IP Networking for Studio and Outside Broadcasting Production Applications

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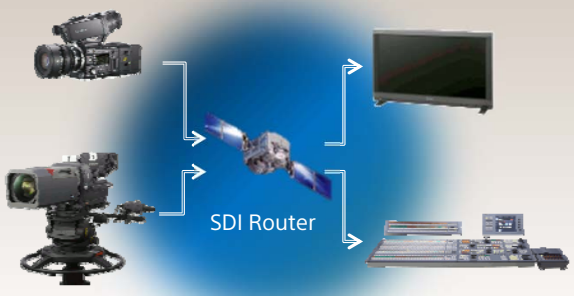
Vision: Creation of IP-based A/V Production Workflows

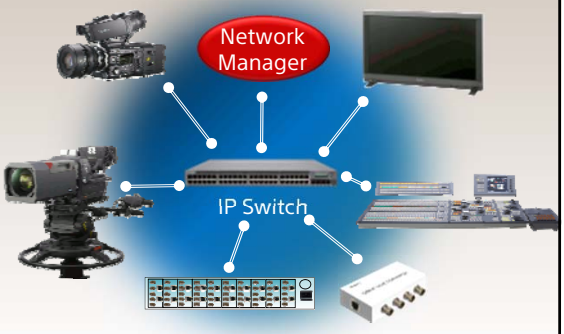
Transition of production A/V Interfaces from SDI to IP

Co-existence of Video, Audio and Control signals with File-based Systems

Today's Live Production System

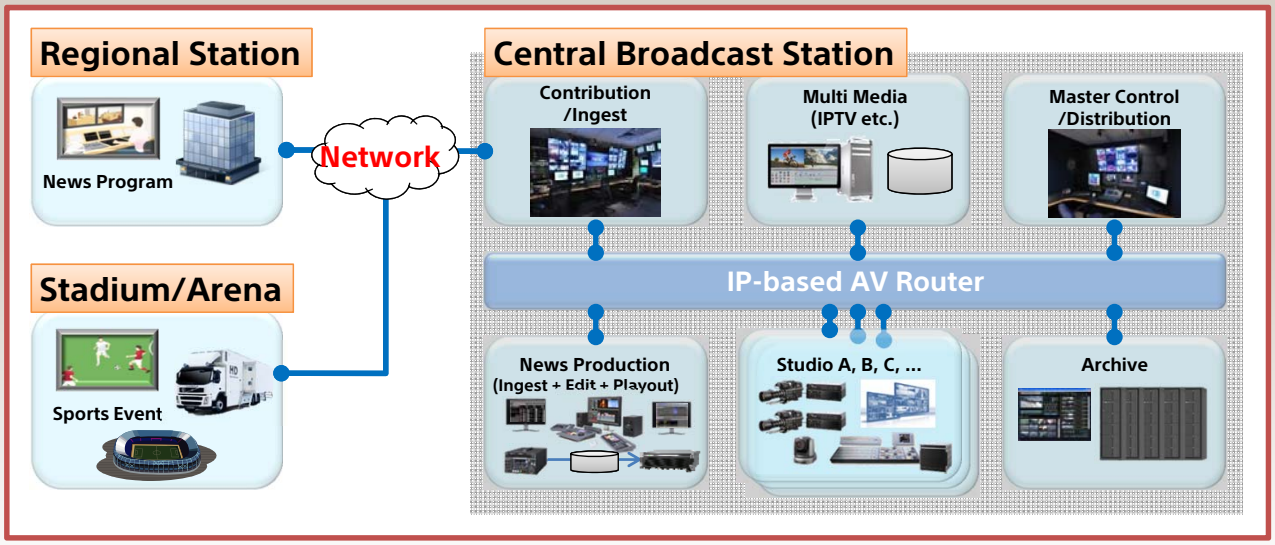


IP Live Production System



Vision

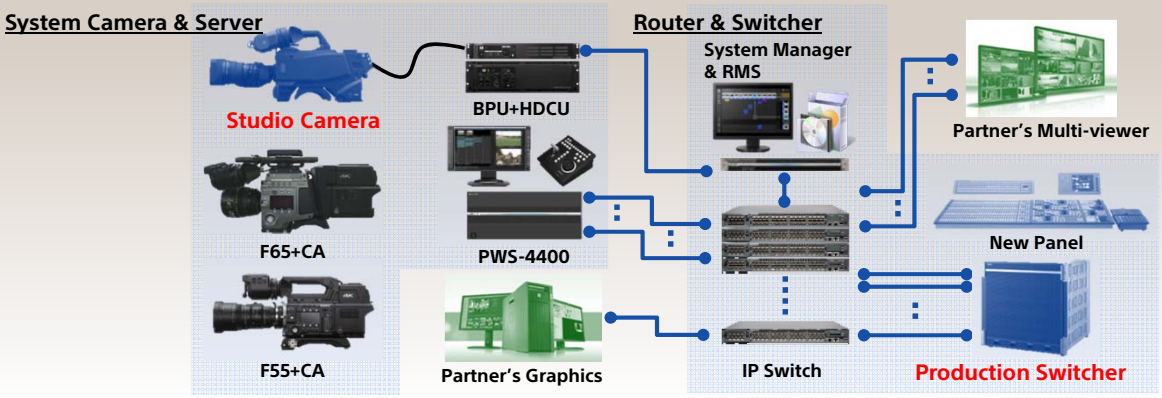
Enabling IP-based AV Production Workflow



HD/4K AV & IP Live - Future Direction -

Fully integrated "IP Live Production" :

- **Multi-resolution & expandability:** Mixture up to 4K or more, Easy I/O expansion, ...
- **High-reliability & SI efficiency:** Full-redundant network & switch, Cable reduction, ...
- **Total-cost reduction:** COTS products, Remote production, RMS based maintenance, ...



HD/4K AV & IP Live　Live Production Environment

Fully integrated "IP Live Production" :

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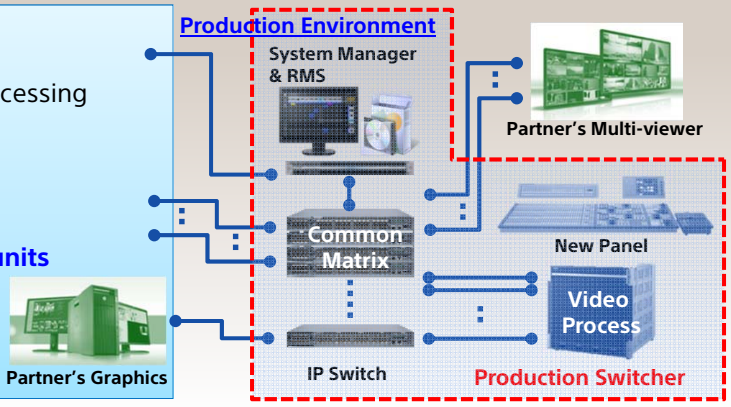
Fetures:

- **Switching matrix → IP router**
- Switcher unit focuses on video processing
- All devices are IP connected

- **Unlimited I/Os; over 1,000s**
- Unit size & cost reduction
- **Scalable video process by multi units**
  Super-Resolution technology
  for Up/down-conv.
- IP partner integration



Why Apply IP to Live Production Now?

IP is NOT a new technology even in the AV industry:

– Monitoring / Controlling / File transfer　(File-based System)

Live Production may be the last challenge for IP because it requires:

- Real time operations with minimum latency
- Synchronous processing
- Video stream switching without picture disruption

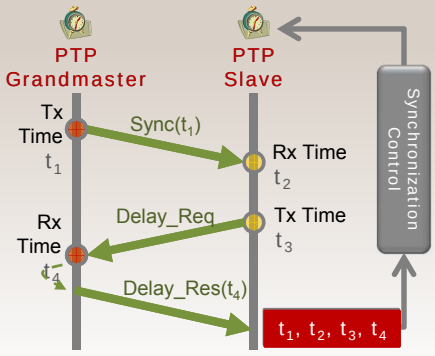
Technology improvements are now resolving these challenges:

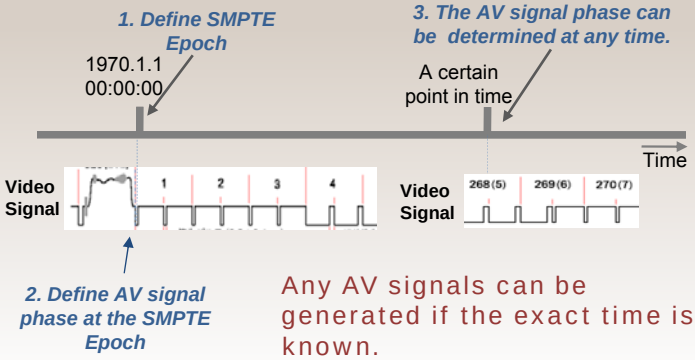
- Rapid increase of available network bandwidth
- Introduction of sub-microsecond-accurate time distribution protocol
  - IEEE1588 PTP (Precision Time Protocol)

Introduction to Network Synchronization

Network synchronization is realized by the combination of:

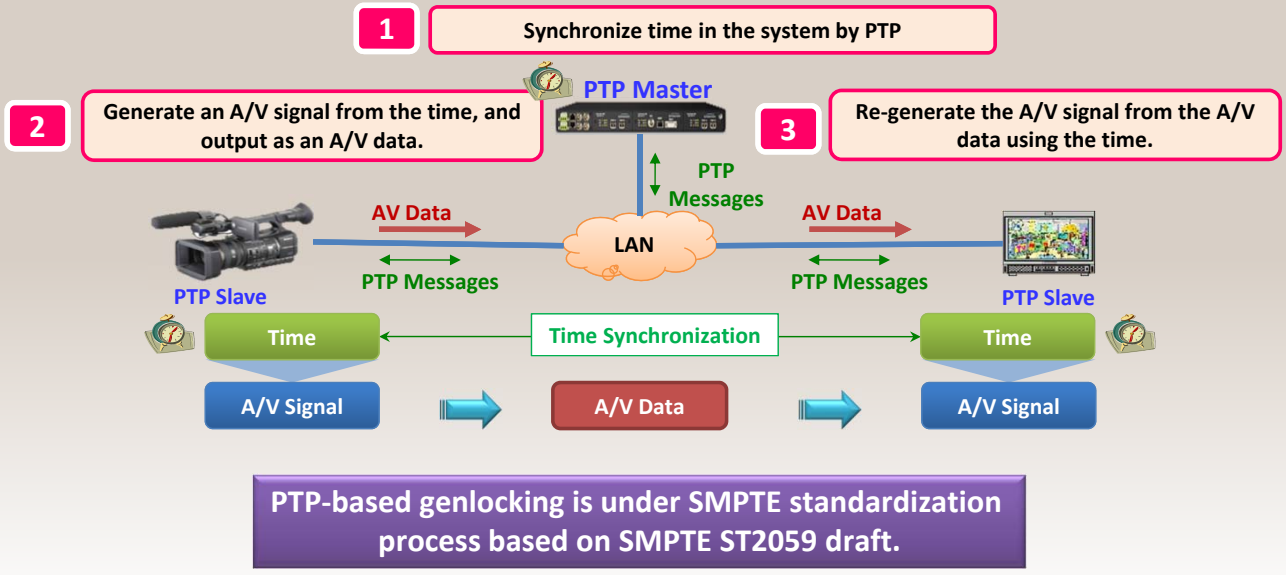
- IEEE 1588 PTP for **time synchronization**
- SMPTE draft ST 2059 for **AV signal synchronization**





Any AV signals can be generated if the exact time is known.

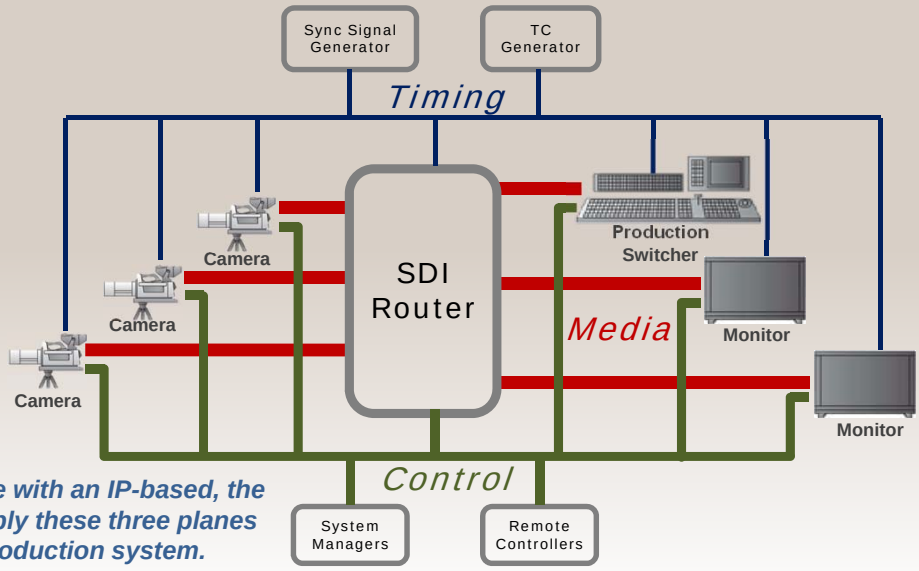
Network Synchronization



PTP-based genlocking is under SMPTE standardization process based on SMPTE ST2059 draft.

SDI-based Live Production System

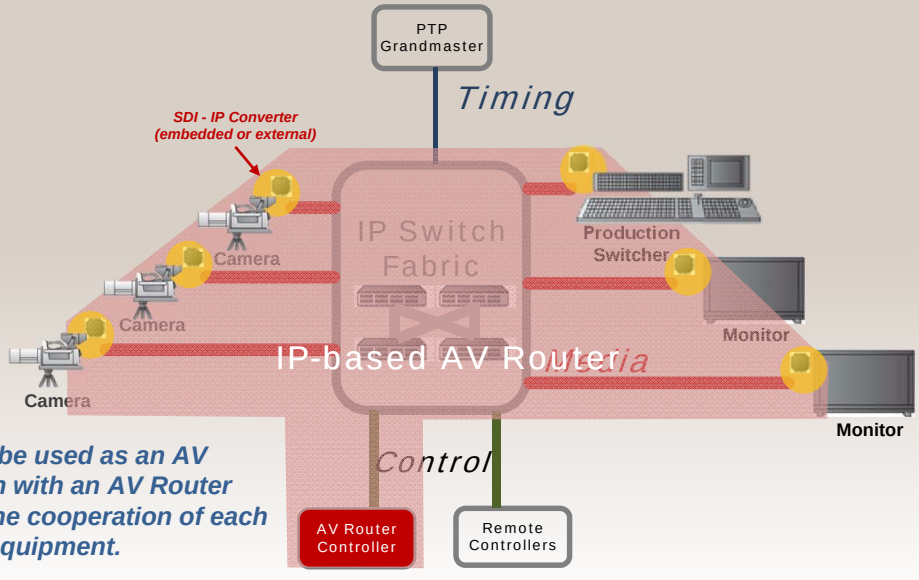
Three Planes
- Media
- Timing
- Control



When trying to replace with an IP-based, the question is how to apply these three planes to an IP-based Live Production system.

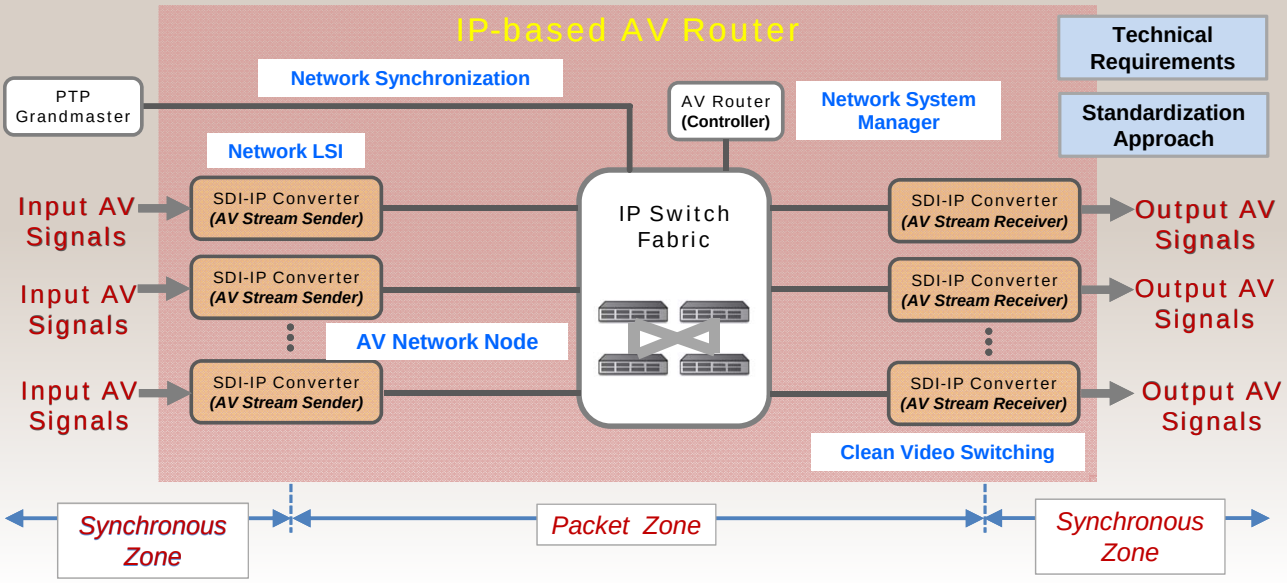
IP-based Live Production System

Three Planes
- Media
- Timing
- Control



IP Switch Fabric can be used as an AV Router in conjunction with an AV Router Controller and with the cooperation of each piece of production equipment.

IP-based AV Router Sample Implementation



Technical Requirements

General Requirements

- **The current operational practice should not be changed**
- **Use existing and emerging standards wherever possible**
  - *in order to ensure interoperability.*
- **Use Standard IT-Technology, especially generic Ethernet Switches**
  - *available in the market at reasonable price.*
  - *can improve system performance as standard IT technologies improve.*
  - *in order to maximize the benefits, use only functions that are supported by multiple vendors.*

Technical Requirements

Requirement for the Timing Plane

- **Network synchronization able to achieve sub-microsecond accuracy**
  - *Sub-microsecond accuracy is required over the IP network for some applications such as clean video switching.*

Technical Requirements

Requirements for the Media Plane

- **Frame-accurate clean video switching**
  - *Video switching should be performed at the specified time point during the vertical blanking interval on the specified video frame.*
- **Essence-independent mapping**
  - *in order to process essences at packet level*
  - *e.g. video signal can be compressed in order to save network bandwidth.*
- **Mechanism to protect against transmission errors**
  - *UDP/IP is commonly used, which does not ensure transport reliability.*

IP Live Production Technologies

IP-based AV routing

Multi-format: SD, HD, 4K and 8K

IP Multicast & QoS for AV, Metadata, Control and File transfers. They all must co-exist

Genlock over IP

-- Based on Precision Time Protocol SMPTE profile: ST2059 draft

-- Clean video switching

Baseband or Low-latency video codec

HD-SDI mapping (ST2022-6) or Advance mode

Visually lossless picture quality & Ultra low latency video codec

Network Redundancy

Hitless failover based on ST2022-7

IP Live System Manager

Manages AV devices, routing and network resources

Most Difficult Challenge:

4K Live Production Cabling

Future Vision of 4K Live Production

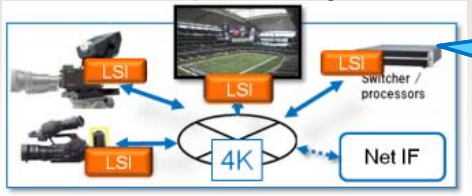
- 3G SDI x 4 Tx (for 4K/422/10bit/60p x 1ch)

4K Parallel Data → 3G SDI x 4 → Connecter x 4 → BNC Cable x4

- 3G SDI x 4 Rx (for 4K/42

4K Parallel Data → 4 → C Connecter x 4 → BNC Cable x4

IP Network Solution (4K over single 10GbE cable)



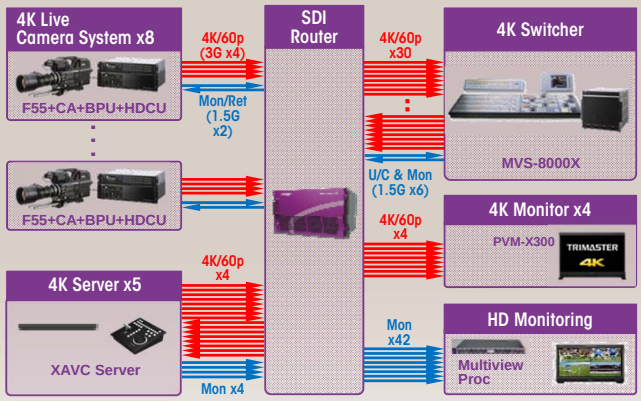
LSI ↔ SFP+ → 10GBASE-SR SFP+ Optical Module → Optical Cable → 4K Video Stream

Network LSI (w/ Low Compression 4K Codec)

Production Truck
SDI Based 4K System

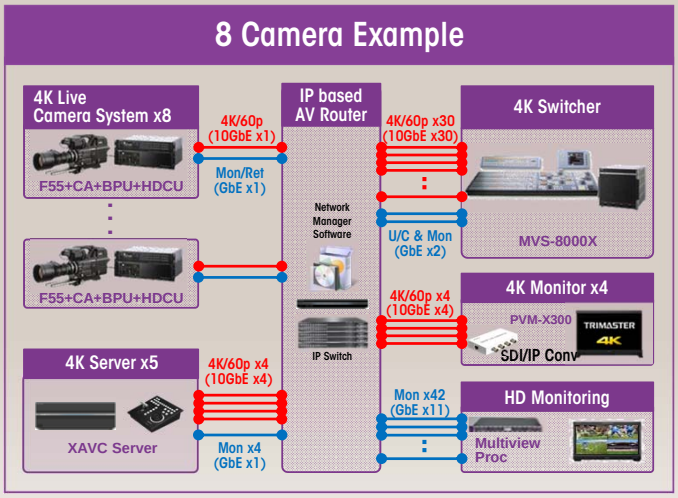
	SDI Based
Cable Number	BNC: 362 pcs
Cable Weight	268 kg. (590 lb.) (5C2V: 74g/m)

8 Camera Example



Production Truck
"IP Live" Based 4K System

	SDI Based	IP Live Based
Cable Number	BNC: 362 pcs	LAN: 88 pcs
Cable Weight	268 kg. (590 lb.) (5C2V: 74g/m)	40 kg. / 11kg. (89 lb. / 24 lb.) (Copper: 45g/m, Fiber: 13g/m)



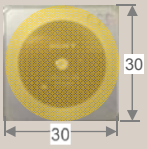
Total cable weight reduced by 85%*

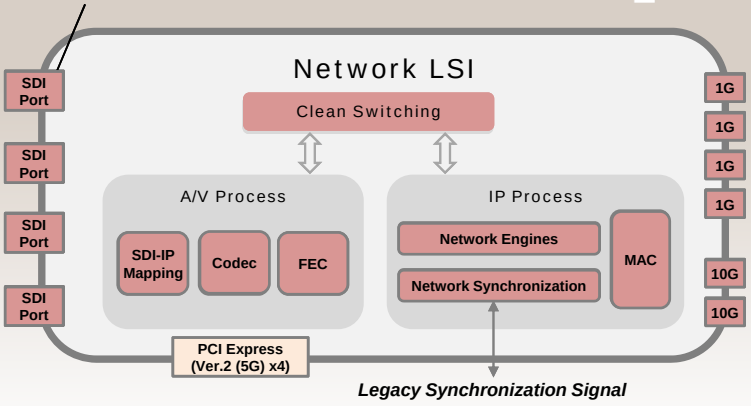
*Example only. Actual weight reduction will vary by situation.

Network LSI

Configurable SDI ports:

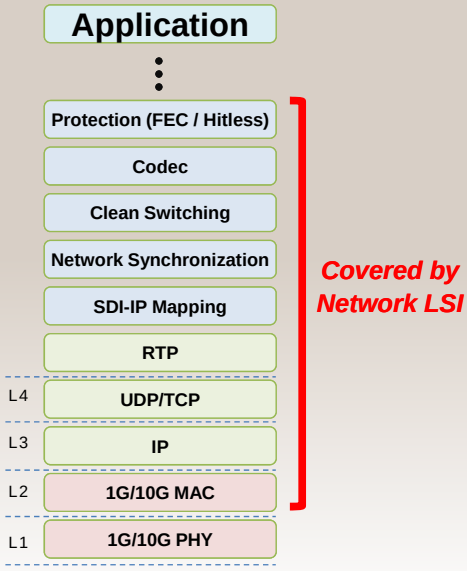
- ***4 x HD-SDI***
- ***2 x 3G-SDI***
- ***2 x 4K***



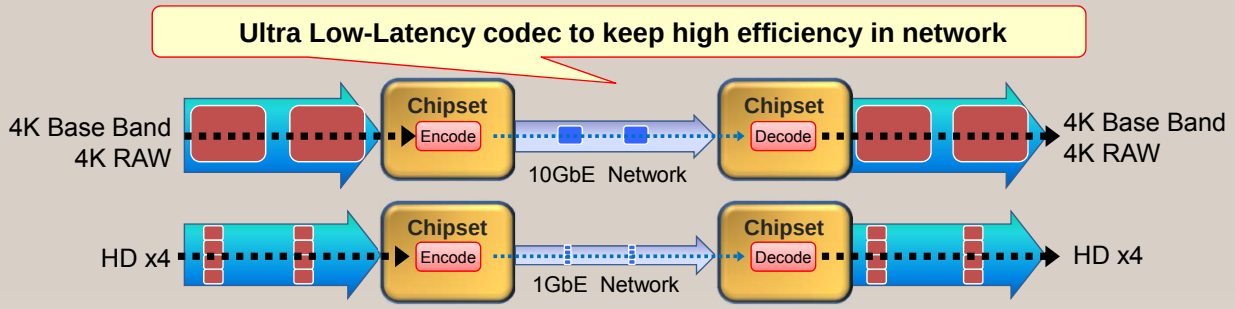


Legacy Synchronization Signal

Network Layer Structure



Video Format Support



Video Format	Number of Channels
1920x1080/422/50i,60i	4ch/1GbE
1920x1080/422/50p,60p	2ch/1GbE
3860x2160/422/24p,30p	1ch/1GbE x3
4096x2160/422/24p,30p	2ch/10GbE
3860x2160/422/50p,60p 4096x2160/422/50p,60p	2ch/10GbE
4K RAW	2ch/10GbE

Network System Manager

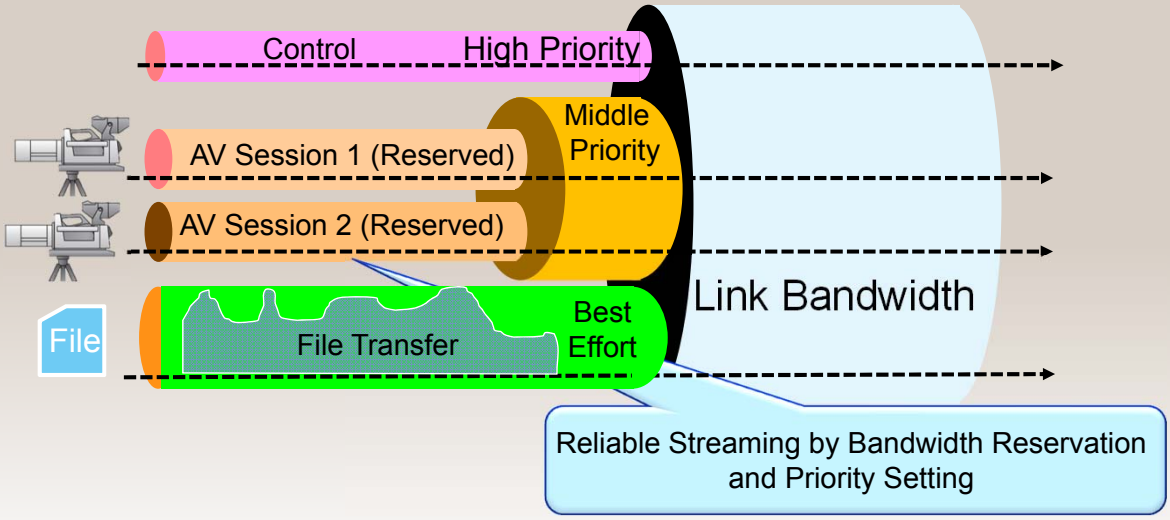
Three main services:

- **AV Stream Management**
  - Manage the cross point matrix and Control AV stream routing
- **Network Resource Management**
  - Maintain network topology and Manage network resources
- **Device Management**
  - Manage AV network streams and Device capability

Question is how to identify 'AV network streams'?

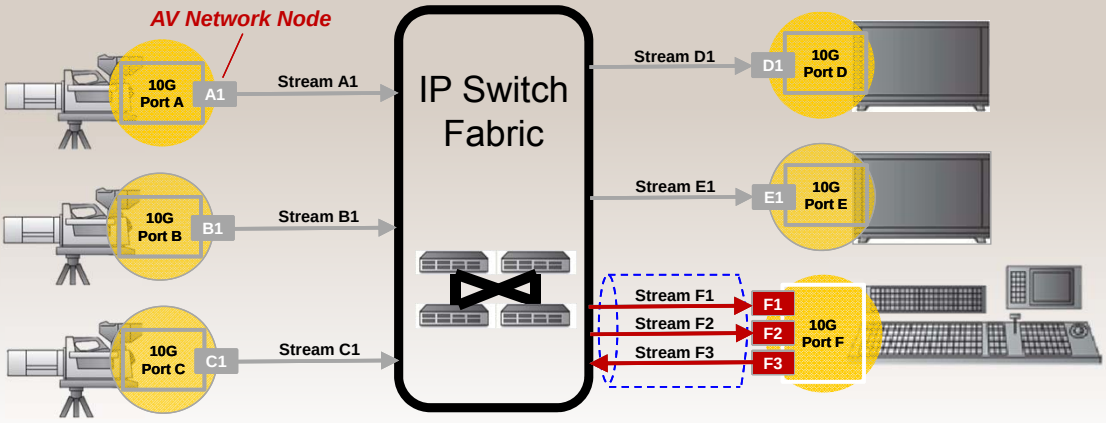
- *A network by nature carries a multiplicity of AV network streams.*

Resource Reservation



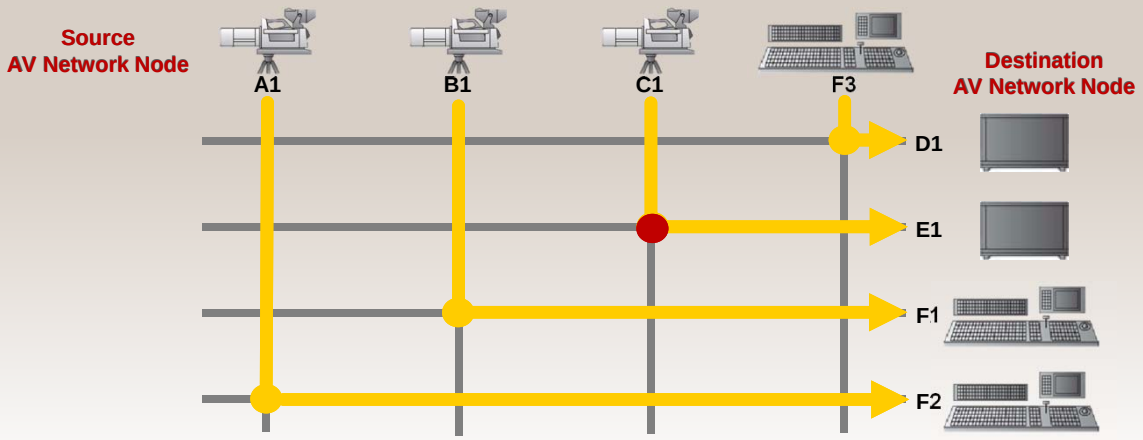
AV Network Node

AV Network Node is a new concept to identify an AV network stream at each node.



Cross Point Matrix

Cross Point Matrix can be defined based on the AV Network Node.



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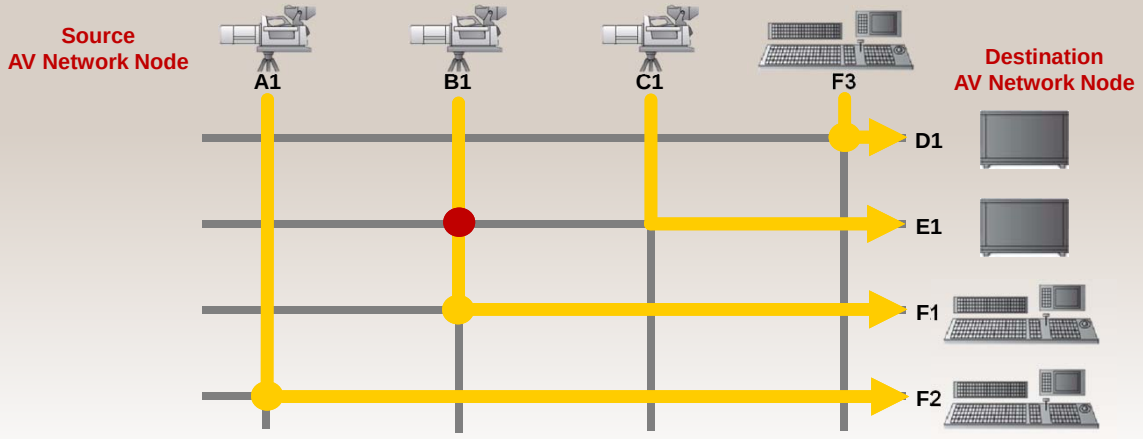
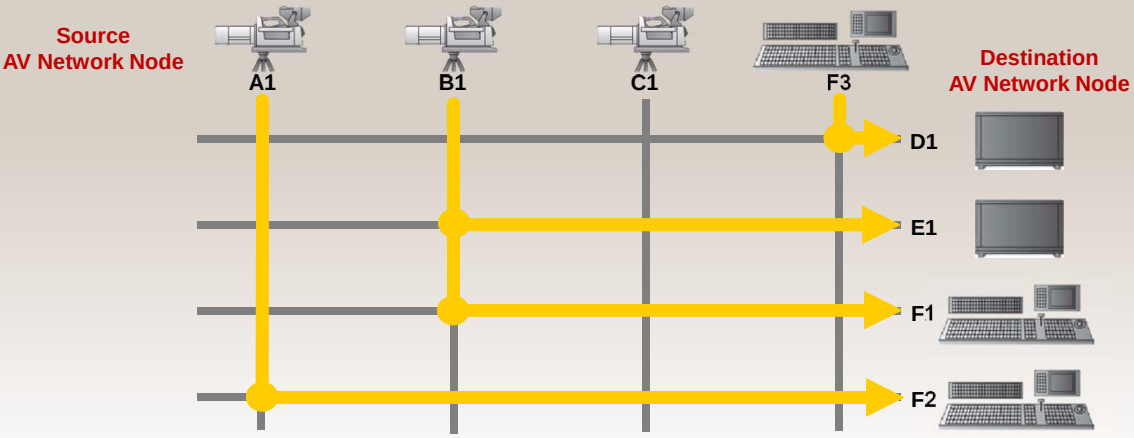


Cross Point Matrix

Control of the IP-based AV Router can be realized without changing the current operational practice using AV Network Node.
Cross Point Matrix can be defined based on the AV Network Node.



Problems in Clean Video Switching using general IP method

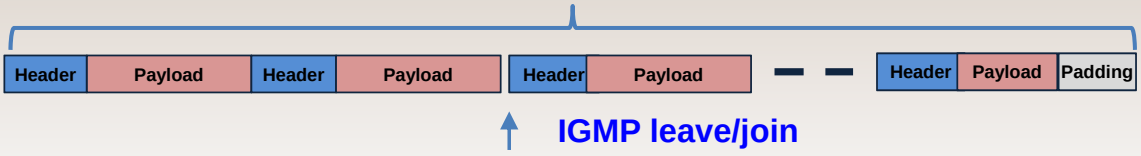
Using Multicast IGMP (Internet Group Management Protocol) is accepted method to start/stop stream packets

However as Ethernet Switches do not know the video frame boundary, streams may start or stop in the middle of video frame

-- It leads to a picture disruption

Also Ethernet Switches do not know the exact video frame to be switched

-- One video frame consists of a few thousand packets depending on the video format



IGMP leave/join

Stream packet may start or stop in the middle of video frame as Ethernet Switches do not know the video frame boundary. It leads to picture disruption

Clean Video Switching

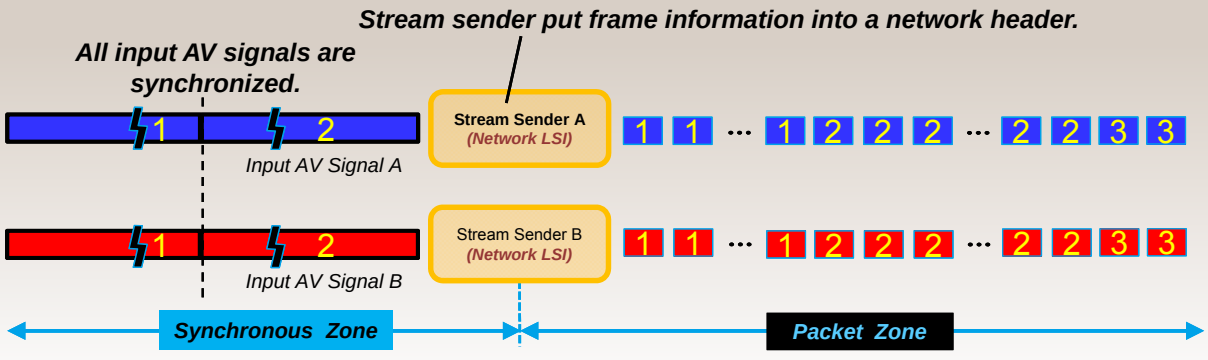
Four steps are used in order to realize the 'clean video switching':

1. Frame Information Insertion
2. Rough Video Switching
3. Clean Video Switching
4. Synchronization between input signals and output signals

1. Frame Information Insertion

Stream sender extracts frame information from input AV signal and puts it into a network header.

– i.e. All AV stream packets contain frame information.

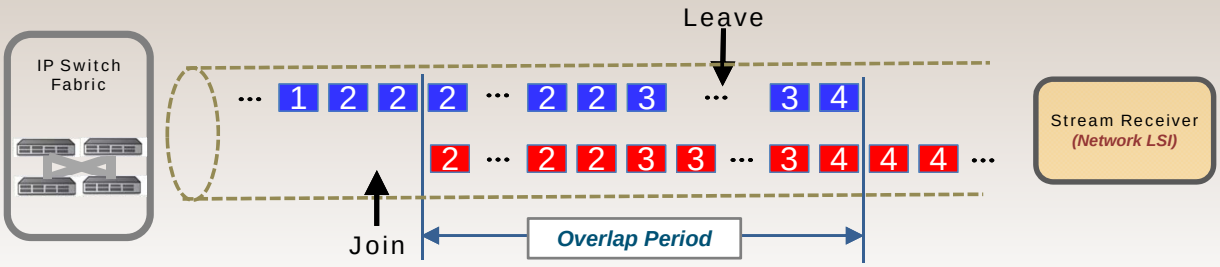


2. Rough Video Switching

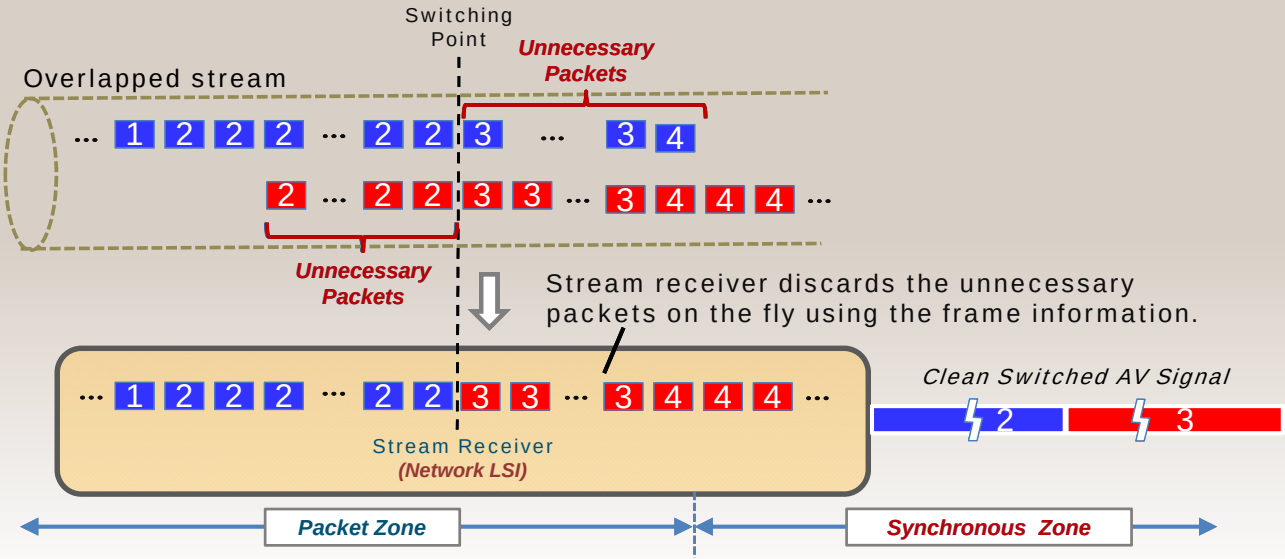
IP multicast IGMP (Internet Group Management Protocol) is used:

– In order to realize rough video switching, stream receiver

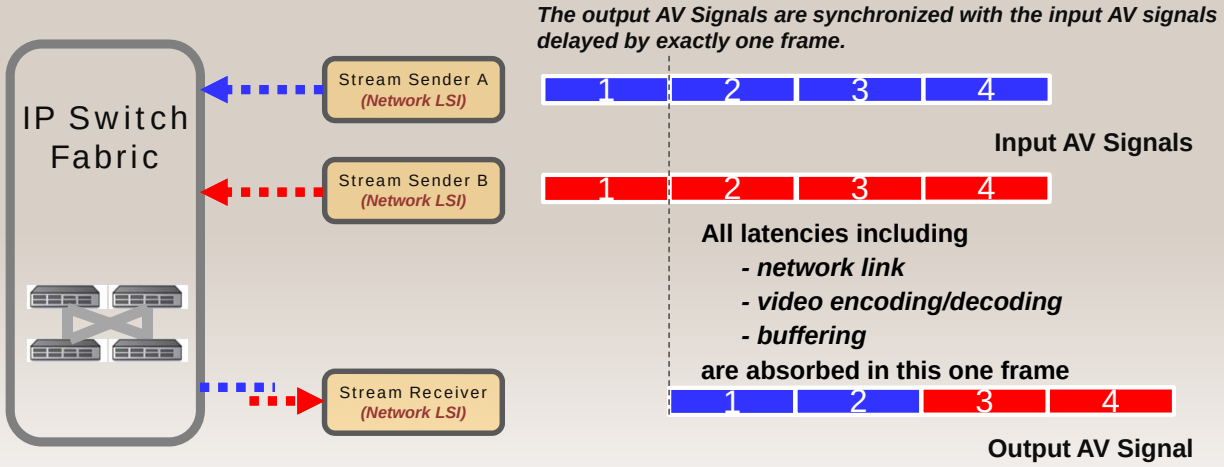
- ***joins a new multicast group*** *and*
- ***leaves its current multicast group***



3. Clean Video Switching

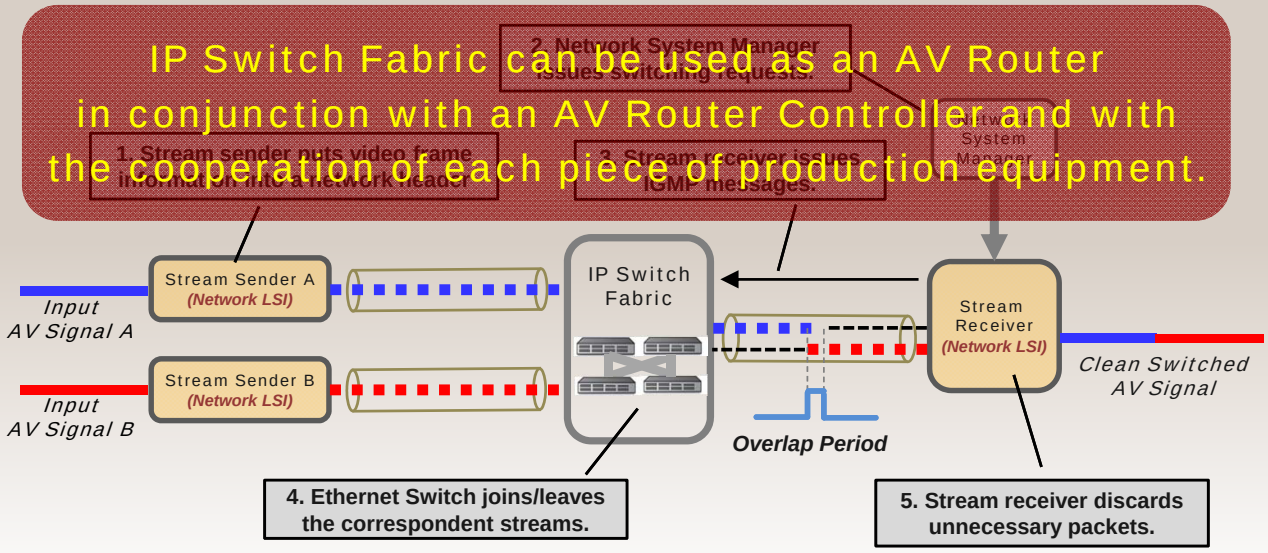


4. Synchronization between Input and Output



As a result, any video format, SDI, HD-SDI, 3G-SDI, 4K, uncompressed or compressed, can be handled in the same manner.

Clean Video Switching Summary

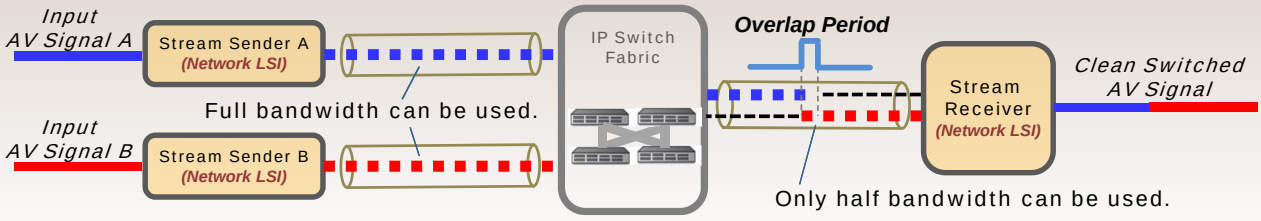


Consideration of Clean Video Switching

This solution requires double network bandwidth during the overlap period.

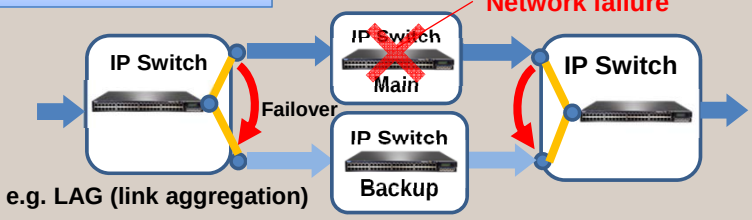
A big advantage of this solution is that any generic Ethernet Switch can be used.

- This is an issue of cost of IP Switches
  - All necessary functions and performances are already satisfied.
  - This is most cost effective way to realize the clean video switching for now.
- Another approach which does not require double bandwidth will be adopted in the future when it will be realized using generic Ethernet Switches.



Network Redundancy

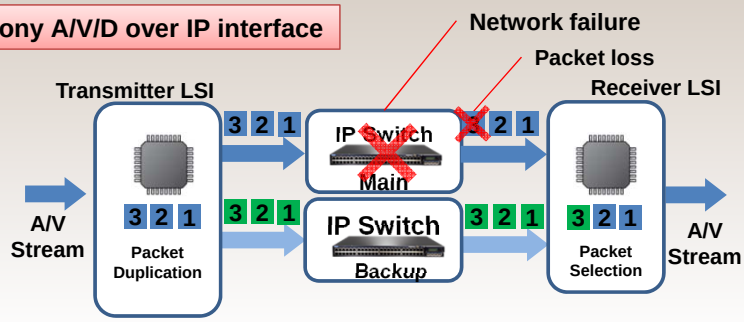
General IP technique



Picture distortion

When switching active network, **data is interrupted temporarily.**

Sony A/V/D over IP interface



Hitless failover

Even if one stream packet is missed, the other packet outputs seamlessly.

Standardization Approach

In principle, the following SMPTE (draft) standards are used:

- For the media plane
  - ST 2022-6 : SDI - IP mapping
  - ST 2022-7 : Hitless Switchover
- For the timing plane
  - ST 2059-1 (draft) : SMPTE Epoch, AV signal alignment
  - ST 2059-2 (draft) : SMPTE PTP Profile

In addition, several extensions are proposed in order to fully satisfy all the requirements of IP Live Production.

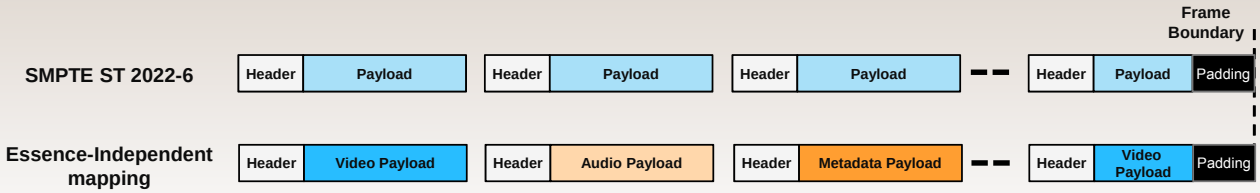
SMPTE ST 2022-6 and Proposal

SMPTE ST 2022-6 maps the whole SDI payload information including video, audio and metadata as a package.

- It cannot deal with video, audio, metadata independently at packet level.

Our proposal (Essence-Independent Mapping):

- **A mapping in which video, audio, and metadata are placed in separate packets so that they can be dealt with independently.**

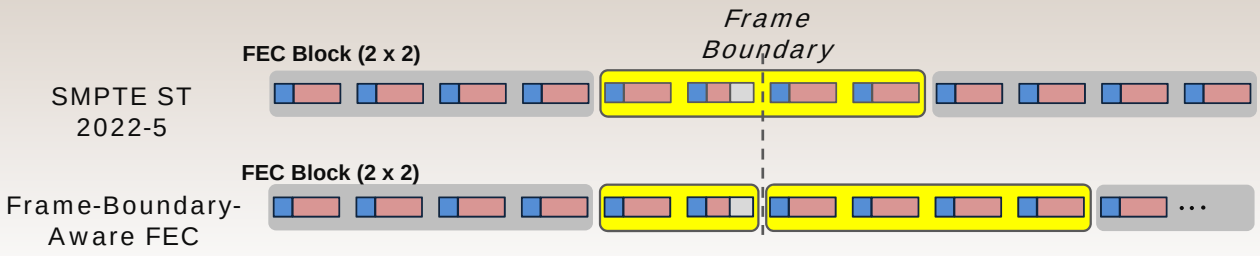


SMPTE ST 2022-5 and Proposal

SMPTE ST 2022-5 is not aware of video frame boundaries and a single FEC block may contain information related to two frames

Our proposal (Frame-Boundary-Aware FEC) :

– A FEC block is terminated when a frame boundary is detected.



Network Synchronization ("Genlocking")

Implementation of sufficient synchronization accuracy ("genlocking") using general Ethernet switches

One of the major reasons to adopt IP technology is the **"use of standard IT technologies"**, in other words, the use of COTS.

However, when seeking to realize high accuracy synchronization under high network load, **the use of specialized time-aware network devices such as Transparent Clock Switches is commonly considered to be necessary**.

Adoption of SMPTE PTP (ST2059-2) rather than AVB gPTP (IEEE802.1AS).

SMPTE PTP allows either ordinary clocks (general Ethernet switches) or time-aware clock such as Transparent clock switches.

While gPTP allows only time-aware devices (End stations or Bridges).

Issues of AVB Technologies

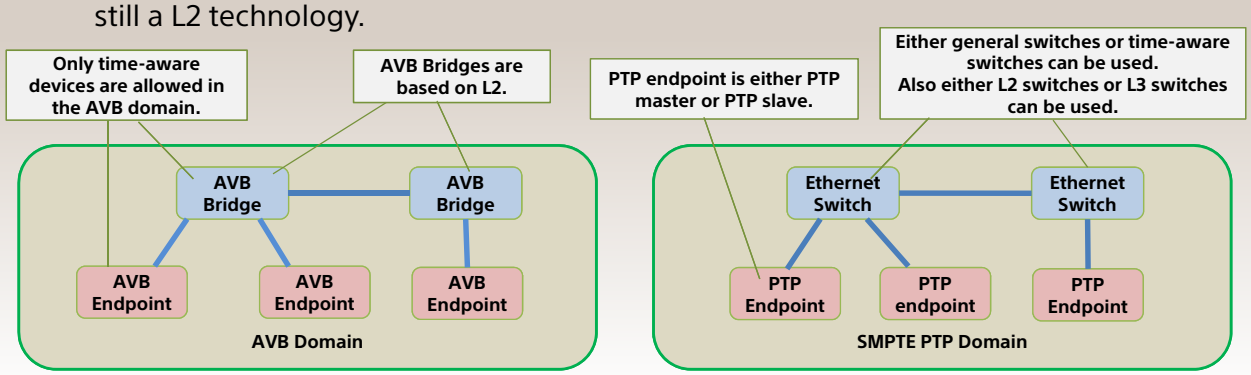
AVB mainly consists of the following two technologies:

Network Synchronization (gPTP): IEEE802.1AS

Stream Reservation (inc. shaping): IEEE802.1Q, IEEE1722, IEEE1733

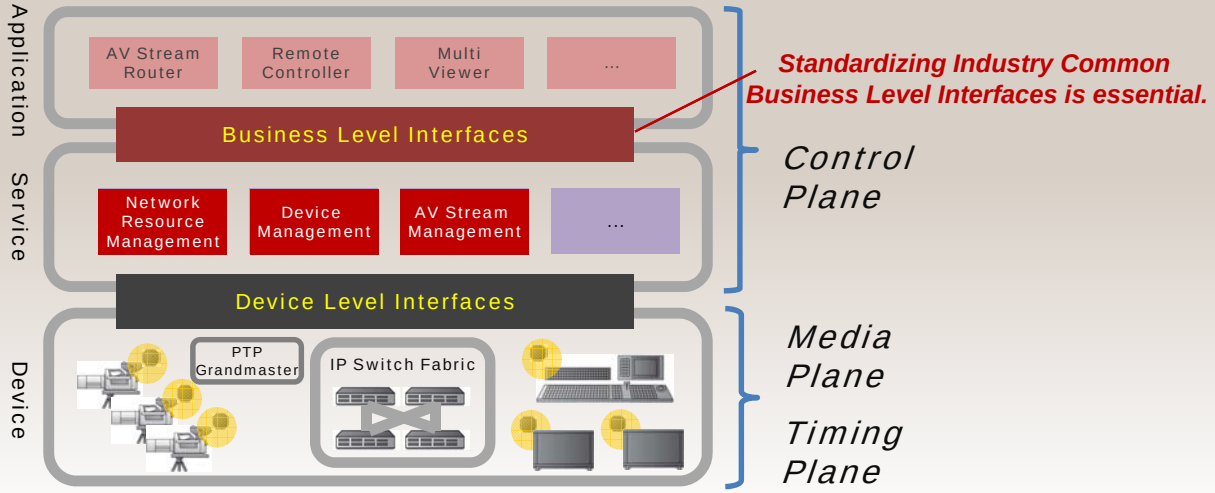
gPTP requires specified time-aware switches (AVB Bridges).

Although stream reservation function is extended to cover an IP (IEEE1733), gPTP is still a L2 technology.

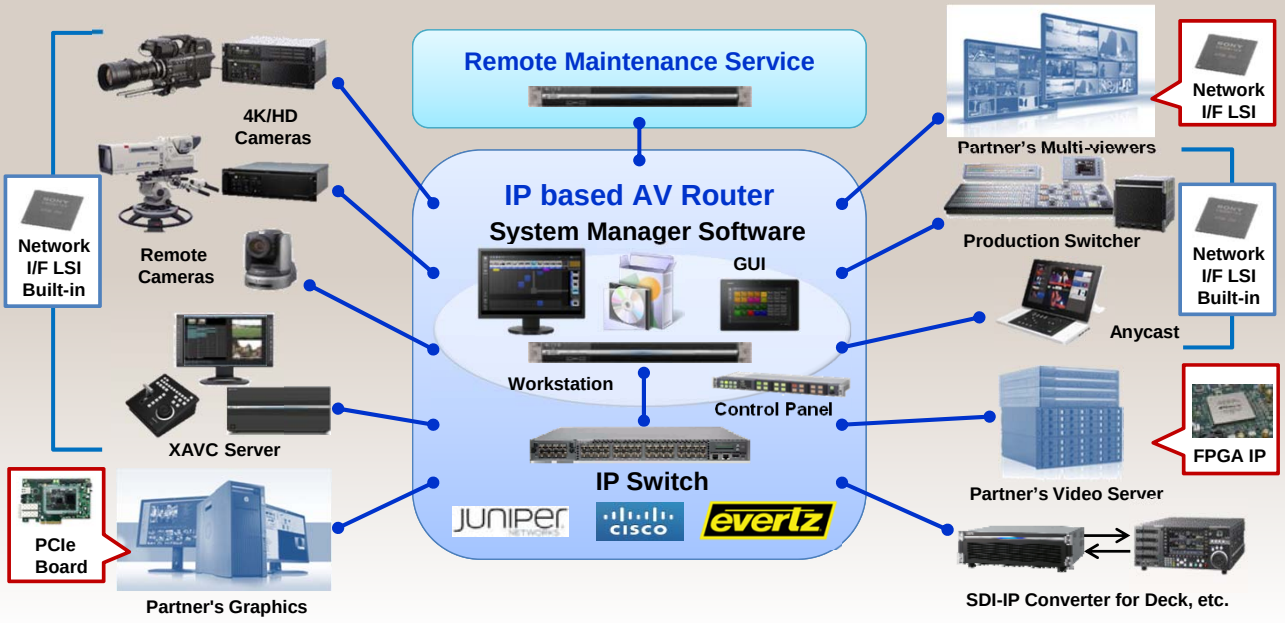


Architecture Proposal

SOA approach is also applicable to IP Live Production system.



IP Live Production System – Overview



Network Media Interface key components

IP LIVE SYSTEM MANAGER

- Setup, Matrix Config. & Cross-point Switching, System Maintenance, SDK for Alliance Partners, Integration with Evertz and other router manufacturers

SIGNAL PROCESSING UNIT

- Rack mountable frame for Networked Media Interface Converter boards, 18 slots, Redundant PSU, 3RU

SDI-IP CONVERTER BOARDS

- Convert SDI from/to Networked Media Interface, Frame Sync, AES/EBU Audio supported

Network Media Interface Supporters

ODA Systems

Optical Disc Archive

Technology Overview

- Based on Blu-ray with key attributes from Sony's XDCAM
- 50 Year archival life
- Large volume media
- Growing Line-up of Sony and 3rd Party Solutions!

Optical Disc Drive and Cartridge

Each cartridge mounted as single large volume
- 12 bare discs in a media cartridge

Several cartridge types offered
- Capacity range 300GB – 1.5TB*
- Write Once/Re-Writeable media
- Ultra high durability 50 year rated media life

Open File System (UDF)

Future drive generation backward (read) compatibility

Optical Disc Archive Technology

Ideal for Data Permanence

- Audio, video and graphics preservation-file agnostic
- Removable data exchange and transport
- Simplified management-single large volume with directory
- Media managemet applications for drives and robotic libraries

Cartridge Line-up and Capacity

	SL (300GB)	DL (600GB)	TL (1.2TB)	QL (1.5TB)
R	 ODC300R	 ODC600R		 ODC1500R
RE	 ODC300RE	 ODC600RE	 ODC1200RE	

R=Write-once

RE=Re-writable

Optical Disc Archive

Optical Disc Archive

Ultimate File Protection – File Agnostic

XAVC

MXF

MPEG IMX

AVI

Optical Disc Cartridge

AVC INTRA

PDF

XDCAM EX

DVCPRO HD

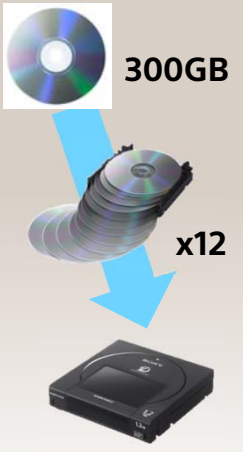
Avid DNxHD

Office

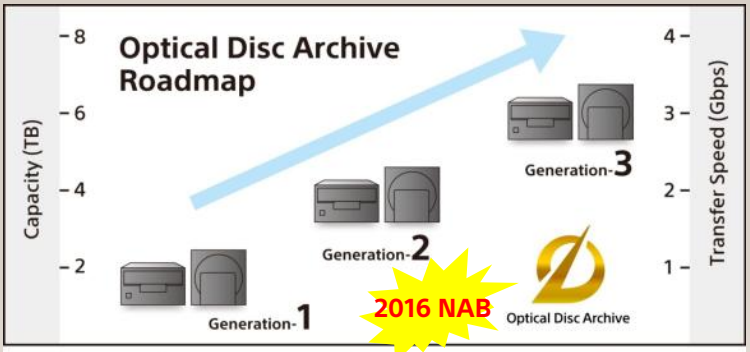
R&D Roadmap as "bare disc" format

Archival Disc Roadmap

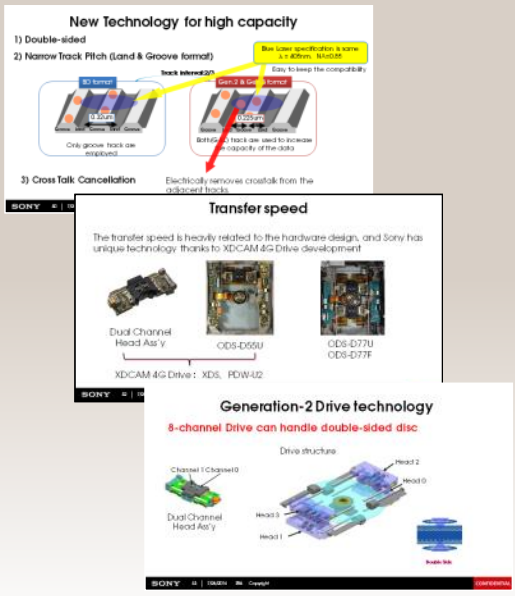
Capacity	300GB	500GB	1TB
Signal Processing Technology			High Linear Density (Multi Level Recording Technology)
		High Linear Density (Inter Symbol Interference Cancellation Technology)	
	Narrow Track Pitch (Crosstalk Cancellation Technology)		
Basic Specification	Double-Sided Disc Technology λ=405nm, NA=0.85, Layer Structure: 3Layers/side		



ODA technology continues to evolve



		Generation-1	Generation-2	Generation-3
Capacity		Up to 1.5TB	3.6TB	6TB
Transfer Speed	Read	Up to 1.1Gbps	2Gbps	3Gbps
	Write (w/Verify)	Up to 440Mbps	1Gbps	1.5Gbps



Optical Archival Systems

Optical Disc Archive

ODS-D77U/F
ODS-D55U
USB 3.0 Drive

- Bundled External Drive and Content Manager App

ODS-L10
Compact Library

- 10 slot library
- NAS Appliance Solution
- File Manager/API Interface

X-Disc Archive System

- Combined Archive Management System
- V1.60 Supports ODA drive (ODS-D55U)
- ODS-D55U Ready!
- XDA v1.7/ support for ODS-L10/30 coming Nov 2013!

ODS-D77U/F

ODS-L30
Library

- 30 slot library, 5U
- ODS-D77U Drive
- NAS Appliance Solution
- File Manager/API Interface

ODS-L30M
Scalable "PetaSite" Library

- Scalable "PetaSite" library
- ODS-D77F Library Drive
- MBB Production Archive
- Dalet MAM, FPD Archive and other 3rd party software support

How to Interface ODA With IP Live (NetMedia)

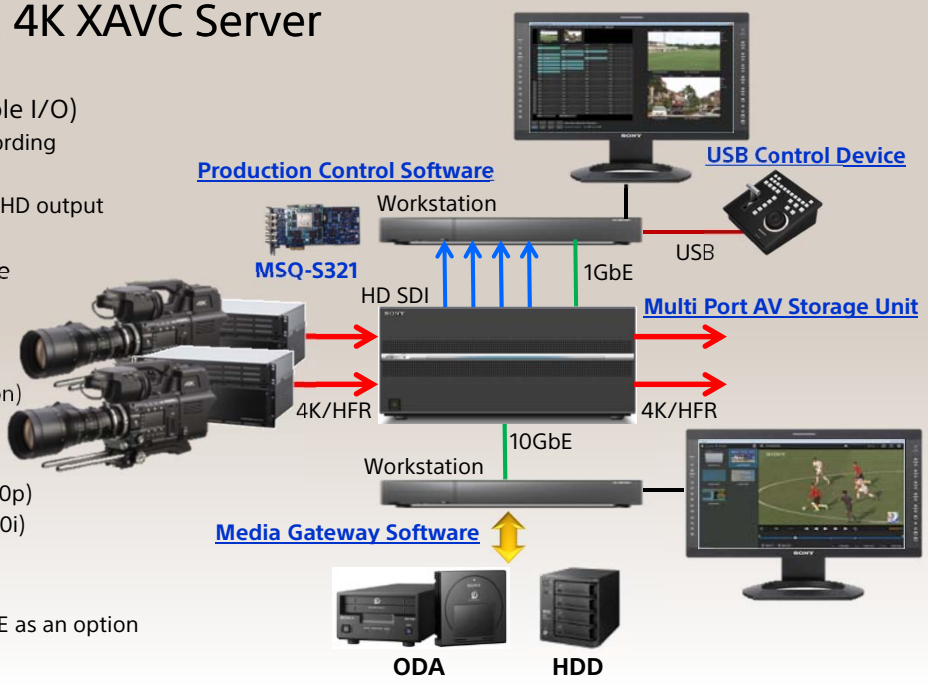
PWS-4400: 4K XAVC Server

4K x 4 ports (Configurable I/O)
- 4K/HD simultaneous recording
- HD 360p HFR recording
- 4K to HD cutout and D/C HD output

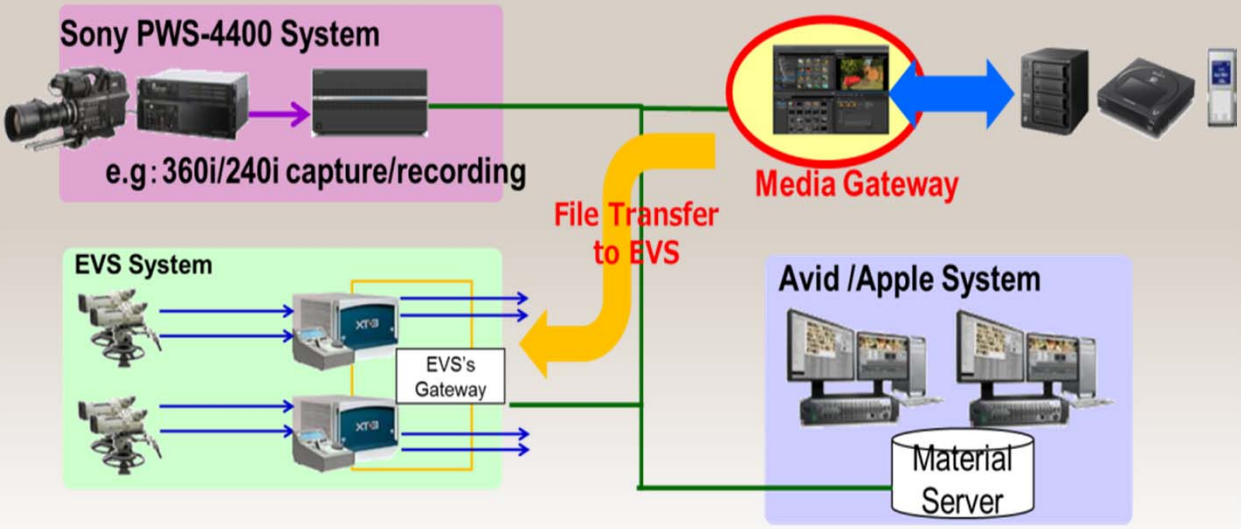
Internal memory storage
- 2TB as standard
  - 5H@4K/60p 600Mbps
  - 24H@HD/60i 100Mbps
- Expandable to 8TB (Option)

Video & Audio format
- 4K XAVC-I (600Mbps @ 60p)
- HD XAVC-I (100Mbps @ 60i)
- Audio : L-PCM 24bit 16CH

Network Interface
- 1GbE as standard & 10GbE as an option



PWS-4400: 4K XAVC Server



Tape Digitization Server

Optical Disc Archive

PWS-100TD1

- Enables video tape encoding, QC and preservation of digitized content
- Easy to use Web browser interface
- Multiple VTR control and direct recording to Optical Disc Archive media

Main Features
PWS-100TD1

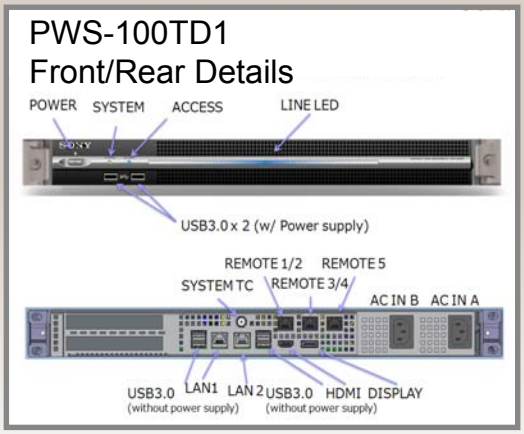
- Channel condition monitor
- Selectable SD/HD SDI ports-control up to 4 VTR's
- Embedded Auto and Manual QC

Front

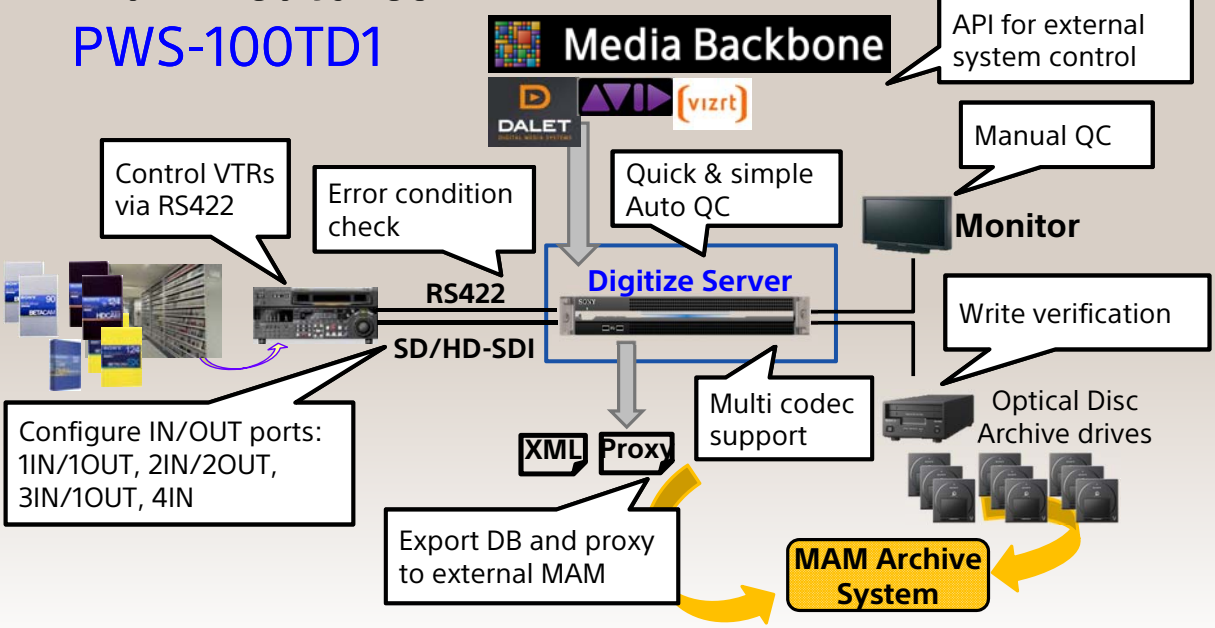
Rear

Main Features
PWS-100TD1

- Multi Codec support
- High resolution preview
- File transfers across network
- Stream to multiple Optical Disc Archive drives simultaneously



Main Features
PWS-100TD1



Conclusion

Replacement of SDI-based live production system with IP-based can be realized without changing the current operational practices with:

- Generic Ethernet Switches
- Existing and emerging standards

There are several standardization proposals to fully satisfy all the requirements such as:

- Essence-Independent mapping
- Frame-Boundary-Aware FEC
- Industry Common Business Level interfaces

There are still some issues to be improved:

- One of the biggest advantages of adopting IT technology is that ***system performance can be improved as IT technologies improve.***

Thank You !