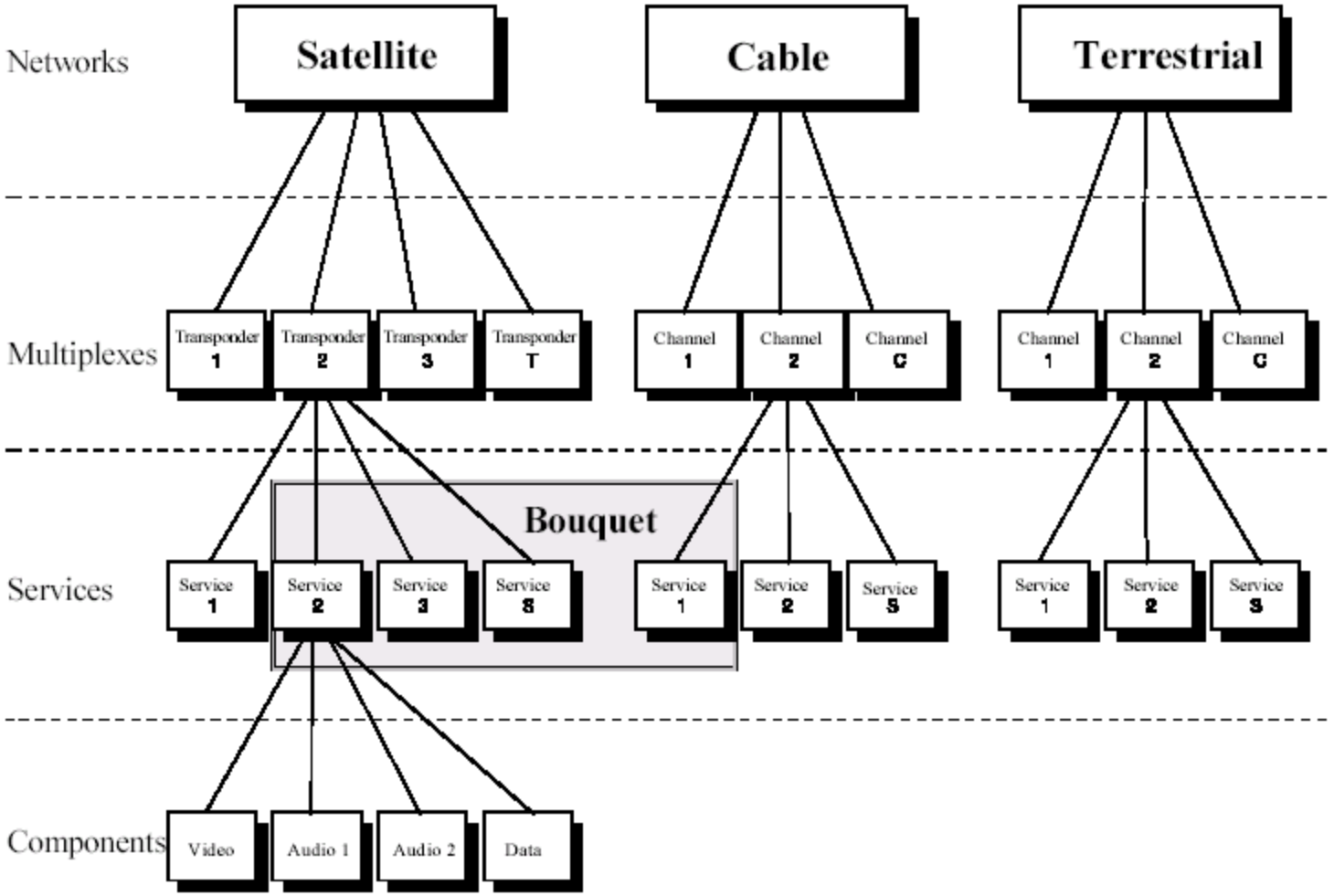
Lecture 4

Digital television

The DVB transport stream

- The need for a general transport stream
- DVB overall stream structure
- The parts of the stream
  - Transport Stream (TS)
  - Packetized Elementary Stream (PES)
  - Program Specific Information (PSI -> ESG)

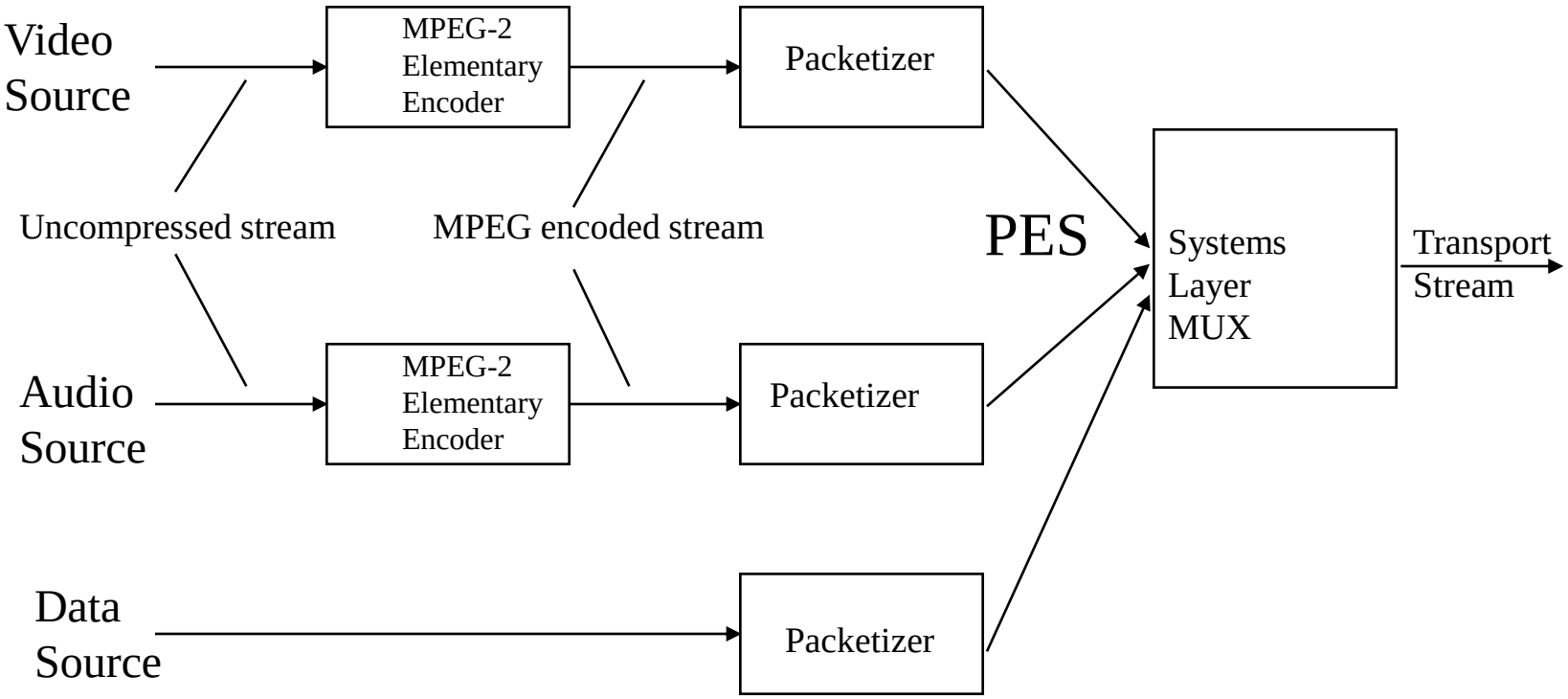
Digital broadcasting, service delivery model



Standards

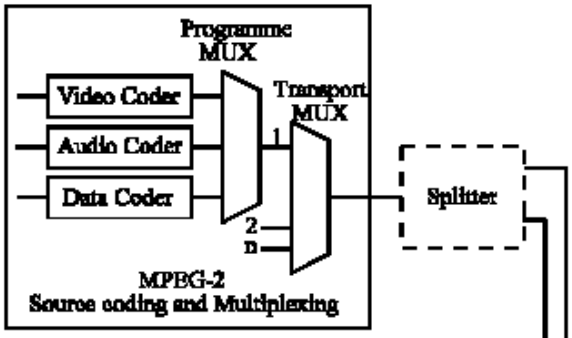
- MPEG standard (ISO-13818-1) defines ways of multiplexing more than one stream (video, audio and data) in order to produce one program
- Used by -
  - DVB
  - DVD
  - HDTV
- Provides basic framework for integrated video, audio and data services
- ETS 300 486 gives PSI documentation (for DVB)

MPEG-2 Systems Layer (Transport Stream)

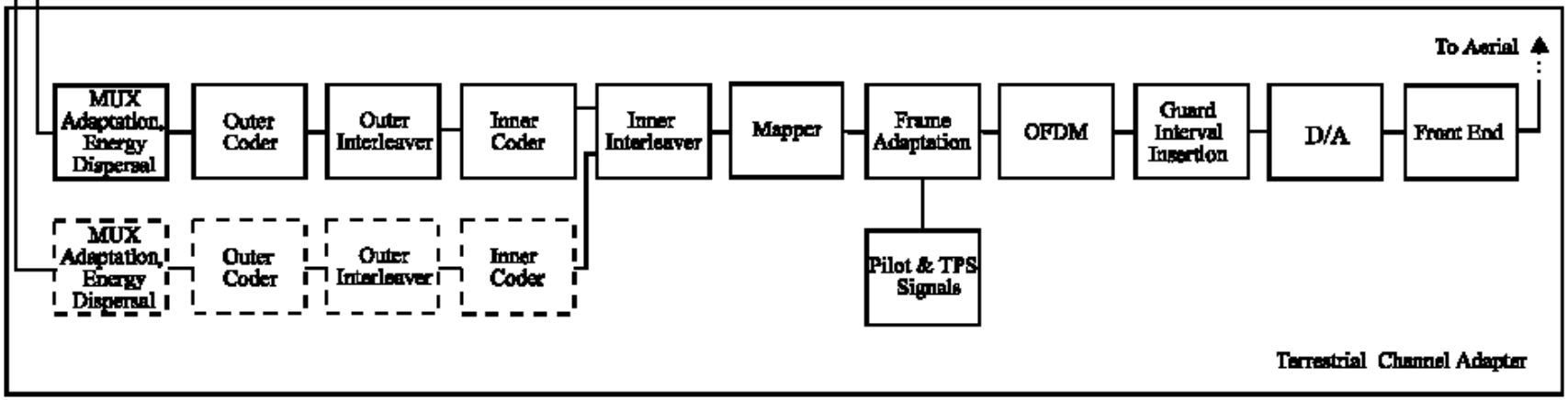


DVB transmitter

- A program consists of one or more elementary streams, which may or may not be MPEG encoded
- Possible to have streams with private data
- 2 schemes for the multiplexing process
  - Program Stream
  - Transport Stream



FEC – Forward Error Correction



- Program Stream
  - Primarily intended for storage and retrieval from storage media
  - Grouping of video, audio, and data elementary streams that have a common time base
  - Each program stream consists of only one program
  - Useful in error free environments
    - Large packet size
    - Packets size may be variable (hard for decoder to predict start and end of packets)
  - DVD standard uses the MPEG-2 Program Stream

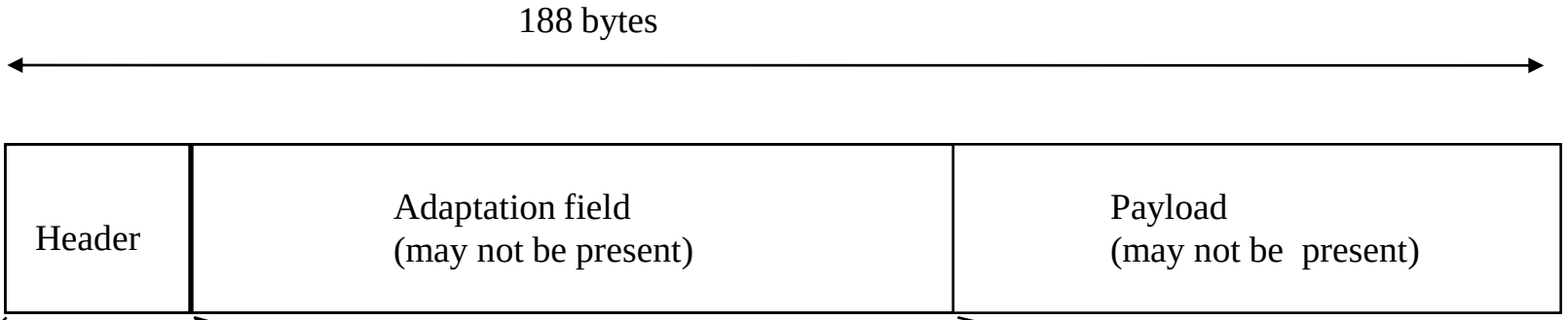
Transport Stream

- Multiplexes various PES into one stream along with information for synchronizing between them
- Short, fixed length packets 188 bytes (4 byte header + adaptation field or payload or both)
- Constraints for forming transport packets:
  - First byte of PES packet must be first byte of transport packet payload
  - Each transport packet must contain data from only one PES packet

Role of transport stream

- General bit-stream that transports all programming information
- Transports all the information that a particular service provider transmits (on a certain frequency)
- Minimize processing effort in order to
  - Retrieve coded data from one stream
  - Extract transport stream packets of one or more programs, from one or more transports and output a new transport stream
  - Enable to transport a program stream over a lossy environment, then recover a valid identical stream.

Transport Packet Structure

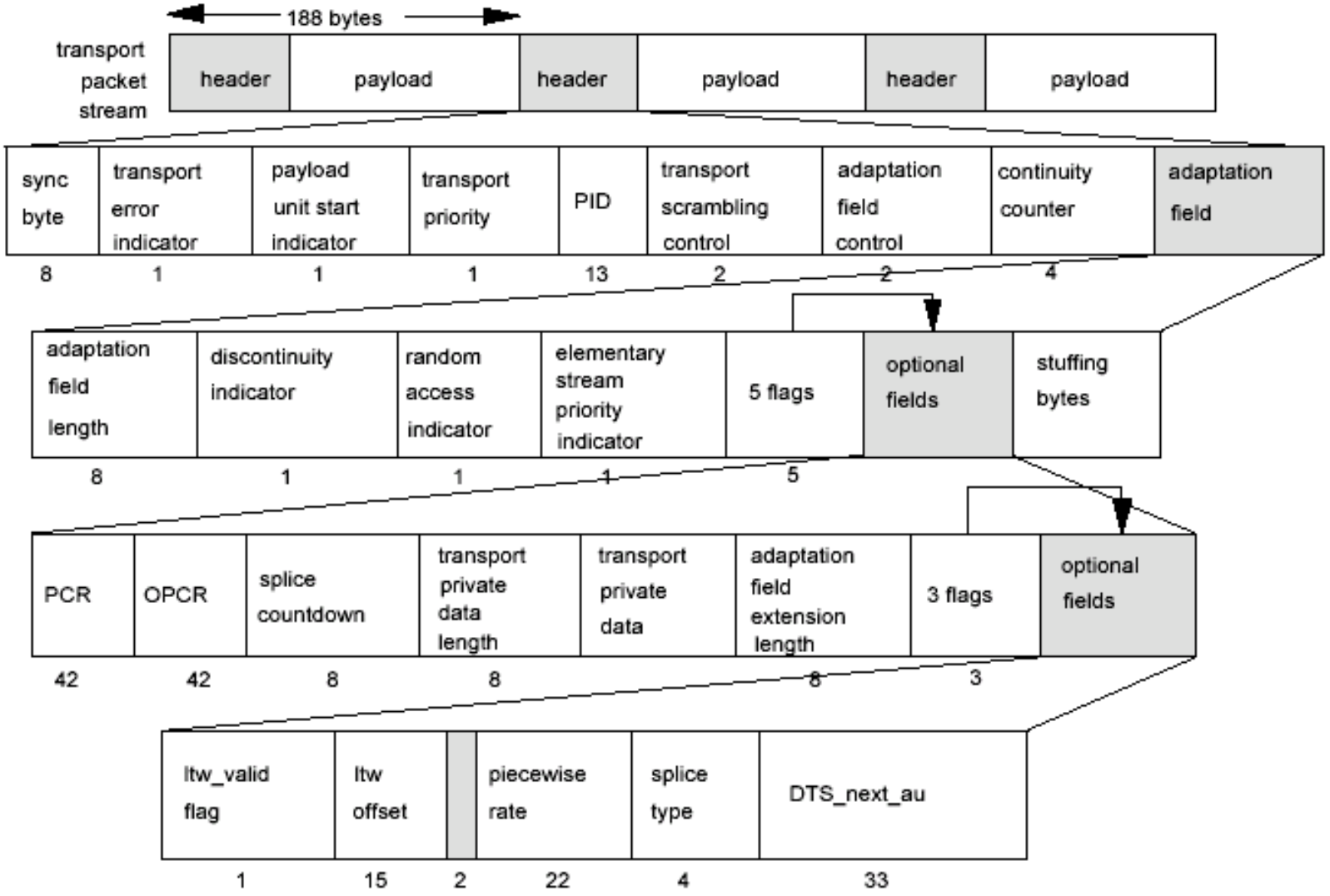


4 bytes

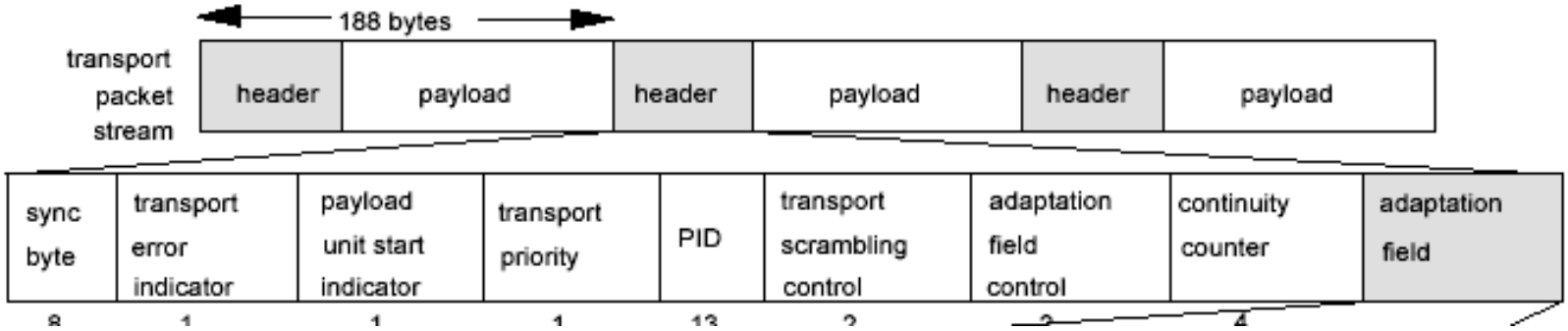
- 8: sync_byte (sync the decoder -47hex-start of TP)
- 1: transport_error_indicator
- 1: payload_unit_start_indicator (PSI or PES packet)
- 1: transport priority (useful in scalable MPEG2)
- 13: PID(13 bit id for each stream)
- 2: transport_scrambling control
- 2: adaptation_field _control
- 4: continuity_counter(counts packets of PES)

- 8: adaption filed length
- 1: discontinuity_indicator
- 1. random_access_indicator
- 1: ES_priority_indicator
- 5: various flags (PCR_flag...)
- PCR (if PCR_flag is set) (system time clock, every 0.1sec, sync decoder and encoder time)
-other fields depending of which flags are set
- stuffing bytes

Overall transport stream



Transport stream header

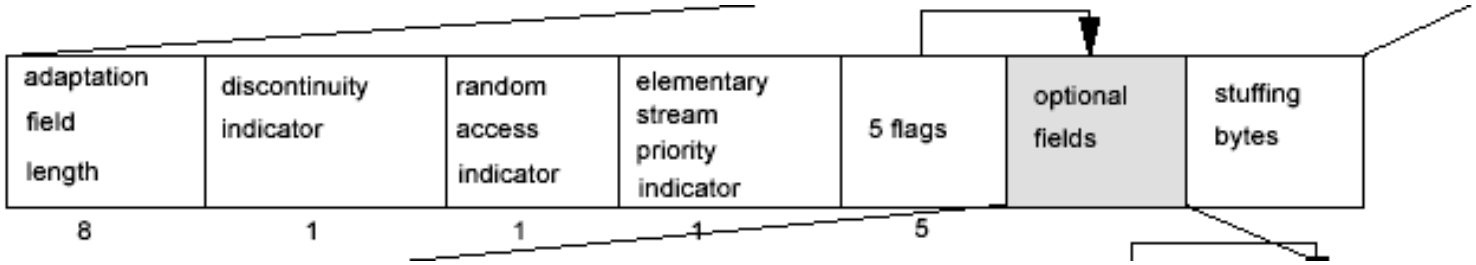


Sync byte – always hex 47 (bin 1000 1111)
Transport error – error during transport
Payload start (PES or PSI data)
Transport priority
PID (13 bits : dec value 0-8192, hex 0-1FFF)
Transport scrambling (only payload): 0 or 1,2,3
Adaption: 1: P, 2: A, 3: A, P
Continuity pointer: Increases modulo per PID basis

PID values

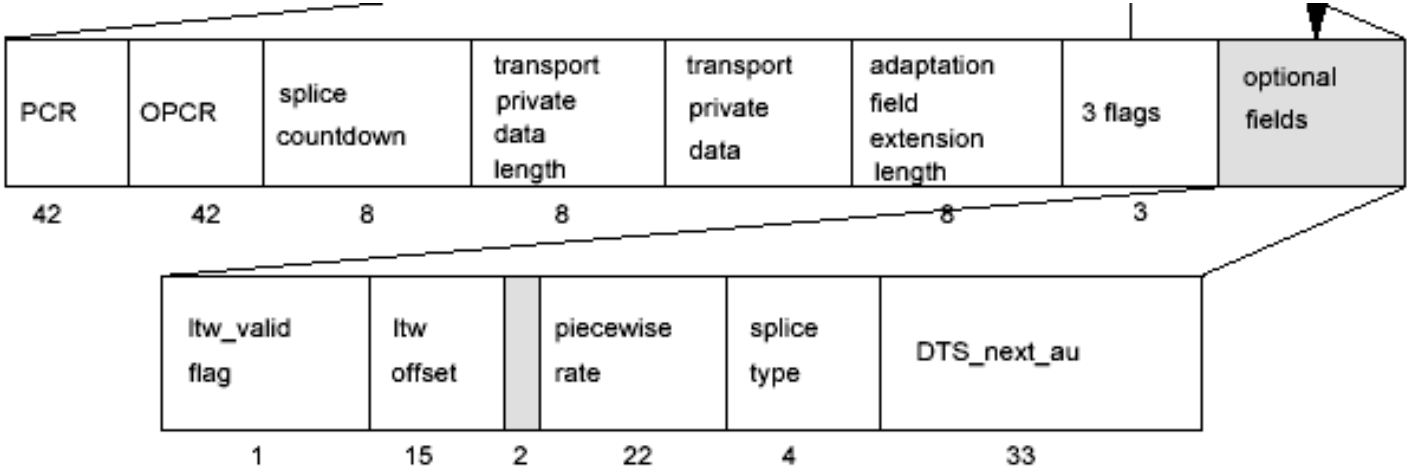
0	Program assocation table (PAT)
1	Conditional access table (CAT)
2 to F	Reserved
10	Network information table
11	Service description table (SDT), bouquet information table (BAT) and stuffing table (ST)
12	Event information table (EIT) and stuffing table (ST)
13	Running status table (RST) and stuffing table (ST)
14	Time/date table (TDT), time offset table (TOT) stuffing table (ST)
15 to 1F	Reserved for future use
20-1FFE	Video / audio / private data
1FFF	NULL packets

Adaptation field (1)



Field length
Discontinuity indicator
Random access indicator – helps random access
Elementary stream priority (e.g. Video Intracoded slice)
Stuffing bytes – fill the transport packet to 188 bytes

Adaptation field (2)

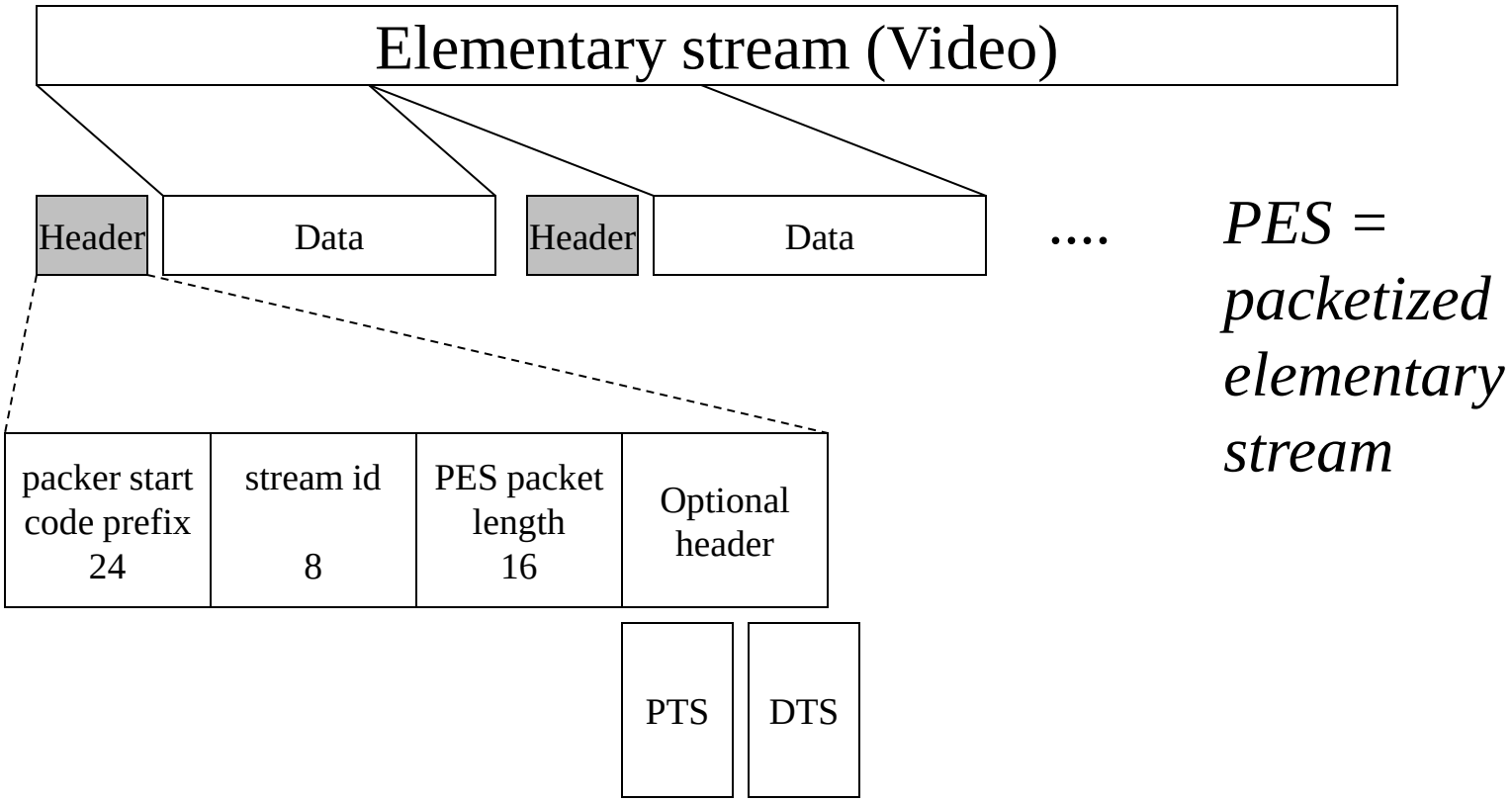


Program clock reference – intended time of arrival
Spliced – signed counter for splicing
Private data length – up to transport
Extenstion length

Packetized Elementary Stream (PES)

- Result of the packetization process
- The payload is the data bytes taken sequentially from the original elementary stream
- No specific format for forming the PES packet
  - Entire video frame in one PES packet (but need variable size frames)
  - Fixed size packets
- PES headers distinguish PES packets of various streams and also contain timestamp information

PES and Elementary streams

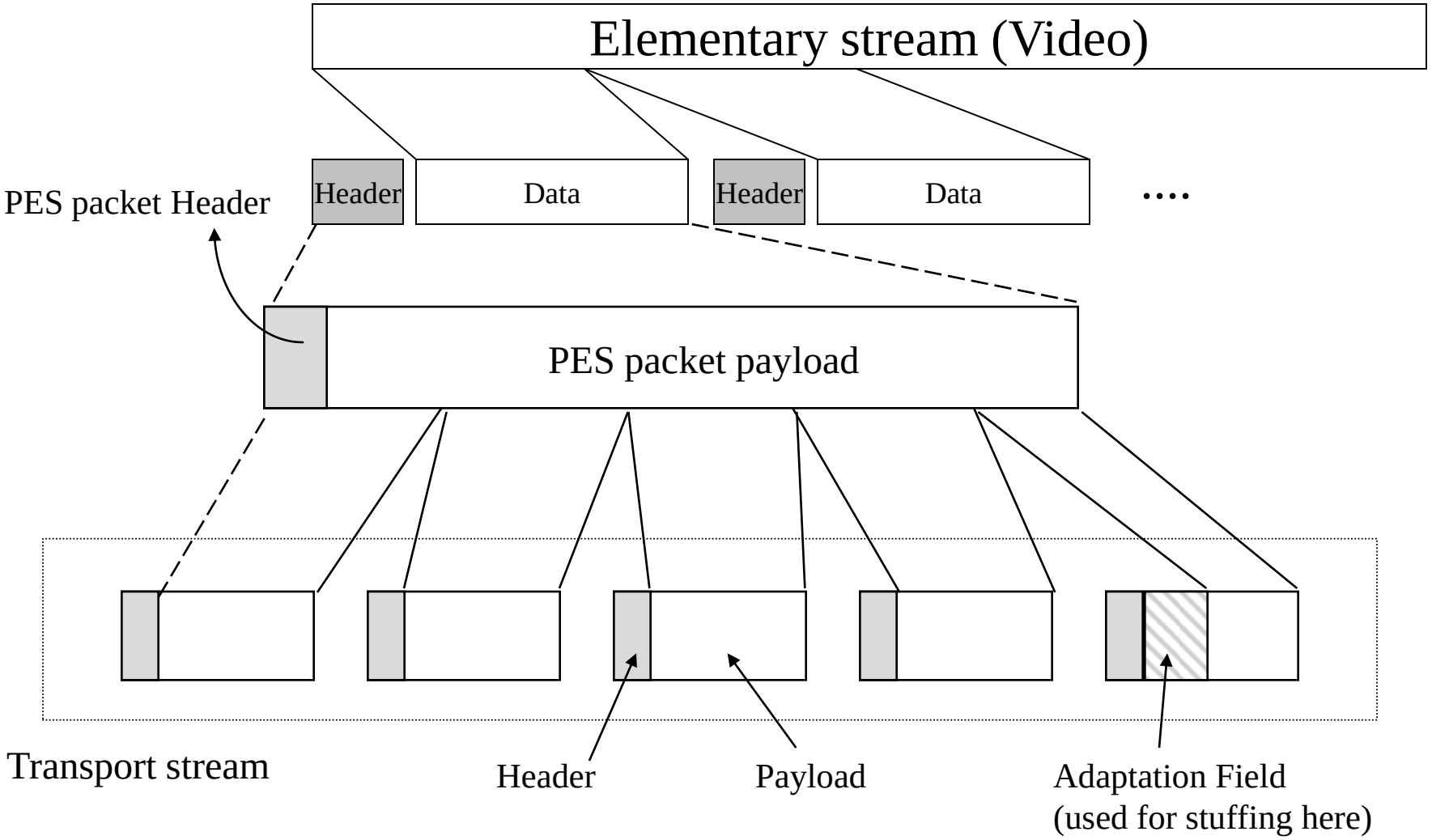


PES = packetized elementary stream

Syncronization

- In PES
  - Presentation Time Stamp (PTS)
    - when an access unit should be displayed in the receiving end
      - at least every 100 ms
  - Decoding Time Stamp (DTS)
    - When it should be decoded (but presented later)
- Program Clock Reference (PCR)
  - 33 bit value, update frequency 90 kHz
  - Used for syncronizing receiver and transmitter
  - Per program, but several programs may share one common clock reference

Transport Stream Generation



Program Specific Information (PSI)

- PSI transport packets - used by decoder to learn about the transport stream
  - Program Association Table (PAT)
    - Contains complete list of all programs in the transport stream along with the PID for the PMT for each program
    - Transmitted in transport packets with PID 0
    - Program number 0 point to the NIT
  - Program Map Table PMT
    - contains the PID for each of the channels associated with a particular program

Program Specific Information (cont.)

- Network Information Table NIT
  - Optional and contents are private(not part of MPEG standard)- can be used to provide useful information about the physical network such as channel frequencies, service originator and service name
  - Conditional Access Table CAT
  - must be sent when the elementary stream is scrambled
  - provides details of the scrambling system in use and provides the PID values of the transport packets that contain the CA information (exact format for this information is not specified)

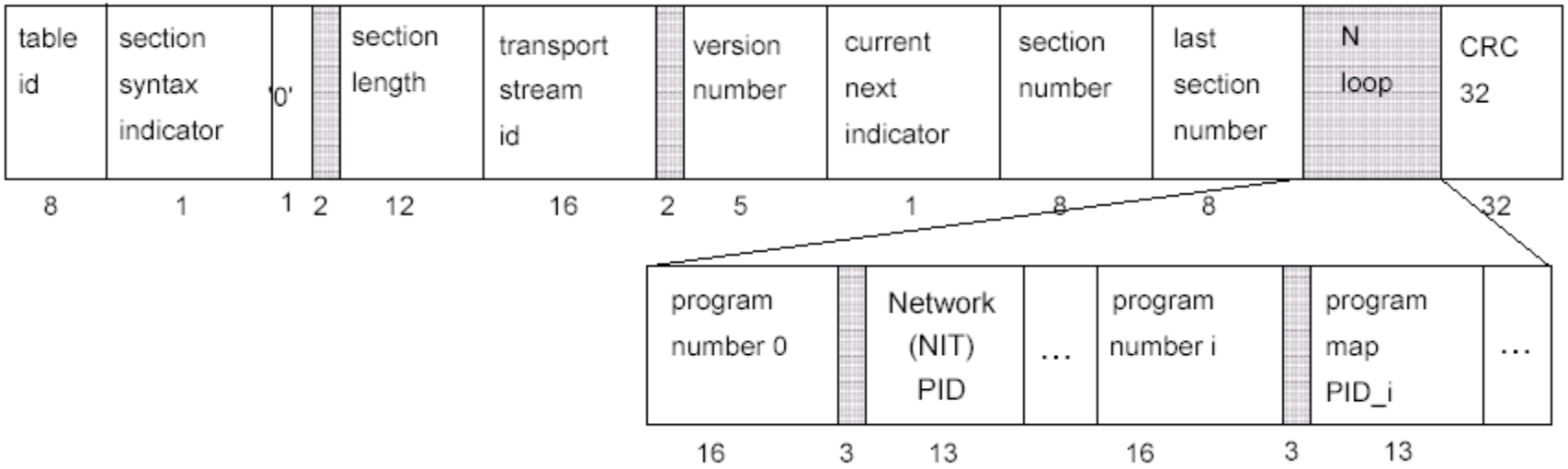
PSI Data

The PSI data provides information to enable automatic configuration of the receiver to demultiplex and decode the various streams of programs within the multiplex.

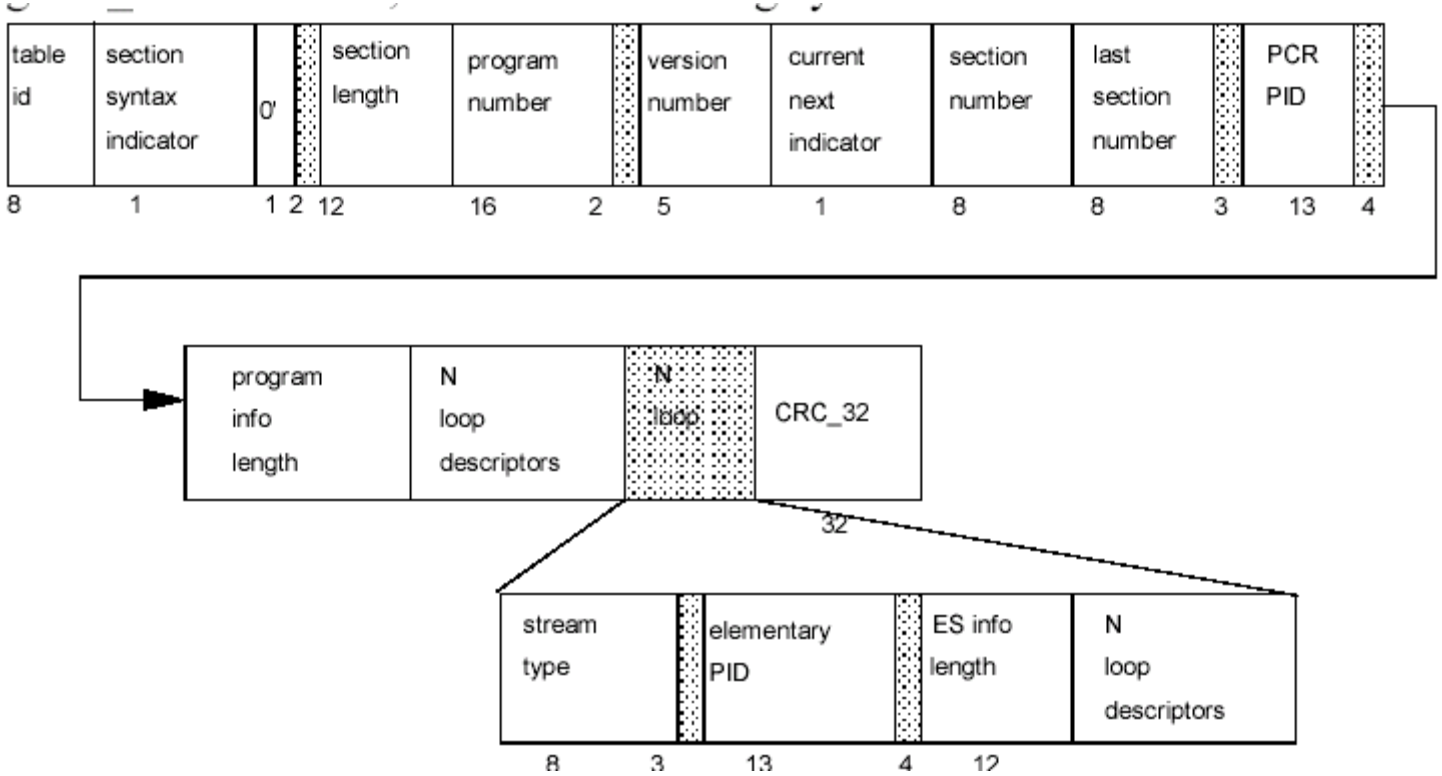
Important

- Program Association Table (PAT)
- Conditional Access Table (CAT)
- Program Map Table (PMT)
- Network Information Table (NIT)

Program association table – TS PID=0



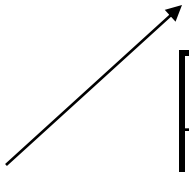
Program map tables – TS PID=from PAT



Network information table

Program association table (PAT)
PID: hex 0

Program 0	NIT PID: hex 33
BBC 1	PID: hex 320
BBC 2	PID: hex 200
Channel 4	PID: hex 220
Channel 5	PID: hex 235
etc.	etc



Program map table (PMT)
of Channel 4: PID: hex 220

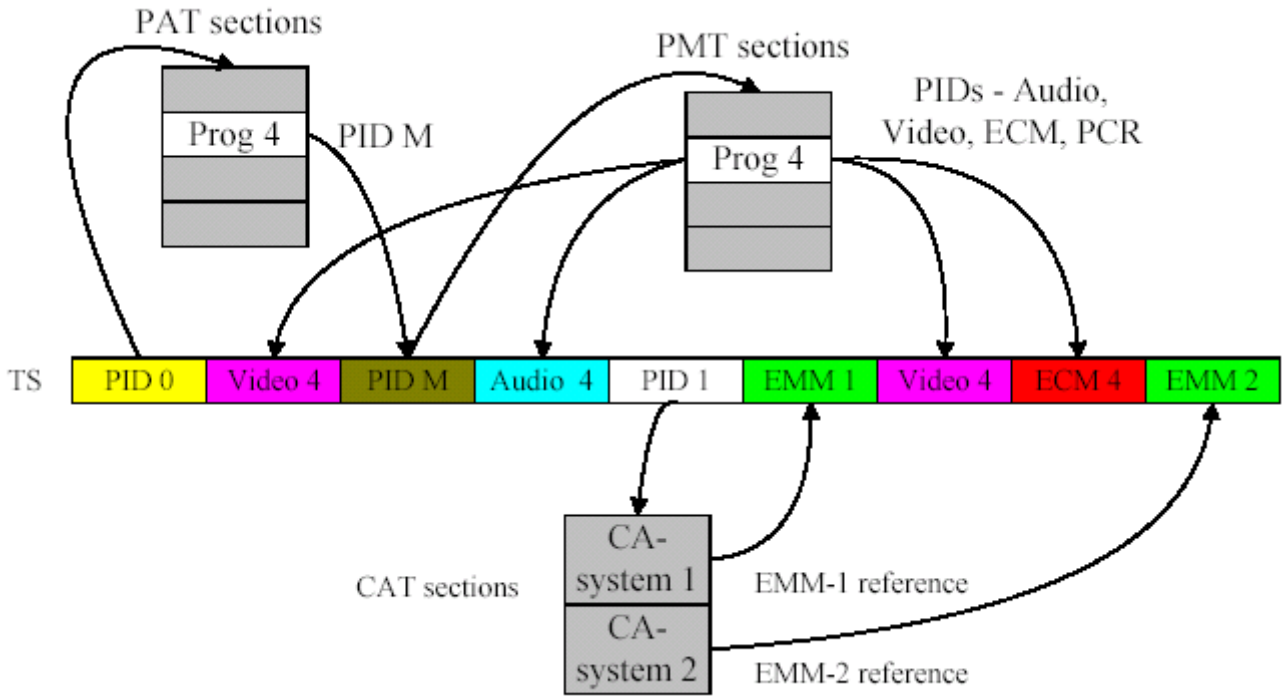
PCR_PID	PID: hex 218
Video	PID: hex 110
Audio English	PID: hex 121
Audio Spanish	PID: hex 115
ECM	PID: hex 108
etc.	etc

Kanavaniput antenniverkossa

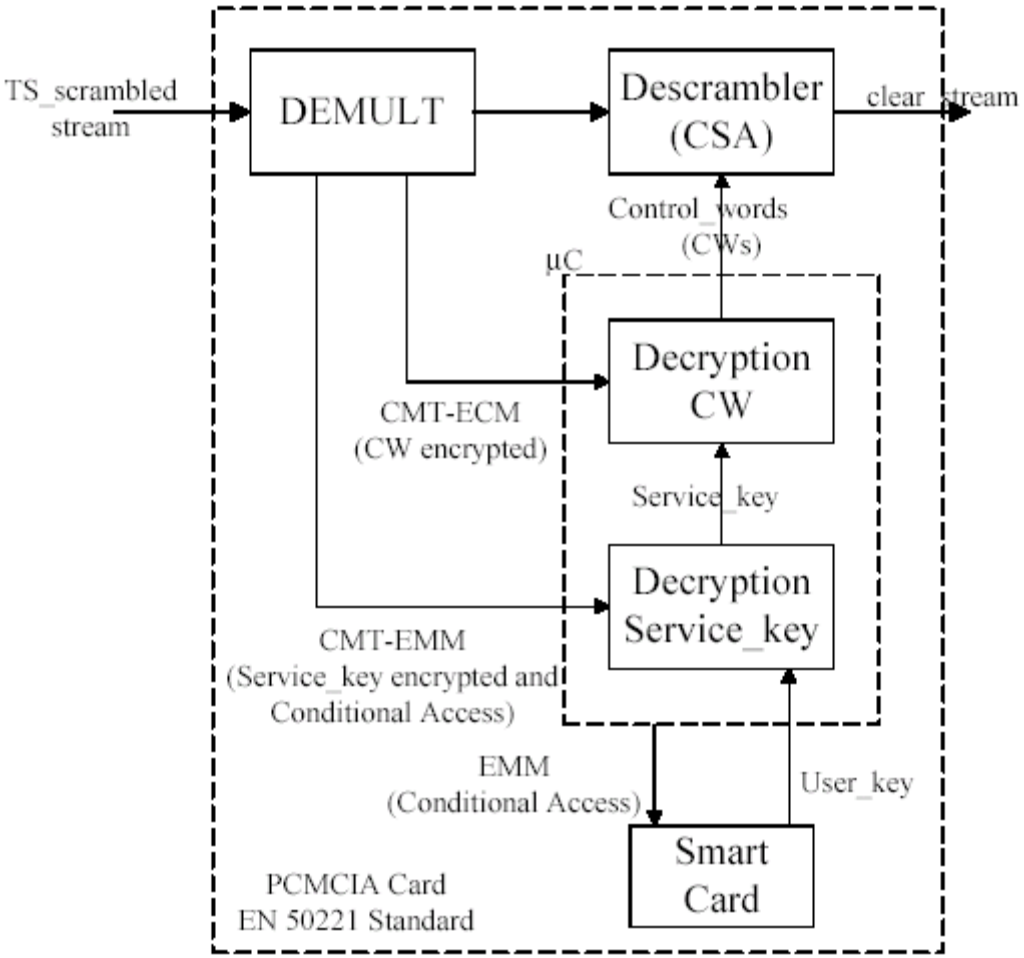
Päivitetty 20.1.2010 Pääasema ja täytelähetin	Kanavanippu A kanava-numero	Keski-taajuus (MHz)	Kanavanippu B kanava-numero	Keski-taajuus (MHz)	Kanavanippu C kanava-numero	Keski-taajuus (MHz)	Kanavanippu E kanava-numero	Keski-taajuus (MHz)	Digitan omistamien pääasemien koordinaatit leveys,pituus
Transmitter	Mux A Channel	f (MHz)	Mux B Channel	f (MHz)	Mux C Channel	f (MHz)	Mux E Channel	f (MHz)	Coordinates of Transmitters
Anjalankoski	**22**	**482**	**27**	**522**	**53**	**730**	**56**	**754**	60 as. 41 min 27 as. 03 min
Espoo	**32**	**562**	**44**	**658**	**46**	**674**	**53**	**730**	60 as. 10 min 24 as. 38 min
Hyvinkää, Musta-Männistö	29	538	49	698			56	754	
Karkkila	36	594	39	618	57	762	49	698	
Lohja	48	706	55	746	56	754	60	650	
Nummi-Pusula, Hyönölä	47	682	59	778			42	642	
Sipoo, Norrkulla	49	698	56	754			53	730	
Vantaa, Hakunila	32	562	44	658	46	674	53	730	
Eurajoki	**38**	**610**	**45**	**666**	**52**	**722**	**55**	**746**	61 as.17 min 21 as. 42 min
Kankaanpää	43	650	47	682			51	714	
Lavia, Lavianjärvi	24	498	31	554					
Vammala, Sävi	46	674	49	698					
Fiskars	**32**	**562**	**44**	**658**	**46**	**674**	**58**	**770**	60 as. 07 min 23 as. 29 min
Hanko	39	618	55	746			50	706	
Tammisaari	39	618	43	650			37	602	
Haapavesi	**34**	**578**	**42**	**642**	**53**	**730**	**57**	**762**	64 as. 10 min 25 as. 15 min
Kalajoki	34	578	42	642					
Raahe, Mestauskallio	30	546	39	618			44	658	
Raahe, Piehinki	34	578	42	642					
Vaala	58	770	60	786					
Iisalmi	**26**	**514**	**38**	**610**					63 as. 37 min 27 as. 04 min

Source
www.digita.fi

PAT -> PMT -> PES


PAT sections
Prog 4
PID M
PMT sections
Prog 4
PIDs - Audio,
Video, ECM, PCR
TS
PID 0
Video 4
PID M
Audio 4
PID 1
EMM 1
Video 4
ECM 4
EMM 2
CAT sections
CA-
system 1
CA-
system 2
EMM-1 reference
EMM-2 reference

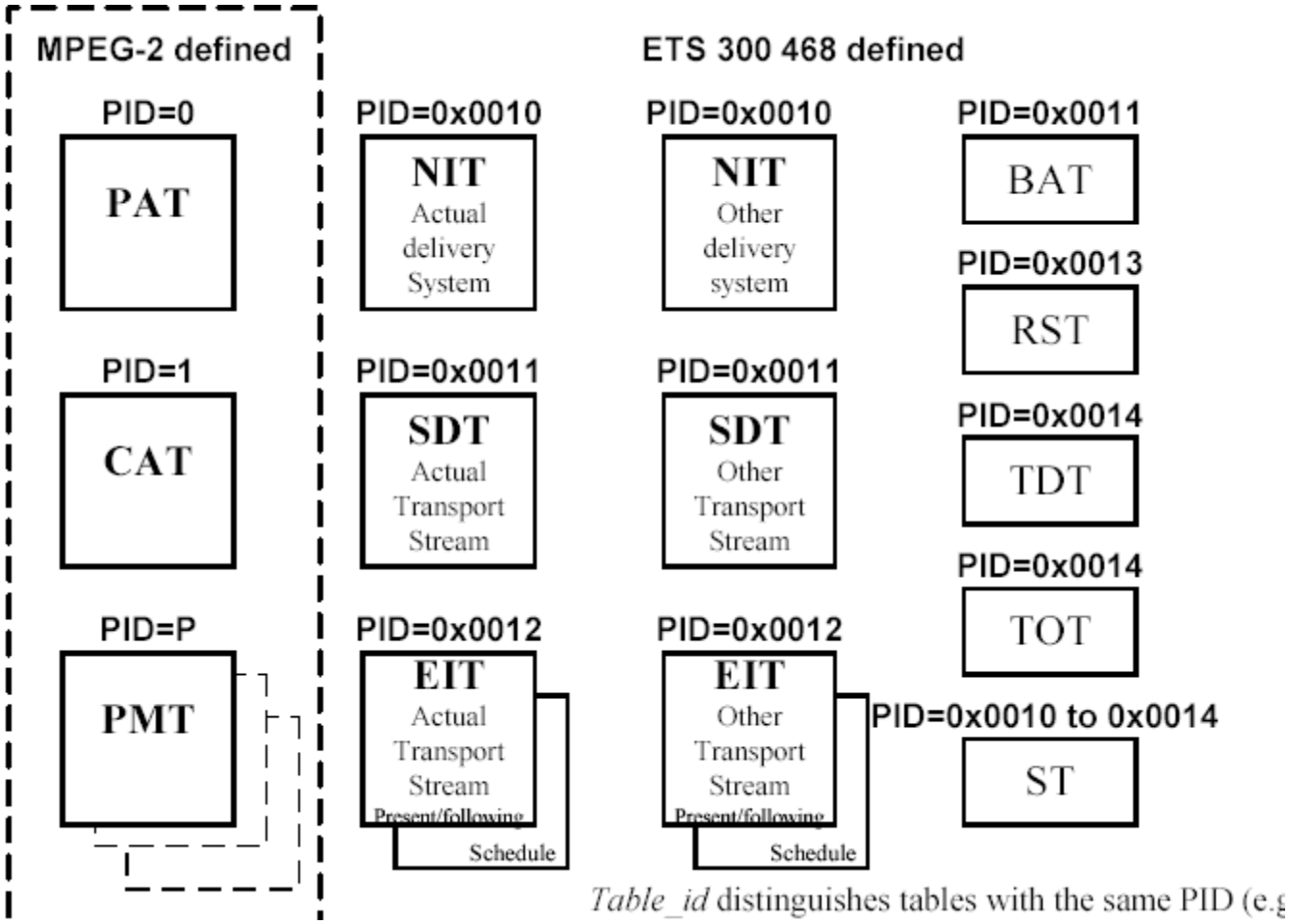
Descrambling transport stream



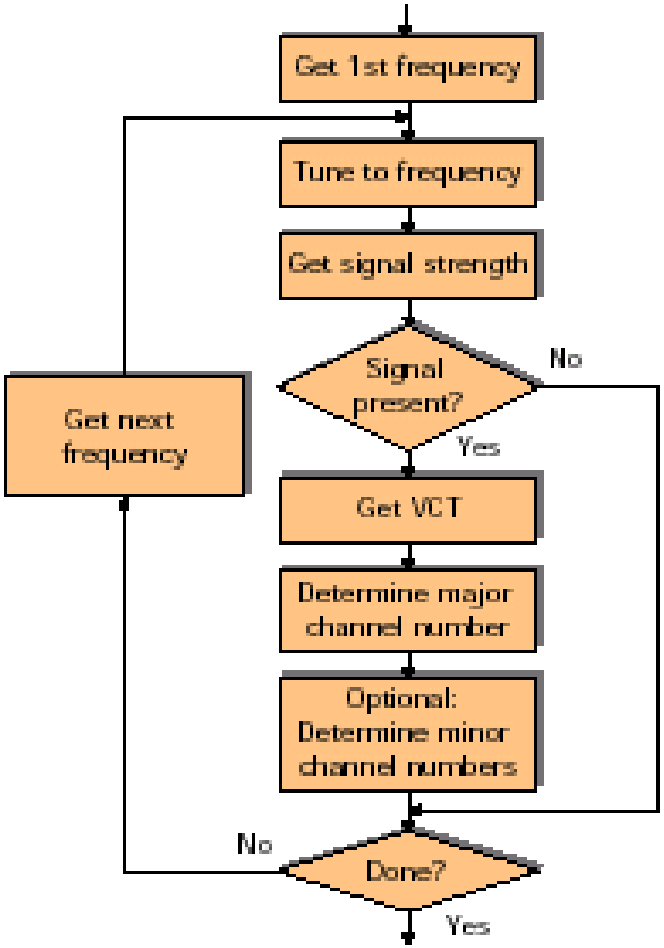
Other tables in ETS 300 468

Network information table (NIT) - Information on physical network
Bouquet association table (BAT) – List of services for bouquet (EPG)
Service description table (SDT) – Service provider names etc.
Event information table (EIT) – Information on events, start times etc
Running status table (RST) – Status of an event
Stuffing table (ST) – Invalidates old data
Time and date tables (TDT) – Information abount present time and date
Time offset tables (TOT) – Information on local time

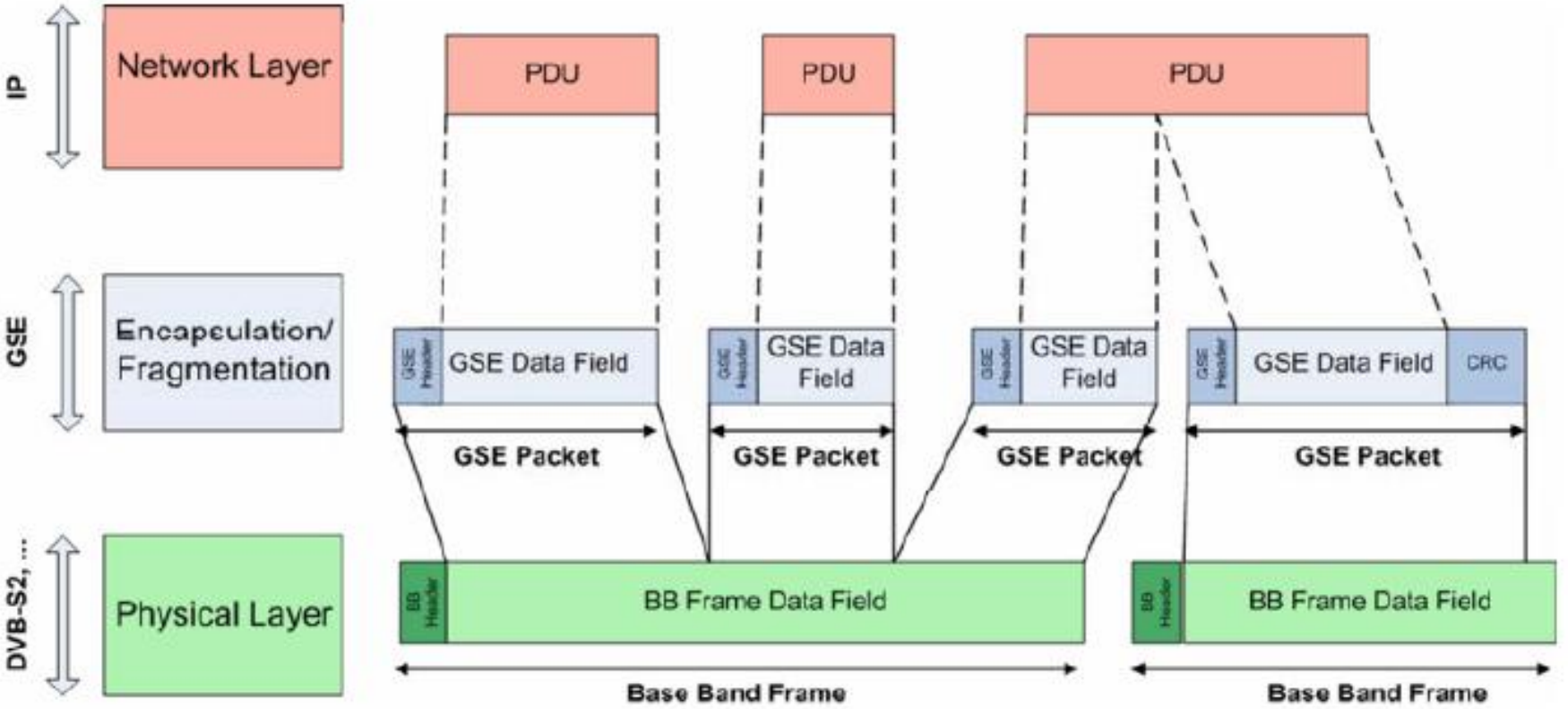
Other tables in ETS 300 468



Autotuning


Get 1st frequency
Tune to frequency
Get signal strength
Signal present?
No
Yes
Get next frequency
Get VCT
Determine major channel number
Optional: Determine minor channel numbers
No
Done?
Yes

General Streaming Extension (GSE)



Integrated Video, Audio and Data

- MPEG-2 systems layer provides us with a standardized method of providing integrated video, audio and data services
- Currently programs consist of primarily one video channel and possible multiple audio channels
- The data streams are used only to broadcast program related data, like close captioning
- Multiple video streams for the same program (different camera shots of a football game!!)

Integrated Video, Audio and Data (cont.)

- Interactive broadcasts - news broadcast with related URL
- Data download (non interactive) - create PES stream from the data to be broadcast, split into transport packets, use MPEG-2 system layer to generate either a seperate Program stream (channel with data only) or associate the data PES with another Program stream (- viewing news broadcast automatically dumps the daily newpaper on your computer...)

Integrated Video, Audio and Data (cont.)

- Interactive internet type data - can be inserted in MPEG-2 transport stream without affecting any other data, you will still be MPEG-2 system compliant, it is upto the decoders to figure out if they can handle the data or not (TV v/s PC- we can use the same broadcast)
- Interactive internet type data - must be a “program” and not part of another program - therefore decoder must be capable of tuning to two programs

Sources

European Telecommunications Standards Institute (Sophia Antipolis, France)

Digita, Finland

MPEG-2 Profiles

The profiles are specific subset of the bit stream syntax in the MPEG-2 standard (profile-P@level-L):

- **Main Profile** was designed to accommodate most initial applications of MPEG-2, in terms of both functionality requirements and cost constraints
- **High Profile** has more functionalities thn Main Profile; allows SNR, spatial and an additional type of scalability giving high quality picture quality when all features are utilized in the decoder
- **Simple profile** is intended for low cost applications; no B-pictures (8 Mbits of memory required)
- **Spatial Scalable Profile** can provide two layer coding with different resolutions on layers (low resolution reproduction and combination gives full-resolution reproduction)
- **SNR Scalable Profile** provides layers with the same pixel resolution by different picture quality (quantization level); the first stream gives a reasonable picture quality and the other stream gives a refinement to the fisrt stream reproduction

MPEG-2 Levels

A level is a defined set of constraints imposed on the parameters of the MPEG-2 bit stream (profile-P@level-L):

- **Main Level** is to be used by initial applications of MPEG-2. Upper bounds of the sampling density correspond to CCIR601 picture format: 720 x 576 (PAL, 25 Hz) or 720 x 480 (NTSC, 30 Hz)
- **High Levels** are intended for HDTV systems. The High Level supports 1920 pixels per line (1920 x 1152), and the High- 1440 Level 1440 pixels per line respectively (1440 x 1152)
- **Low Level** corresponds to the quarter-CCIR601 picture format (SIF)

Levels		Profiles			
		SNR 4:2:0	Spatial 4:2:0	High 4:2:0;4:2:2	Multiview 4:2:0
High	Enhancement			1920 X 1151/60	1920 X 1151/60
	Lower			960 X 576/30	1920 X 1151/60
	Bitrate			100, 80,25	130, 50, 80
High-1440	Enhancement		1440 X 1152/60	1440 X 1152/60	1920 X 1152/60
	Lower		720 X 576/30	720 X 576/30	1920 X 1152/60
	Bitrate		60, 40, 15	80, 60, 20	100, 40, 60
Main	Enhancement	720 X 576/30		720 X 576/30	720 X 576/30
	Lower			352 X 288/30	720 X 576/30
	Bitrate	15, 10		20, 15, 4	25, 10, 15
Low	Enhancement	352 X 288/30			352 X 288/30
	Lower				352 X 288/30
	Bitrate	4, 3			8, 4, 4

MPEG-2 Profiles & Levels

Table 3: MPEG-2 Profiles @ Levels

Profile @ Level	Resolution	Maximum Frame Rate	Sampling	Rate	Comments
SP@LL—Simple Profile @ Low Level	176x144	15	4:2:0	96Kbps	Wireless handsets
SP@ML—Simple Profile @ Main Level	352x288 320x240	15 24	4:2:0	384Kbps	PDAs
MP@LL—Main Profile @ Low Level	352x288	30	4:2:0	4Mbps	Set-top boxes
MP@ML—Main Profile @ Main Level	720x480	30	4:2:0	15Mbps; limited to 9Mbps for DVDs	DVD
MP@H-14—Main Profile @ High 1440	1080i with 1440 pixels/line or 720p with 1280 pixels/line	1080i: 30 or 720p: 30	4:2:0	60Mbps; limited to 25Mbps for DV tape	HDV Potential to move to tape-based at 50Mbps
MP@HL—Main Profile @ High Level	1080i with 1920 pixels/line or 720p with 1280 pixels/line	1080i: 30 or 720p: 60	4:2:0	80Mbps; limited to 19Mbps for over-the-air	ATSC 1080i 720p60
422P@LL—4:2:2 Profile @ Low Level					
422P@ML—4:2:2 Profile @ Main Level	720x480	30	4:2:2	50Mbps	Sony IMX using I-frame only
422P@H-14—4:2:2 Profile @ High 1440	1080i with 1440 pixels/line or 720p with 1280 pixels/line	1080i: 30 or 720p: 60	4:2:2	80Mbps	Potential future MPEG-2-based HD products from Sony and Panasonic
422P@HL—4:2:2 Profile @ High Level	1080i with 1920 pixels/line or 720p with 1280 pixels/line	1080i: 30 or 720p: 60	4:2:2	300Mbps	Potential future MPEG-2-based HD products from Panasonic