10: System Streams

Mark Handley

Motivation for System Streams

- We have raw data streams:
  - Video (H.261, MPEG-2, etc)
  - Audio (G711, G722, MP3, etc)
  - Data (eg. shared presentation tools)
  - Signalling (metadata, channel setup)
- Need to store or transmit all this together.
- Need to protect data against corruption.
- Need to allow re-synchronization after corruption, fast-forward, channel switching, etc.

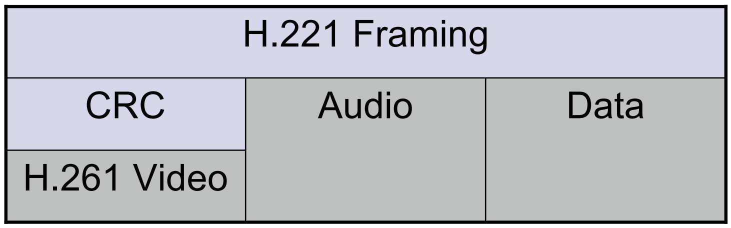
ITU Multimedia Standards Roadmap (simplified)

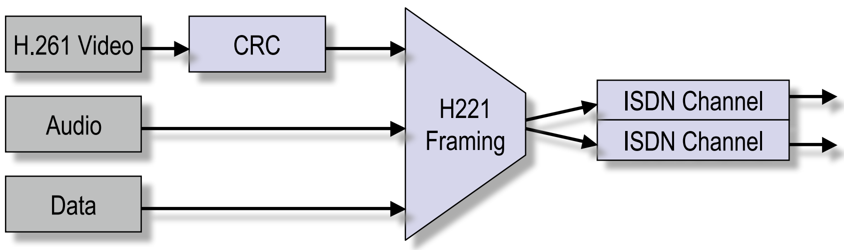
	Narrow band (H.320)	Low Bitrate (H.324)	Ethernet (H.323)	ATM (H.321)
Video	H.261	H.261, H.263	H.261, H.263	H.261
Audio	G.711, G.722, G.728	G.723	G.711, G.722, G.723, G.728, G.728, G.729	G.711, G.722, G.728
Data	T.120	T.120, T.434, T.84	T.120	T.120, H.281
Signalling	H.230, H.242	H.245	H.230, H.245	H.230, H.242
Multiplex	H.221	H.223	H.225.0 (RTP)	H.221
Multipoint	H.243	NA	NA	H.243

H.221 Framing

- ITU standard for videotelephony framing.
  - Aimed primarily at ISDN (64 or 128kbit/s, but can go up to 1920kbit/s).
- Part of H.320 protocol suite which also includes:
  - H.261 video.
  - G.711 (mu-law), G722 (64kbit/s), G728 (16kbit/s) audio.
- Pretty dated now.
  - First standardized in 1988, but revised several times since.
  - ISDN isn't so popular anymore.

H.221 Framing





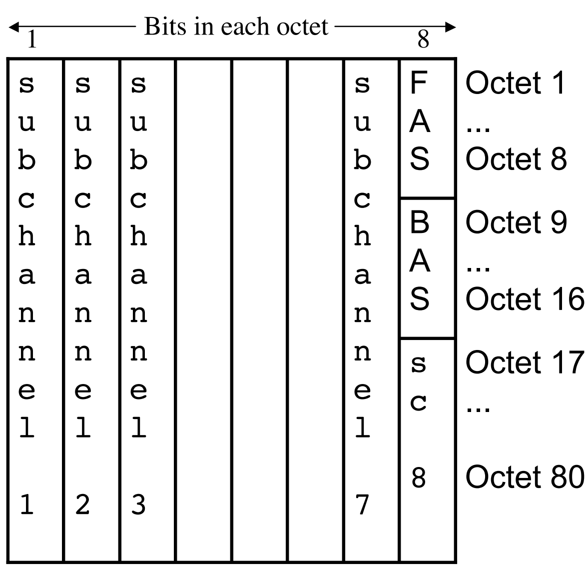
H.221 Framing

- Serious telephony mentality!
  - We have p x 64Kb/s serial channels we wish to transmit audio, video and data over.
  - Need to be backwards compatible with regular 64Kb/s telephony when audio-only.
  - Need to negotiate up from one 64Kb/s channel to multiple channels for higher bitrates.
  - No external framing available - raw bitpipes!

H.221 Framing

- We don't even know where the octets are in the bitstream!
- Divide bitstream into 80 octet frames.
- Logically, divide each frame into 8 subchannels
  - Bit 1 of each octet is in subchannel 1, etc.
- Subchannel 8 contains metadata (and some real data):
  - FAS: *Frame Alignment Signal.*
    - Easily recongnized bitpattern repeated in alternate frames.
  - BAS: *Bandwidth Allocation Signal.*
    - Sequence of codepoints used to negotiate how the subchannels are used and to add subchannels for higher datarates.

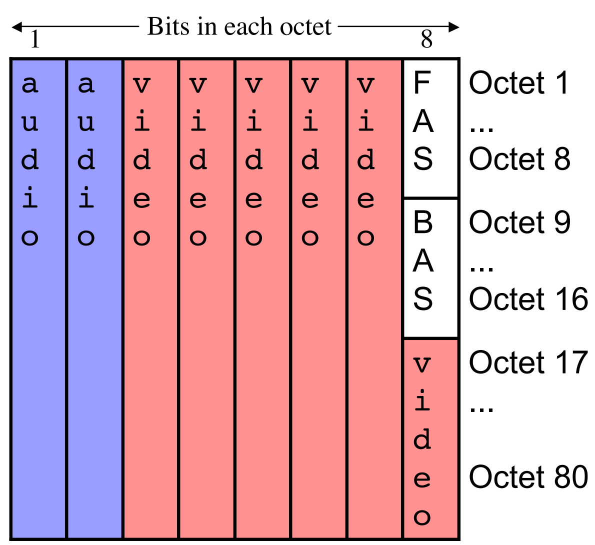
Subchannels



Using subchannels

- Defaults to being all audio.
  - BAS signals changes
- There are many different ways of dividing up the subchannels between audio, video and data.
  - Depends on audio codec and data use.
  - Video takes remainder.
- Audio gets a contain number of bits in each octet.
  - Motivation: minimal delay to the audio at low bitrates.

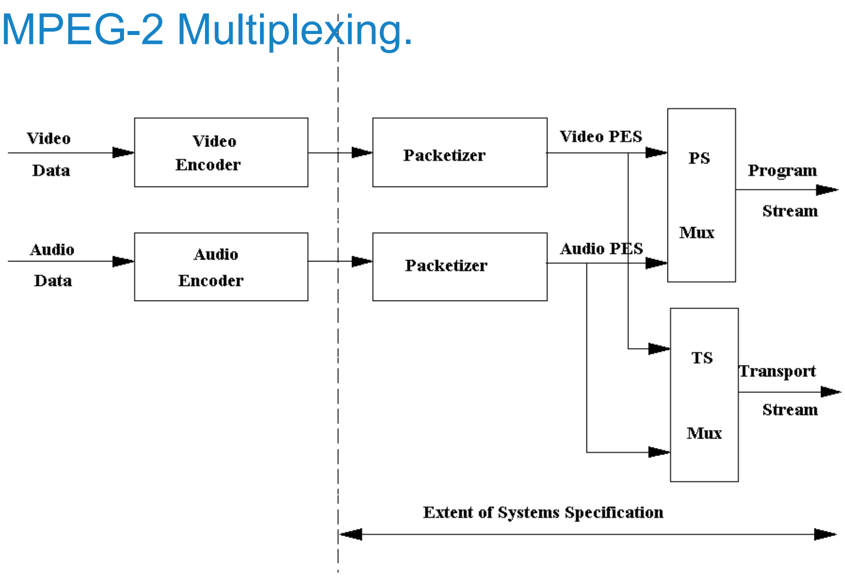
Using Subchannels



MPEG Audio/Video Multiplexing

- MPEG-1 Video + Audio
  - Framed in MPEG Systems Stream
- MPEG-2 Video + Audio
  - Framed in either:
    - MPEG Program Stream.
    - MPEG Transport Stream.

MPEG-2 Multiplexing.



PES: Packetised Elementary Stream

- MPEG video encoder produces *video elementary stream*
- MPEG audio encoder produces *audio elementary stream*.

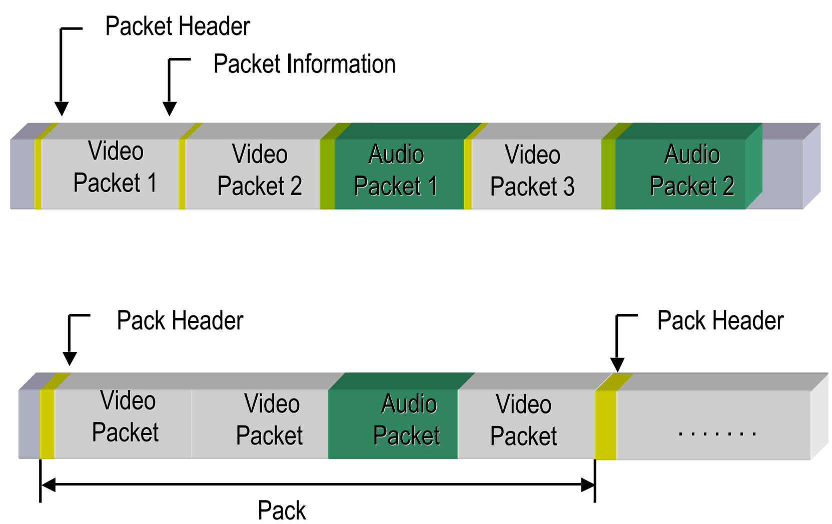
Before being multiplexed, the elementary streams are packetized to form a *Video PES* and an *Audio PES*.

- PES packet format is variable length:
  - **Header:**
    - packet start-code prefix (3 bytes)
    - stream identifier (1 byte)
    - PES packet length (2 bytes)
    - optional PES HEADER (variable length)
    - stuffing bytes (FF) (variable length)
  - **PES packet data bytes**

MPEG-2 Program Stream

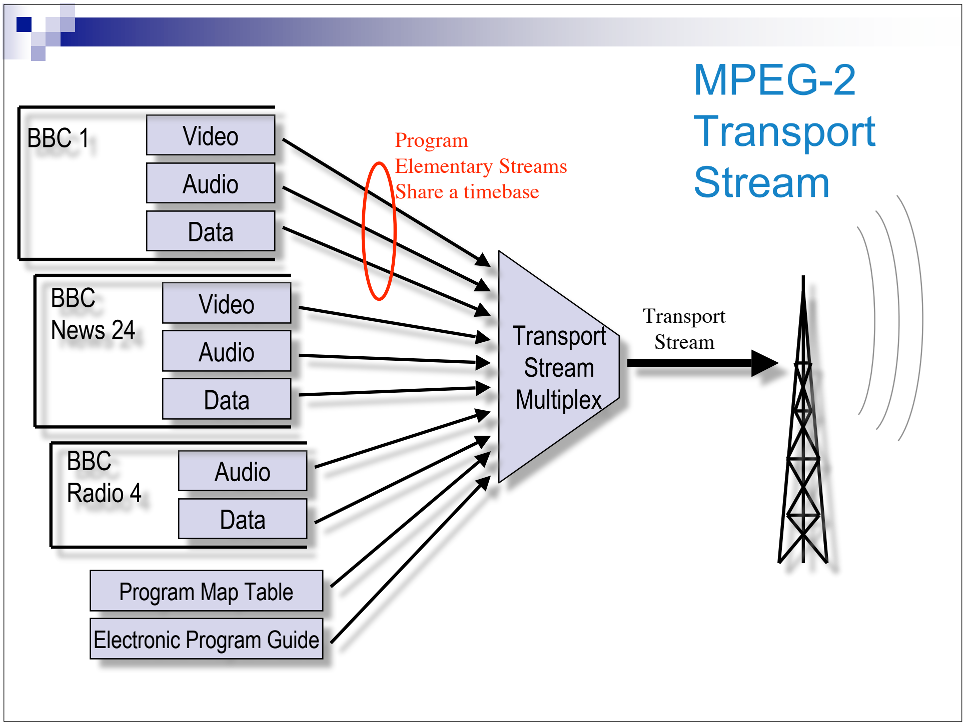
- Results from combining one or more Packetized Elementary Streams (PES), which have a common time base, into a single stream.
- Designed for use in relatively error-free environments
- Program stream packets may be of variable and relatively great length.

Program Stream Format



MPEG-2 Transport Stream

- The Transport Stream combines one or more Packetized Elementary Streams (PES) with one or more independent time bases into a single stream.
- Elementary streams sharing a common timebase form a program.
- The Transport Stream is designed for use in environments where errors are likely, such as storage or transmission in lossy or noisy media.
- Transport Stream has a fixed-length packet structure.



MPEG-2 Transport Stream

Transport stream packets are 188 bytes long:

- Header: 4 bytes
- Payload: 184 bytes

Why 188 bytes? Inevitable compromise:

- longer packets more efficient.
- shorter packets more resilient to loss, easier resync.

ATM cells: 53 bytes (5 bytes header, 1 byte adaptation layer, 47 bytes payload). 47 * 4 = 188 bytes.

MPEG-2 Transport Packet Header

Item Name	Description	Bits
Sync byte	Synchronization code of value 0x47	8
Transport error indicator	When set at least one bit error is present in the packet	1
Payoad start indicator	When set the payload of this transport packet is the start of a PES packet	1
Transport priority	Used by the decoder	1
PID	Identifies which PES the data stored in this transport packet payload is from	13
Scrambling control	Scrambling mode	2
Adaptation field control	Indicate if there is an adaptation field (additional information) following the transport stream header 01 : no adaptation field, payload only 10 : adaptation field only, no payload 11 : adaptation field followed by payload 00 : RESERVED for future use	2
Continuity counter	4 bit counter which increments with each transport packet containing the same PID, when it reaches 15 it loops back to zero	4

MPEG-2 Stream Usage

- DVB-T (Freeview) uses MPEG-2 Transport Stream.
  - Need to be robust to bit errors and allow easy resync on channel switching.
- The **`.VOB`** files on a DVD actually contain MPEG-2 Program Streams.
  - The DVD storage medium provides error protection.

Summary

- System streams allow us to multiplex audio, video and data (eg subtitles) together into a single stream for transmission or storage. Need to preserve timing information.
- Many different constraints:
  - CBR vs VBR
  - Corruption, loss.
  - Need to resync, rewind, etc.
- H.221 for ISDN (telephony)
- MPEG Program Stream for DVDs (files)
- MPEG Transport Stream for Digital TV (broadcast)