MPEG-2 Systems

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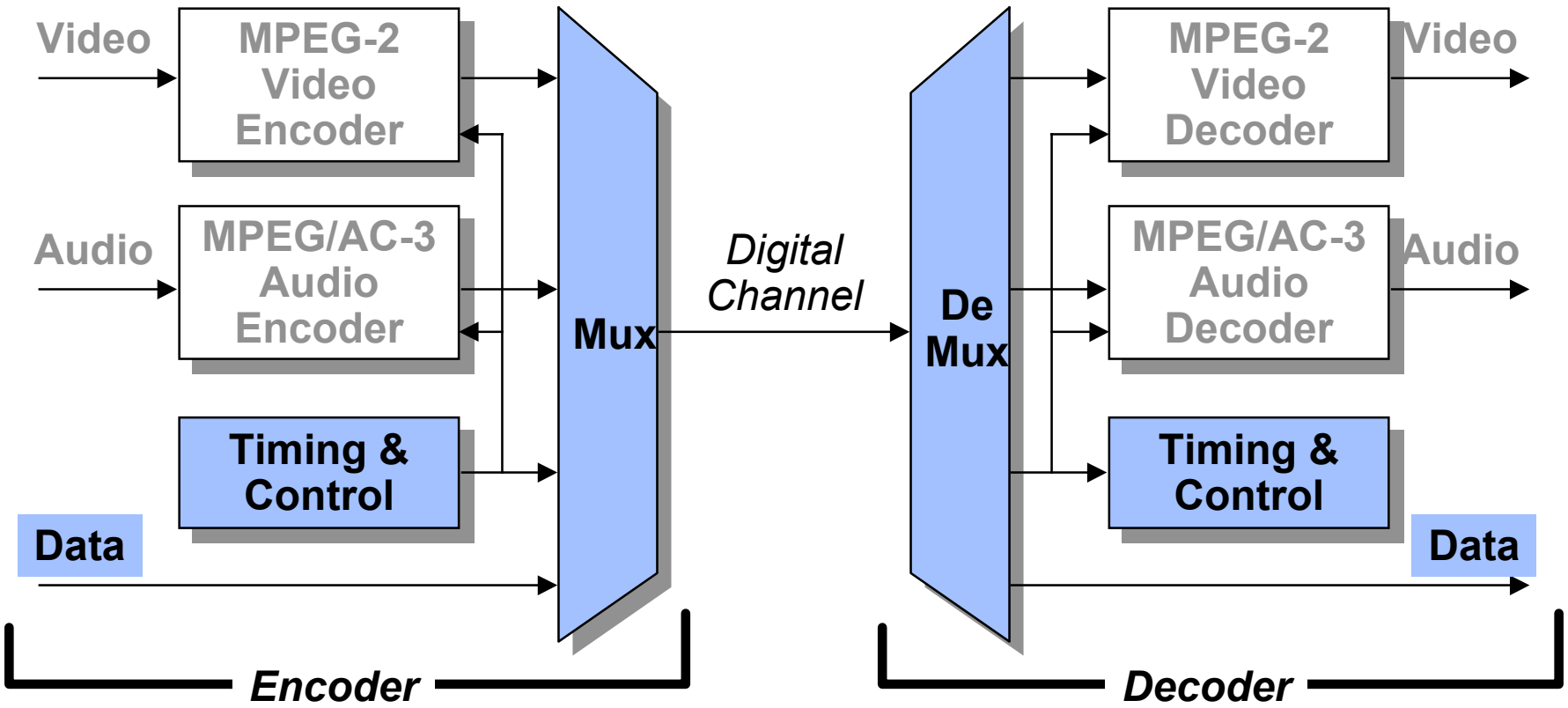
Outline

- MPEG-2 Systems Overview (13818-1)
- Packet Concepts
- MPEG-2 Program Streams
- MPEG-2 Transport Streams
- Timing Mechanisms
- A/V Synchronization
- Transport System Target Decoder (T-STD)
- MPEG Bitstream Syntax and Table Structure
- Program Specific Information
- DVB and ATSC Transport Formats

What is MPEG-2 Systems?

- It's a communications layer that encapsulates compressed video, audio and data streams in packets.
- Multiplexes elements of a single program: video, audio, program-related data, etc.
- Multiplexes multiple programs
- Synchronizes all elements of a program
- Provides flexibility by allowing dynamic mix of content
- Provides extensibility by allowing new services to be added without losing existing audience share.

MPEG-2 Systems

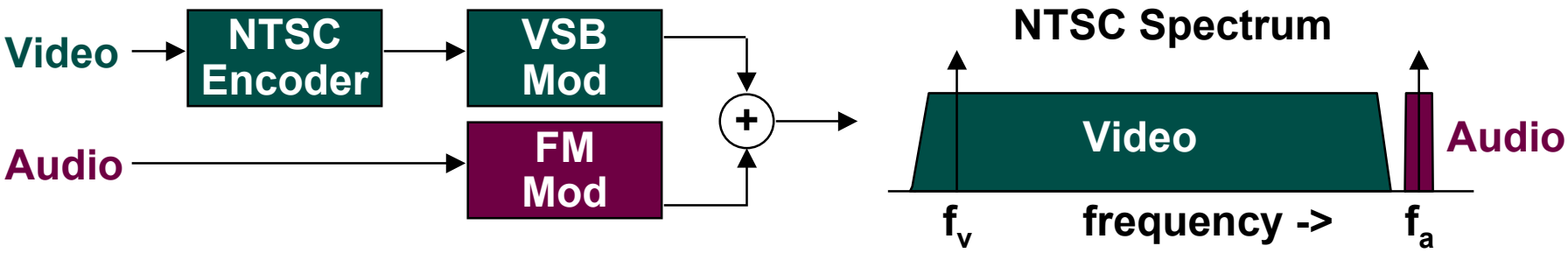


ATSC Transport is based on the MPEG-2 Systems Spec (ISO/IEC 13818-1), which covers Muxing, Timing and Control

ISO/IEC 13818-1 Highlights

- Supports two constructs
  - Transport Stream
    - For error-prone applications
    - Transport System Target Decoder (T-STD)
    - Program Specific Information (PSI)
  - Program Stream
    - For error-free applications
    - Program System Target Decoder (P-STD)
    - Program Stream Map and Directory
  - Supports conversion via Packetized Elementary Stream (PES)
- Defines Program and Program Element Descriptors

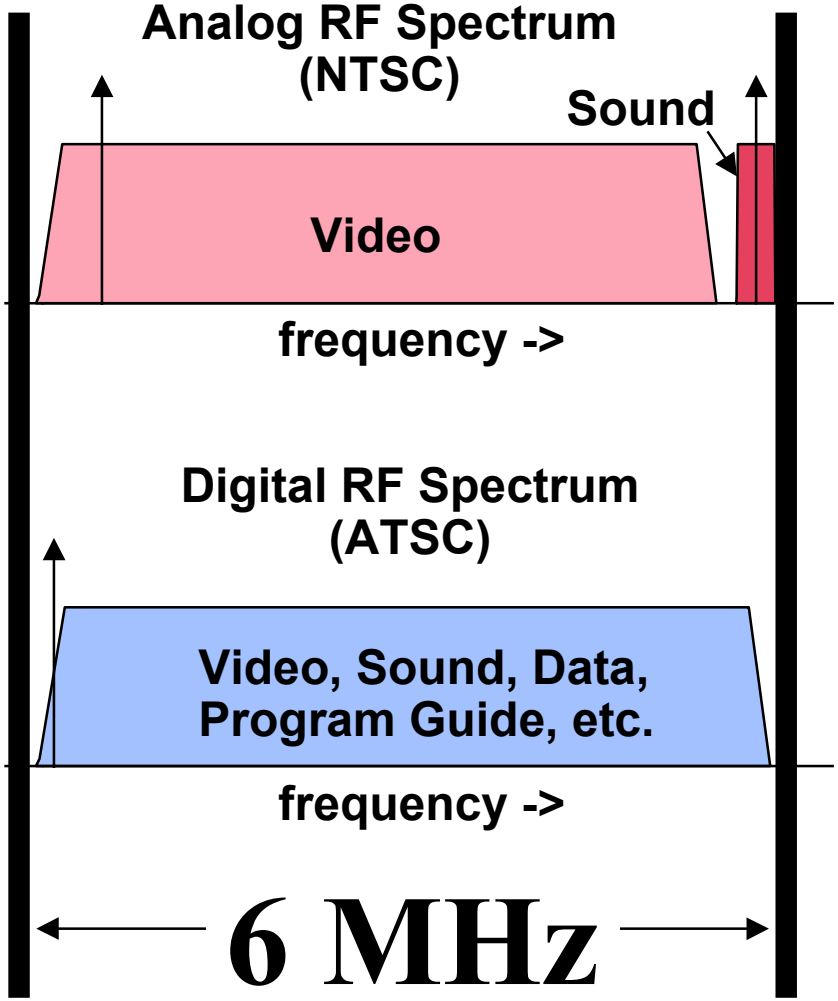
Programs: Analog and Digital

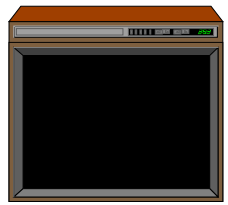


- Analog TV transmission (e.g., NTSC) uses *frequency division multiplexing* (FDM) to send program elements.

- Digital TV transmission (e.g., ATSC) uses time division multiplexing (TDM) to send program elements.

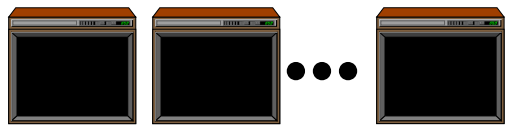
Spectrum: Analog vs. Digital



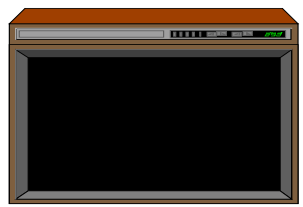


1 SDTV

4-6 SDTV

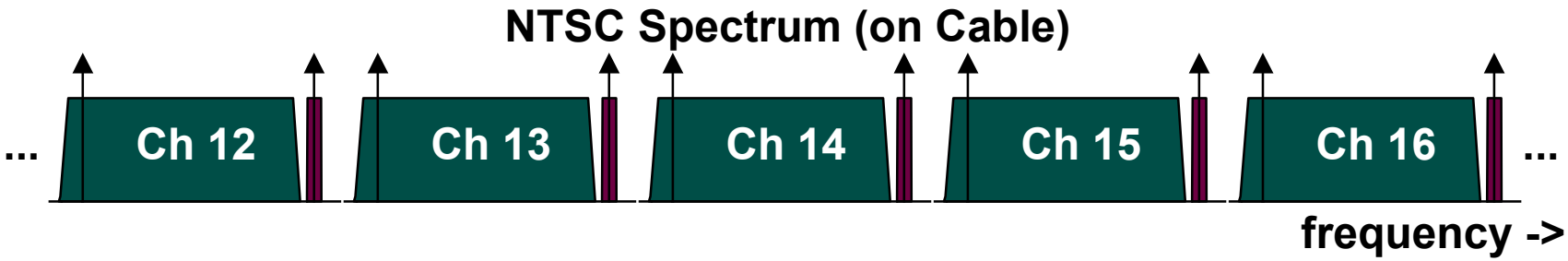


or 1 HDTV



+ other services

Multiple Programs: Analog and Digital



- Analog TV uses FDM for multiple programs.

Vn: Video for Program n
An: Audio for Program n
PG: Program Guide

time ->

- Digital TV uses TDM for multiple programs within a single channel, and FDM for multi-channel systems.

What are Packets?

- **Packets are a collection of bits of the same program type: video, audio or data.**

- **Packets can be variable length...**

- **... or fixed length.**

Packet Lengths

Variable Length Packets

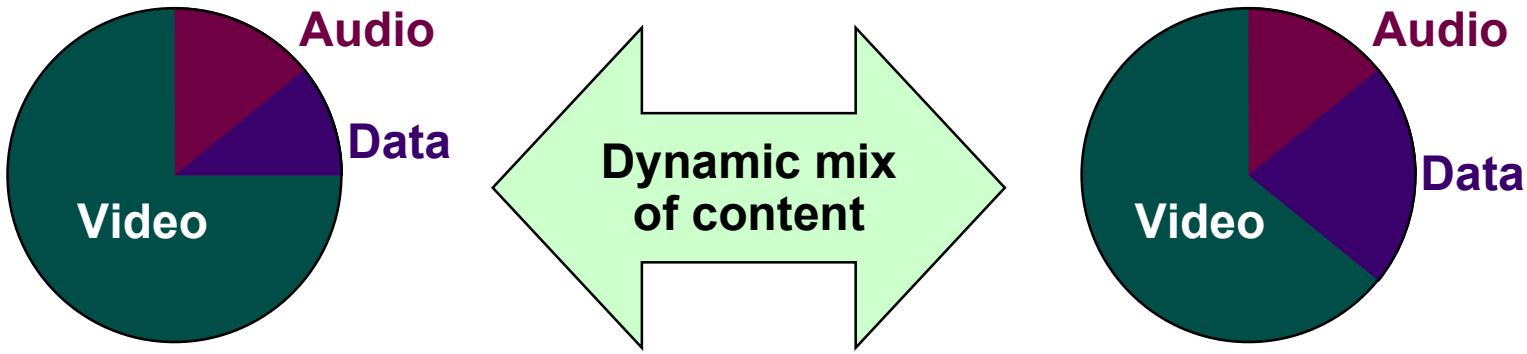
- use the natural grouping of coded data (e.g., pictures)
- tend to be relatively long
- generally used for error-free media (e.g., CD-ROM's)

Fixed Length Packets

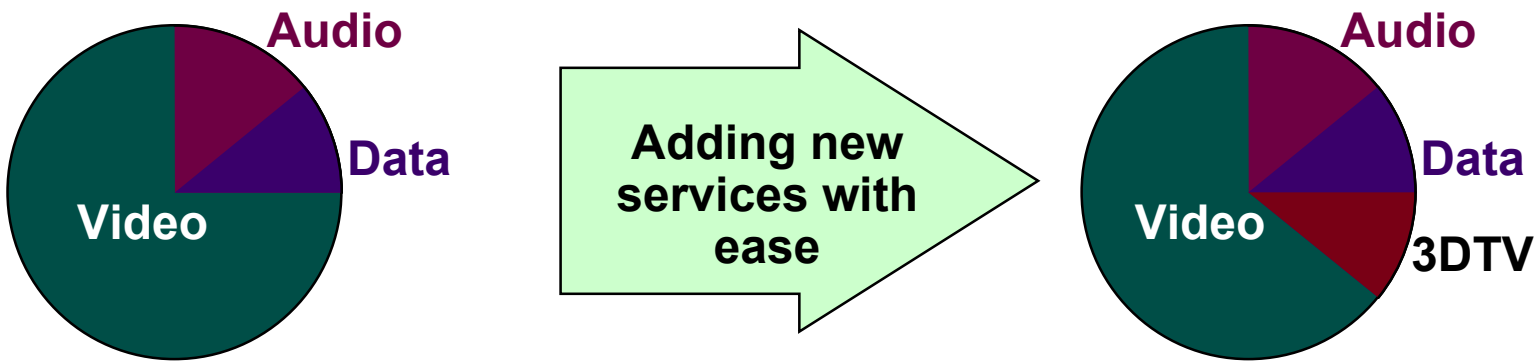
- tend to be relatively short
- amenable to error correction and fast switching
- generally used for error-prone media (e.g., broadcast)

Why use Packets?

- **Flexibility**

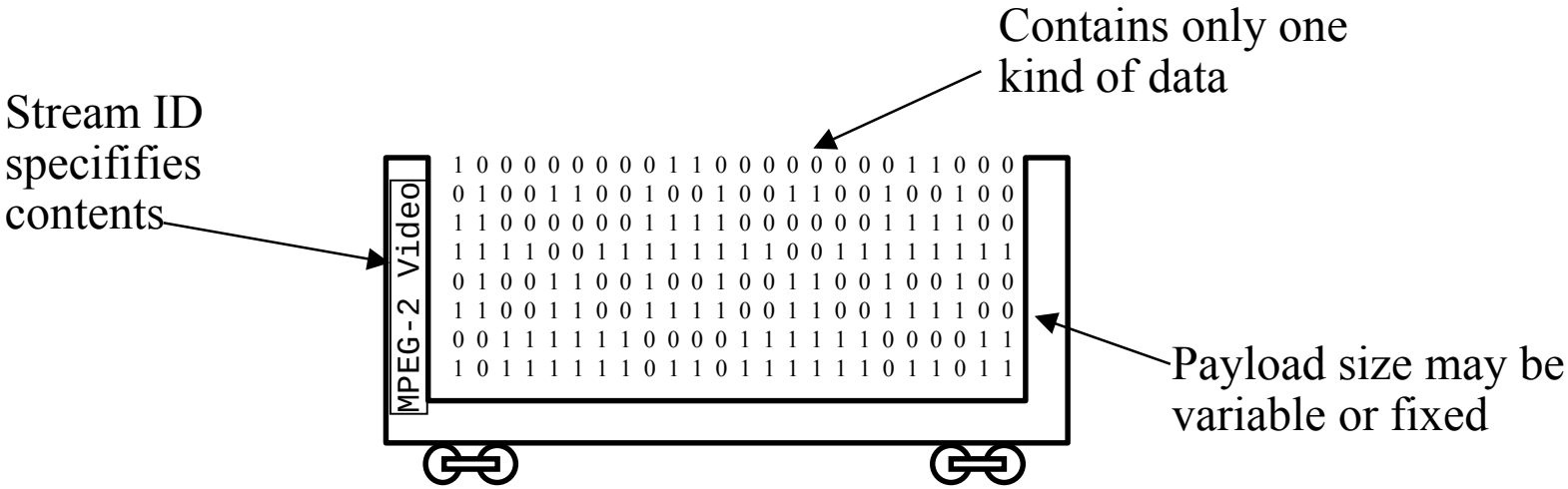


- **Extensibility**



Packets

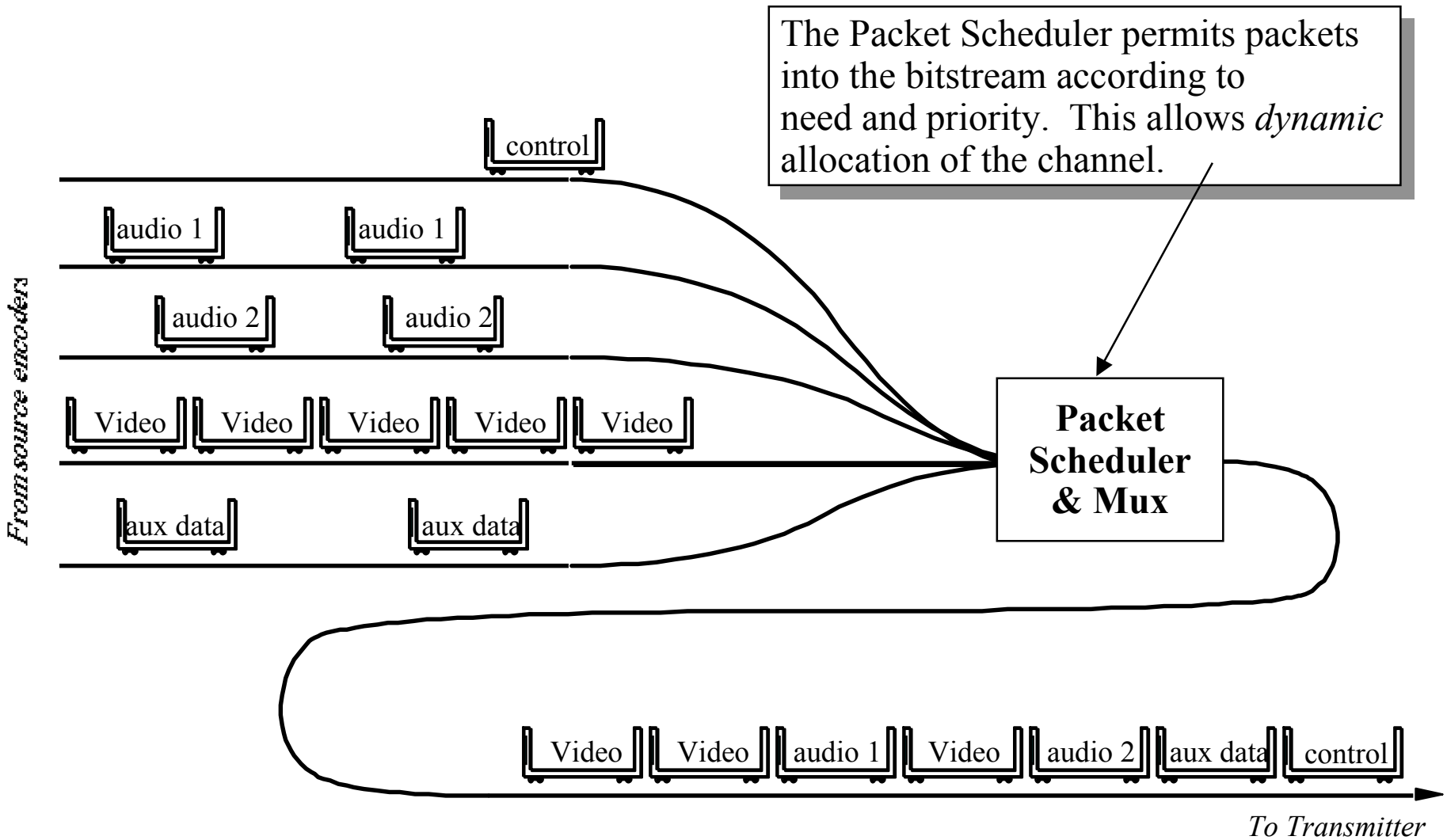
...the key to flexibility and extensibility...



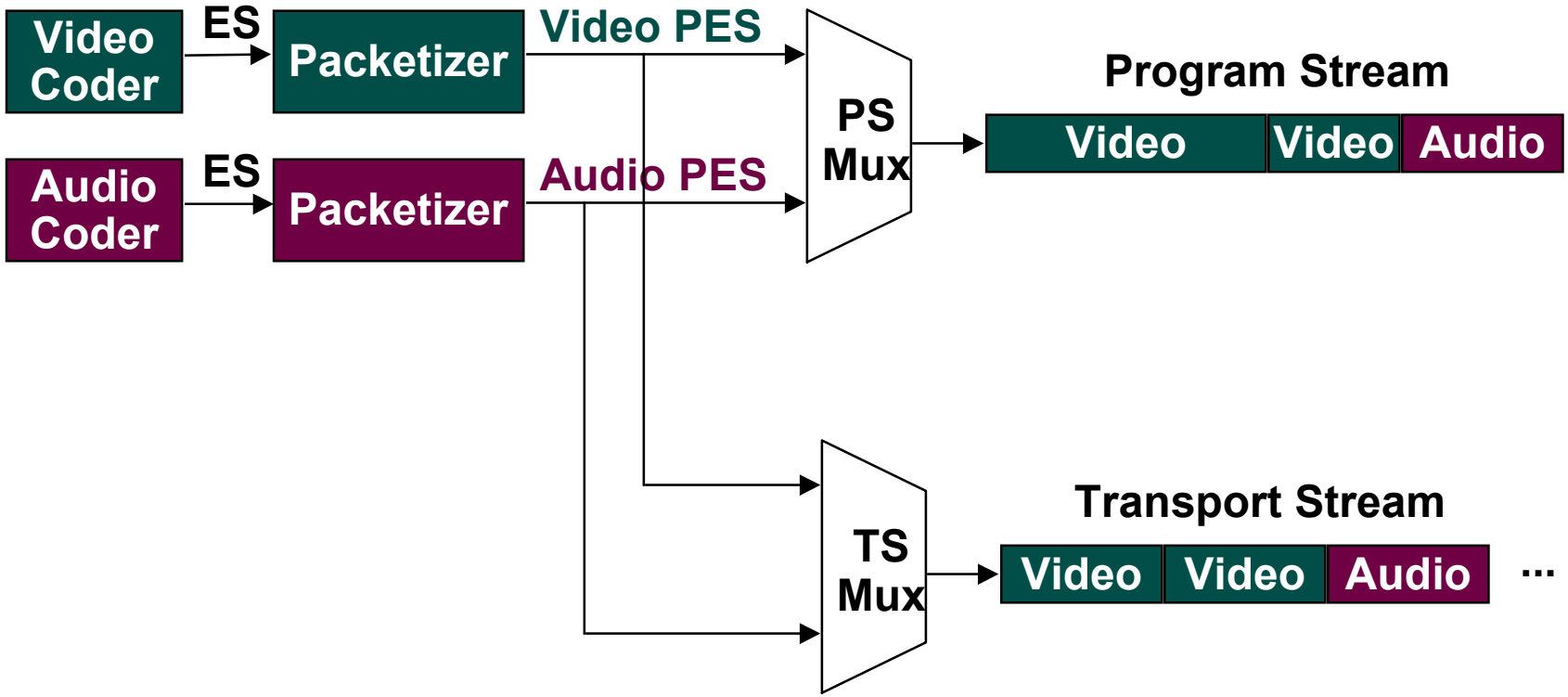
- **A packet is like a freight car that carries just one type of data (audio, video, etc).**
- **Each packet has a "label" called a Packet ID (*PID*).**

Packet Multiplexing

...like a freight car switch yard...

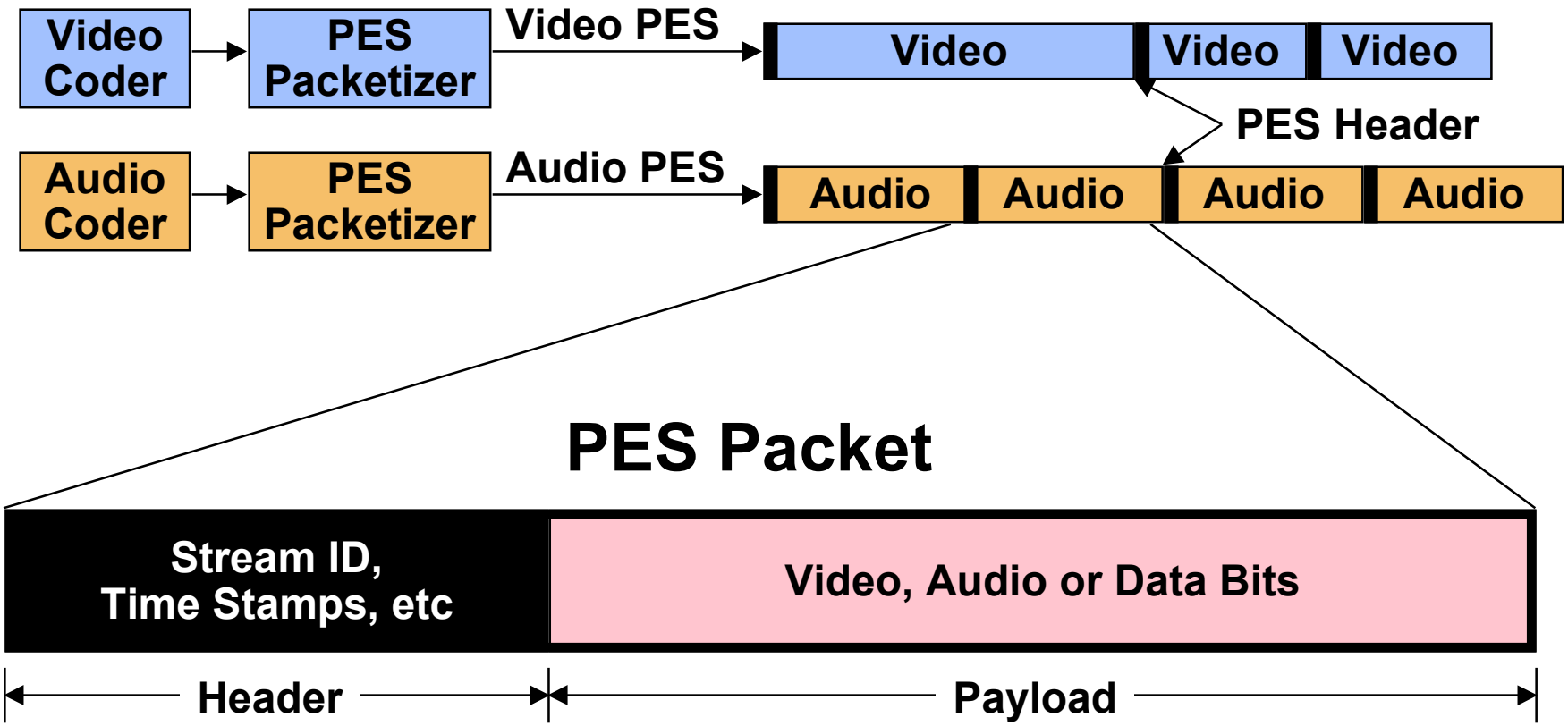


Program and Transport Streams



ES: Elementary Stream
PES: Packetized Elementary Stream
PS: Program Stream
TS: Transport Stream

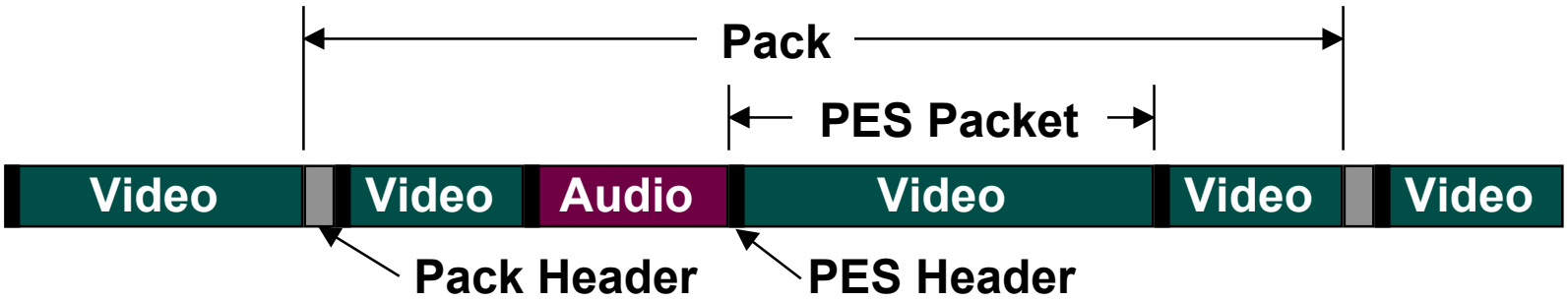
Packetized Elementary Streams (PES)



PES Stream ID

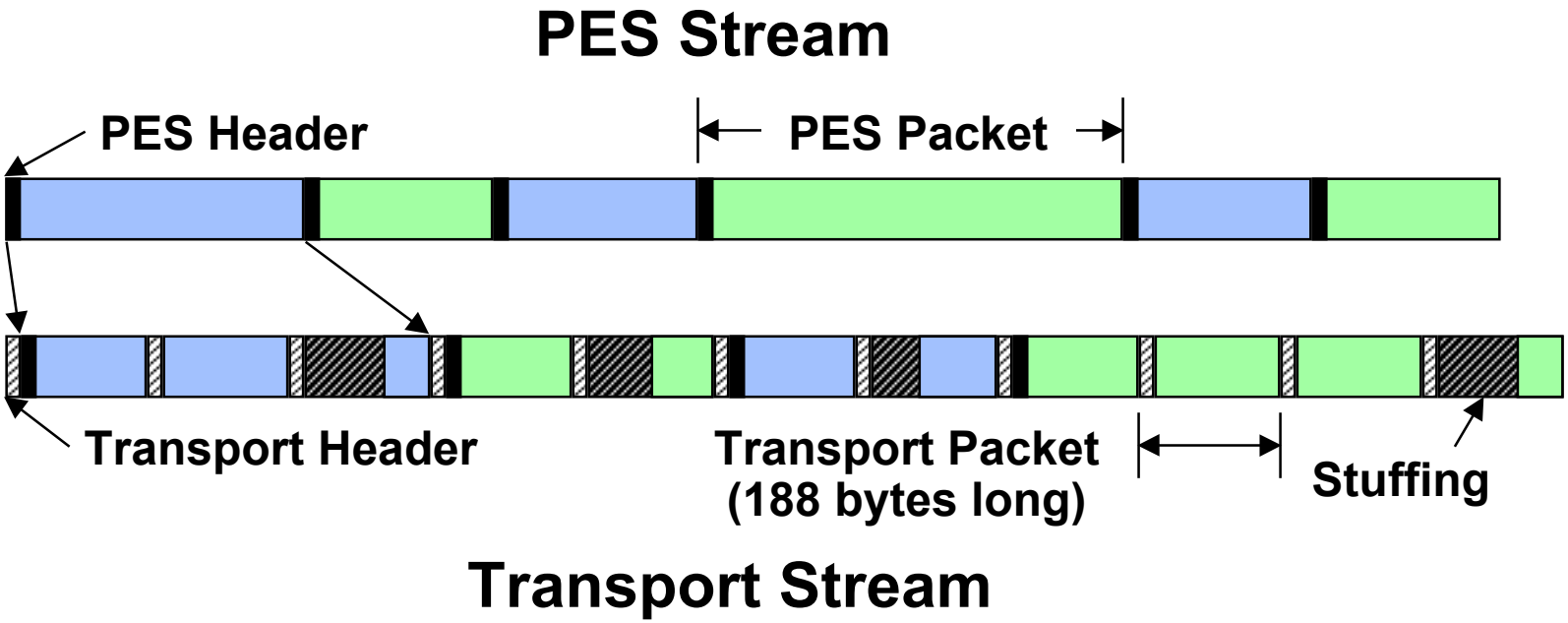
- Stream ID describes the elementary stream
- Example Stream ID's
  - Program Stream Map
  - Program Stream Directory
  - Private Stream
  - Padding Stream
  - MPEG Audio Stream
  - MPEG Video Stream
  - ECM Stream (used for Conditional Access)
  - EMM Stream (used for Conditional Access)
  - DSM-CC (Digital Storage Media Command & Control) Stream
  - Ancillary Stream

MPEG-2 Program Streams



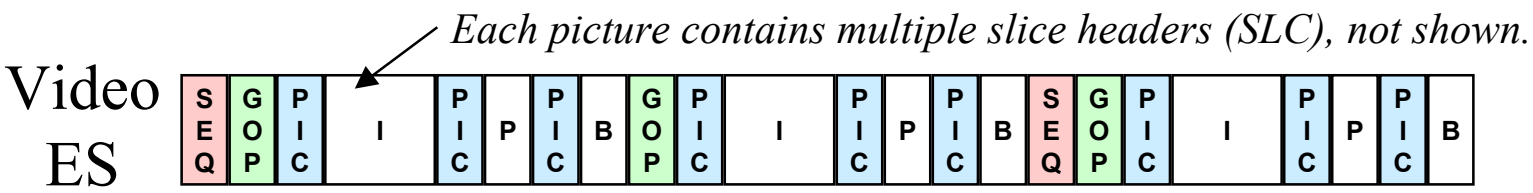
- **A Program Stream consist of Packs, which in turn consist of PES packets.**
- **The Pack Header contains info about synchronization and time base recovery.**
- **Can carry up to 16 video and 32 audio streams, all with <u>same</u> timebase.**

MPEG-2 Transport Streams

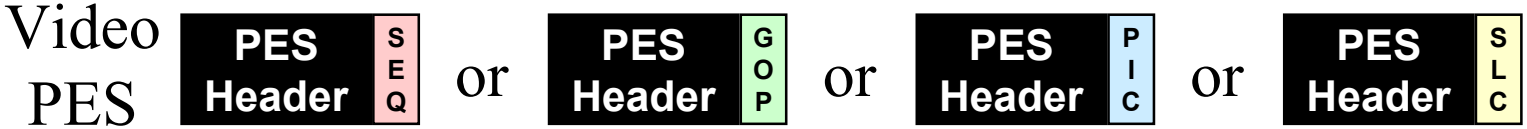


- **A Transport Stream consists of fixed-length Transport Packets, which are re-packaged PES packets.**
- **A PES packet header is always preceded by a transport header.**

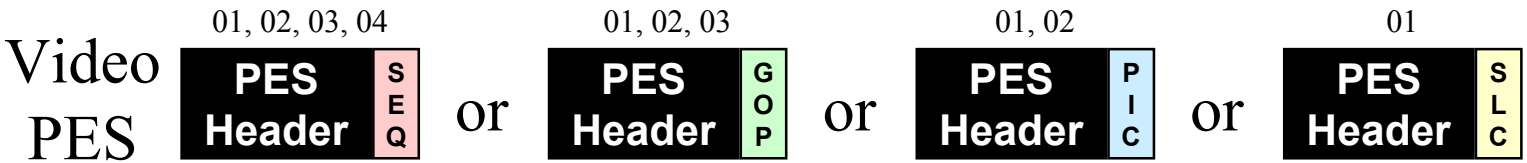
MPEG-2 Video Data Alignment



If `data_alignment_indicator = 1` in PES Header, and the `data_stream_alignment_descriptor` is not present, then one of the following data alignments is required:

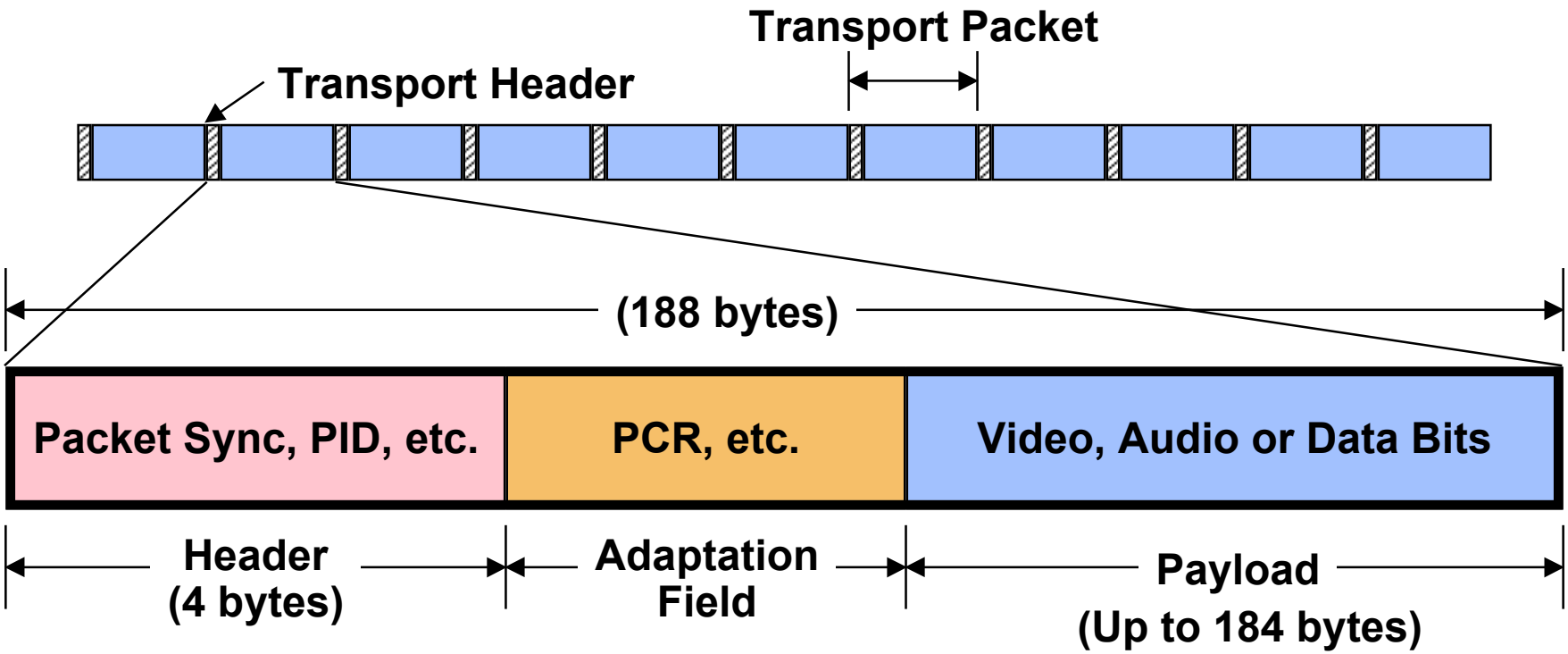


If `data_alignment_indicator = 1` in PES Header, and the `data_stream_alignment_descriptor` is as indicated, then one of the specified data alignments is required:



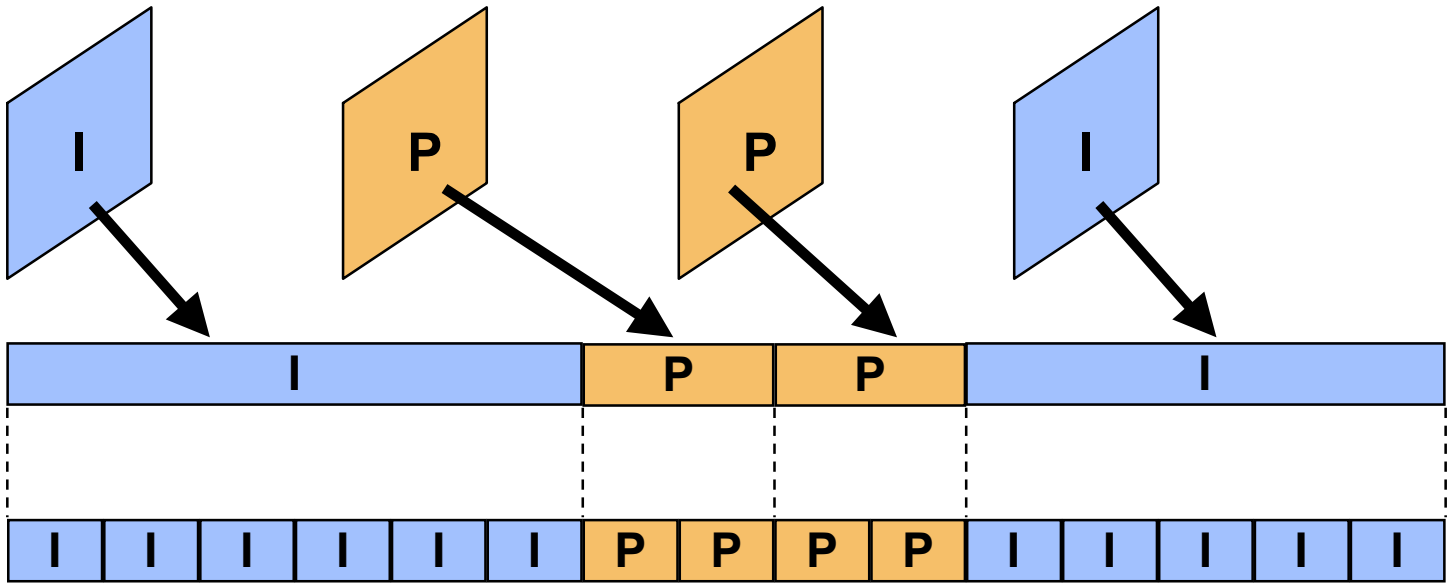
If `data_alignment_indicator = 0` in PES Header, then no data alignment is required:

MPEG-2 Transport Packet



- **PID = Packet ID**
- **PCR = Program Clock Reference (Master Clock)**

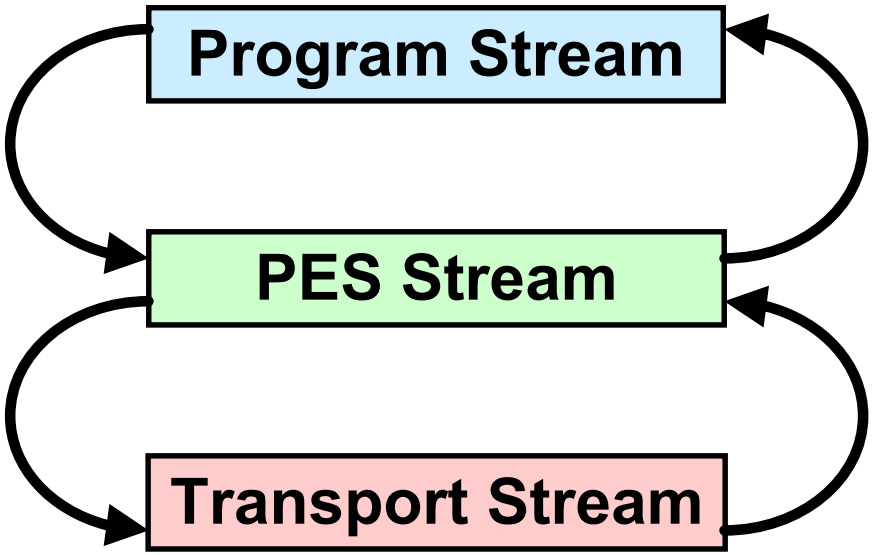
Packets - Key to Flexibility and Extensibility



Fixed Length Packets

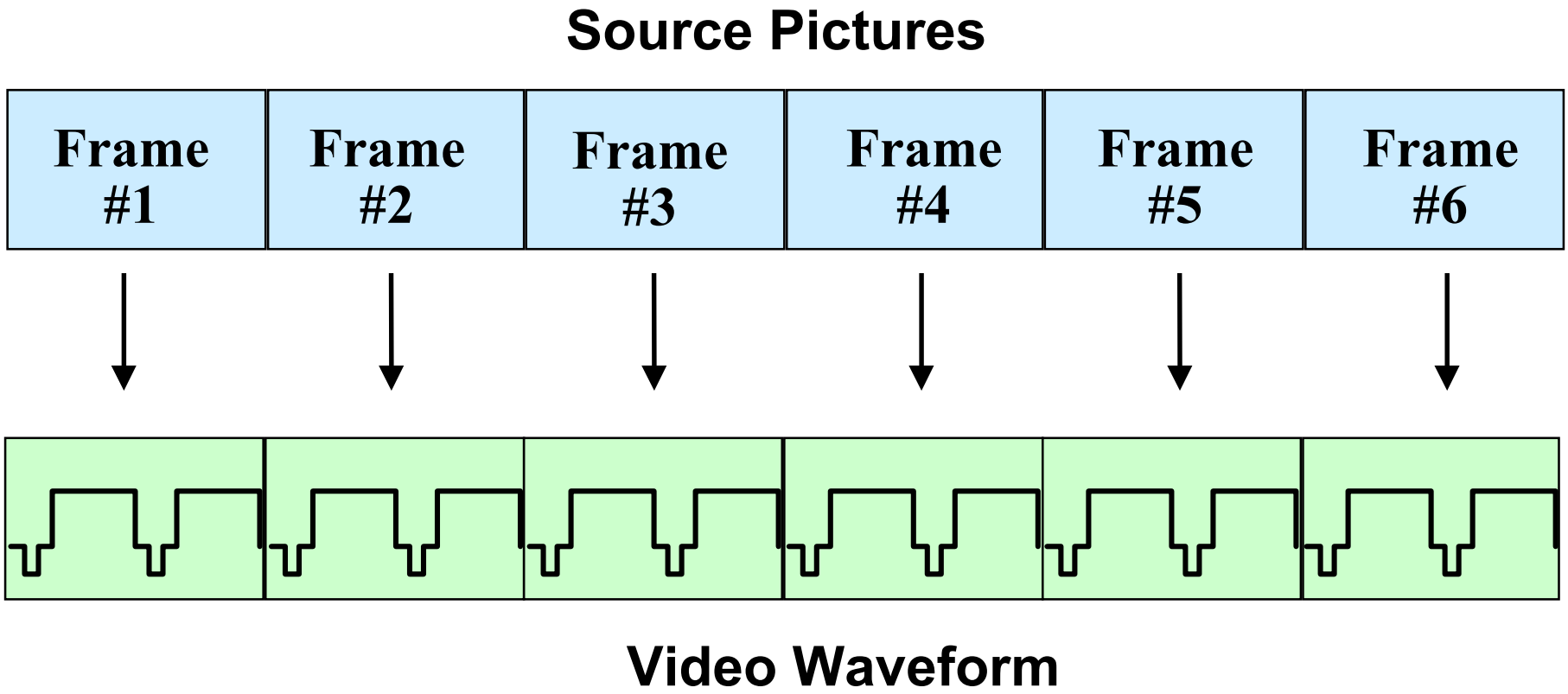
- **relatively short**
- **amenable to error correction and fast switching**
- **best for error-prone media (e.g., broadcast)**
- **MPEG-2 calls them *Transport Packets***

Conversion Between Stream Types



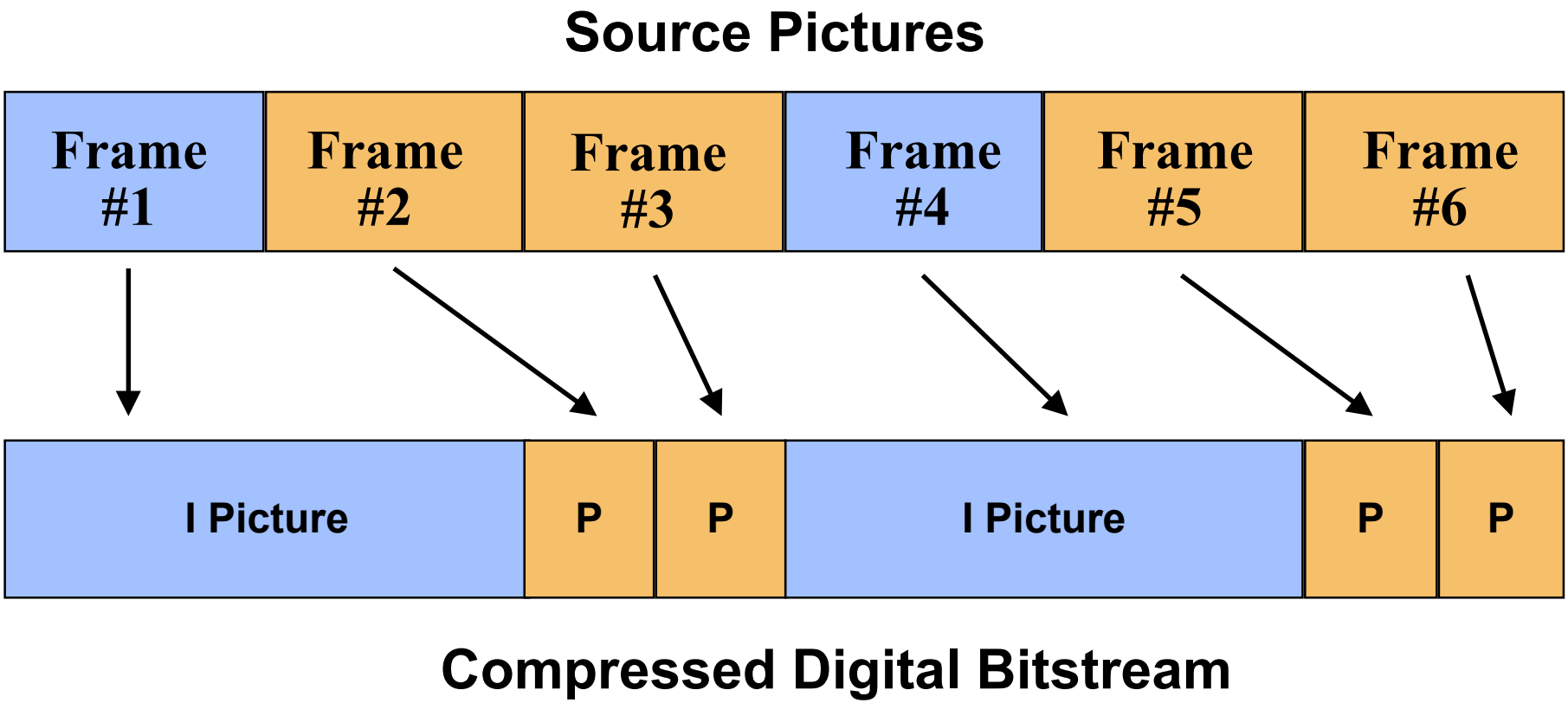
- **Conversion can be performed via intermediate PES format.**

Display Synchronization - Uncompressed



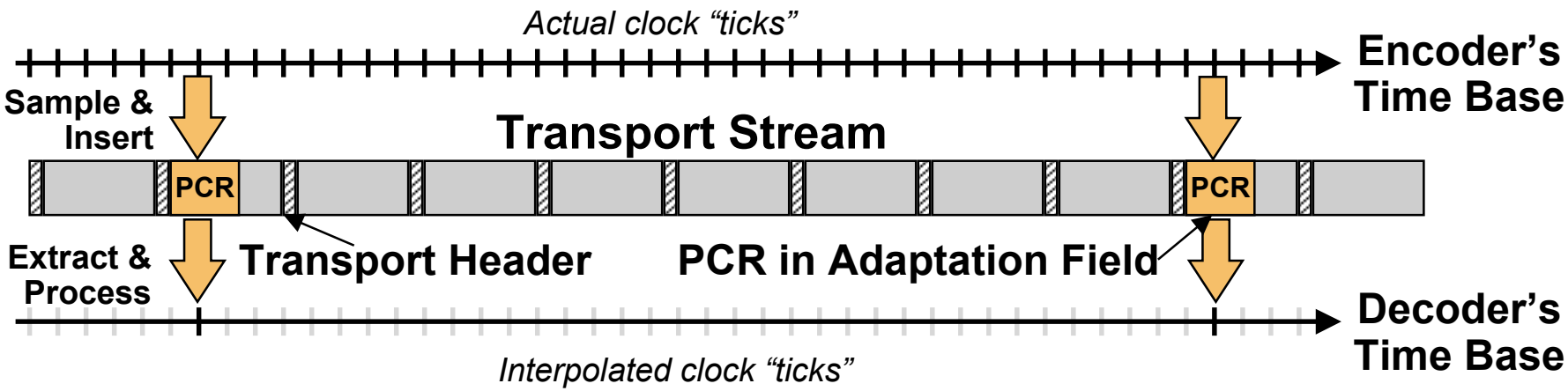
- Display and Clock Synchronization Info is Carried Directly by the Video Signal

Display Synchronization - Compressed



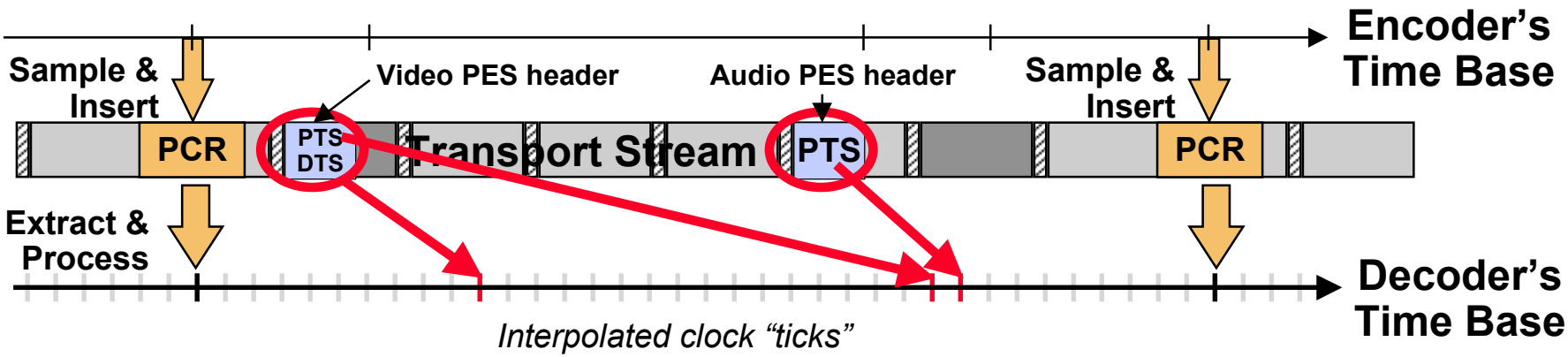
- Compressed Bitstream Must Carry Display Synchronization Info and Clock Information

Program Clock Recovery



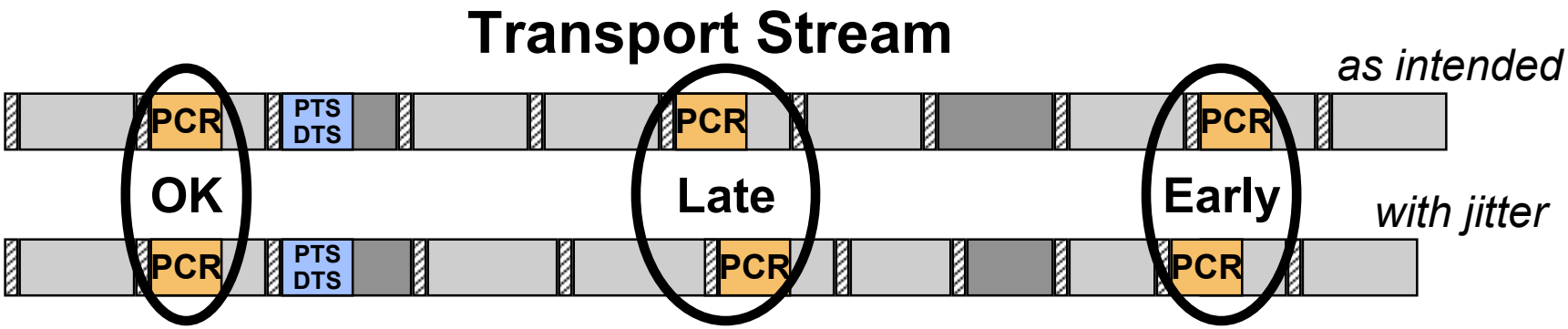
- Program Clock References (PCR's) are 42-bit sample values of the Encoder's 27-MHz Time Base (System Clock).
- At the encoder, PCR's are inserted in selected Transport Packets, at least 10 times/sec.
- The decoder extracts PCR's and uses them to recreate the Program Clock.

Synchronizing Audio and Video



- Presentation Time Stamps (PTS) indicate when video or audio frames should be presented.
- Decode Time Stamps (DTS) indicate when video anchor frames should be decoded.
- PTS and DTS are samples of a 90 kHz clock locked to the PCR Time Base. They are sent in PES headers.
- Lip Sync is achieved by presenting video and audio frames at the proper value of the Program Clock (PCR timebase).

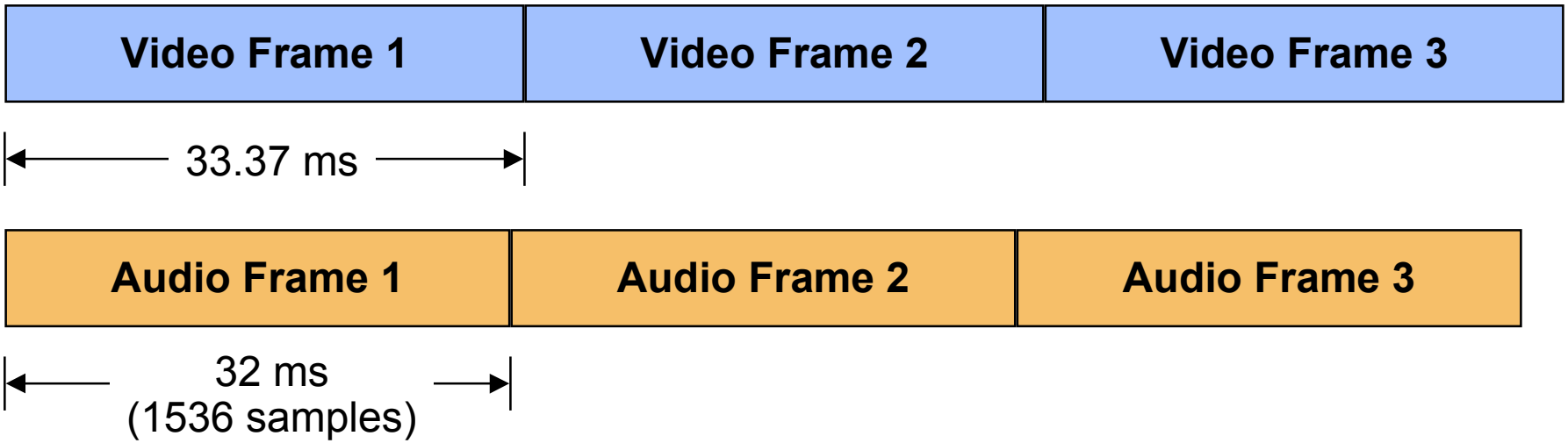
Effect of PCR Jitter



- PCR jitter can be introduced by variable delays in networks or by Mux/Remux operations.
- PCR jitter causes decoder's Program Clock to erroneously speed up or slow down.
- Depending on decoder implementation, this can lead to frozen or skipped pictures, unstable color or "wow and flutter".
- Additional buffers can be used to reduce effect of PCR jitter.

Video vs. AC-3 Frames

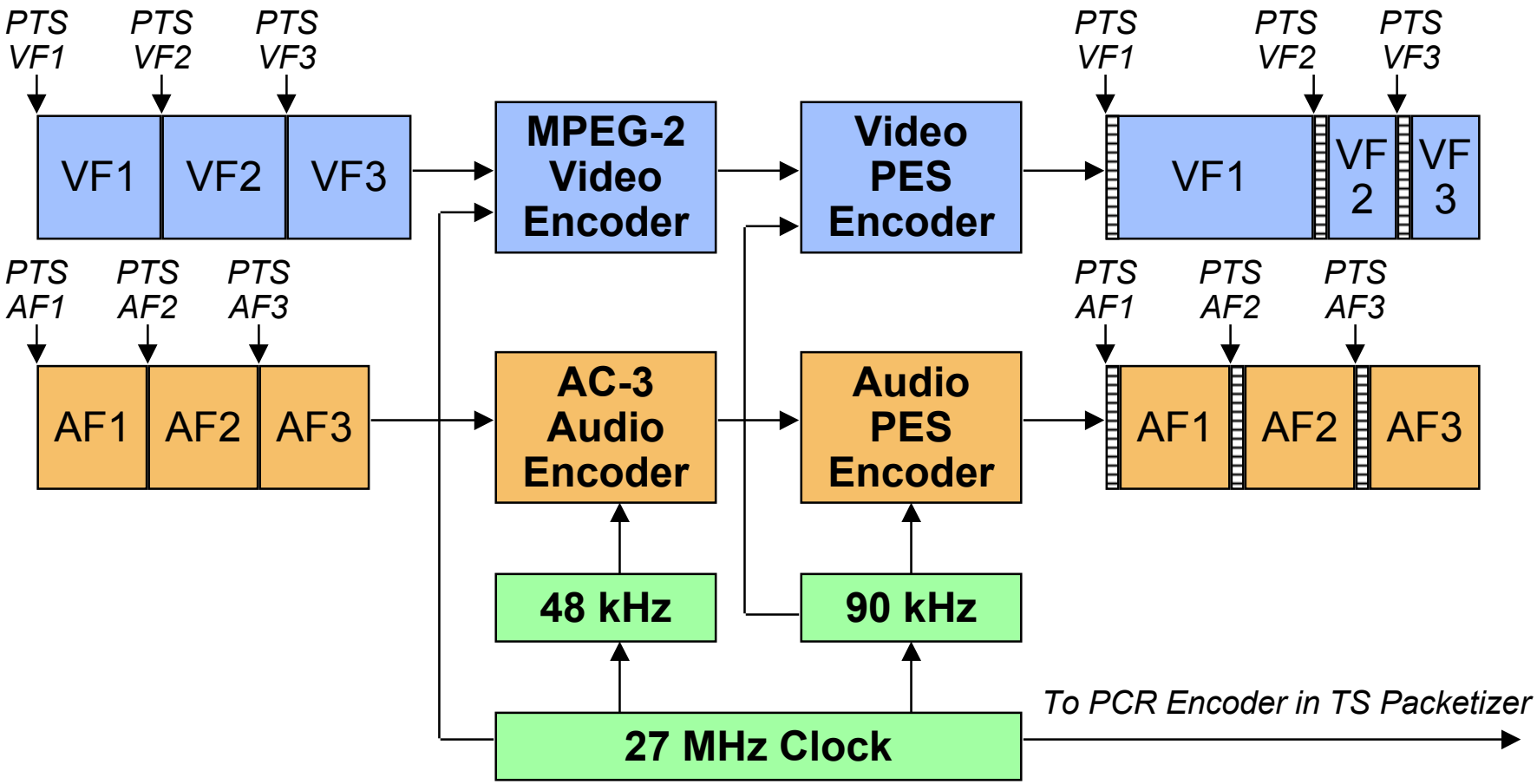
Uncoded Video Frames (29.97 frames/sec)



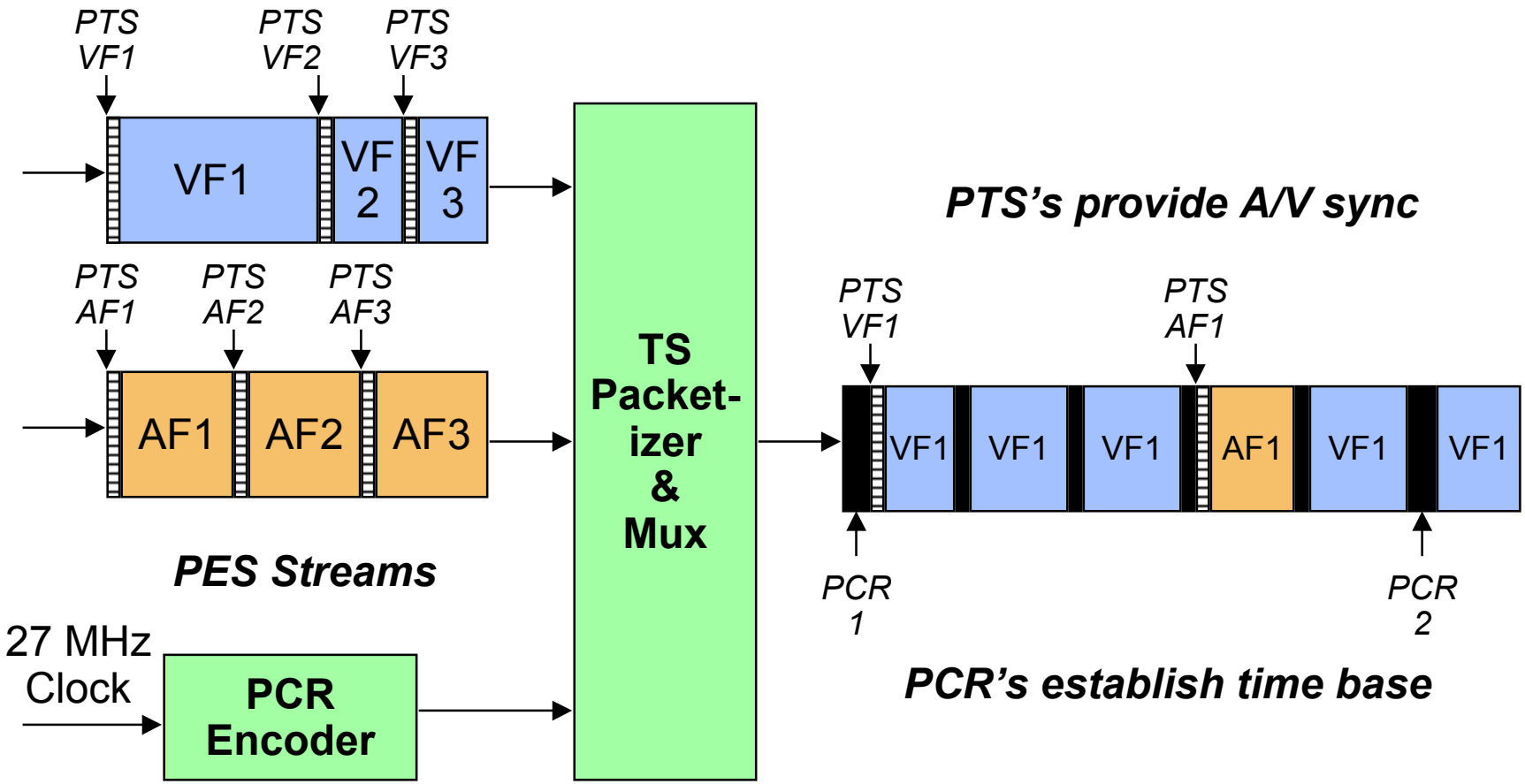
Uncoded Audio (showing AC-3 frame boundaries)

Note: Video and audio frames boundaries are rarely (if ever) aligned.

Synchronizing MPEG-2 Video and AC-3 Audio



A/V Synchronization (cont'd)

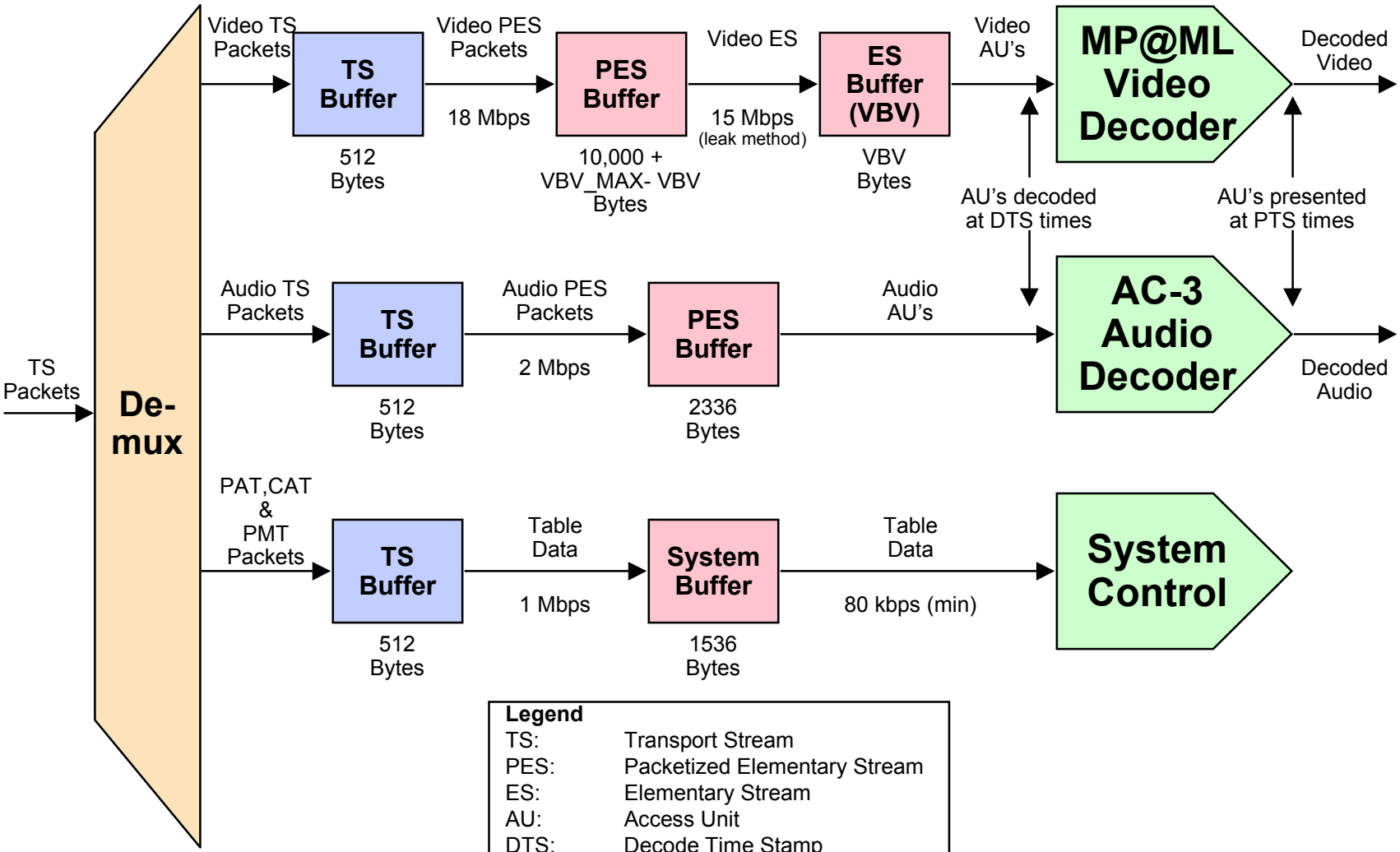


Transport System Target Decoder (T-STD)

- The T-STD is a conceptual decoder used to model the decoding process during the construction or verification of Transport Streams.
- It is described in detail in Annex D of the MPEG-2 Systems Spec (ISO/IEC 13818-1)
- The T-STD consists of three decoder types:
  - video
  - audio
  - systems
- A demux, buffers and decoders comprise the T-STD.

T-STD Block Diagram

...for MP@ML Video and AC-3 Audio...



Program Specific Information (PSI)

Table Name	PID #	Description
Program Association Table (PAT)	0	Associates Program No. with PMT
Program Map Table (PMT)	Assigned	Associates PID's with Progam(s)
Network Information Table (NIT)	Assigned	Contains physical network params
Conditional Access Table (CAT)	1	Associates PID's with private streams

- In addition to PSIP, PAT and PMT are required in every ATSC MPEG-2 Transport Stream.
- PAT/PMT form a "mini Program Guide", and certain information in those tables and in PSIP must be consistent.
- NIT not used in ATSC. System information contained in PSIP.
- CAT must be present if any stream is scrambled.

Program Association Table (PAT)

Program #	PMT PID #	Meaning
2	32	PID 32 contains map for Program 2
3	48	PID 48 contains map for Program 3
4	64	PID 64 contains map for Program 4

Example PAT for 3-program multiplex

- PAT provides correspondence between a Program Number and the PMT PID that carries program definition.
- Program # is similar to Channel # in broadcast TV.
- PAT always assigned to PID 0

Program Map Table (PMT)

PID #	Stream Type
32	PMT
33	Video & PCR
36	Audio
42	Data

Example Map for Program 2

- PMT provides correspondence between a Program Number and the elementary streams that comprise it.
- Descriptors may be sent to provide more information about the program and/or program elements.

PMT Stream Type

- Stream Type describes the elementary stream
- Example Stream Types
  - MPEG-1 Video
  - MPEG-2 Video
  - MPEG-1 Audio
  - MPEG-2 Audio
  - Private Sections
  - PES Private Data
  - MHEG
  - DSM-CC
  - User Private (e.g., AC-3 Audio)

Conditional Access Table (CAT)

CA System	CA PID
1	201
2	202
3	203

Example CAT for Transport Stream Containing 3 CA Systems

- CAT provides correspondence between CA systems and their Entitlement Management Message (EMM) streams.
- EMM's are system-wide private streams that specify authorization levels of specific decoders.

Other Tables

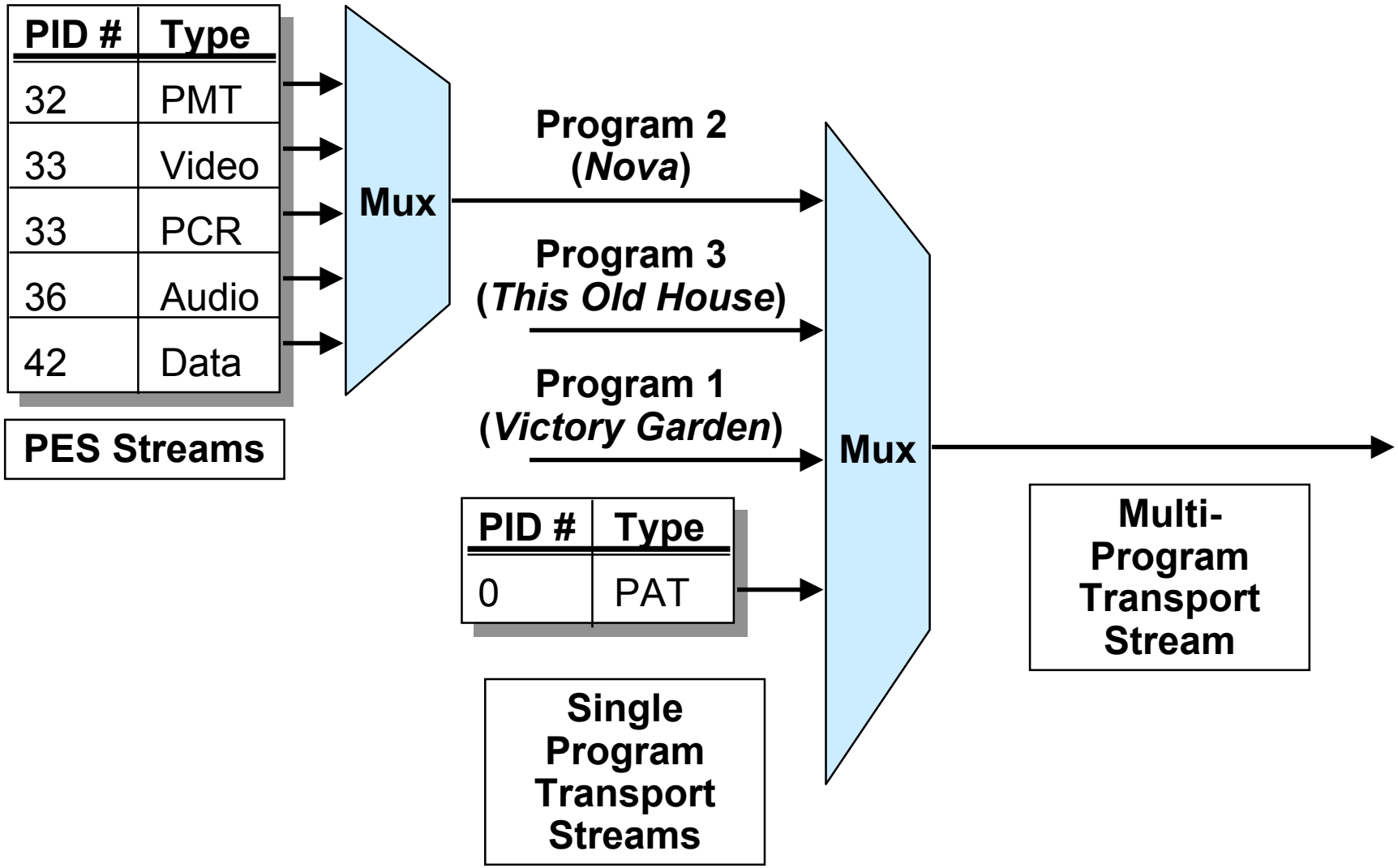
Network Information Table

- NIT provides information about physical network parameters, such as FDM frequencies, satellite transponder numbers, etc.
- NIT is optional and its contents are private.
- If present, NIT is Program 0 in PAT.

Private Tables

- Structure provided for transmission of private data.
- Can be used for sending non-MPEG data, such as stock quotes, downloadable software modules, etc.

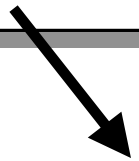
Multi-Program Multiplex



Review of Program Mapping

PID 0 **Program Association Table**

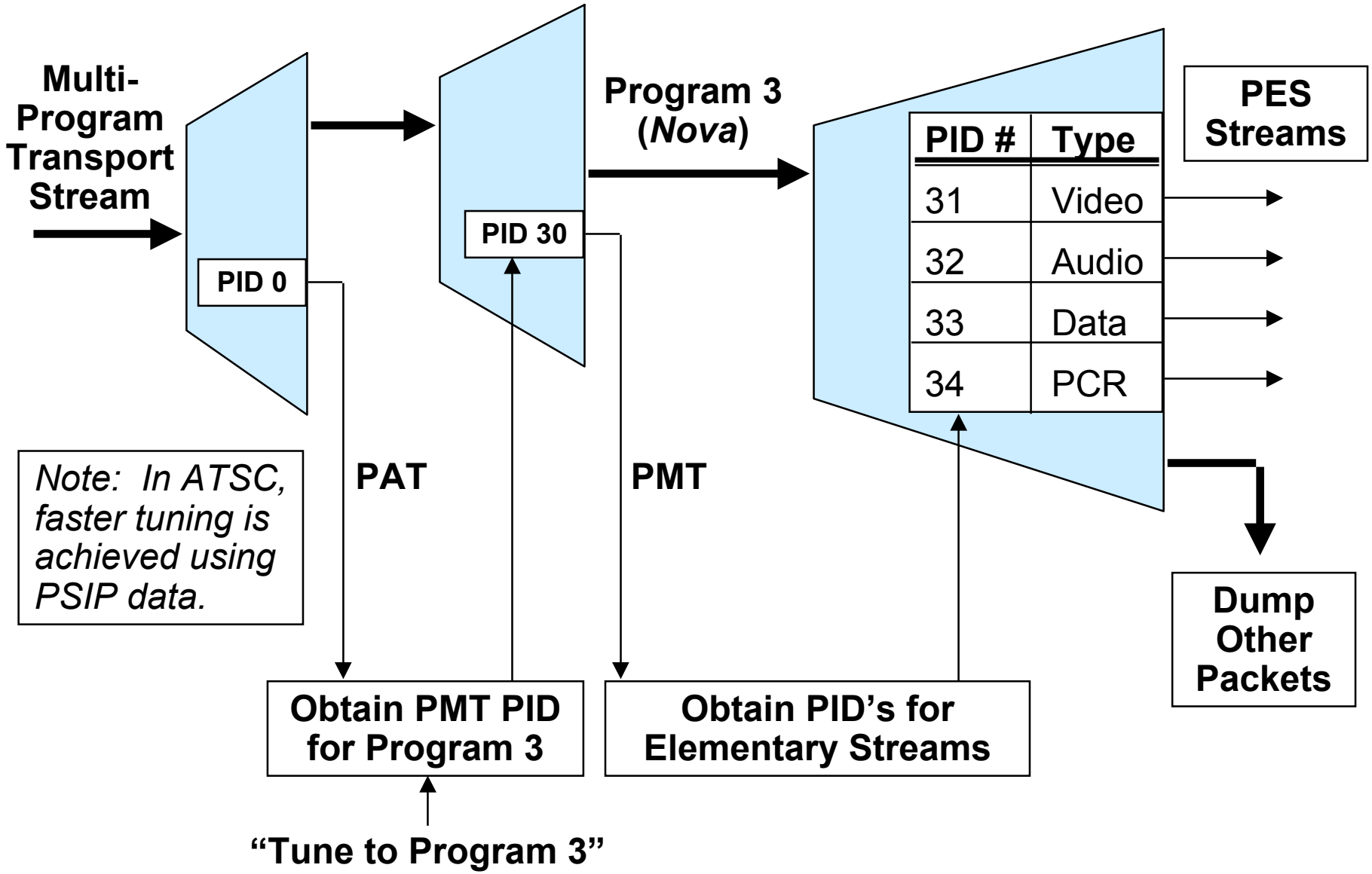
Program #	PMT PID #	Meaning
1	10	Program 1 (*Victory Garden*) info at PID 10
2	20	Program 2 (*This Old House*) info at PID 20
3	30	Program 3 (*Nova*) info at PID 30



PID 30 **Program Map Table for Program 3**

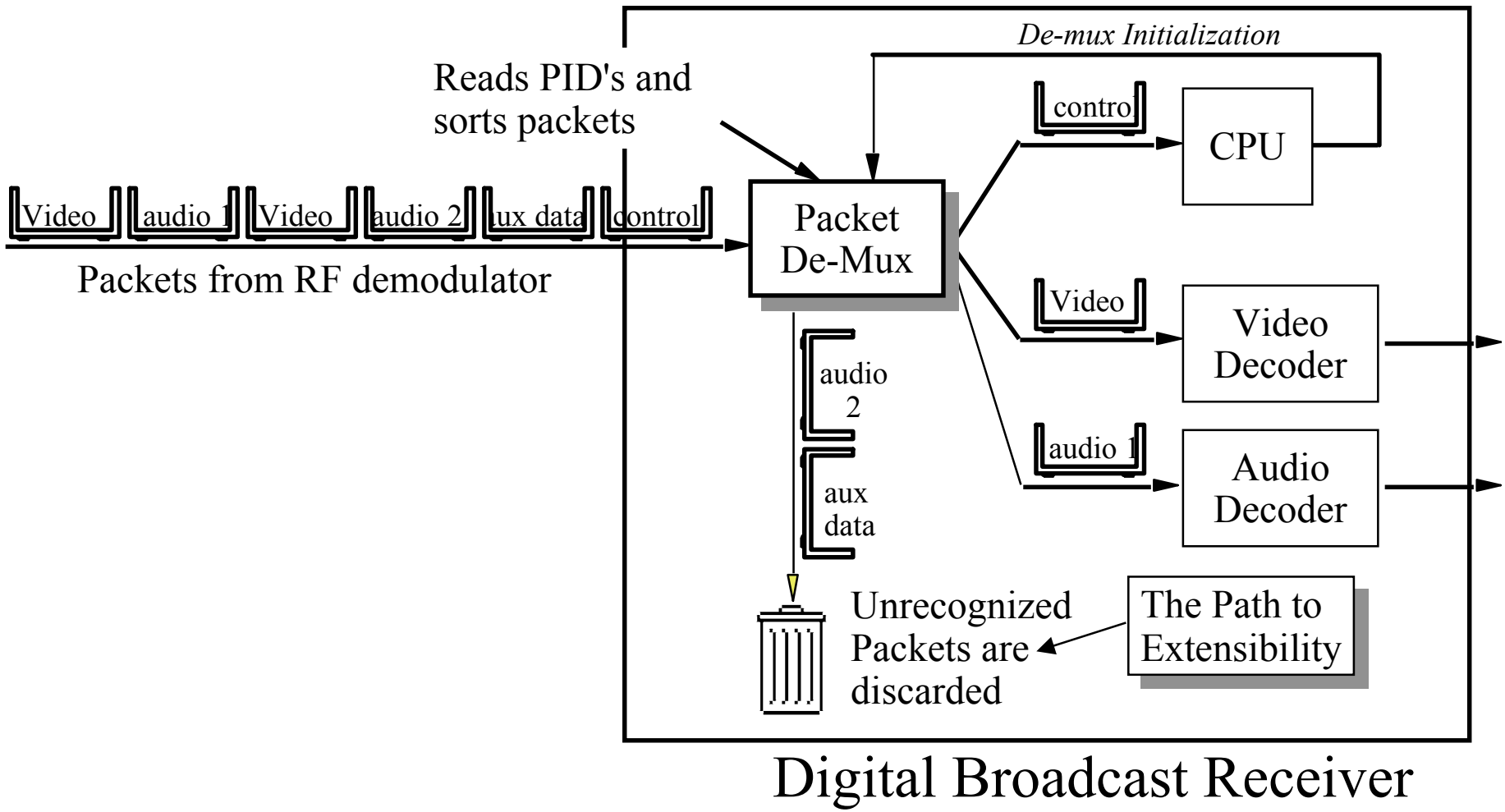
PID #	Stream Type
31	Video
32	Audio
33	Data
34	PCR

Tuning Example Using PAT and PMT



Packet Demultiplexing

...unrecognized packets are discarded...



MPEG-2 Systems Descriptors

- Descriptors can be used to extend the definition of programs and program elements
- Currently Defined Descriptors
  - Video Stream
  - Audio Stream
  - Hierarchy
  - Registration
  - Data Stream Alignment
  - Target Background Grid
  - Video Window
  - Conditional Access
  - ISO 639 Language
  - System Clock
  - Multiplex Buffer Utilization
  - Copyright
  - Maximum Bitrate
  - Private Data Indicator
  - Smoothing Buffer
  - STD
  - IBP

MPEG Bitstream Syntax

MPEG uses C code conventions:

- while (condition) { data_element … }
  - If condition is true, then the group of data elements occurs next in the data stream. This repeats until condition is not true.
- do { data_element … } while (condition)
  - Data element occurs at least once and is repeated until condition is not true.
- if (condition) { data_element … } else { data_element … }
  - If condition is true, then the first group of data elements occurs next. Otherwise, the second group occurs next.
- for (i=0; i<n; i++) { data_element … }
  - The group of data elements occurs n times. The loop control variable, i, is set to zero for the first occurrence and increments each time.

Example for Transport Packet

Table 2-3 -- ITU-T Rec. H.222.0 | ISO/IEC 13818 transport packet

Syntax	No. of bits	Mnemonic
transport_packet(){		
sync_byte	**8**	**bslbf**
transport_error_indicator	**1**	**bslbf**
payload_unit_start_indicator	**1**	**bslbf**
transport_priority	**1**	**bslbf**
PID	**13**	**uimsbf**
transport_scrambling_control	**2**	**bslbf**
adaptation_field_control	**2**	**bslbf**
continuity_counter	**4**	**uimsbf**
if(adaptation_field_control=='10' || adaptation_field_control=='11'){		
adaptation_field() ← af appears only if afc = 10 or 11		
}		
if(adaptation_field_control=='01' || adaptation_field_control=='11') {		
for (i=0;i<N;i++){		
data_byte ← data_bytes appear N times (N = 184 - af length)	**8**	**bslbf**
}		
}		
}		

These must appear

bslbf Bit string, left bit first, where "left" is the order in which bit strings are written in the Recommendation | International Standard. Bit strings are written as a string of 1s and 0s within single quote marks, e.g. '1000 0001'. Blanks within a bit string are for ease of reading and have no significance.

uimsbf Unsigned integer, most significant bit first

AFC Values

Table 2-6 -- Adaptation field control values

value	description
00	reserved for future use by ISO/IEC
01	no adaptation_field, payload only
10	adaptation_field only, no payload
11	adaptation_field followed by payload

Three Basic Transport Packet Types

Table 2-3 -- ITU-T Rec. H.222.0 | ISO/IEC 13818 transport packet

Syntax	No. of bits	Mnemonic
transport_packet(){		
sync_byte	**8**	**bslbf**
transport_error_indicator	**1**	**bslbf**
payload_unit_start_indicator	**1**	**bslbf**
transport_priority	**1**	**bslbf**
PID	**13**	**uimsbf**
transport_scrambling_control	**2**	**bslbf**
adaptation_field_control	**2**	**bslbf**
continuity_counter	**4**	**uimsbf**
if(adaptation_field_control=='10' || adaptation_field_control=='11'){		
adaptation_field()		
}		
if(adaptation_field_control=='01' || adaptation_field_control=='11') {		
for (i=0;i<N;i++){		
data_byte	**8**	**bslbf**
}		
}		
}		

Table 2-6 -- Adaptation field control values

value	description
00	reserved for future use by ISO/IEC
01	no adaptation_field, payload only
10	adaptation_field only, no payload
11	adaptation_field followed by payload

188 bytes

sync '0x47'	tei (1)	pusi (1)	tp (1)	PID (13)	tsc (2)	afc '01'	cc (4)	Payload data_bytes (184 bytes)

sync '0x47'	tei (1)	pusi (1)	tp (1)	PID (13)	tsc (2)	afc '10'	cc (4)	Adapt. Field (AF bytes)	Decoder ignores these 184-AF bytes

sync '0x47'	tei (1)	pusi (1)	tp (1)	PID (13)	tsc (2)	afc '11'	cc (4)	Adapt. Field (AF bytes)	Payload data_bytes (184-AF bytes)

MPEG Tables

- Tables are structures that are segmented into one or more sections.
- A section is used to map a table into Transport Packets.
- A special private section is defined to carry private data.
- Sections may be variable in length.
- The beginning of a section is indicated by a pointer_field syntax element.
- MPEG sets byte limits:
  - max length of PSI table = 1024 bytes
  - max length of private_section = 4096 bytes

Tables and Sections

Examples: Program Assocation Table with 3 sections

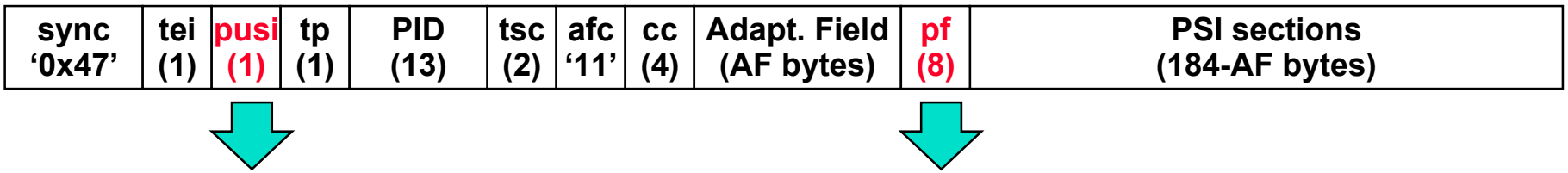
table_id = 0x00	identifies this section as belong to PAT
section_syntax_indicator=1	identifies short form of table
section_length = 0x55	number of bytes in this section
…	
version_number = 1	first version
current_next_indicator = 1	this table is applicable now
section_number = 0x00	this is the first section
last_section_number = 0x02	number of last section
...	

table_id = 0x00	identifies this section as belong to PAT
…	
section_number = 0x01	this is the second section
last_section_number = 0x02	number of last section
...	

table_id = 0x00	identifies this section as belong to PAT
…	
section_number = 0x02	this is the third (last) section
last_section_number = 0x02	number of last section
...	

Section Mapping Semantics

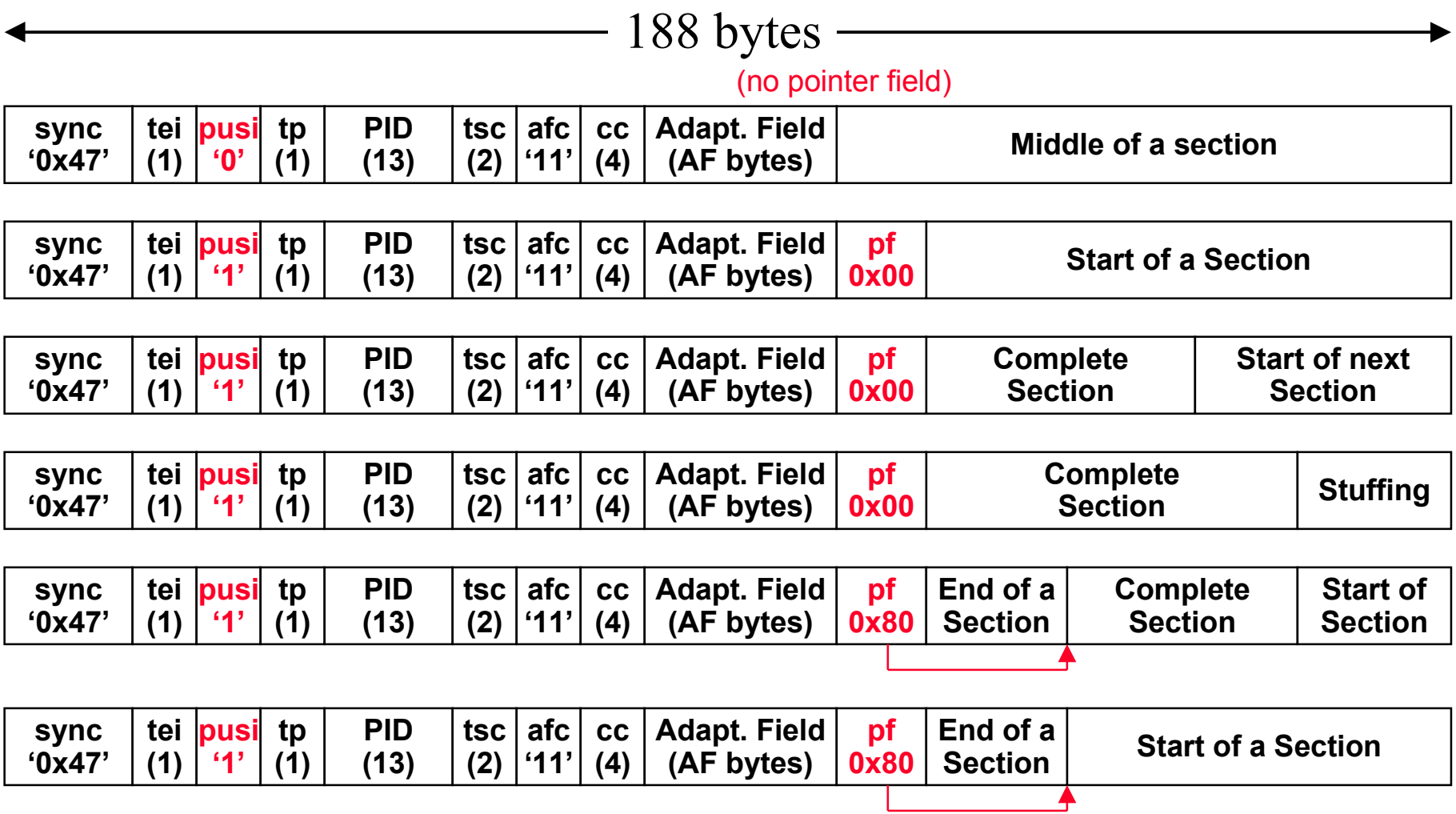
Transport Packet Format



- pusi = payload_unit_start_indicator
- if pusi = 0, then no section starts in the payload, and no pointer field is present
- if pusi = 1, then at least one section starts in the payload. A pointer field is the first byte of the payload and indicates the byte offset to the first byte of the first section.

- pf = pointer_field
- if pf = 0x00, then a section starts immediately after this field
- if pf = 0x09, then a section starts 9 bytes after this field

Example Section Mappings



Program Association Section

Syntax	No. of bits	Mnemonic
program_association_section() {		
table_id	**8**	**uimsbf**
section_syntax_indicator	**1**	**bslbf**
'0'	**1**	**bslbf**
reserved	**2**	**bslbf**
section_length	**12**	**uimsbf**
transport_stream_id	**16**	**uimsbf**
reserved	**2**	**bslbf**
version_number	**5**	**uimsbf**
current_next_indicator	**1**	**bslbf**
section_number	**8**	**uimsbf**
last_section_number	**8**	**uimsbf**
for (i=0; i<N;i++) {		
program_number	**16**	**uimsbf**
reserved	**3**	**bslbf**
if(program_number == '0') {		
network_PID	**13**	**uimsbf**
}		
else {		
program_map_PID	**13**	**uimsbf**
}		
}		
CRC_32	**32**	**rpchof**
}		

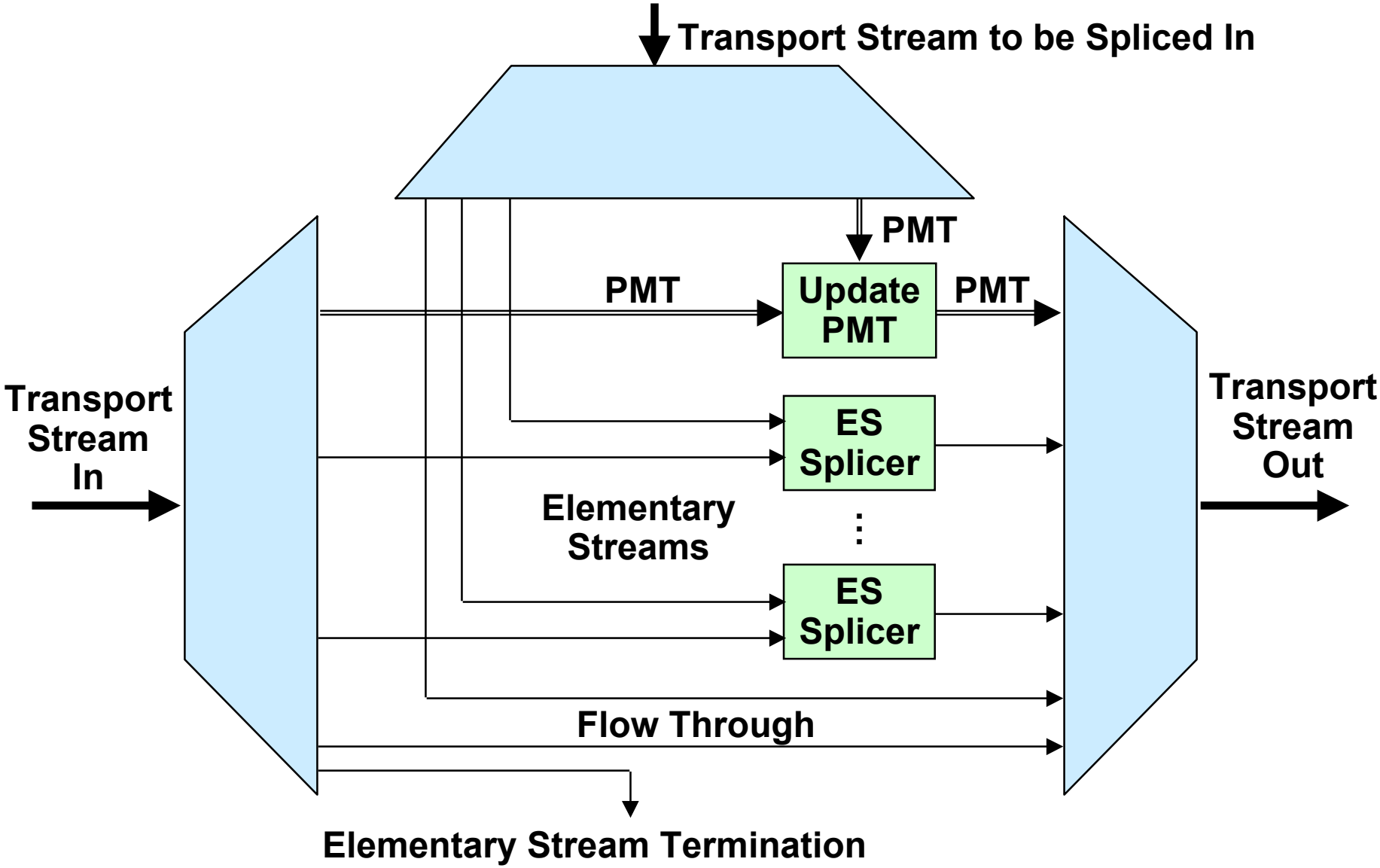
Program Map Section

Syntax	No. of bits	Mnemonic
TS_program_map_section() {		
table_id	**8**	**uimsbf**
section_syntax_indicator	**1**	**bslbf**
'0'	**1**	**bslbf**
reserved	**2**	**bslbf**
section_length	**12**	**uimsbf**
program_number	**16**	**uimsbf**
reserved	**2**	**bslbf**
version_number	**5**	**uimsbf**
current_next_indicator	**1**	**bslbf**
section_number	**8**	**uimsbf**
last_section_number	**8**	**uimsbf**
reserved	**3**	**bslbf**
PCR_PID	**13**	**uimsbf**
reserved	**4**	**bslbf**
program_info_length	**12**	**uimsbf**
for (i=0; i<N; i++) {		
descriptor()		
}		
for (i=0;i<N1;i++) {		
stream_type	**8**	**uimsbf**
reserved	**3**	**bslbf**
elementary_PID	**13**	**uimsnf**
reserved	**4**	**bslbf**
ES_info_length	**12**	**uimsbf**
for (i=0; i<N2; i++) {		
descriptor()		
}		
}		
CRC_32	**32**	**rpchof**
}		

Private Section

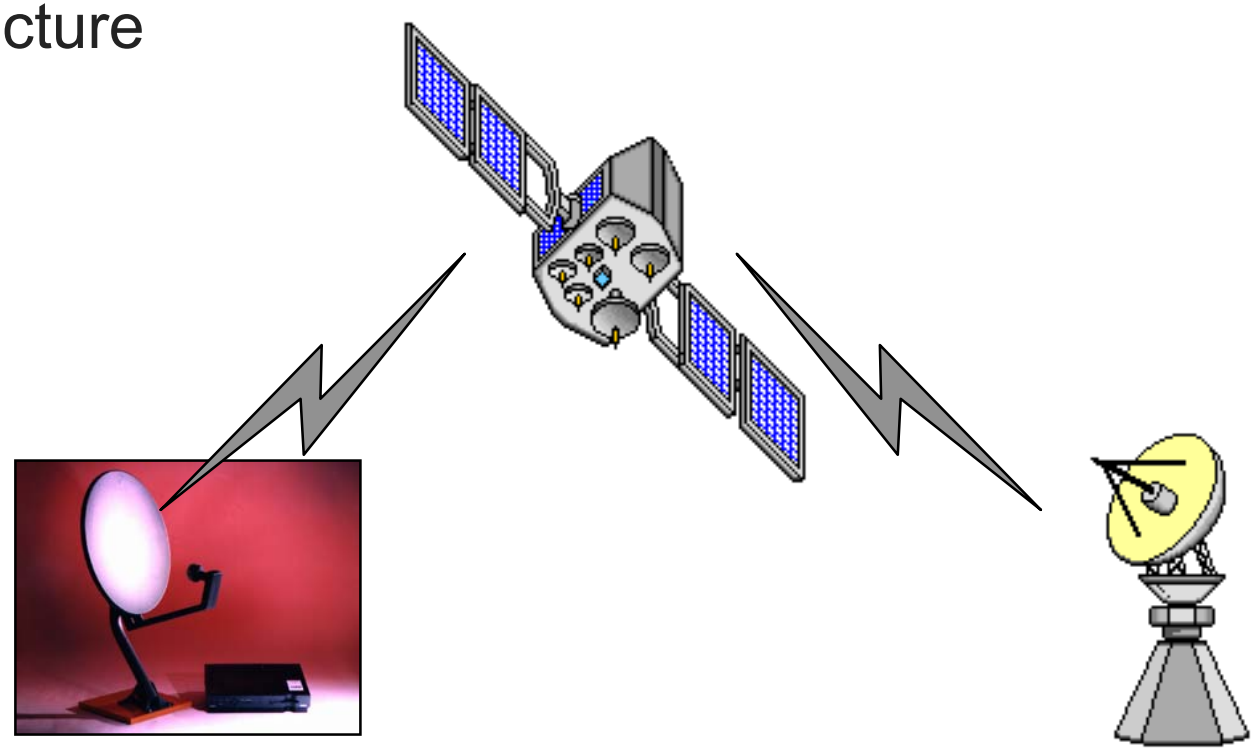
Syntax	No. of bits	Mnemonic
private_section() {		
table_id	**8**	**uimsbf**
section_syntax_indicator	**1**	**bslbf**
private_indicator	**1**	**bslbf**
reserved	**2**	**bslbf**
private_section_length	**12**	**uimsbf**
if (section_syntax_indicator == '0') {		
for (i=0;i<N;i++) {		
private_data_byte	**8**	**bslbf**
}		
}		
else {		
table_id_extension	**16**	**uimsbf**
reserved	**2**	**bslbf**
version_number	**5**	**uimsbf**
current_next_indicator	**1**	**bslbf**
section_number	**8**	**uimsbf**
last_section_number	**8**	**uimsbf**
for (i=0;i<private_section_length-9;i++) {		
private_data_byte	**8**	**bslbf**
}		
CRC_32	**32**	**rpchof**
}		
}		

Transport Stream Splicing



Specialized Transport Formats

- Digital Satellite
  - DIRECTV uses proprietary transport packet structure
  - Echostar and DVB-S systems use MPEG-2/DVB packet structure



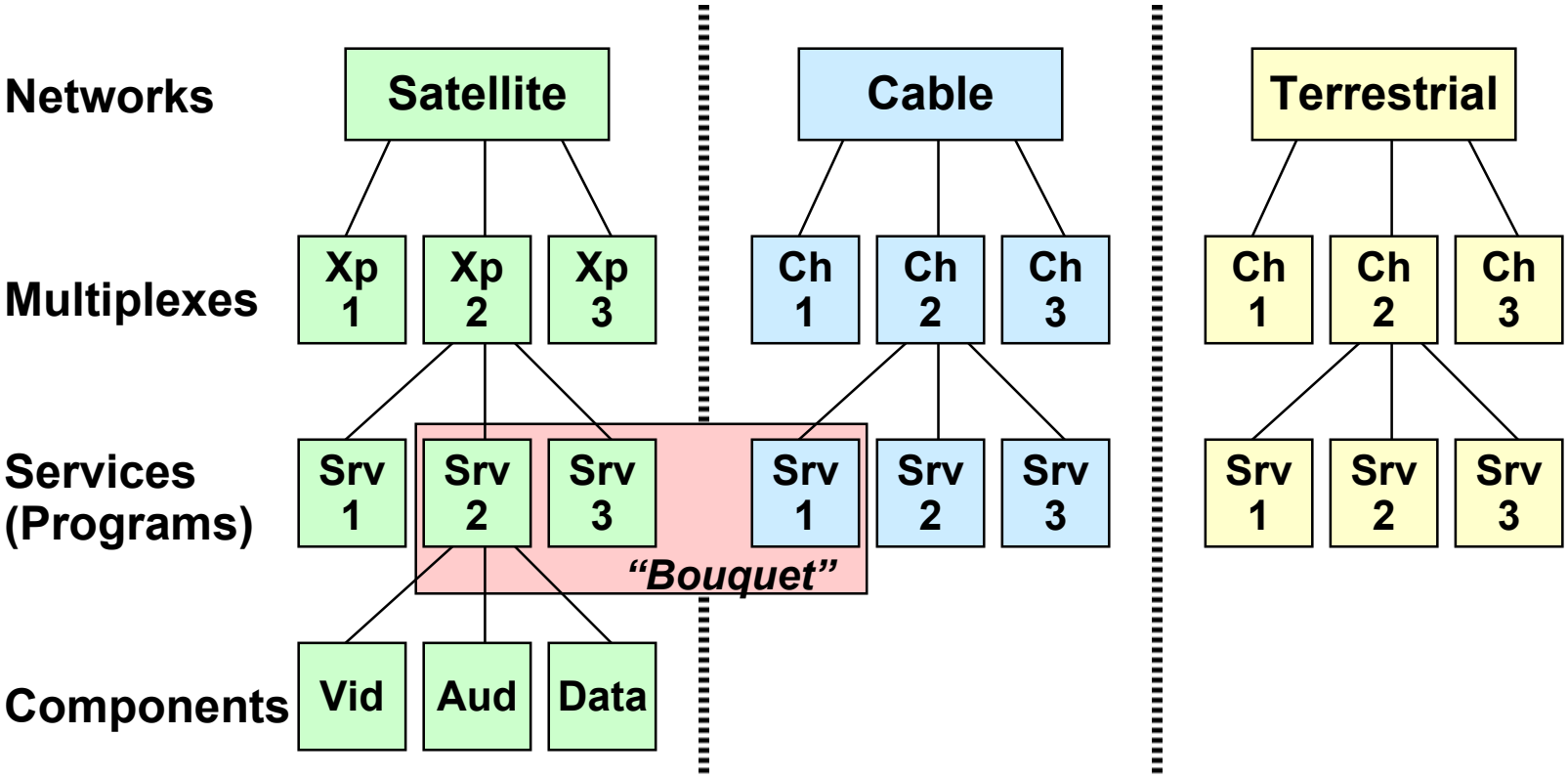
Digital Video Broadcasting (DVB)

- DVB, started in September 1993, is a European project that aims at near-term implementation of digital TV and data broadcasting.
- Consists of 200+ organizations from 25+ countries.
- Includes broadcasters, content providers, network operators, manufacturers and regulatory bodies.
- Is creating a family of standards for:
  - Cable (DVB-C)
  - Satellite (DVB-S)
  - Terrestrial (DVB-T)
- For more information, see *www.dvb.org*

DVB Core System

- Based on MPEG-2 Video, Audio and Transport
- Extends MPEG-2 Service Information with additional tables:
  - NIT: Network Information Table
  - SDT: Service Description Table
  - EIT: Event Information Table
  - TDT: Time and Date Table
  - BAT: Bouquet Association Table
  - RST: Running Status Table
  - ST: Stuffing Tables
- Uses Reed-Solomon and FEC
- Uses common Scrambling system and Conditional Access Interface
- Uses channel-dependent modulation and channel coding schemes

DVB Service Paradigm



A "bouquet" is a collection of services that can cross network boundaries.

DVB Measurement Guidelines

- At the Transport level, DVB has defined more stringent guidelines than MPEG-2.
- Some examples:
  - PCR's should be spaced no more than 40 ms apart (MPEG-2 Transport spec says 100 ms max).
  - PCR accuracy should be within ±500 ns. (MPEG-2 Transport spec recommends < 4 ms jitter)
  - PTS's should occur at least every 0.7 sec (same as MPEG-2 Transport spec)
  - PAT's and PMT's should occur at least every 0.5 sec (no recommendation given in MPEG-2 Transport spec)
- For more information, see the report: *"Measurement Guidelines for DVB Systems"*

ATSC Transport Format

- ATSC Digital Television Standard
  - MPEG-2 Transport Stream with constraints and extensions
  - Supports the following:
    - A/V Synchronization
    - Electronic Program Guide (PSIP)
    - Conditional Access Hooks
    - Private Data Services

ATSC PSI Constraints

- One program per PMT
- Max 400 ms between PMT's
- Max 100 ms between PAT's
- Alignment of Video Access Units in PES Packets
- No Adaptation Headers allowed in PAT and PMT Packets unless version number is discontinuous

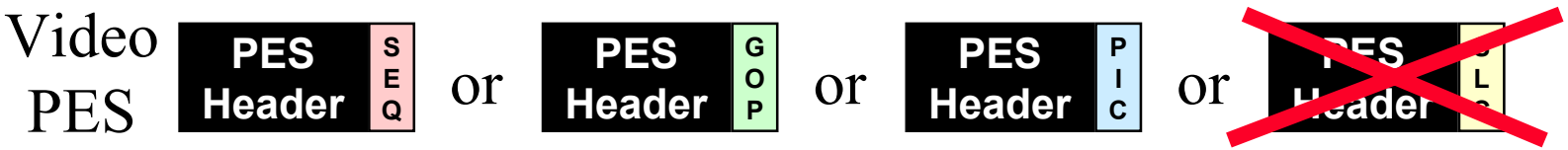
ATSC PES Constraints

- PES Payload must not be scrambled
- PES Header must not contain:
  - Clock or Rate Info for Elementary Stream
  - CRC or Private Data
  - MPEG-1 System Fields
  - Program System Target Decoder Fields
- Video PES Packets
  - must start with a SEQ, GOP or PICTURE header
  - must contain only one coded picture
  - must carry PTS and DTS (if applicable)

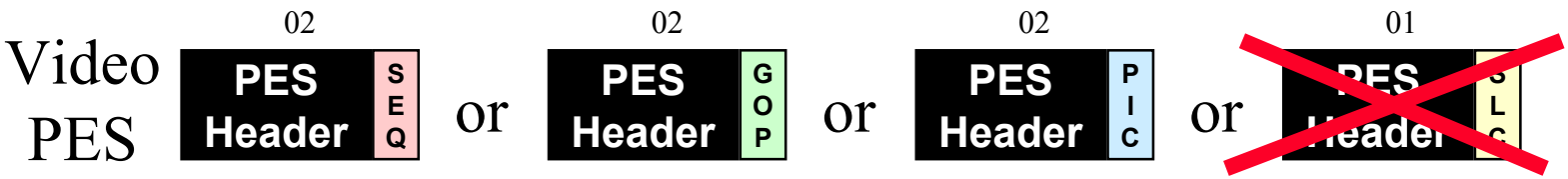
ATSC Video Data Alignment

ATSC Constraint #1: Each PES packet payload shall start with a video access unit (e.g., SEQ, GOP or PIC header).

`data_alignment_indicator = 1` in PES Header. If `data_stream_alignment_descriptor` is not present, then one of the following data alignments is required:

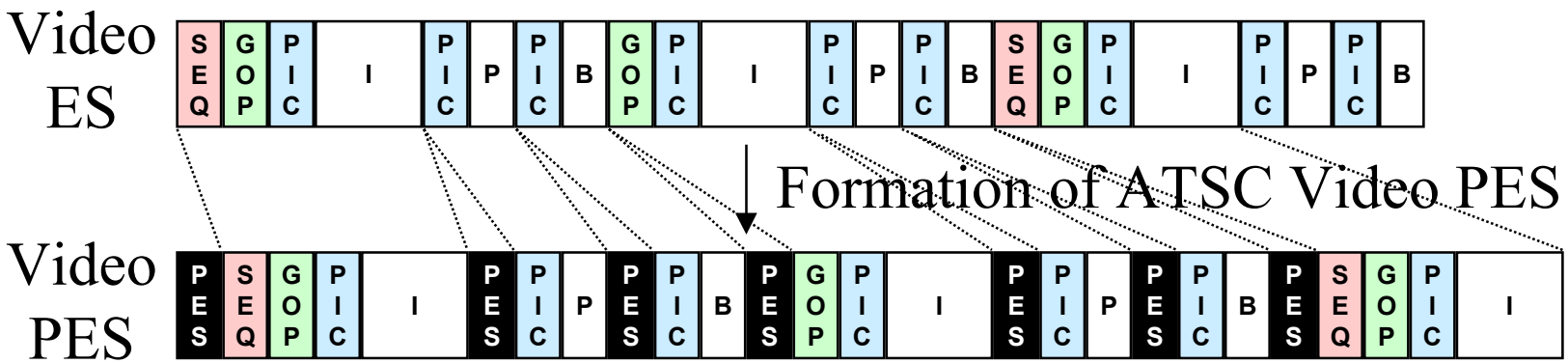


`data_alignment_indicator = 1` in PES Header. If `data_stream_alignment_descriptor` is present, it should equal 02, and one of the specified data alignments is required:



ATSC Video PES Payload

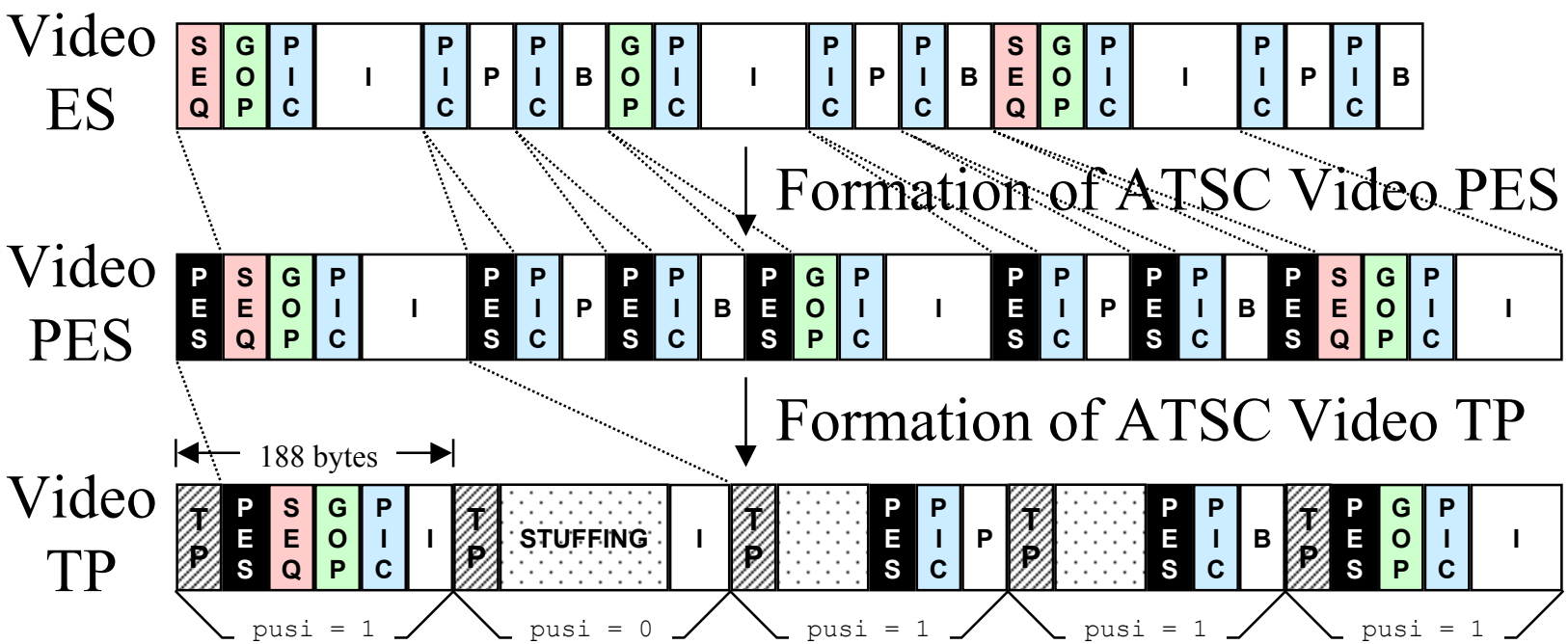
ATSC Constraint #2: Each PES packet payload shall not contain more than one coded frame.



ATSC Video Transport Packets

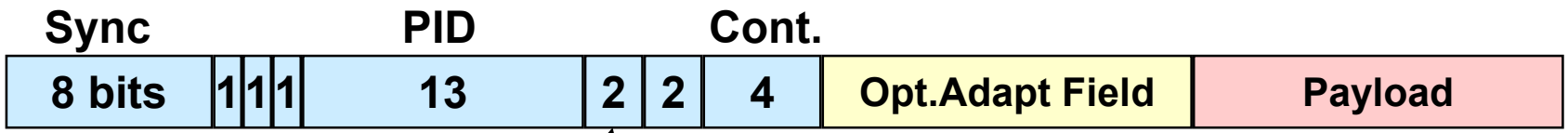
MPEG-2 Rules:

1) If `payload_unit_start_indicator = 1` in Transport Header, then payload starts with the first byte of a PES header, and one and only one PES packet starts in this Transport Packet.
2) If `payload_unit_start_indicator = 0` in Transport Header, then no PES packet shall start in this Transport Packet.



ATSC Transport Extensions

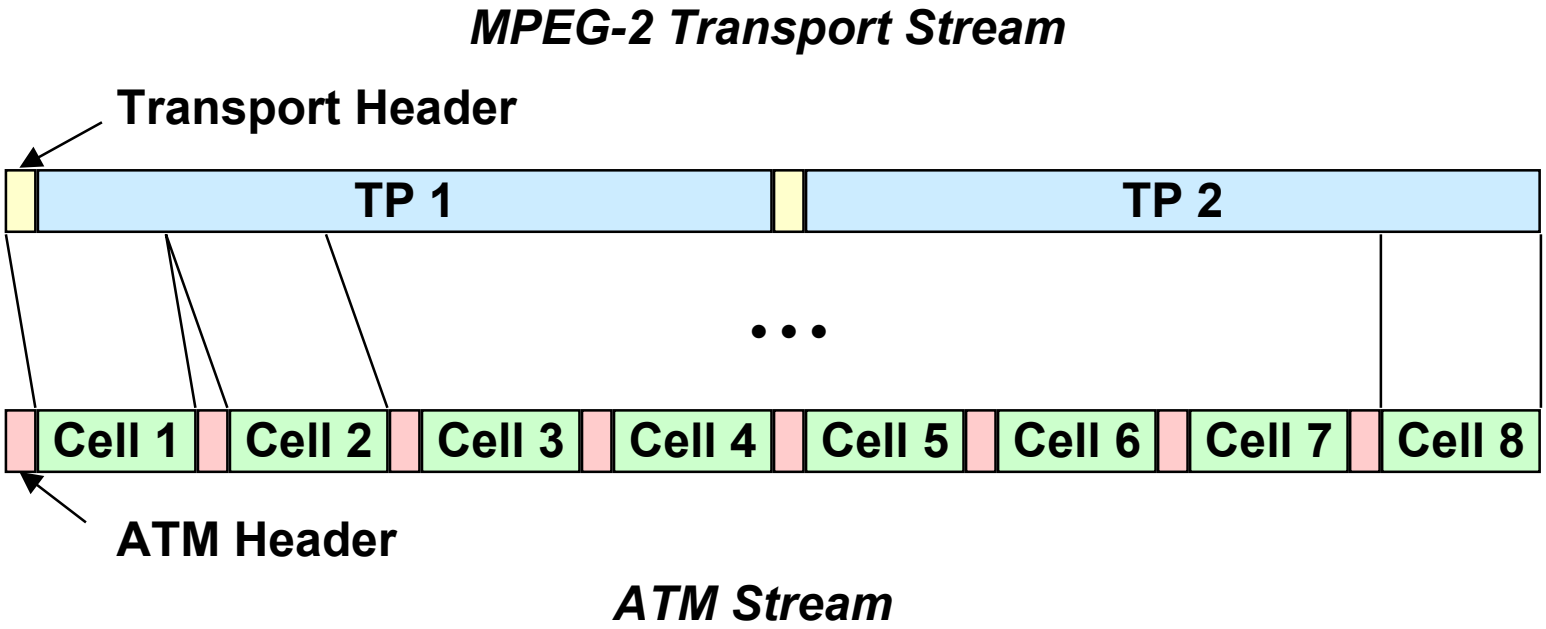
- The 2-bit Scrambling Control Field of the Transport Header is defined as follows:



Transport Header (shown shaded)

transport_ scrambling_ control	Function
00	Packet Payload not scrambled
01	Not scrambled (flag for private use)
10	Scrambled with “even” key
11	Scrambled with “odd” key

Interoperability with ATM



- ATM = *Asynchronous Transfer Mode*, a telecommunications protocol using short, fixed-length packets.
- There are several possible mappings between MPEG-2 Transport and ATM. One example is shown above.

So what does this all mean?

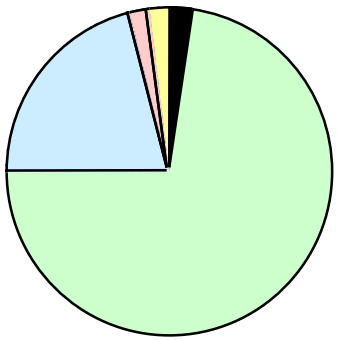
With packetized transmission, broadcasters will be able to:

- Alter service mix dynamically throughout programming day.
- Trade off quality among programs, or between program components (e.g., audio vs. video).
- Authorize pay-per-view and subscription services remotely.
- Add new services without losing existing subscriber base
- Possible new services:
  - 3-D TV
  - Video games
  - Alternate views in picture-in-picture
  - Stock quotes
  - Advertising brochures and catalogs

A Possible Broadcast Day

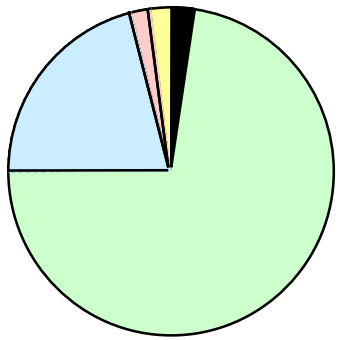
...matching the service profile to the viewer's needs...

6:00 am to 9:00 am



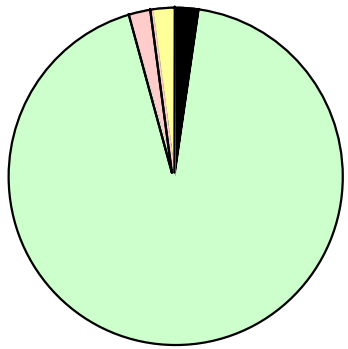
HDTV Morning news with Business news in standard resolution

9:00 am to 3:00 pm



Daytime HDTV with specialized programming to Schools and Business

3:00 pm to 1:00 am



Prime Time HDTV Lineup

References

- *Digital Television Standard for HDTV Transmission*, U.S. Advanced Television Systems Committee, Doc. A/53, April 12, 1995.
- *Switching Facilities in MPEG-2: Necessary But Not Sufficient*, S. Merrill Weiss, SMPTE Conference Proceedings, San Francisco, CA, Feb. 1995.
- "Specifications for Service Information in Digital Video Broadcasting Systems", ETSI Draft prETS 300 468, November 1994.
- *ISO/IEC 13818 Parts 1,2, and 3 – "Information Technology: Generic Coding of Moving Pictures and Associated Audio"*
- *ISO/IEC 11172 Parts 1,2, and 3 – "Coding of Moving Pictures and Associated Audio for Digital Storage Media at up to About 1.5 Mbit/s"*