



# Video over IP

and a few more things

NASTA CONFERENCE 2017 @ GUILD TV

PETER WEITZEL – HON SEC AND TREASURER SMPTE UK

Let's start with  
What is SMPTE



## SMPTE is .....

The worlds largest members society for those working  
with the moving image  
– and its audio and metadata\*

- **Built on Three Pillars**
  - Membership - we have about 7000 members - 550 in UK
  - Education – Journals (from 1916) webinars courses conferences
  - Standards - over 800 enabling interoperability
- **Very Active in the UK**
  - - c36 meetings from Southampton to Salford & Newbury to Ipswich
  - One VP 3 Directors and 1 Governor on SMPTE Board ( out of 4/9/16)
  - The third largest section in SMPTE ( after Hollywood and New York)
  - 5 student chapters – and this link with NaSTA – backed by £500 to the NaSTA tech award winner
- **Something you Should Join** – Its free for Students for a year and then \$10 £7 after that
- **Something that will help your Career** [www.smppte.org/uk](http://www.smppte.org/uk)

\* metadata – the bits about bits – see other lecture



## UK section

**UK Section serves all who are working with  
the technology of moving pictures  
and associated sound & metadata  
– creatively, practically and innovatively  
in any format, and on any platform.**

[www.smppte.org/uk](http://www.smppte.org/uk)



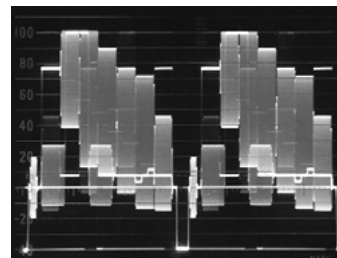
## Agenda

- ~~What is SMPTE~~
- What is current (and past) video etc. ?
- What is IP ?
- Why is Video etc. over IP such a current topic?
  - ..... And yet "old technology"
- Video over IP in 2017 plus and minus 2 years
- Video over IP in Studio
- Video over IP for Remote working
- Weitzel rules of IP



## What was video

- Analogue
- Interlaced
- Allowed time for TV (display) to catch up
- Squeezed in to the space available
  - Colour rather muddled up
  - State of the art





## What was video - Digital Starts

- Digital but based on Analogue waveform
- Interlaced
- Allowed time for TV (display) to catch up
- Squeezed in to the space available
  - Colour ~~rather muddled up~~ - Separated out Y Pr Pb and Embedded audio ST272
  - State of the art moved to 10 bit and common for "50Hz and "60 Hz (1000/1001)"
- SMPTE ST259 ITU-R BT 601 "270 Mbit/sec" SD
  - Issued in 1982 now version 7 BT601-7 2011
- Implementation started in early 1990s
  - - but Analogue was still there is 2003 ..... And still is?????



## What was video - HD Starts

- Digital but based on Analogue waveform
- Interlaced and Progressive
- Allowed time for TV (display) to catch up
- Squeezed in to the space available
  - Colour ~~rather muddled up~~ - Separated out Y Pr Pb
  - State of the art 10 bit "50Hz and "60 Hz (1000/1001)" two raster
- SMPTE ST292 and ST424 ITU-R BT 709 "1.5G" 1080i 720P and "3G" 1080P
  - Issued in 1990 now version 5 BT709-5 2011
- Implementation started in early 2000s
  - - but BT 601 still is used ( but most "glue" works with SD and HD of any flavour)



## What is video - UHD Starts

- Digital but based on Analogue waveform
- ~~Interlaced~~ **Progressive only**
- Allowed time for TV (display) to catch up
- Squeezed in to the space available
  - Colour ~~rather muddled up~~ – Separated out Y Pr Pb
  - State of the art 10++ bit “50Hz and “60 Hz (1000/1001)” **two raster “4k” “8K”**  
**3840 by 2160 Quad HD and 7680 by 4320 16\* HD**
- SMPTE ST2081 and ST2082 ITU-R BT 2020 (and BT2100) “6G” and “12G”
  - Issued 2012 - but NHK practical “8k” demo London – Amsterdam 2008
- Implementation started in early/mid 2010s
  - - but BT 601 and BT709 still is used ( but most “glue” works with SD and HD of any flavour)



## Some quick points re UHD

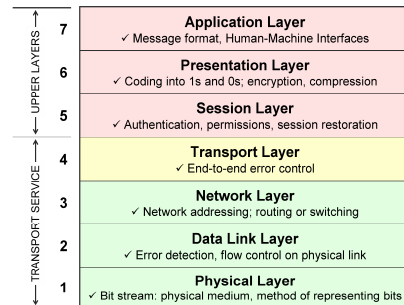
- Static resolution is not enough  
need to sit 1.5 Picture Height for UHD1 to see the pixels  
BBC WHP 287 shows we sit >5H!! Even with bigger screens
- It needs WOW that can be seen across the room
- High Dynamic Range HDR – Darks blacker White/specular brighter
  - BT2100 Hybrid Log Gamma Scene referred (BBC NHK) PQ Display referred (Dolby)
- Wide Colour Gamut WCG
- Higher Frame rate HFR
- Immersive audio
  - Object based (using Metadata\*) MPEG H or Atmos™

\* metadata – the bits about bits – see other lecture



## What is IP

- short for Internet Protocol.
- "a digital media transport system that runs over standard IP networks"
- Works (asynchronously) with Packets
- Layer 3 in the ISO/OSI model
- Inherently Routable
- Two Main Protocols
  - TCP/IP – files – resend if a packet gets lost
  - UDP – Streams – Send and forget – often RTP  
UDP=RFC768 RTP=RFC3550 IPV4 = RFC791 V6=RFC2460



## Pros and Cons of IP for AV content

### WHY IP

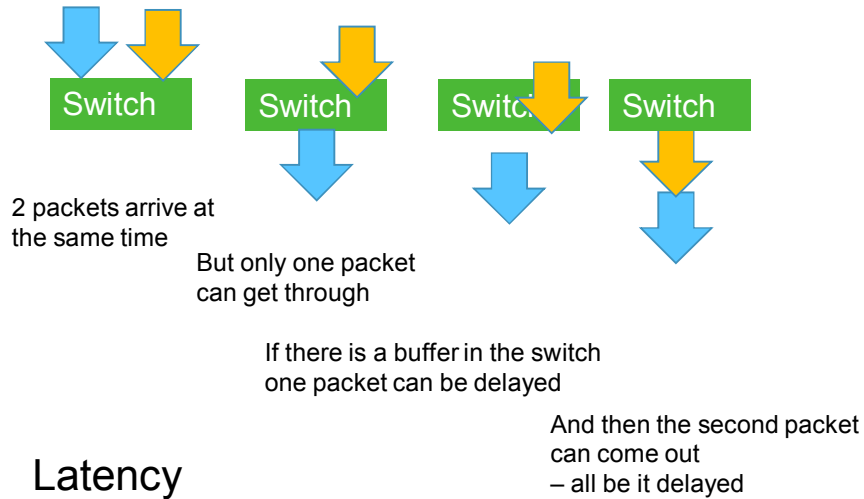
Cheap  
 Universal  
 Ubiquitous  
 The future  
 Fashionable  
 Accountants Heard of it

### WHY NOT FOR AUDIO/VIDEO

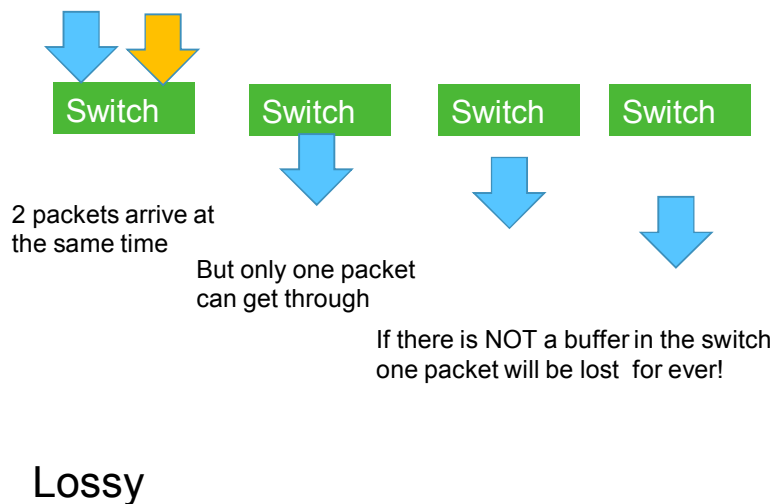
Non Deterministic  
 Lossy  
 Latency  
 No timing reference  
 "Strange"  
 IT department own it!



## Practical IP – the Switch/Router issues (1)

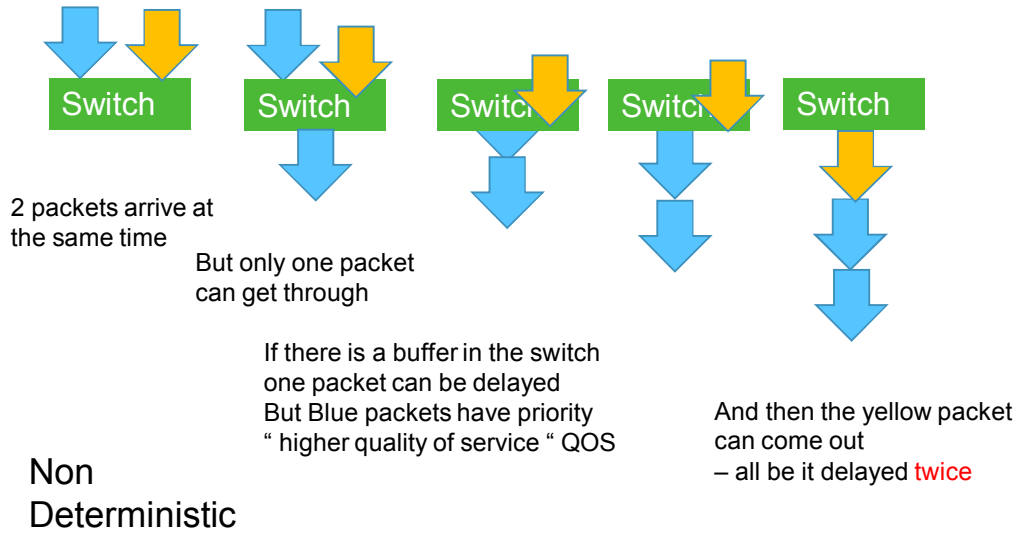


## Practical IP – the Switch/Router issues (2)

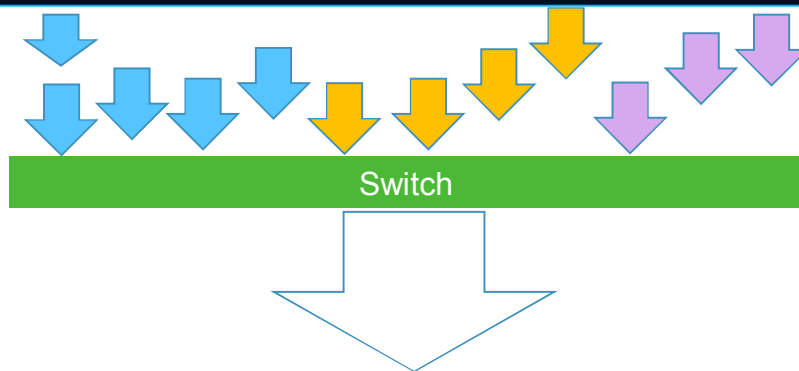




## Practical IP – the Switch/Router issues (3)



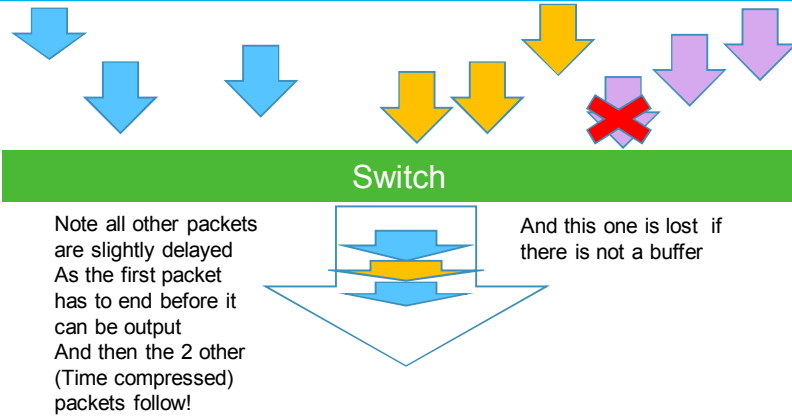
## But in reality its not that simple (1)



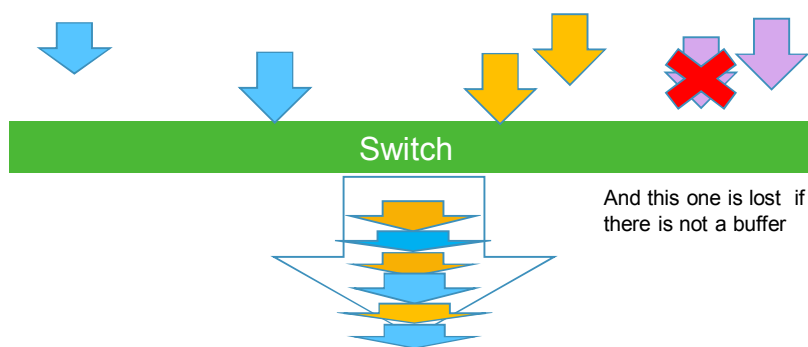




## But in reality its not that simple (2)

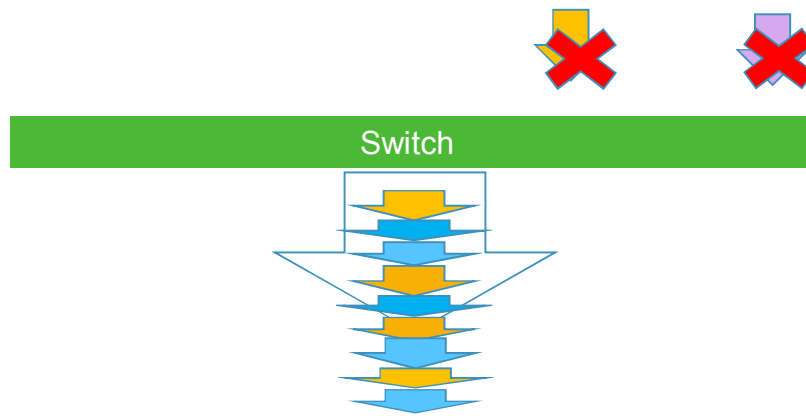


## But in reality its not that simple (3)

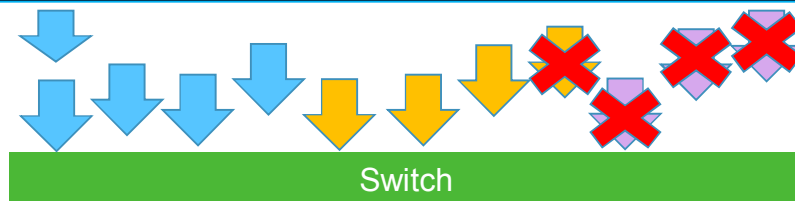




## But in reality its not that simple (4)



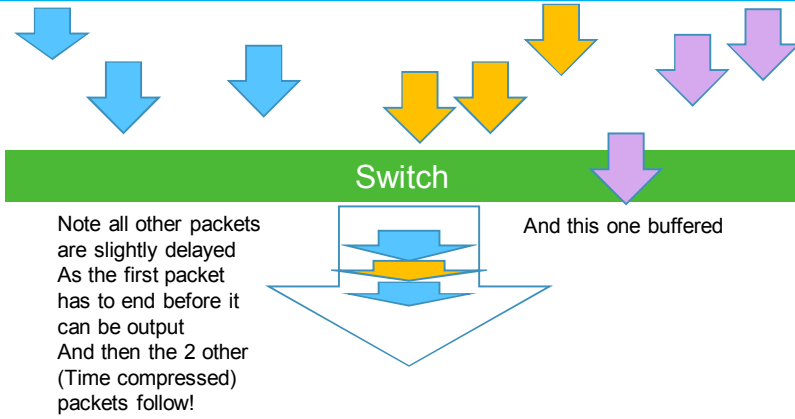
## But in reality its not that simple (Summary 1-4)



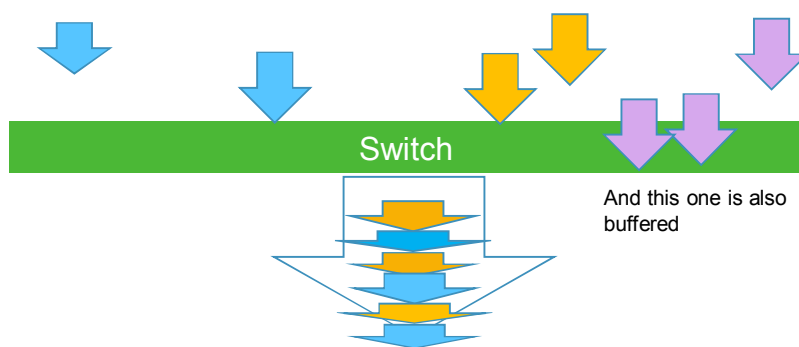
But if the Purple packets can be buffered



## But in reality its not that simple (2B)

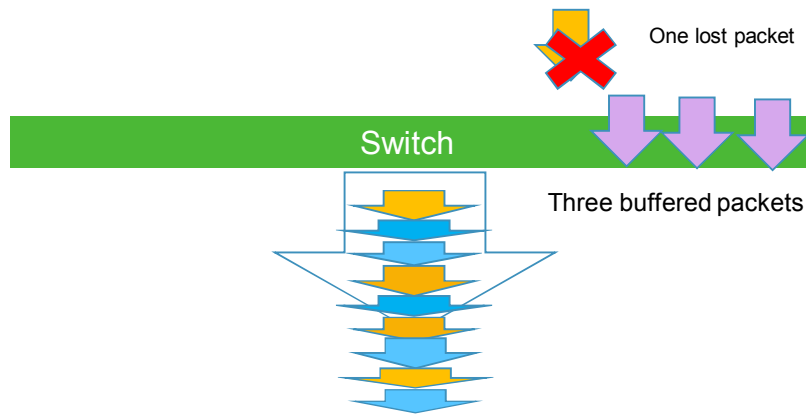


## But in reality its not that simple (3B)

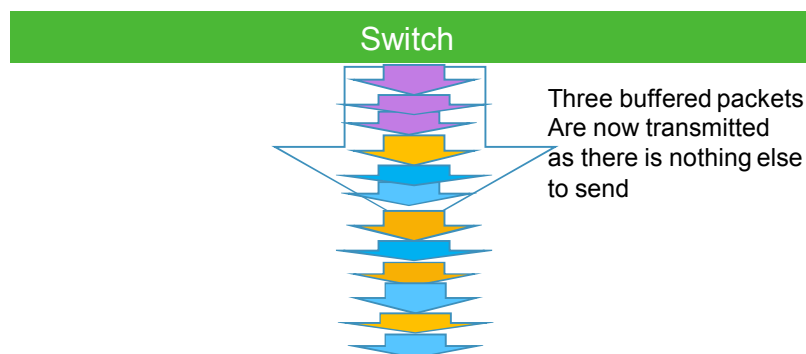




## But in reality its not that simple (4B)

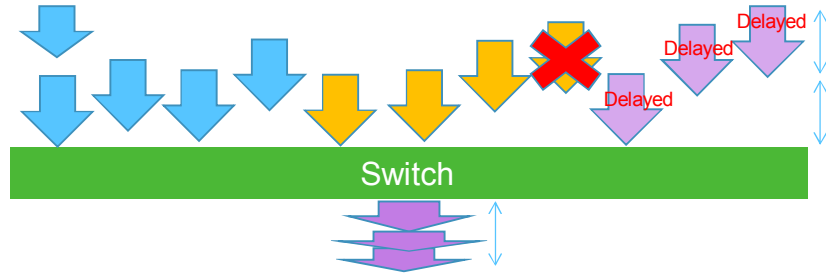


## But in reality its not that simple (5B)





## But in reality its not that simple (Summary 1-5B)



But if the Purple packets can be buffered  
They will be delayed – but all three Packets are  
delivered in one I/p time interval not the 2 in which  
they arrived = It “Splurges”

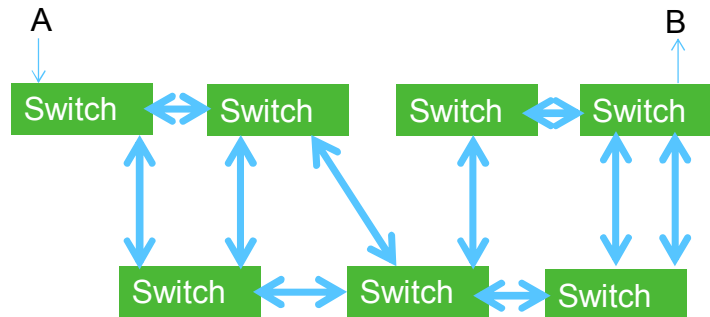


## But in reality its not that simple

- And it just get even more confusing –
- What if four Blue Packets arrive at once – and no Buffering?
  - Packet loss and some latency
- And four Blue packets – But this time with Buffering
  - No packet loss but one pack et is a lot later than the others
- And then four More Blue packets arrive next period with Buffering
  - Maybe the four packets from the first period are output  
3 in period 1 (ABC) one in period 2 (D)with Two from Period 2(ab)  
and 2 buffered (cd)
  - Or the three packets from the First period are output in period 1 and Three  
from Period 2 are output and thus 1 packet from each period is Buffered  
(but is it AaBbCc or Dd?)



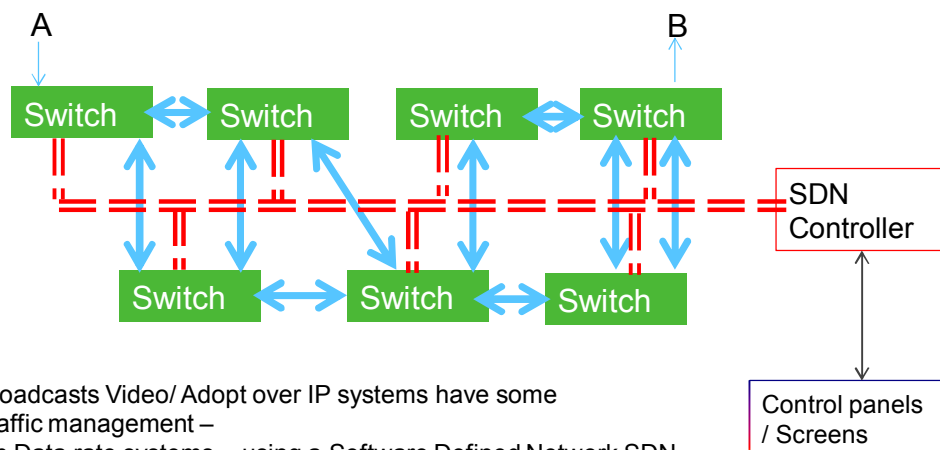
## And there are always multiple switches



So packets may not arrive in the same order – and many opportunities for them to get lost – particularly if each Switch decide what to do with each packet ..... As they do in Normal office systems



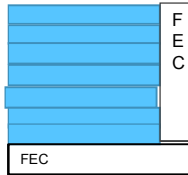
## So add some management – Ultimately a SDN



So most Broadcasts Video/ Adopt over IP systems have some Forms of Traffic management – And for High Data rate systems – using a Software Defined Network SDN which controls **where each and every packet is consistently routed** – i.e.. A central Management plane – and it can also reroute if a link fails!



## How can we handle Packet loss



- Forward Error Correction – sending some extra packs which enable you to reconstruct a missing packet.
- BUT – adds latency – as the [7] packets need to be assembled at source and destination
- BUT increases the IP traffic – in this case by [2] packet every [7] packets

Send two streams and then (hitlessly) switch between them

- this is quite well liked as IP systems often are 100% redundant
- so the second stream uses “empty capacity”



## A few other things.....

- Packets can be different sizes
- They may not arrive exactly at the same interval – particularly as any network has multiple switches
- Buffering can ensure no packets are lost but they can also cause Splurging ( which can over load down stream buffers) and wider range of latency....
- BUT most existing SDI (active) equipment can buffer video so it is not a great change to handle the IP jitter –
- BUT this assumes no packets are lost (or cannot be recovered)  
SO aim **NOT to loose packet** not to try to recover them



## So lets look at video over IP – past

As the IP circuits had capacity less than Video –

Video over IP only works if you compress it!

So a 270 Mbit/s SD SDI  
over a 100Mbit/s link used for business –email file transfer Word etc.

so as this was historic – used the MPEG2 codec ....

Some standards ST2022-

- ST2022-1 FEC for Real-Time Video/Audio Transport
- ST2022-2 Constant Bit Rate MPEG-2 Transport Streams
- ST2022-3 Variable Bit Rate MPEG-2 Transport Streams
- ST2022-4 Non-Piecewise Constant Variable Bit Rate MPEG-2 Streams

There was going to be a -8 For JPEG2k (VSF TR/01) and the BBC Had systems



## Video over IP now and recent past

IP circuits having about the same capacity as the Video

Say SD and 1 Gbit/sec IP or HD and 10 Gbit/sec IP

So why not just wrap SDI 270M/ 2.5 or 3 G in IP?

- ST2022-6 High Bit Rate Media Signals over IP Networks
- ST2022-5 Forward Error Correction for Transport of High Bit Rate Media Signals
- ST2022-7 Seamless Protection Switching of SMPTE ST 2022 IP Datagrams



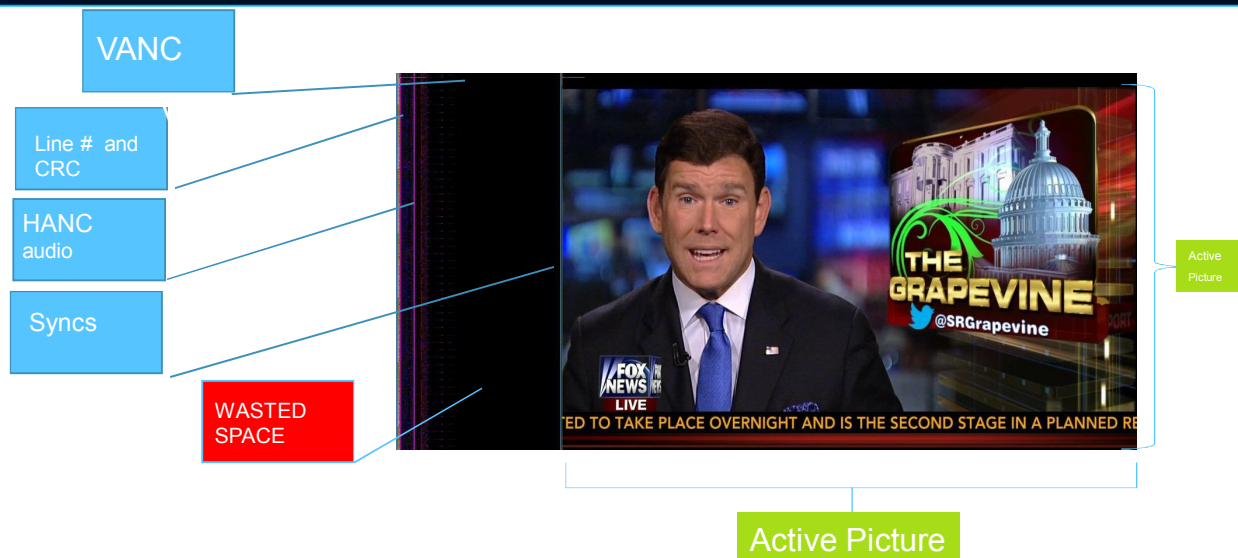


## ST2022-6 issues

- Fairly simple to achieve
- But it still has all the problems of embedded audio
- Lots of embedders and de-embedders
  - and wrapping and un wrapping of SDI in IP
- BUT
  - And like analogue before it ...is unidirectional ....
  - All be it with audio and metadata transport !
  - AND it is not very efficient
- Yet can be used in a studio ....  
AND is used to get ITV and BBC Video around the UK  
(and BBC to/from USA)



## ST2022-6 - the SDI Raster





## ST2022-6 - the SDI Raster much waste

As the signal is  
1.485 Gbit/sec

In 1080i/50  
Active video is  
1.037 Gbit/sec  
The ANC is  
448Mbit/sec  
= 30% Wasted!



ANC  
Wasted  
Space

Active Picture



## RFC 4175 - just active picture

RFC 4175 RTP Payload for  
Uncompressed Video, Sept. 2005

Works for:

- Any bit depth
- Up to 32767 x 32767 resolution
- 4:2:0, 4:2:2, 4:4:4 colour subsampling
- Progressive & interlaced

TR-03 adds HDR & WCG

“Pixel Groups” (pgroups) keeps related  
samples together



Active Picture



## ST2110 – lets use existing standards

### • Video Flows

- RFC 4175 (uncompressed)
- RFC 5371 (J2K)
- RFC 6184 (H.264 I-frame)

### • Audio Flows

- RFC 3190 (AES67) 24 LPCM

### • Ancillary Data

- New ANC RTP payload

### • Clock Distribution

- IEEE 1588 PTP
- SMPTE ST 2059-2 Profile

### Synchronisation –

- RTP Clock source Signalling in SDP
- RTCP Sender Reports RFC3550

### Flow Association

- Session Description Protocol (SDP) RFC4566

### Identity (UIDs)

- Sources: RTCP SDES CNAME
- Flows & Bundles: SDP URI

### Discovery

- Multicast DNS-SD



## ST2110 its parts

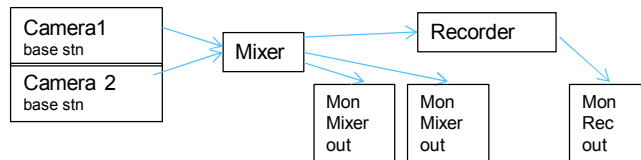
ST2100 IP Media Inter-Networking  
with Separate Essence Flows :

- ST2110-10: System Timing and Definitions (almost issued)
- ST2110-20: Uncompressed Active Video (almost issued)
- ST2110-30: PCM Digital Audio (almost issued)
- ST2110-40: Ancillary Data
- ST2110-50: 2022-6 transport
- ST2210-21: Timing
- ST2110-31: Full AES-3 Transport

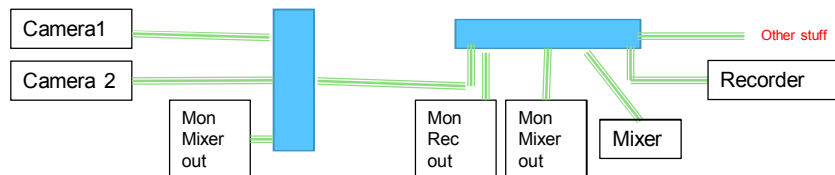


## Discovery and Routing

In a SDI system we know where the equipment is – and how it is connected so that the signal flows



In IP systems equipment/devices (resources) can be anywhere and the flows need to be set up within the IP network



## Elements of the Model

Based on JT NM – SMPTE EBU VSF – see [www.jt-mn.org](http://www.jt-mn.org)

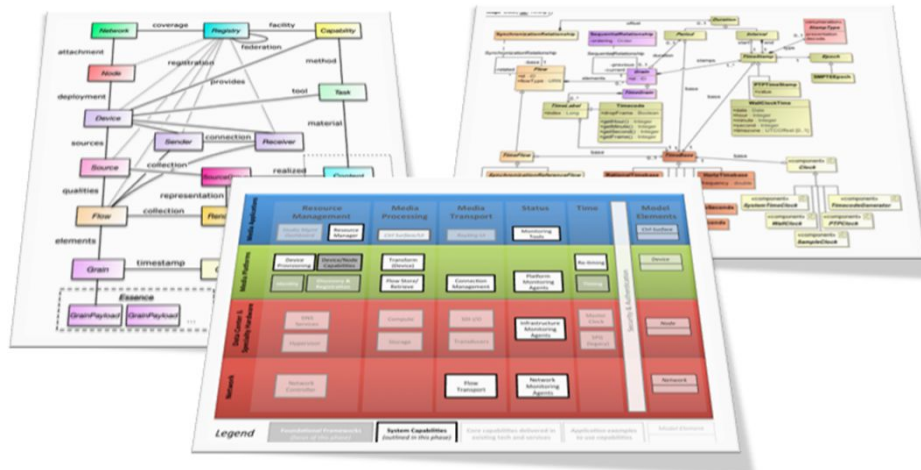
- Network has Nodes “attached” to it
- Nodes “deploy” Devices
- Devices “source” Sources
- Sources have “qualities” which form Flows
- Flows are made up of Grains
- Grains contain the essence

There are also a registry  
– a device can have sender or receiver (or both) functions  
and Flows can be grouped

..... It can get rather complex to visualise as every thing is virtual!



- like this!!



## How to discover - NMOS

Network Media Open Specifications [www.nmos.tv](http://www.nmos.tv)

A way of getting the connections needed in IP to be very easy to configure

A) by telling you what you have got Discovery and registration  
Using multicast DNS and a Registration API

B) By giving you a means of connecting Nodes together  
with flows and the grains  
By a Node (simple) or Query API (registry – complex systems)



## Studio Video (over IP) in the future

- Target is very clearly ST2110 and NMOS
  - BUT in the mean time
  - ST2022-6
  - And if there seems to be bandwidth issues
    - use light Compression Sony mezzanine or Tico
  - Have lots of Video running over say 10Gbit links!
- So a good playpen / Sand box – and it works!!!!
- And BBC Cardiff is specified for entirely IP infrastructure



## IP for Broadcast in the WAN

- How do you get your Pictures and Sound & Metadata from one site to another?
- You can “own” Dark fibre Or Microwave links
  - expensive - often pay by bitrate times distance
  - what happens when you get “JCB strike”
- You can lease a circuit from a Telco
  - Perhaps less bitrate - But now Distance independent pricing
  - And JCB strike is (mostly) their problem.....
  - But the cheapest and future proof circuits are IP ( not SDH PDH or ATM)
  - IP circuits at say 10G can be supplied more or less anywhere in UK Urban areas on a permanent basis! – and you can have your emails etc. also delivered!
  - And you may compress to get the price down - perhaps!



## Remote Working

Idea is

Why have a OB truck ?

Why not get the cameras microphones etc. taken back to a studio where all the mixing etc. etc. Can be done

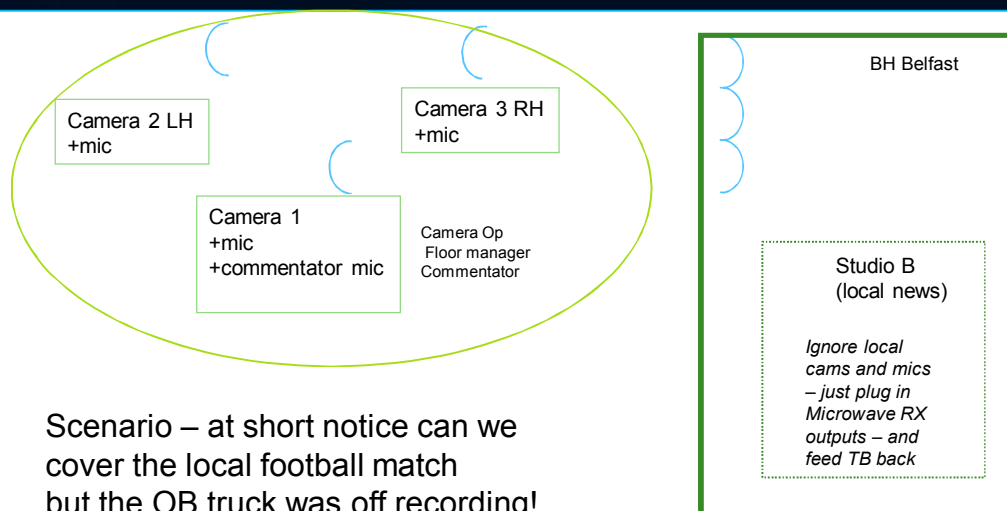
Saves costs – both equipment and staff expenses

Save time – things are “half the same” every time

And main Production team does not need to travel  
(Or have one per location)



## Remote working – its not new!



Scenario – at short notice can we cover the local football match but the OB truck was off recording!



## Remote working – example UK PL

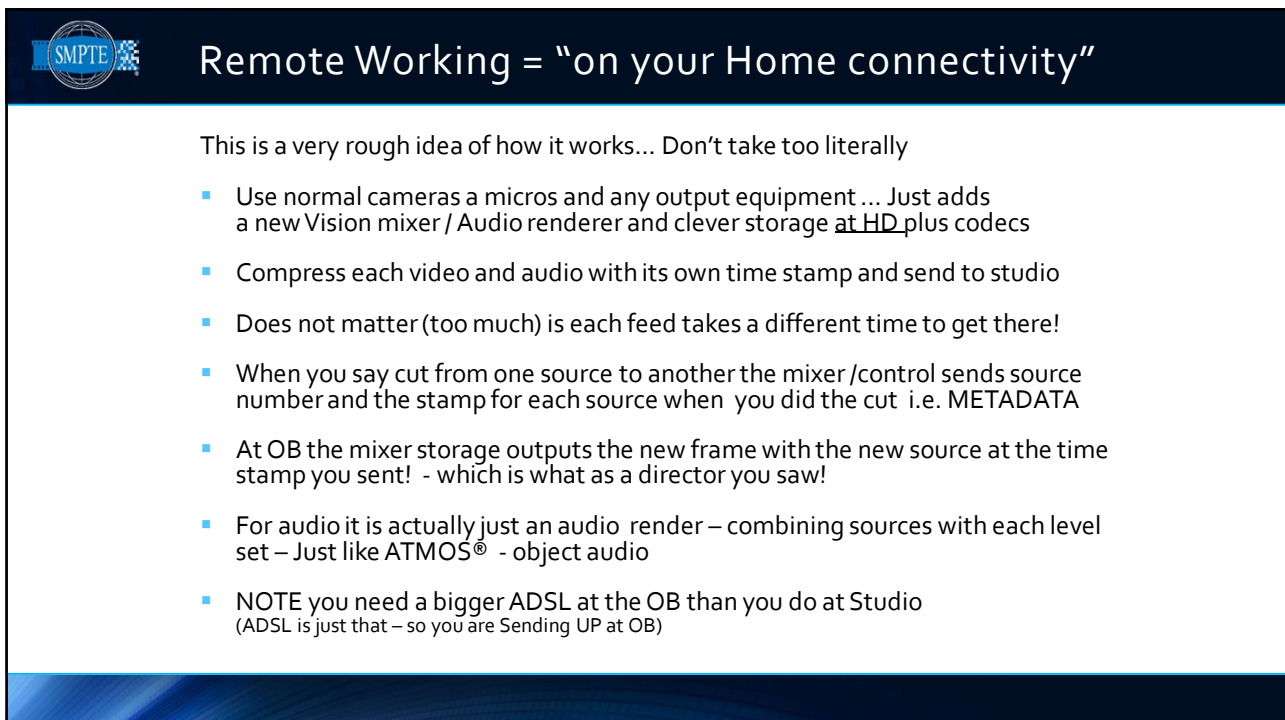
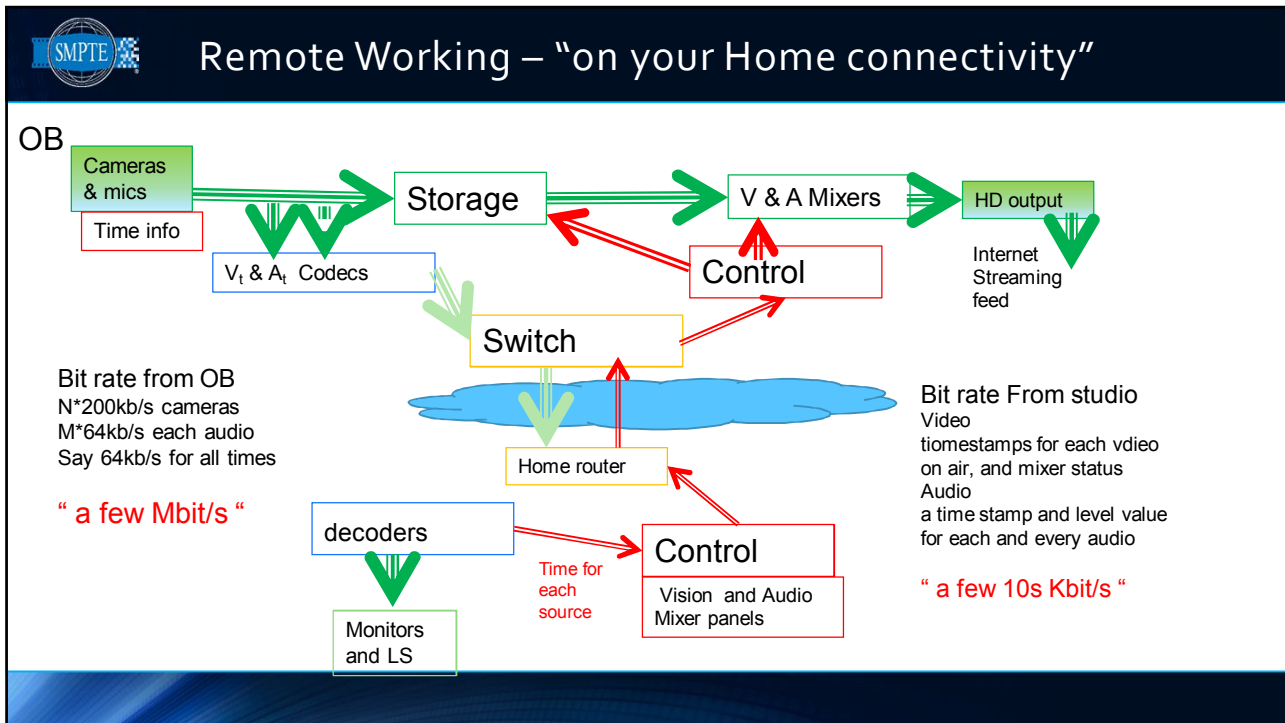
- Each UK Premier league football ground has a BT 40G circuit
- Thus say a dozen cameras can be fed uncompressed
- Need more – then add another 40G (or 10G) or compress
- Feed via BT Tower to IMG at Stockley Park – and mix there!
- Works well - But this is a premium product - !!!!!
- See it at SMPTE UK Summer Visit 22 June



## Remote Working – “on your Home connectivity”

- Problem - UKPL uses multiple 40G you have say 10 M (on a good day)
- Solution – to get you the feeds - Compress
- Problem compression takes time (and you are Live)
- Problems compression ruins the picture
- Solution - edit on Proxy and Conform/ mix on site
- Problem But we are live!!!! ( But what is live ..???)
- Problem The latency of connection may be variable and different for each Camera feed! – as it is the raw internet!
- ..... HELP!!!!!!!!!!
- Comment – but output may not need to be “Premium quality”  
HD will do!







## Weitzel IP Rules

- Every packet counts
- All it needs is **just** best practice
- It is complex because of interrelationships

My AES audio over IP lecture from 2102

See [https://sites.create-cdn.net/sitefiles/2019/02/09/045/AoIP\\_How\\_can\\_it\\_work\\_AES12jun12.pdf](https://sites.create-cdn.net/sitefiles/2019/02/09/045/AoIP_How_can_it_work_AES12jun12.pdf)



## There is a lot more!

There is a lot going on in the technology of the moving pictures industries - and many relearning fundamentals

Today I have only looked at two areas

BUT what matters is that the technology **helps and enhances** the storytelling which get the money flowing in...

– technology on its own is waste of time and money ....

I asked one chief engineer what his Priorities were

- UHD... Practically HDR, but all the other issues of WCG HFR \*
- VR and 360 deg videos ( which are not the same thing) – And AR
- Remote Production
- Scalable Cross platform compliance
- IP Production \*
- IMF (interoperable mastering format ST 2067)\*
- DPP Specs and metadata
- Object audio



## Questions ??

You have the Vision to stay to the end  
- what more do you want to know!

Find this slide pack and how to join SMPTE – at [www.smpte.org/uk](http://www.smpte.org/uk)

If your Station wants to get in touch – [peter@weitzel.org](mailto:peter@weitzel.org)  
(use Subject: NaSTA <Station Name> )

Next some extra slides with Links to useful things!



## Useful Links

Standards bodies

[www.smpte.org/standards](http://www.smpte.org/standards)

[www.itu.int](http://www.itu.int) BT 601, 709 2020 2100

[www.etsi.org](http://www.etsi.org) DVB specs etc.

Specification bodies

[www.digitalproductionpartnership.co.uk](http://www.digitalproductionpartnership.co.uk)

[www.dtg.org](http://www.dtg.org)

[www.Amwa.tv](http://www.Amwa.tv)

[www.nmos.tv](http://www.nmos.tv)



## Useful links

Files are made using MXF SMPTE ST337 As a wrapper /Data model

See <http://academy.dalet.com/video-gallery/bruces-shorts/what-mxf>

A particular Flavour of MXF is uses in the Application specifications AS by Amwa – DPP uses AS11 as the basis

There are Other File formats using MXF  
– the up and coming one is IMF  
see <https://mrmxf.com/shorts/>

And to explain the all Mr MXF ....

<http://academy.dalet.com/video-gallery/file-formats-what-f-are-all-these-formats>

Mr MXF is SMPTE fellow and UK governor Bruce Devlin and he is looking for you to help him! <https://mrmxf.com/shorts/?sponsor>



## Why join SMPTE - go to [www.smpte.org/uk](http://www.smpte.org/uk)

- [Join in our success](#)
- Meeting others working in our industries - that what [SMPTE meetings are all about](#)
- Receiving the [Motion Imaging Journal](#) (not associate members) how to  
- full of the latest techniques and news from SMPTE sections around the World
- Participating the [Technology relevant webcasts](#) at no Charge
- Access our archive - Look back over SMPTEs work over the past 100 years
- Attending events [conferences](#) and [Courses](#) at member discount rates  
– you can easily save your subscription (and it can be offset against tax)
- Discounts on conference papers, proceedings and Standards in the [SMPTE Digital Library](#)
- Getting Preferential booking for [our meetings](#)
- Supporting those joining our industries through the [Graduate Initiative](#)
- Taking part in [standards work](#) and directing the way our industries move
- Just being an active member of the world's largest Members society for those working with the moving image, its audio and metadata- on any platform - Film, Television , Digital media



## Join us and Join in

Student Members First year Free – Following Years only \$10

- Go to [www.smpte.org/uk](http://www.smpte.org/uk) and click on “Student members free” link  
<https://www.smpte.org/store/product/membership-individual-student>  
but choose “Pay Later” as your payment method.  
When it asks for the name of your lecturer etc. put “NaSTA Weitzel”  
(When you join, you will be asked to set up an online account you will use to access your membership benefits)
- Once you have joined, email us at [membership@smpte.org](mailto:membership@smpte.org).  
We will make your membership active, and send you a welcome email.

And problems email SMPTE Home office (East Coast USA)  
[Rgorman@smpte.org](mailto:Rgorman@smpte.org) and all will happen!

AND TAKE PART \_ UK meetings plus the webcasts  
and by contacting any SMPTE member ( via website!)

**YOU have a better idea of the future than we do!!**