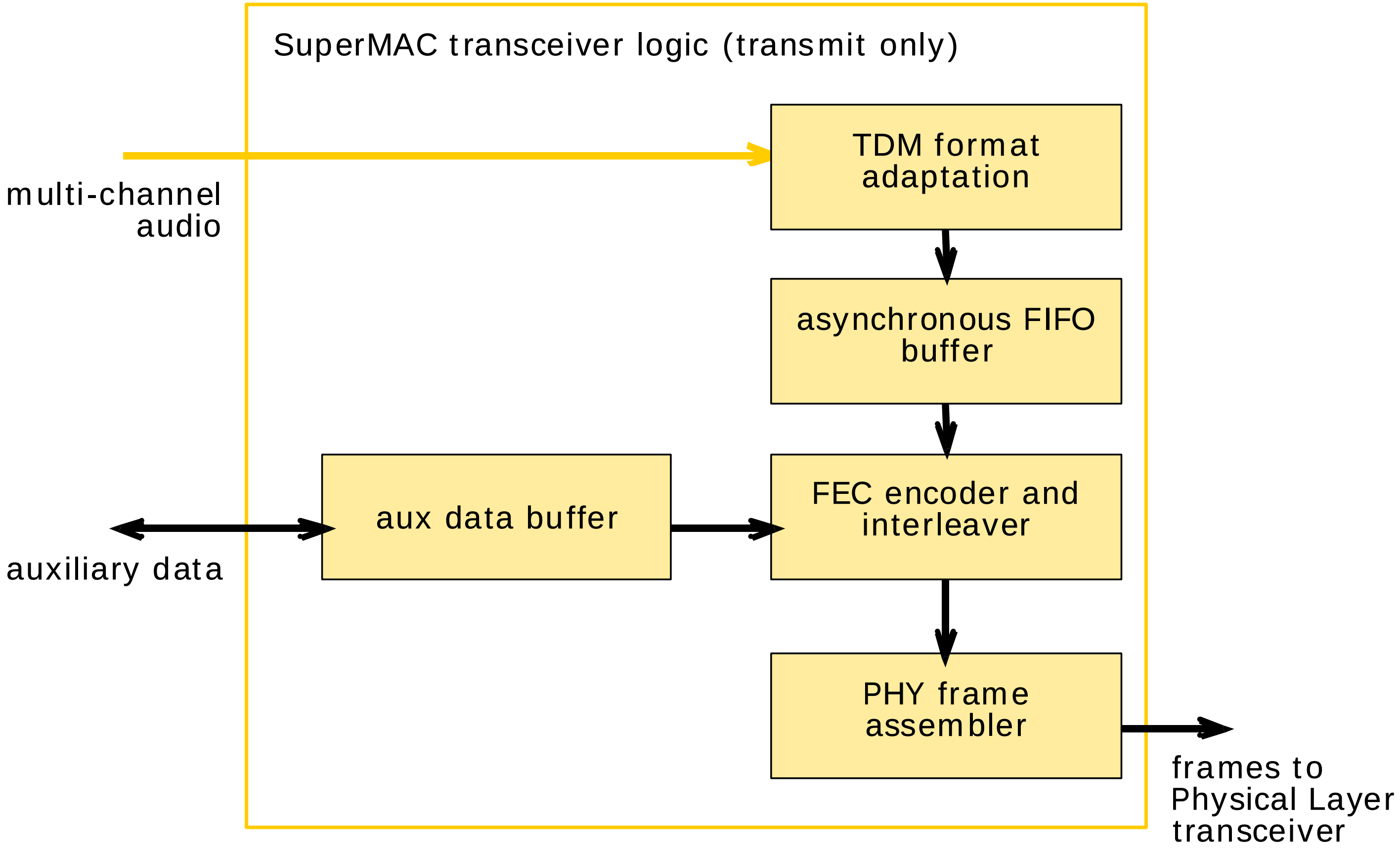
How AES50 works

(The tech stuff)

Transceiver overview



Transmitter logic

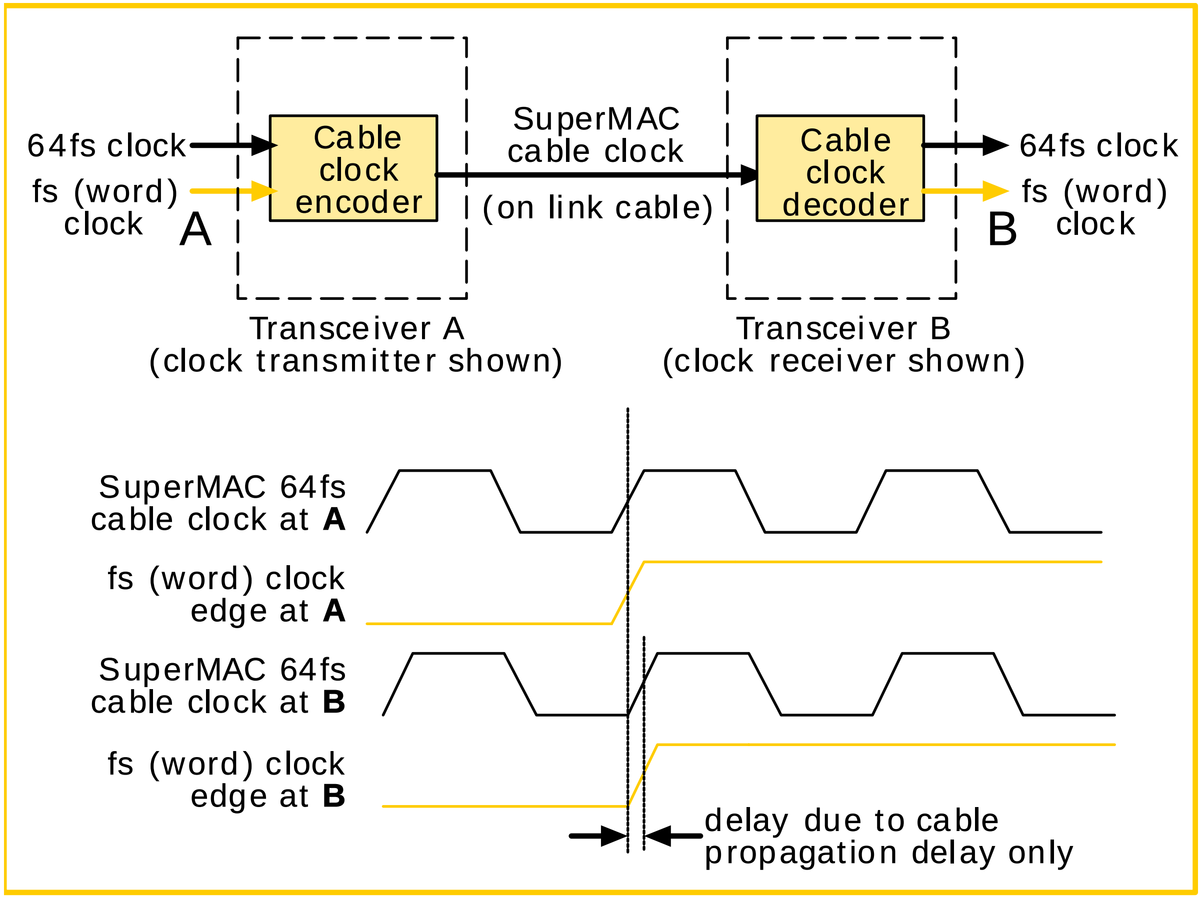


AES50 frame format

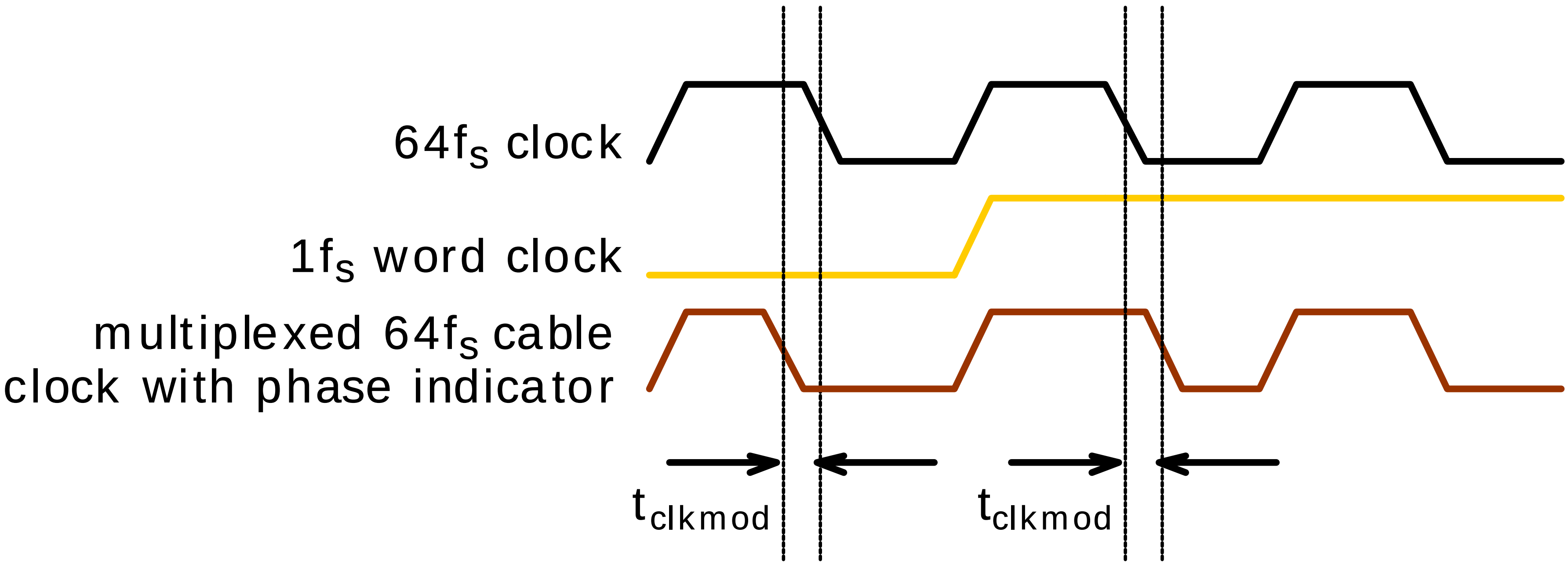
20 octets	Ethernet MAC-compatible header	Preamble, src/dest addresses, length
4 octets	AES Ethertype protocol identifier	Globally-unique protocol identifier
6 octets	AES50 header	Protocol version, audio format
1408 bytes	Payload	Multiplexed and encoded audio data
4 bytes	Ethernet MAC-compatible CRC	For future Ethernet compatibility

Total: 1442 bytes

Audio clock alignment

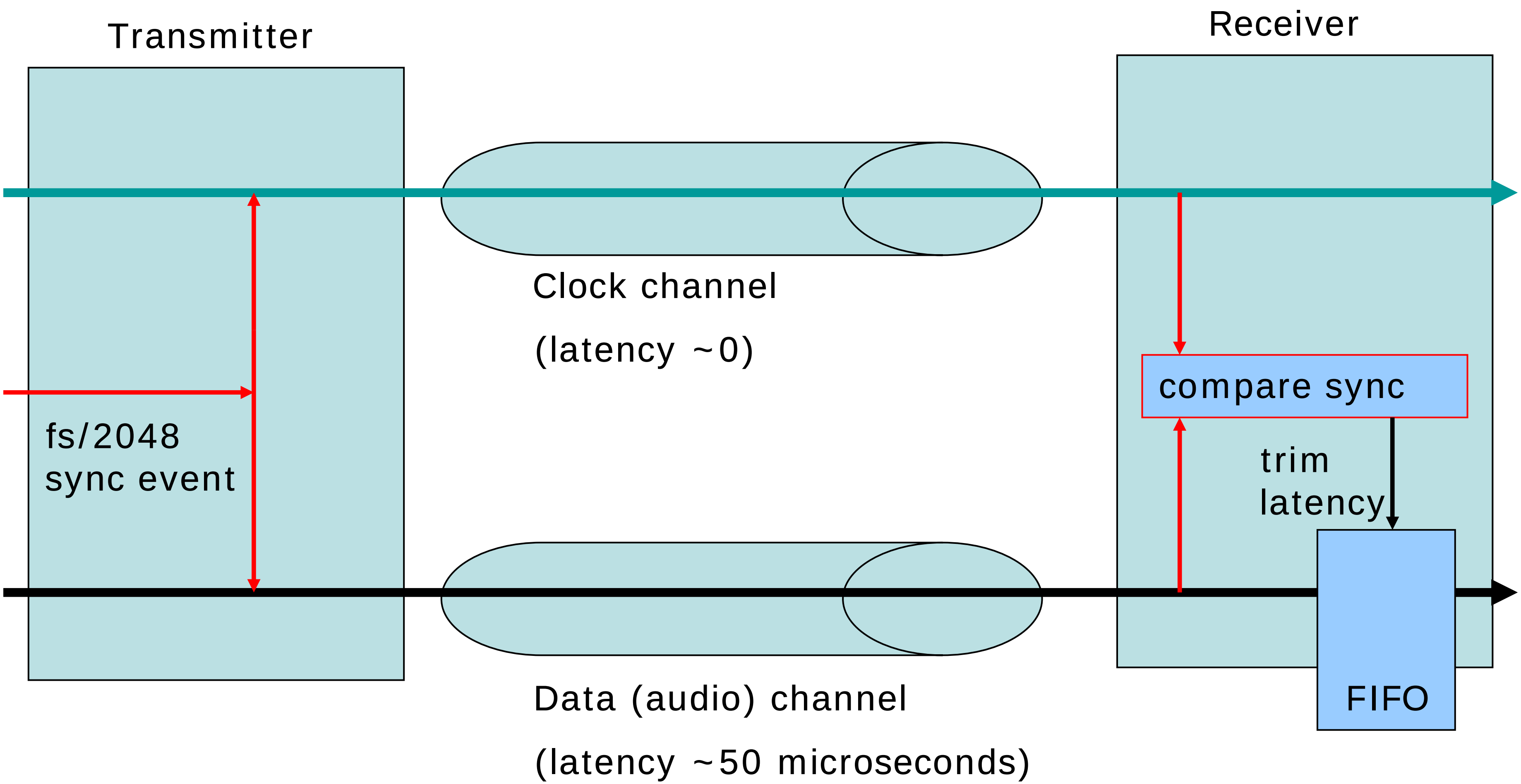


Word clock phase indication



negative edge modulation t_{clkmod} exaggerated for visibility in figure

Latency control

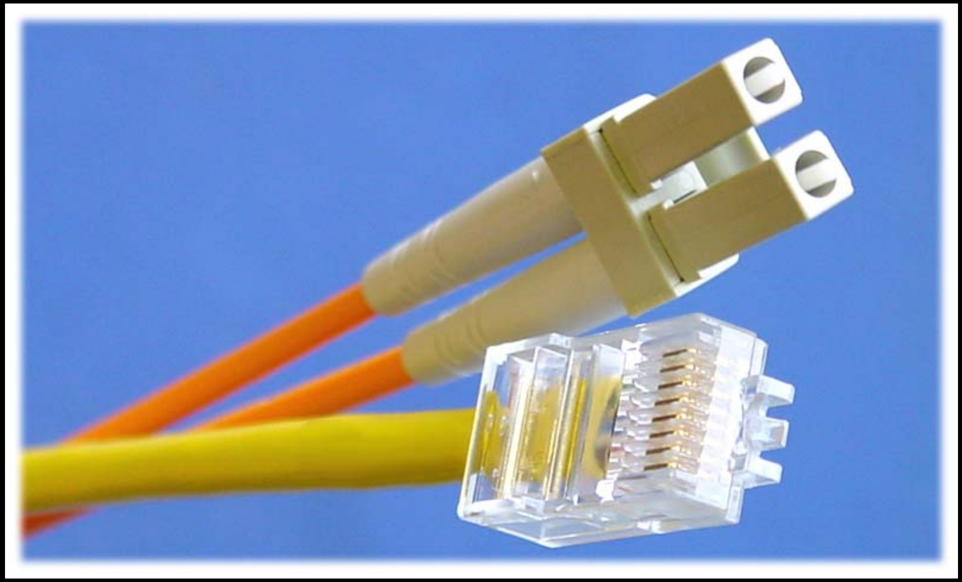


What you can do with AES50

a.k.a. “systemisation”

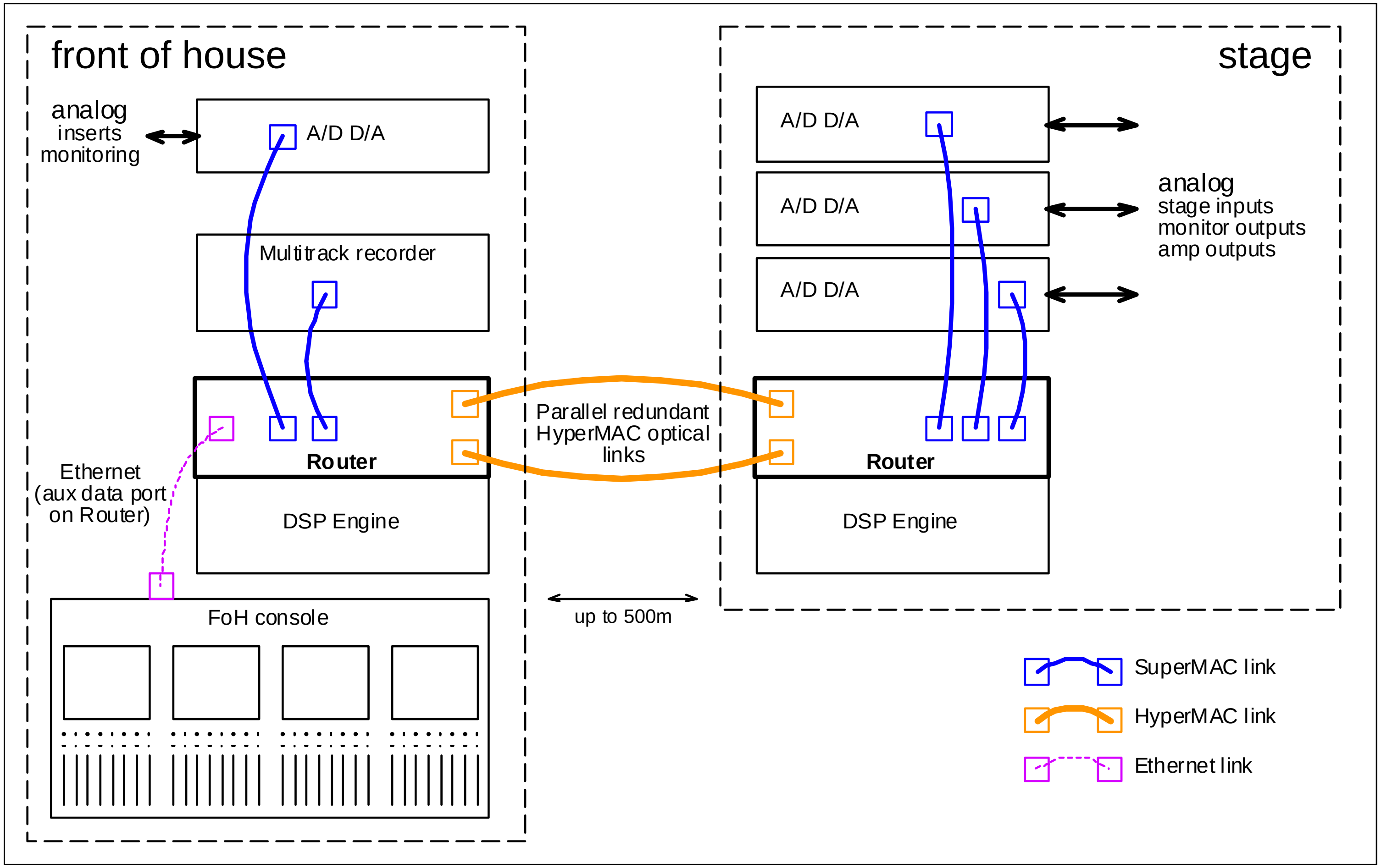
HyperMAC

High-performance Multi-channel Audio Connection

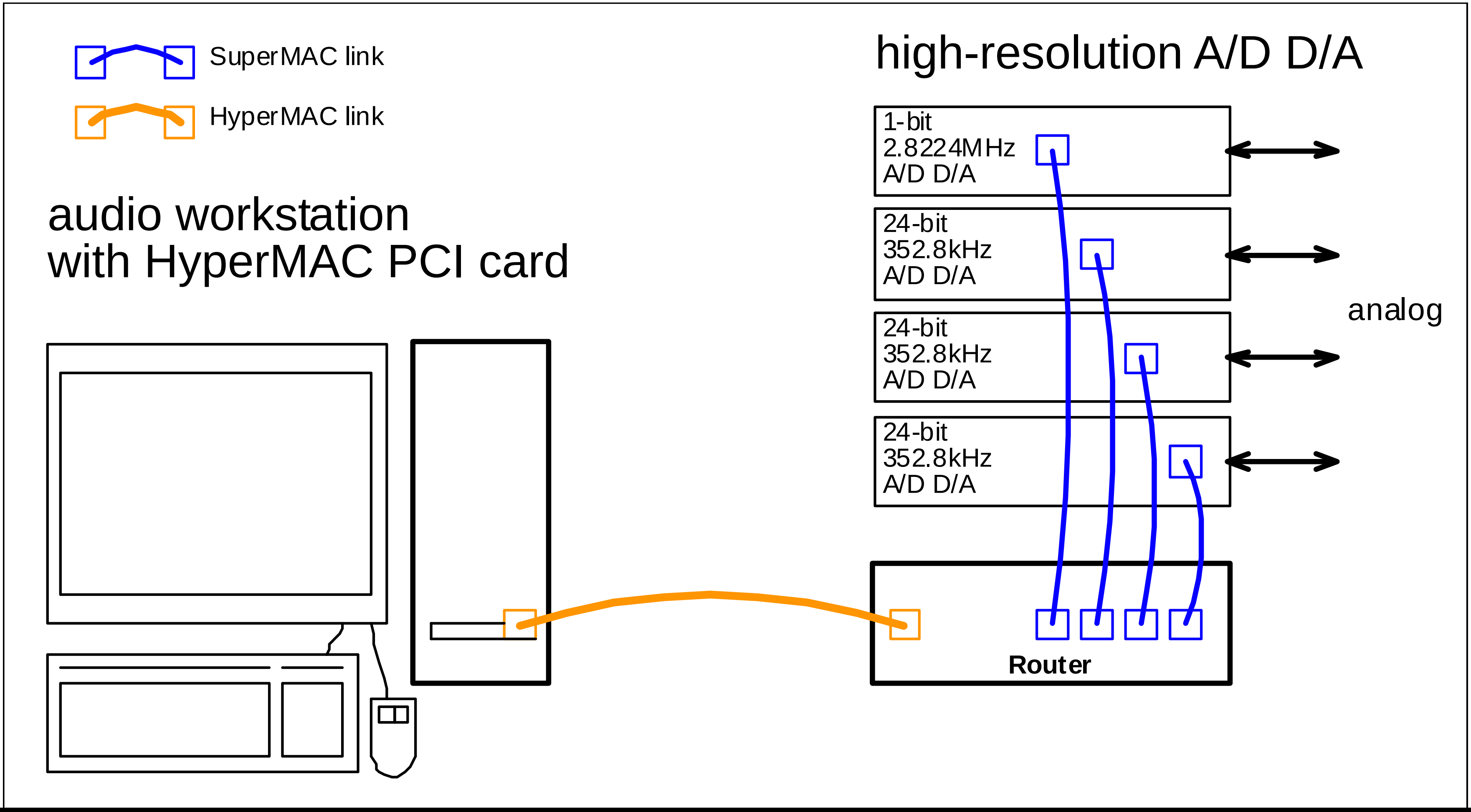


- Gigabit physical layer: copper or fiber
- Up to 384 channel audio, plus 100Mbit/sec auxiliary data

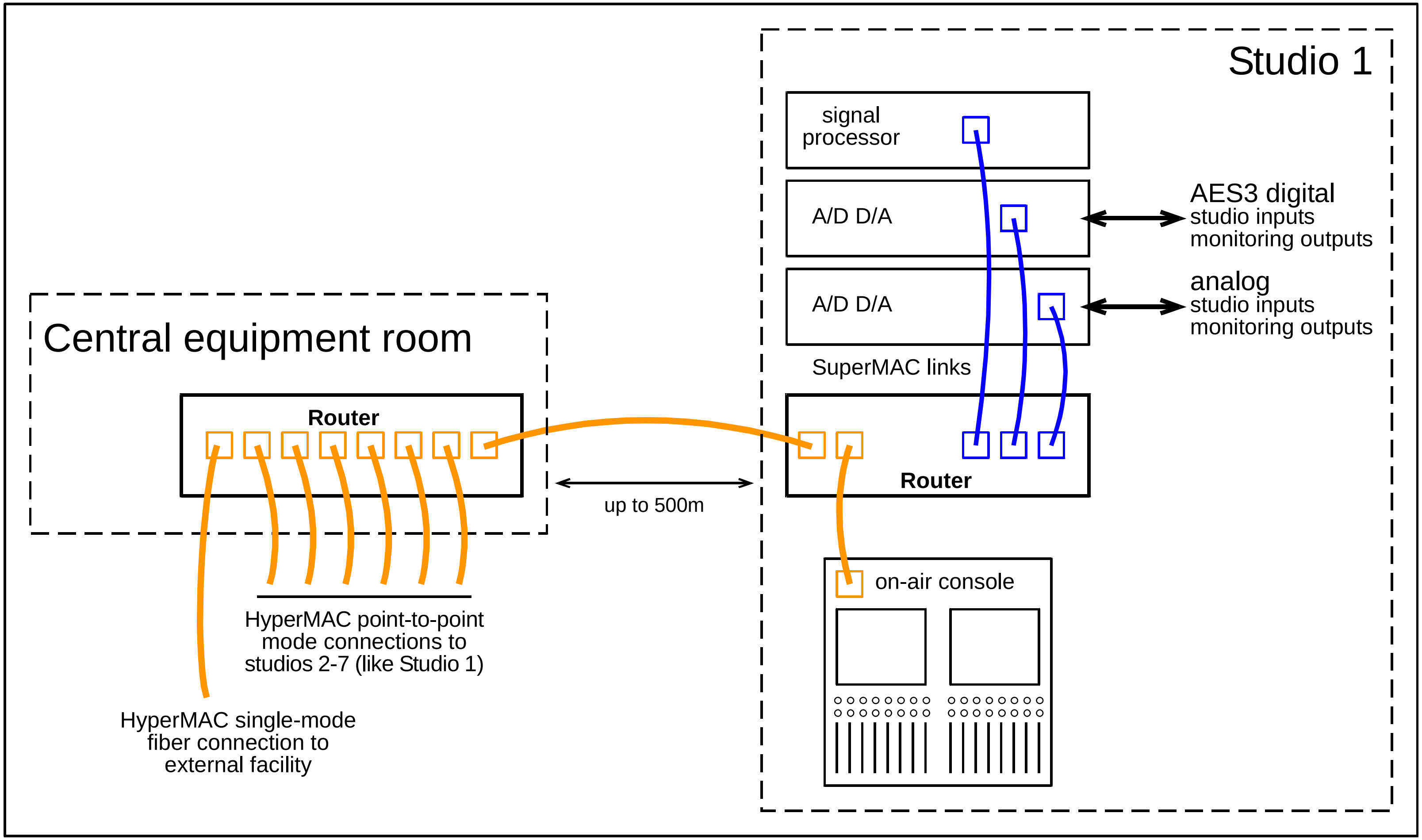
Live sound application



Multi-channel workstation



On-air broadcast

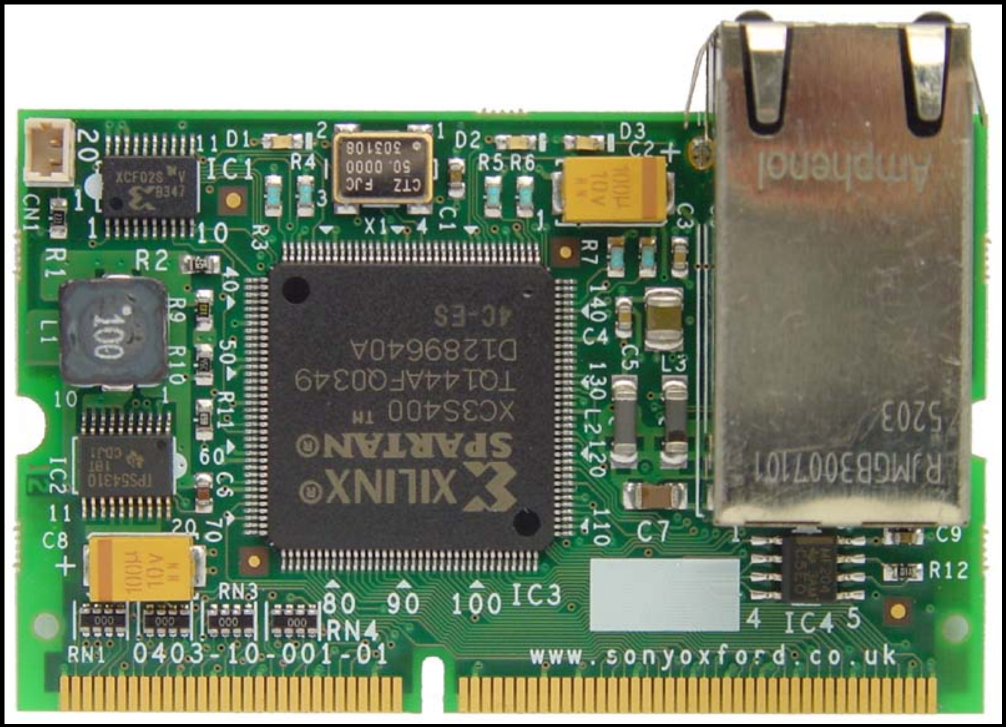


Other applications

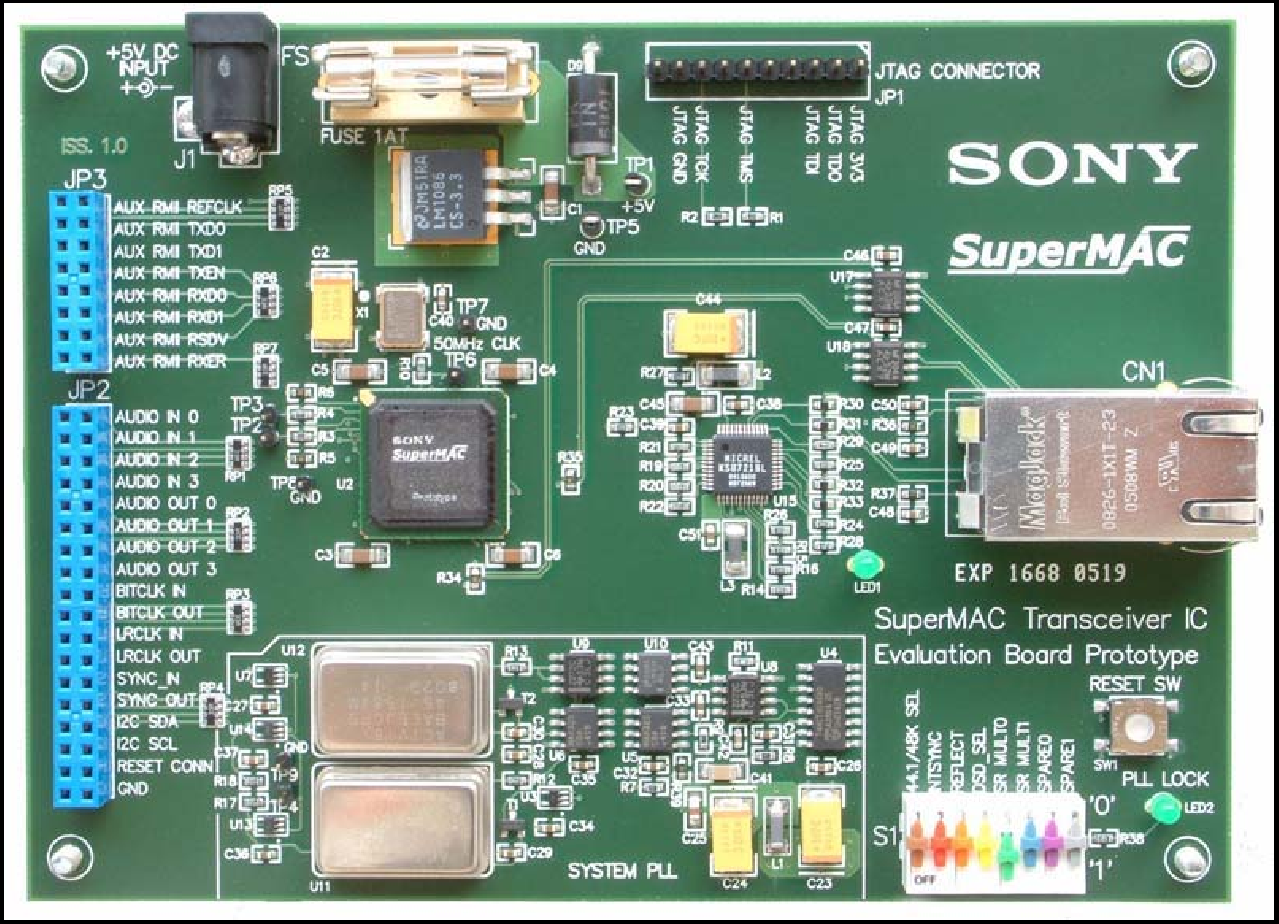
- Installs?
- Consumer?

Current implementations

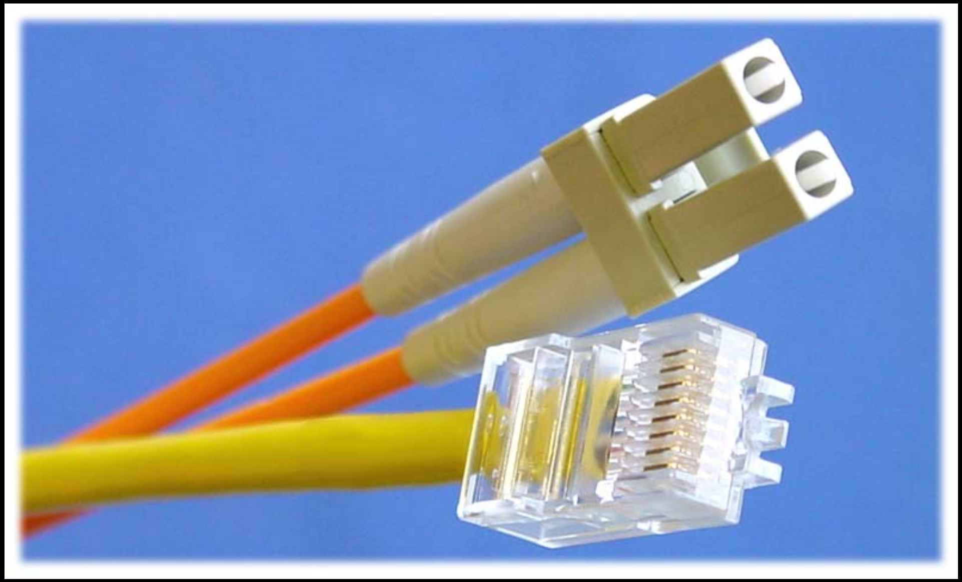
- FPGA logic core licensing



AES50 transceiver chip



The future



- HyperMAC completes the initial family

The future

- Diversify applications for HyperMAC:
  - Installs
  - Network operation
  - Video

More information...

- AES Standards:
  - www.aes.org/standards
  - Search for AES50 and AES-R6
- Implementations:
  - Sony Pro-Audio Lab
  - www.sonyoxford.co.uk/supermac
- Email me: mp@sonyoxford.co.uk