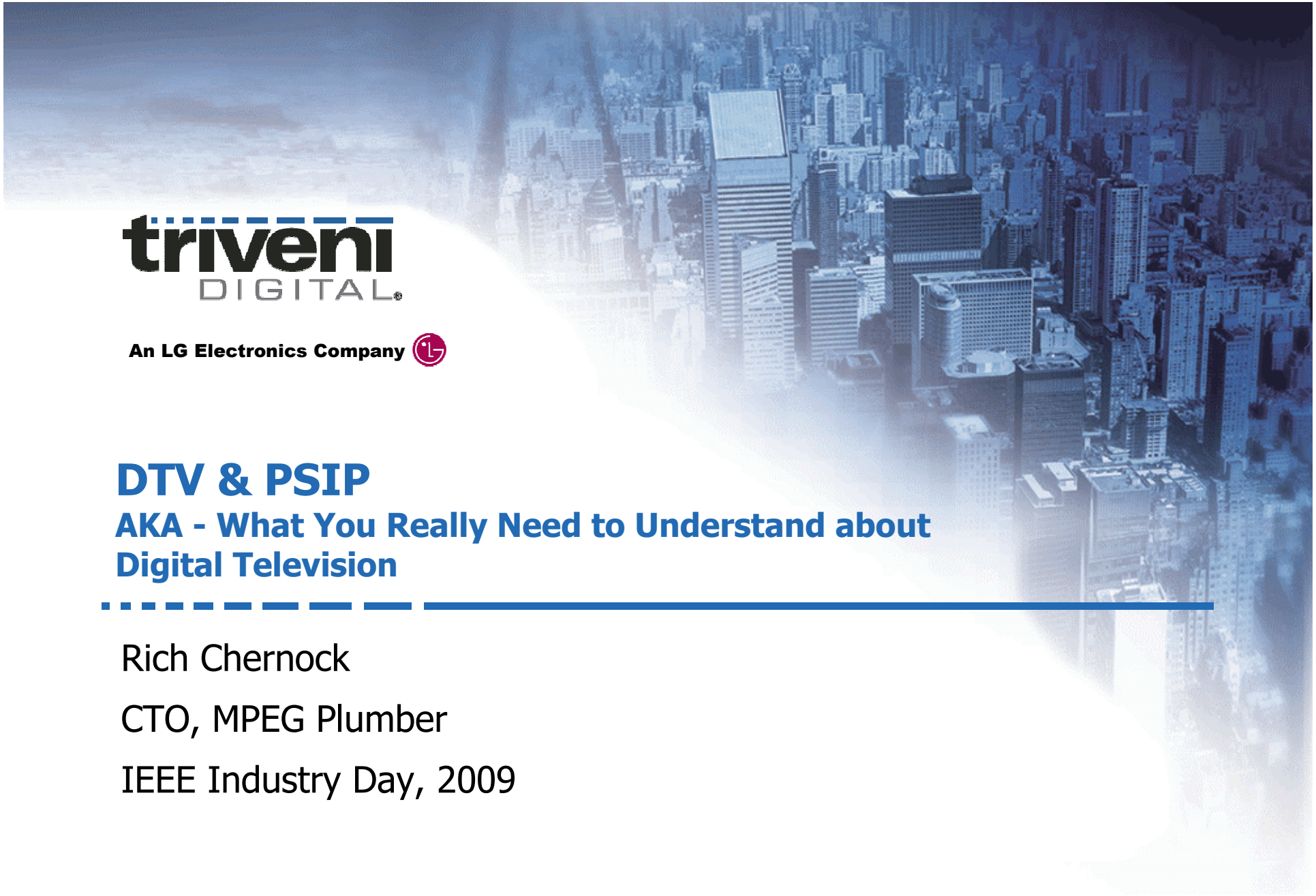


triveni DIGITAL

An LG Electronics Company

DTV & PSIP

AKA - What You Really Need to Understand about Digital Television

Rich Chernock

CTO, MPEG Plumber

IEEE Industry Day, 2009

Outline of Presentation

- **DTV Overview**
- MPEG2 Basics
- PSIP
- IP
- Mobile
- Summary

Environment

The Old Days: Television involves wiggling voltages in the right way at the right times so the receiver can recreate the pictures

The New Paradigm: Television involves transmitting database information and parameters to allow the pictures to be calculated.

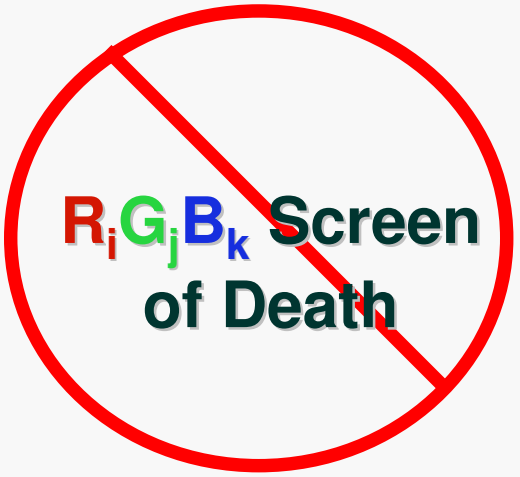
Observations:

A TV is not expected to behave like a computer

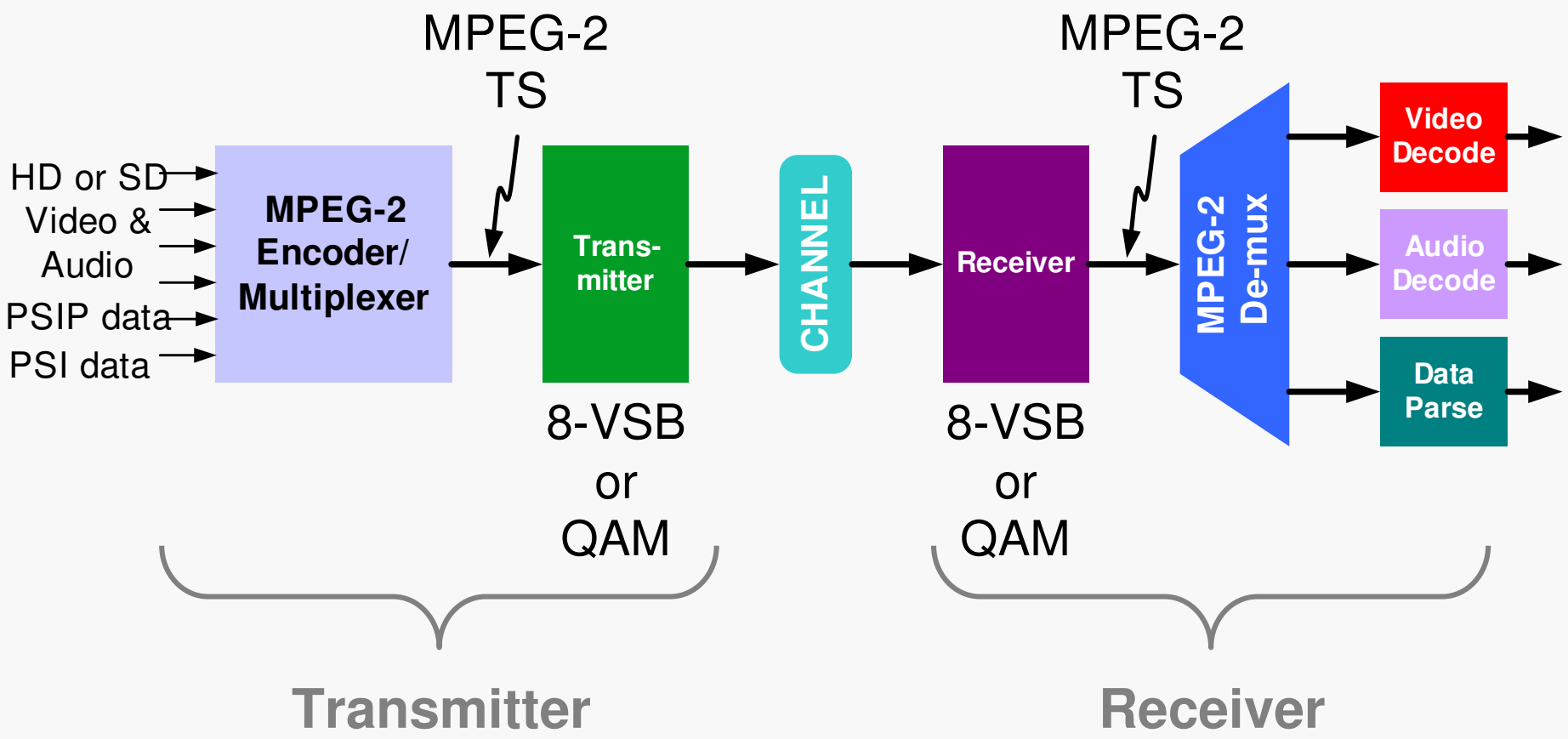
Going black is NOT an option

Viewers should not need training to watch DTV

Going digital offers new revenue opportunities to broadcasters



System Block Diagram

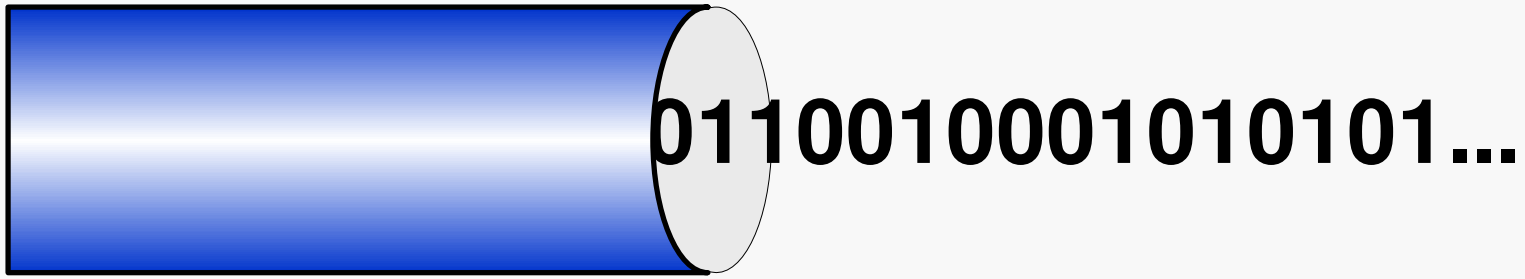


DTV = VIDEO + AUDIO + DATA + Metdata

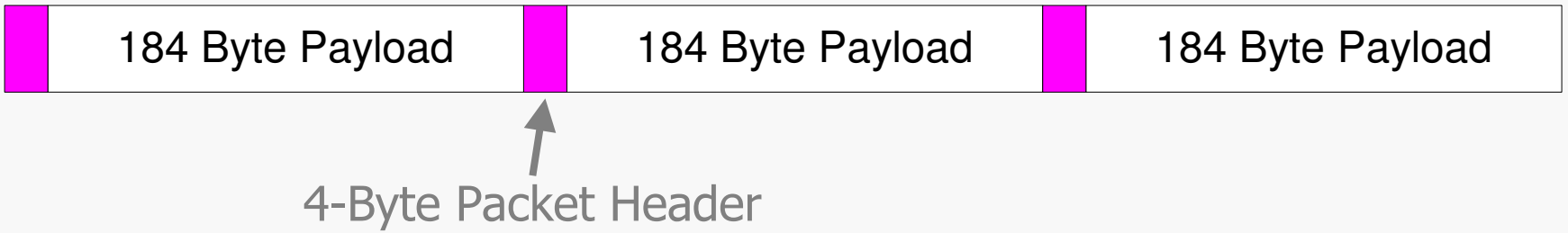
MPEG-2 Transport Streams carrying multiplexed:

- **Service Information (ATSC PSIP + MPEG-2 PSI)**
- **Audio, video and *data elementary streams***

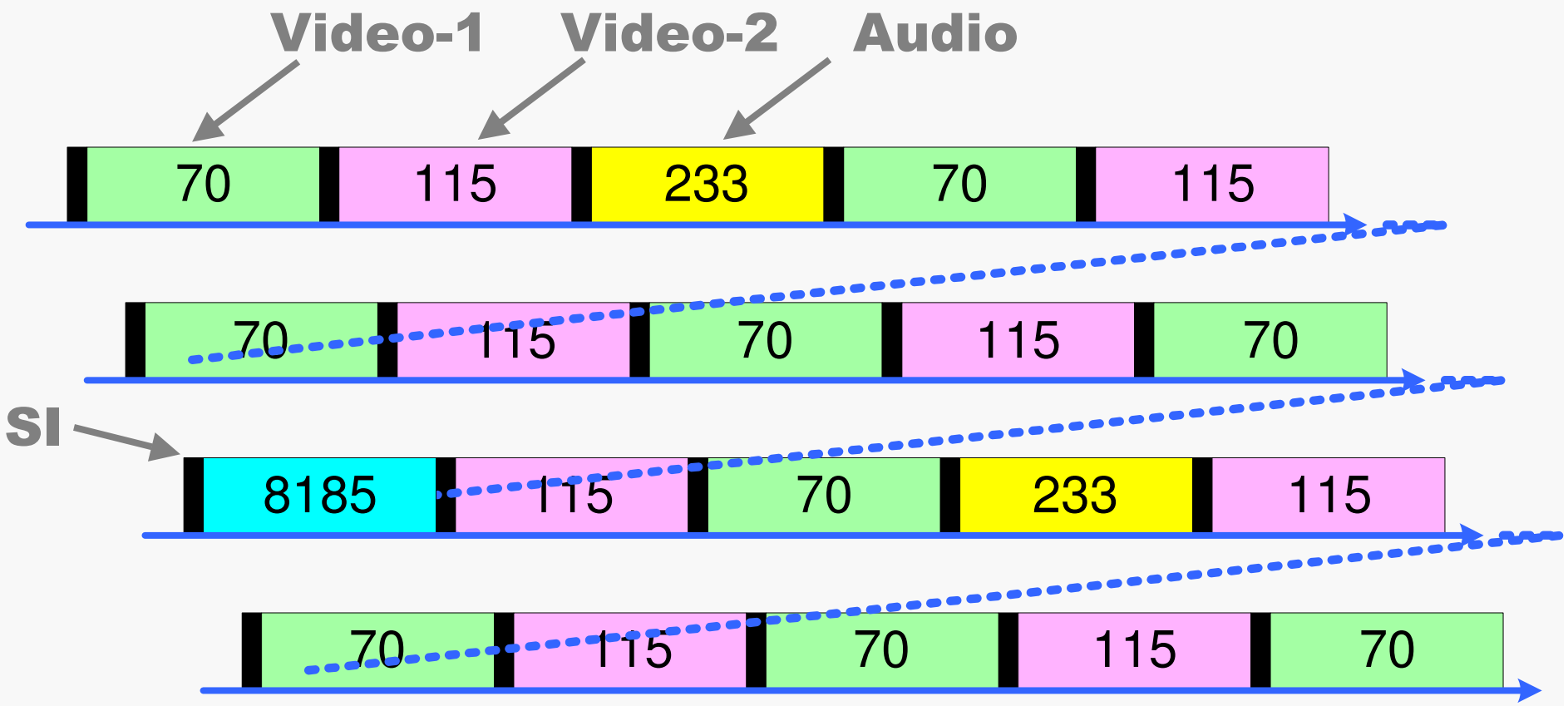
The Digital Pipe

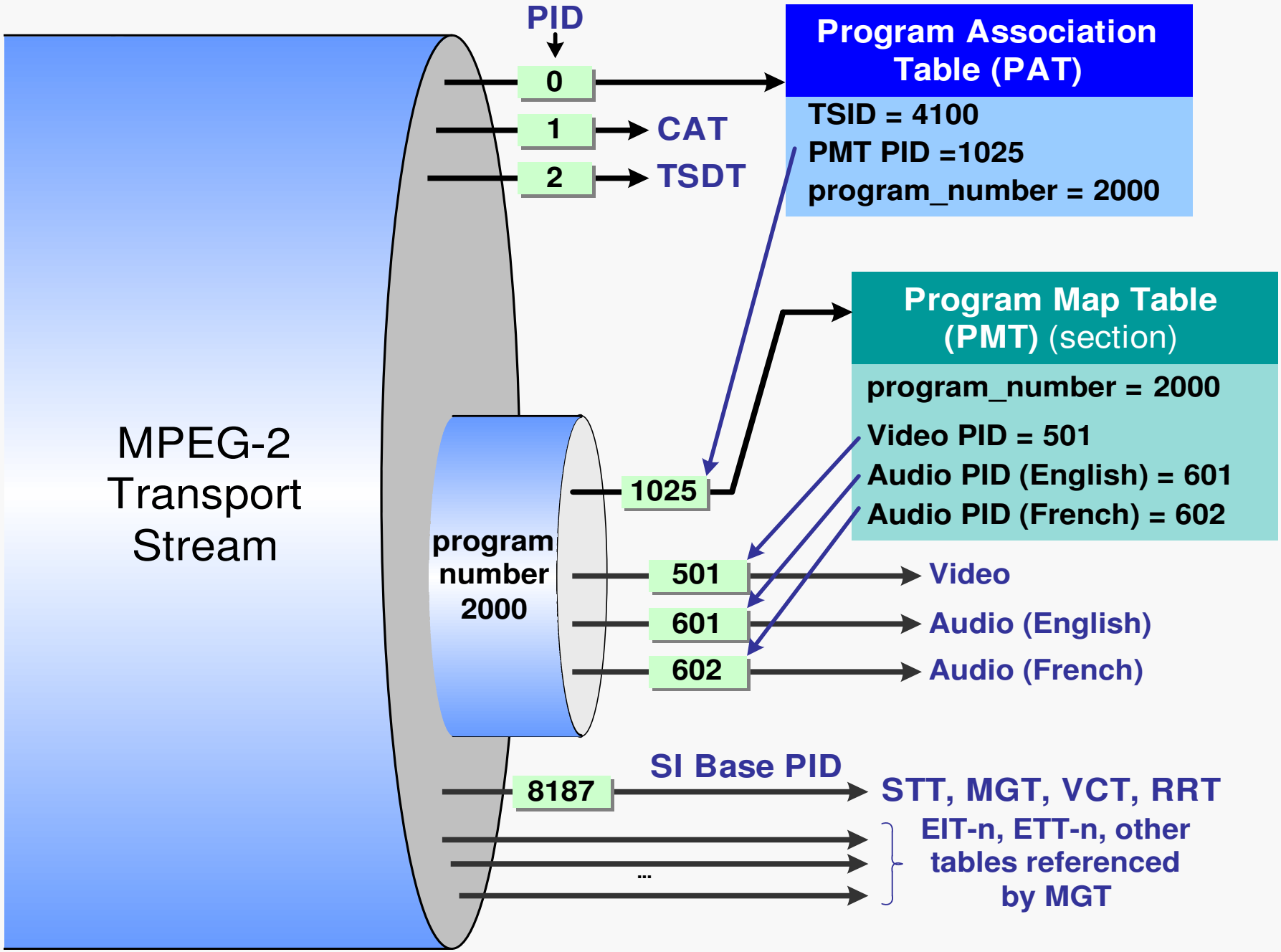


- MPEG-2 Transport Stream

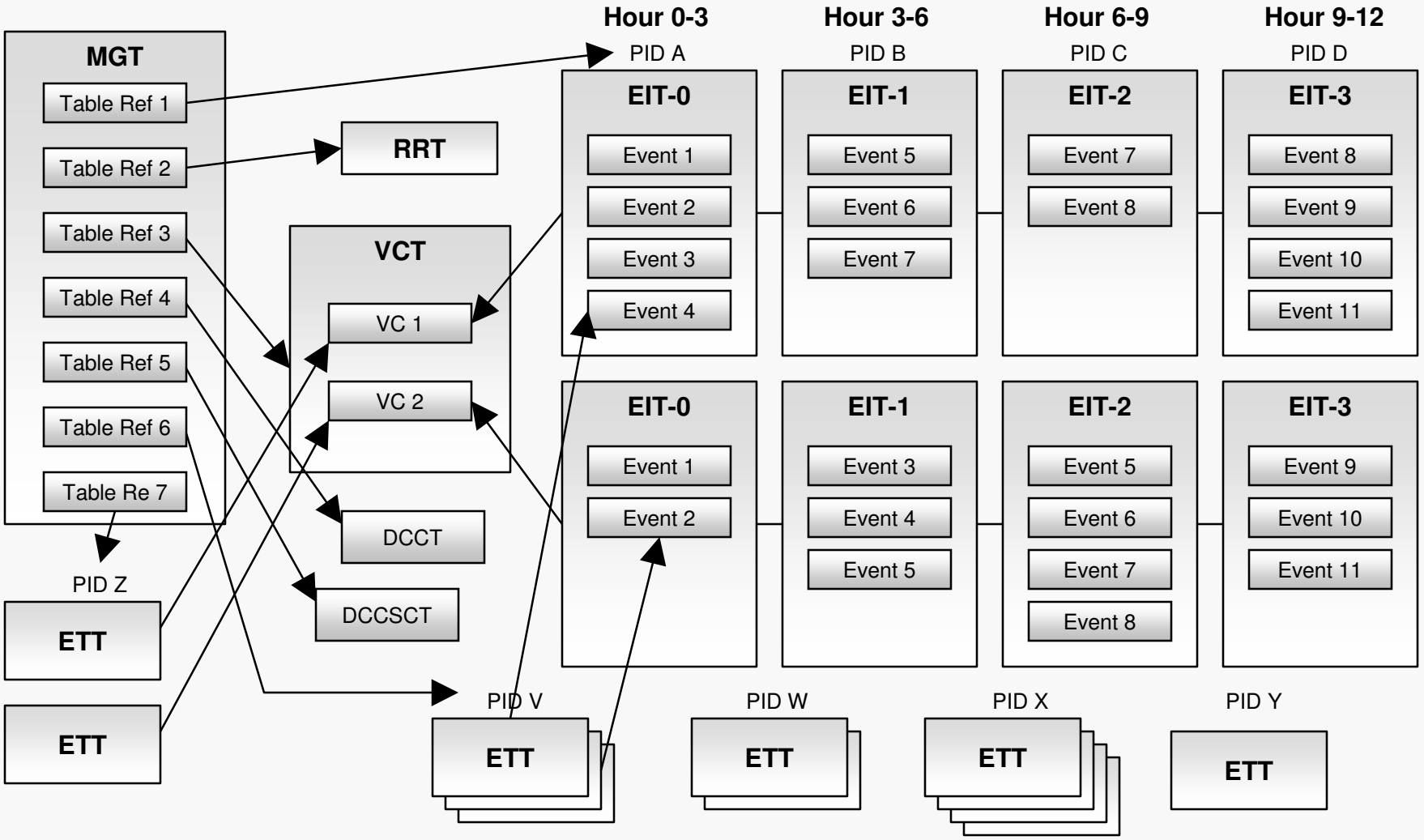


MPEG-2 Transport Stream

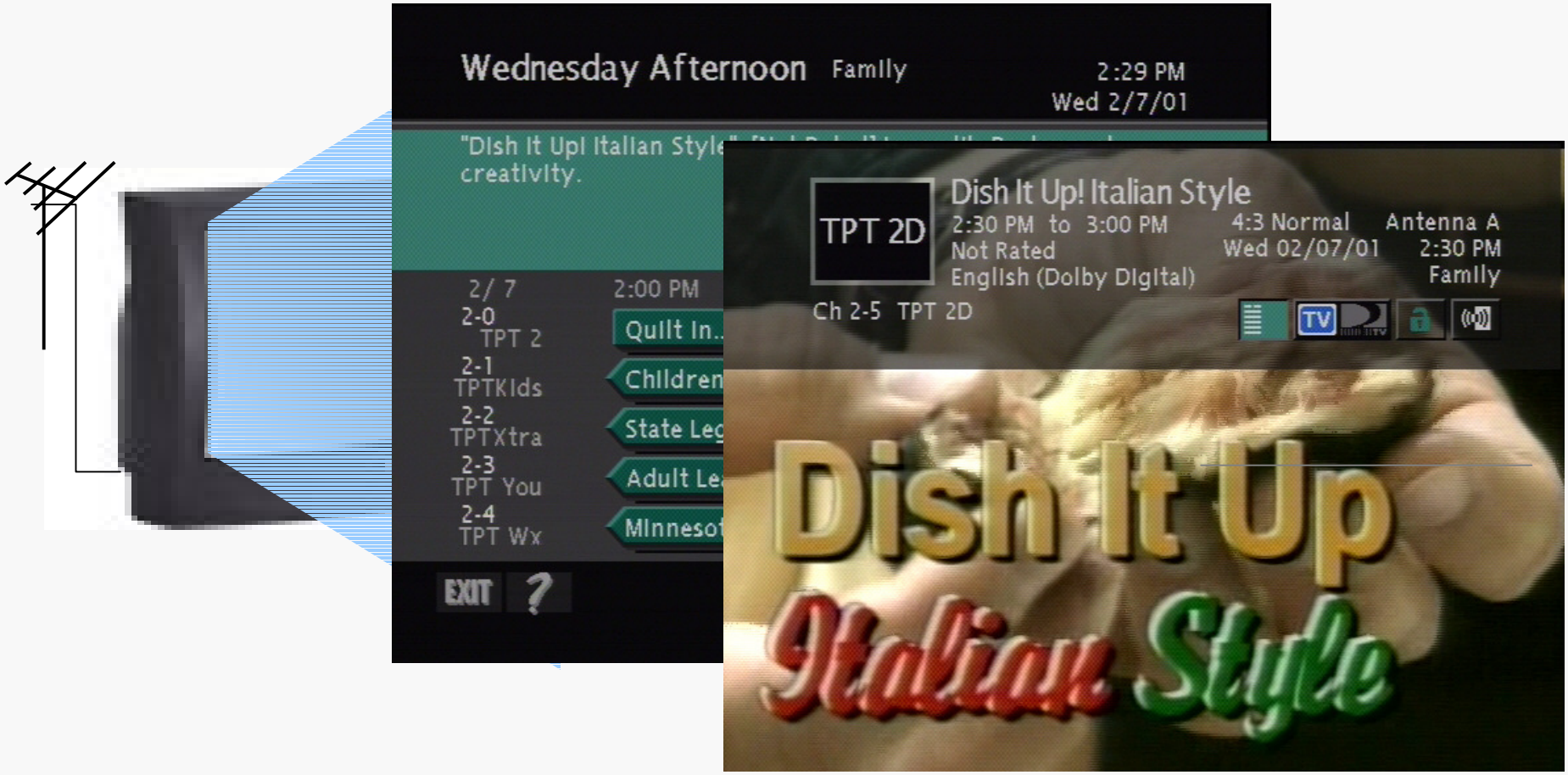



PID
0
1
2
CAT
TSDT
Program Association Table (PAT)
TSID = 4100
PMT PID =1025
program_number = 2000
Program Map Table (PMT) (section)
program_number = 2000
Video PID = 501
Audio PID (English) = 601
Audio PID (French) = 602
MPEG-2 Transport Stream
1025
program number 2000
501
601
602
Video
Audio (English)
Audio (French)
SI Base PID
8187
STT, MGT, VCT, RRT
EIT-n, ETT-n, other tables referenced by MGT
...

PSIP Tables: The Big Picture



End Result - Television



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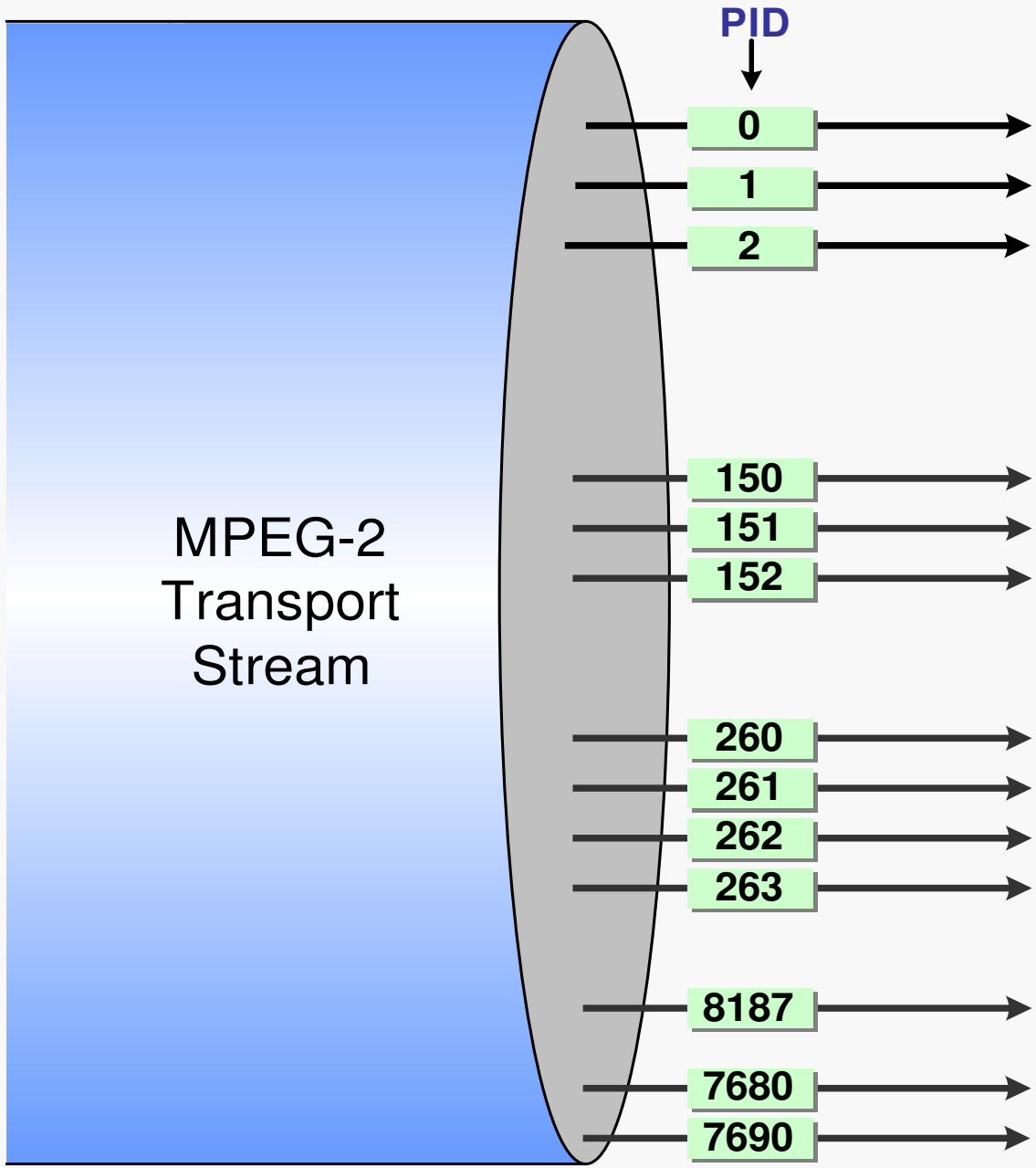
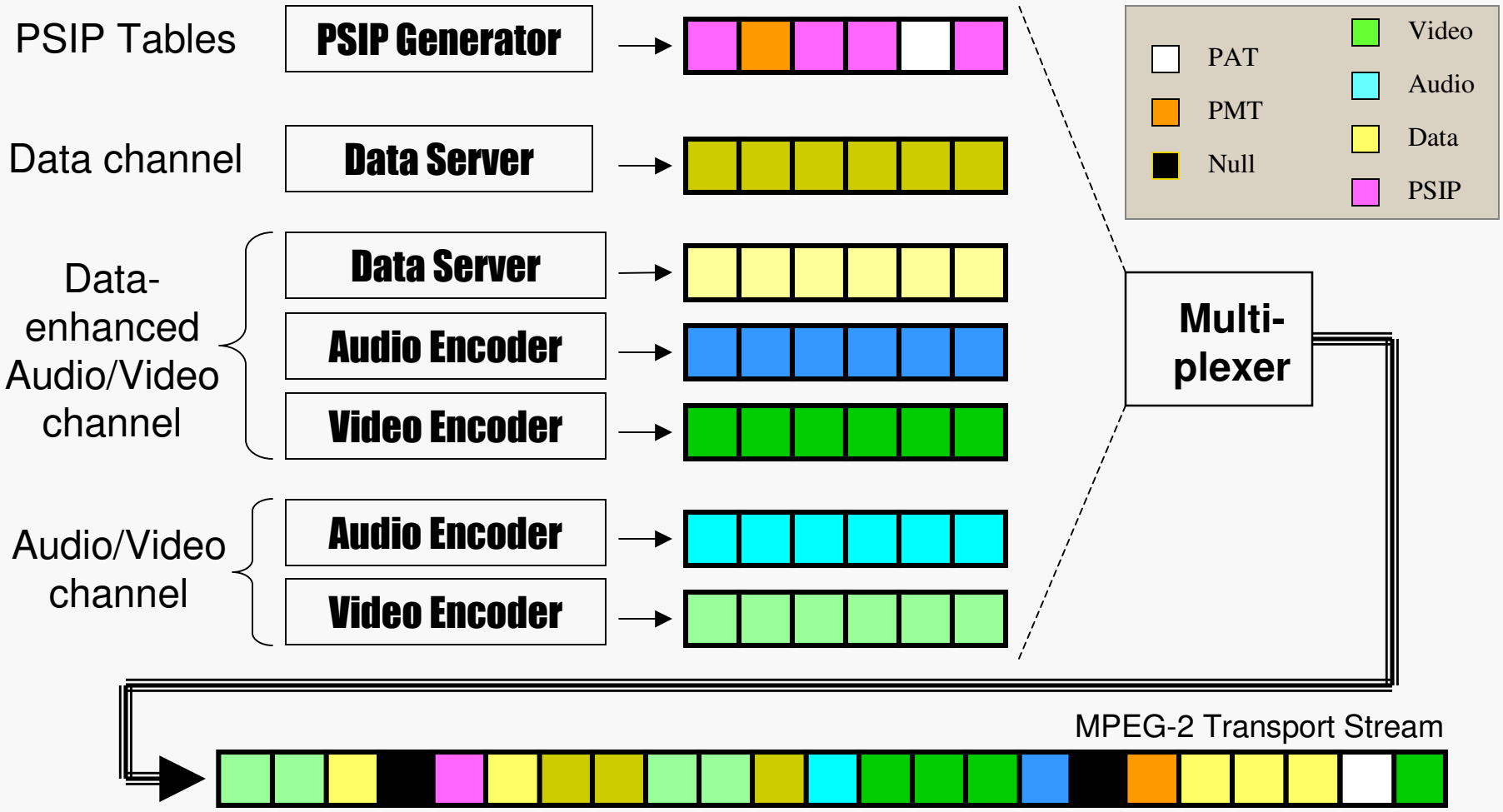

PID
0
1
2
150
151
152
260
261
262
263
8187
7680
7690
MPEG-2
Transport
Stream

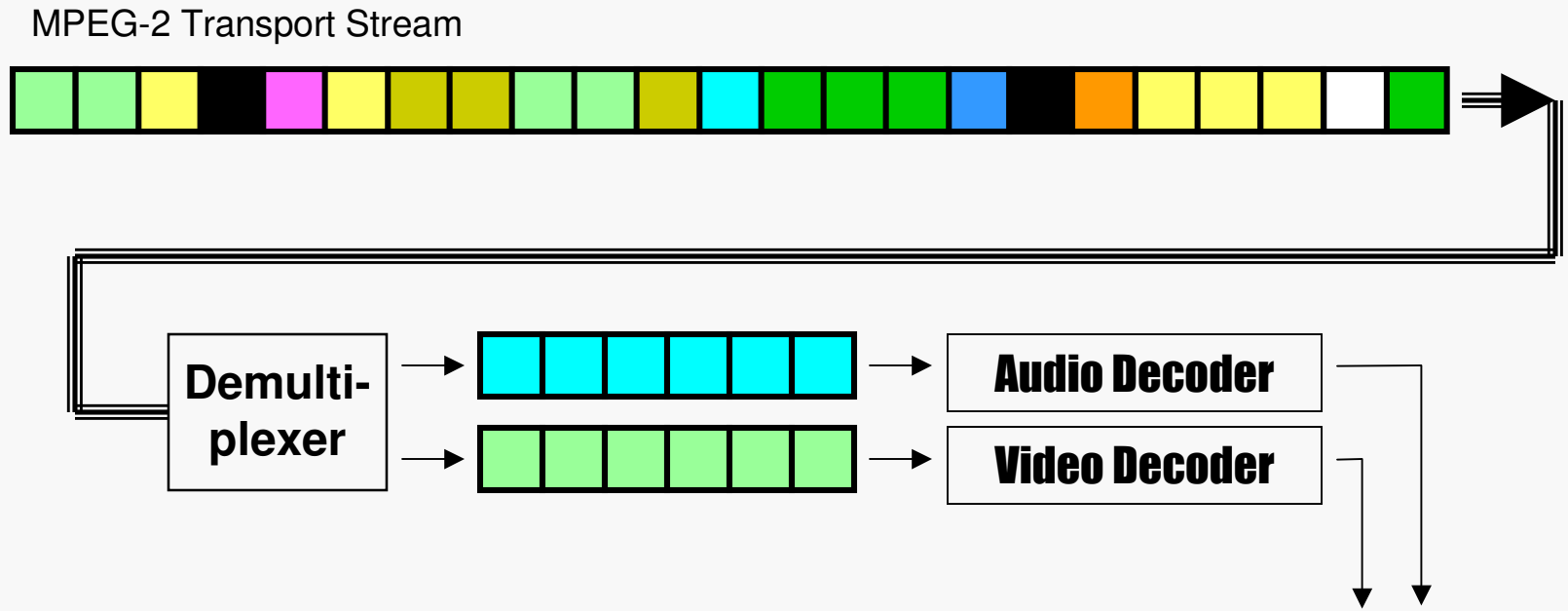
MPEG-2 Transport Stream

- Made up of 188-byte ***transport packets***, each with 4 byte header & 184 byte payload
- Conveys multiple interleaved ***elementary streams*** -- audio, video, data, PSI, ...
- Elementary stream to which each packet belongs is identified by ***packet id*** (PID) in packet header.

ATSC Bitstream Structure



Transport Stream Decoding



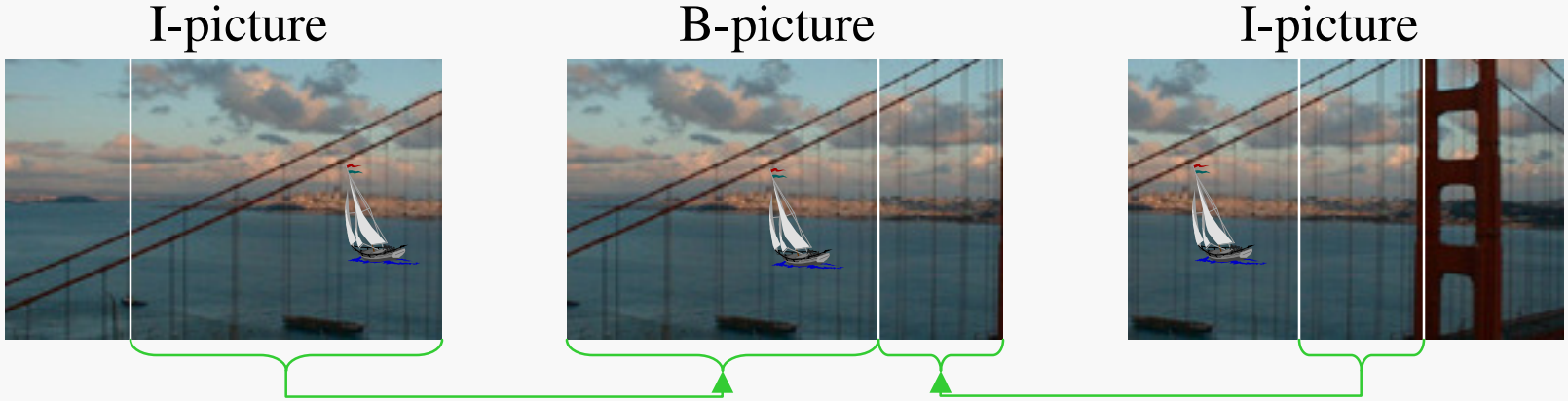
- PSIP tables give mapping from virtual channel number to the correct PIDS.
- MPEG-2 PAT and PMT tables also give mapping, but in less useful form.

MPEG-2 Video Encoding (1)

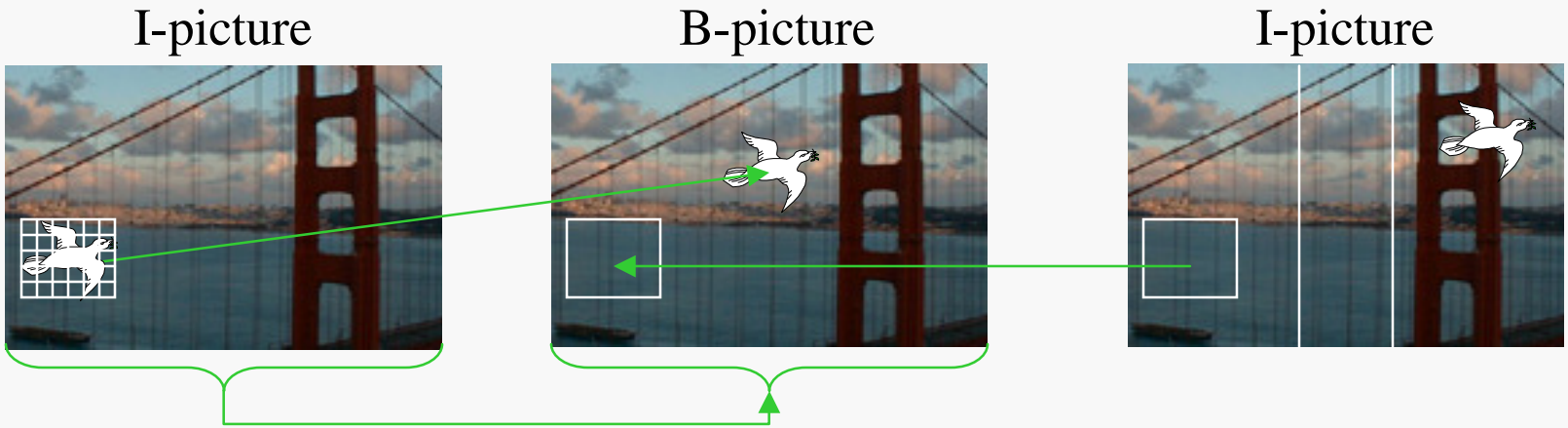
- Video is sequence of ***frames.***
- Each frame is encoded in one of three ways:
  - ***I-picture: intra-picture*** encoding, similar to jpeg encoding (exploiting spatial redundancy).
  - ***P-picture***: ***predictive*** encoding, using motion adjusted deltas from a previous reference frame (exploiting temporal redundancy).
  - ***B-picture***: ***bi-directional*** encoding, using motion adjusted deltas from a previous and a future frame (exploiting temporal redundancy).

MPEG-2 Video Encoding (2)

Example 1. Panning Camera



Example 2. Moving Object



MPEG-2 Video Encoding (3)

- Encoder emits sequence of encoded frames.
- Sizes of encoded frames vary.
- Encoded frames are packed into ***packetized elementary stream*** (PES) packets.
- PES packets are packed into MPEG-2 transport packets. (All packets for single video stream have same PID value.)
- Overall compression ratio is 50:1 or more.

AC-3 Audio Encoding

- ATSC uses AC-3 audio encoding, with up to 6 audio channels: left, right, center, left surround, right surround, low frequency enhancement.
  - The full set is often called 5.1 audio.
- The sampling rate is always 48 kHz.
- The encoded bit rate may be up to 448 kbps.
- Audio ***frames,*** each 32 milliseconds in length, are encoded.
- Encoded frame size depends only on bitrate.
- Encoded frames are packed into ***packetized elementary stream*** (PES) packets.
- PES packets are packed into MPEG-2 transport packets. (All packets for single audio stream have same PID value.)

MPEG-2 as a clocked multiplex

- delivery is based on a constant delay model
- decoder system clock is carried in the stream
- decoder resource management is based on STC
- decoder synchronization is based on STC

Audio-Video Synchronization

- Audio, video are encoded independently, must be synchronized during play.
- Program Clock Reference (PCR) values appear at intervals in ***adaptation headers*** of video transport packets to set time base.
- PES packet headers give Presentation Time Stamp (PTS) values for each video frame and each audio frame (relative to PCR).
- Bad PTS values result in ***lip sync*** problem.

Audio and Video Buffers

- Receiver must buffer audio and video frame data until presentation time.
- If data appears too late in the transport stream, buffer underflow results.
- If data appears too early in the transport stream, buffer overflow results.
- Either condition results in garbled play or incorrect synchronization.

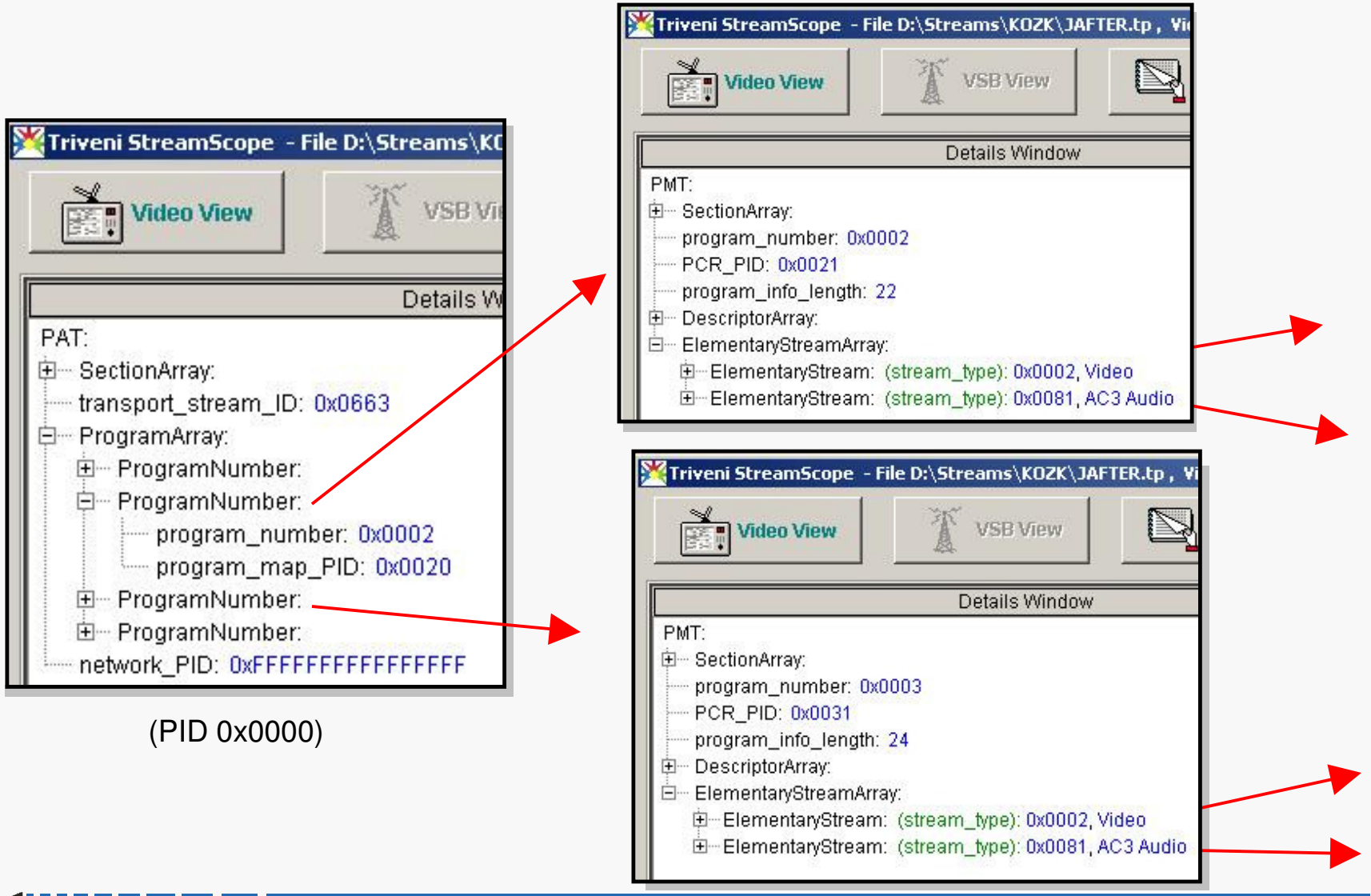
Signaling vs Announcement

- Signaling
  - Information about what is "on now"
  - Used to assemble program elements into whole
    - Provides linkages
    - Ex: PMT and/or VCT used to link different components of television program (I.e. video and audio)
  - Used to define characteristics of current program
    - Captioning, ratings, redistribution…
- Announcement
  - Information about what will be available in the future
  - Program Guide information (name, description schedule)
  - Characteristics of future programs (captioning, ratings, redistribution…)
  - Typically does not provide linkages between program elements

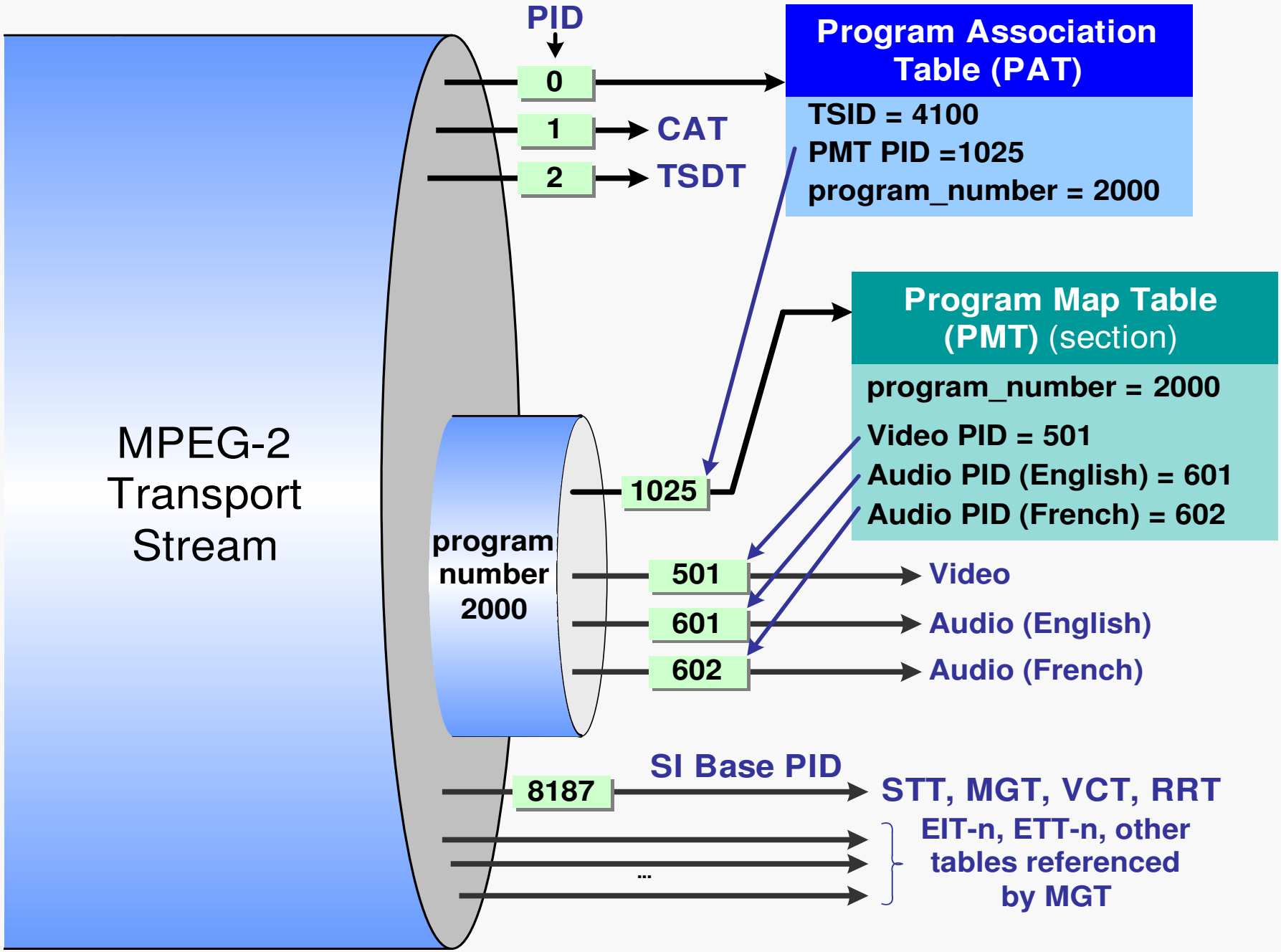
MPEG-2 Program Specific Information (PSI)

- Gives very basic tuning information:
  - PAT (Program Association Table: one for entire transport stream; identifies “programs” (virtual channels) in stream and gives PIDs for PMTs.
  - PMT (Program Map Table): one per “program”; identifies elementary streams in “program” and gives their types (audio, video, etc.) and PIDs.
- Supports tuning by physical channel number and MPEG-2 program number.

Graphical View of PAT/PMT



(PID 0x0000)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STT, MGT, VCT, RRT
EIT-n, ETT-n, other tables referenced by MGT
...

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PSIP Background

- Program and System Information Protocol
- Metadata inserted into broadcast stream
- Enables:
  - Tuning to virtual channels
  - Displaying channel name (on channel changes)
  - Interactive electronic program guides (EPGs)
  - Automatic language selection for audio track
  - Caption decoding
  - "V-Chip" function (parental content blocking)
  - Accurate receiver time-of-day clock setting
  - Redistribution Control

PSIP from the User's Viewpoint

- "Where am I?"
  - Channel number, channel name
- "Where am I going?"
  - Channels organized by major/minor groups
  - Enables EPG in the receiver/STB
    - What's on now?
    - What programs do I want to plan to watch?
- "How can I get where I want to go?"
  - Direct entry of channel number
  - Navigation on the EPG grid

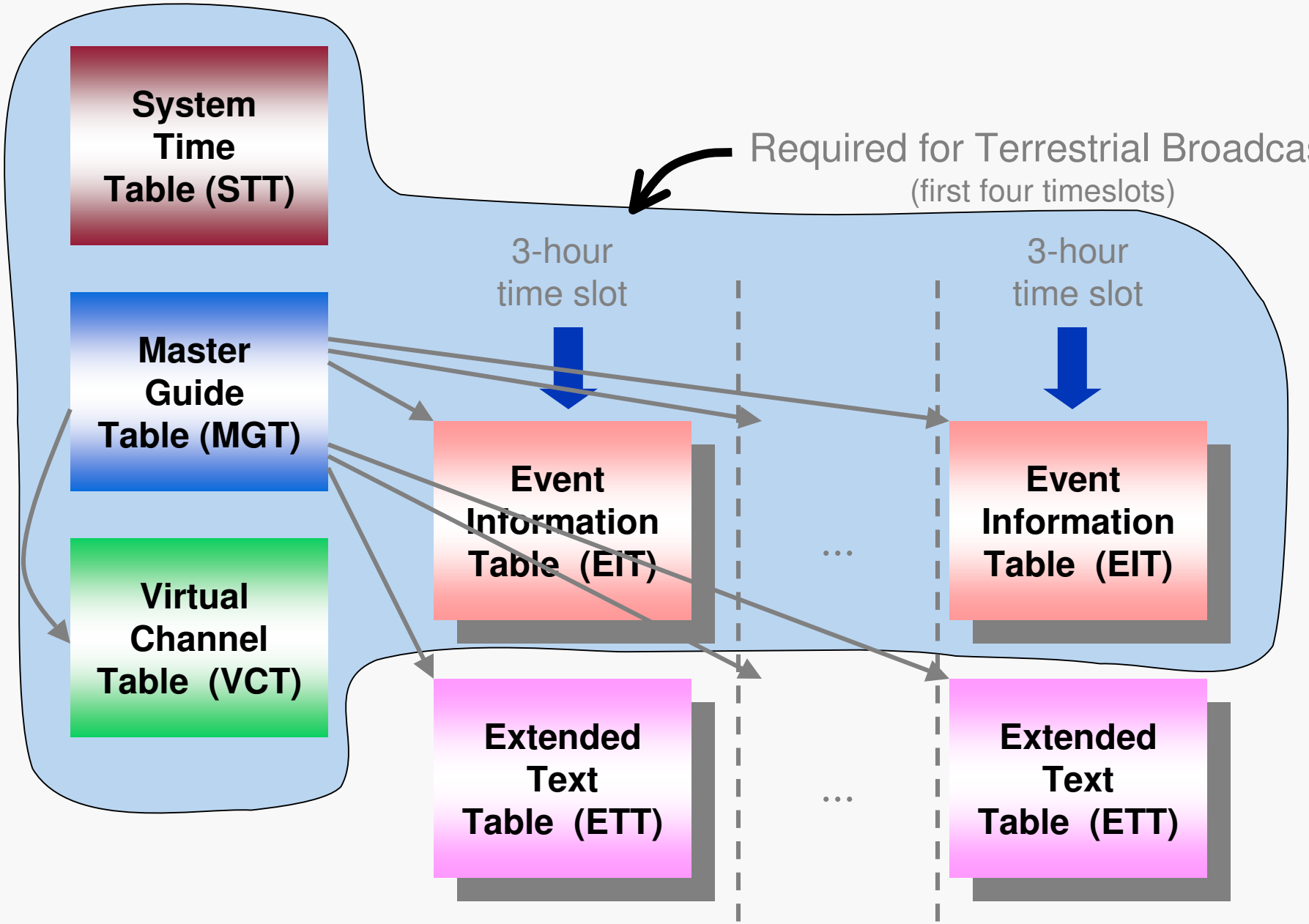
Virtual Channel Concept

- Breaks the link between RF channel number and user's notion of channel number
  - Analog broadcast → "channel number" was the same as the RF carrier designation
  - Digital broadcast → "channel number" is defined by Virtual Channel Table (VCT)
- One digital TS can include multiple channels of programming
- 8-VSB carrier freq. may shift during transitions

ATSC PSIP Tables

- Master Guide Table (MGT)
  - Directory of all PSIP tables (signaling)
- System Time Table (STT)
  - What time is it? (signaling)
- Virtual Channel Table (VCT)
  - List of the virtual channels in the transport (signaling)
- Rating Region Table (RRT)
  - Ratings definitions for the region (signaling)
- Event Information Table (EIT)
  - Event scheduling (announcement - used for EPG)
- Extended Text Table (ETT)
  - Event descriptions (announcement – used for EPG)
- Directed Channel Change Table (DCCT)
- DCC Selection Code Table (DCCSDT)

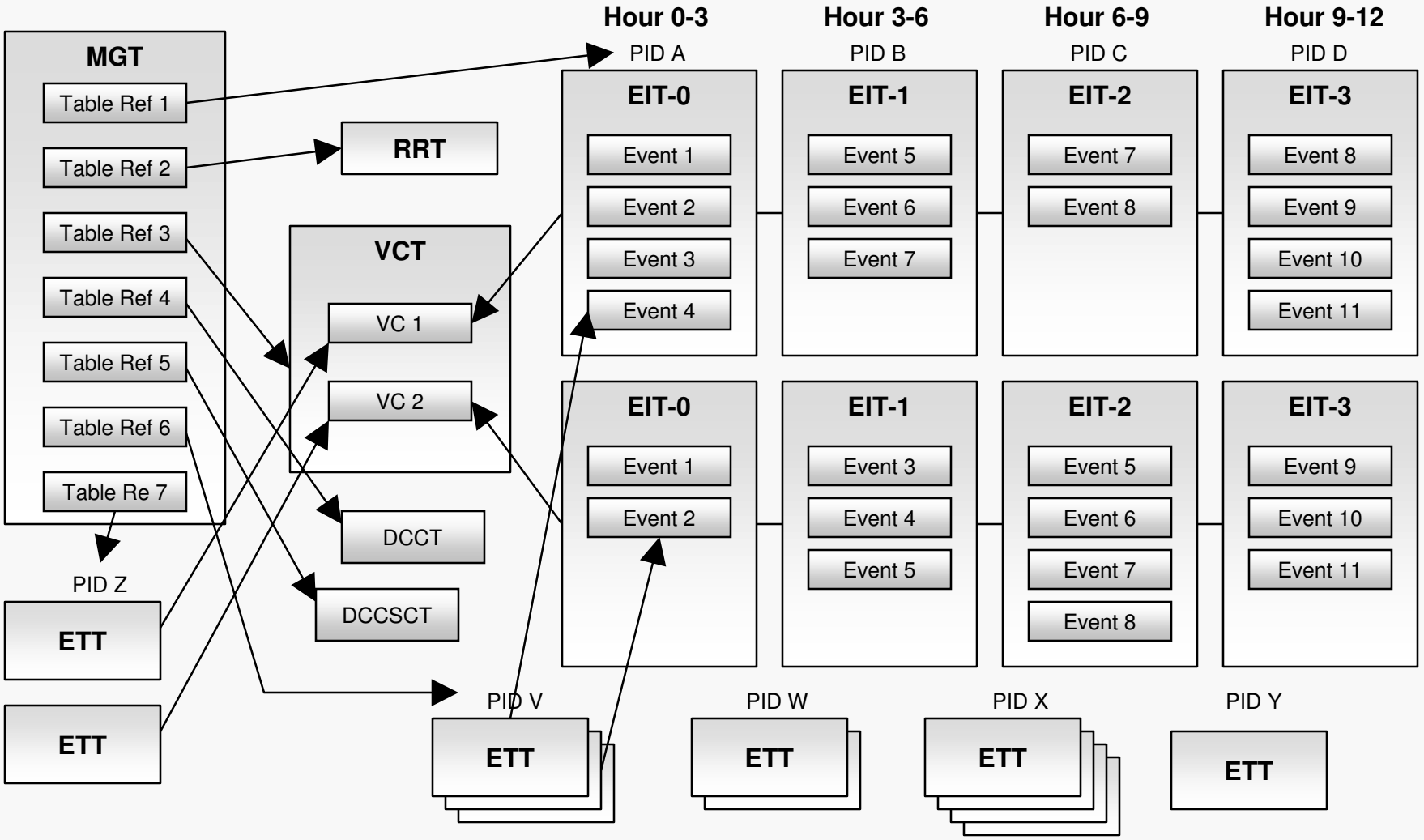
Main PSIP Tables

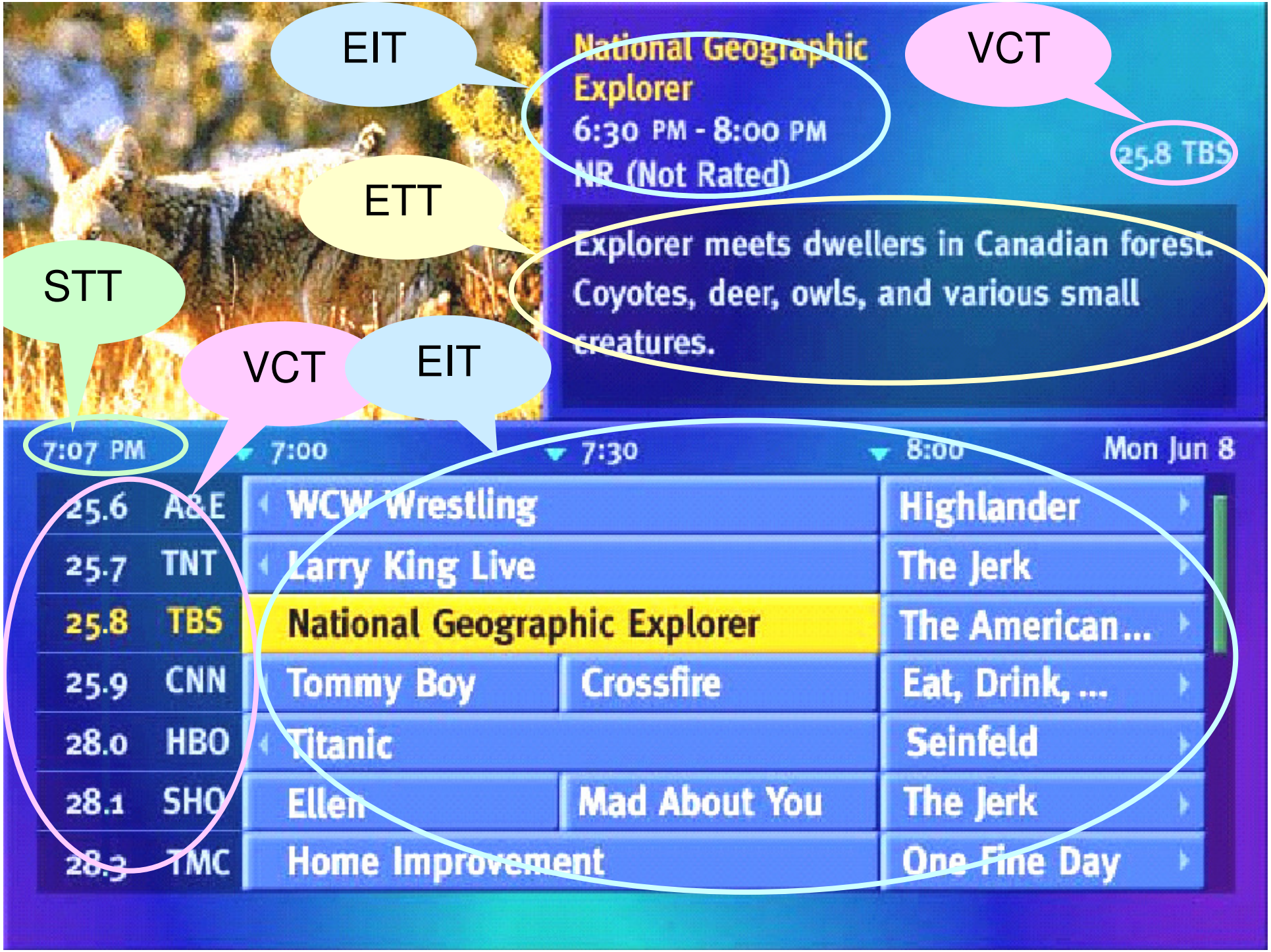


PSIP Descriptors

- Descriptors are tag-length-data structures
- Descriptor tag must be a registered value
- Some ATSC-defined descriptors include:
  - Content Advisory
  - Redistribution Control
  - ATSC Private Info
  - Service Location
  - Component Name
  - Caption Service
  - Audio Stream (AC-3)
  - Extended Channel Name
  - ATSC Conditional Access

PSIP Tables: The Big Picture




EIT
National Geographic Explorer
6:30 PM - 8:00 PM
NR (Not Rated)
VCT
25.8 TBS
ETT
Explorer meets dwellers in Canadian forest. Coyotes, deer, owls, and various small creatures.
STT
VCT
EIT
7:07 PM
7:00
7:30
8:00
Mon Jun 8
25.6 A&E
WCW Wrestling
Highlander
25.7 TNT
Larry King Live
The Jerk
25.8 TBS
National Geographic Explorer
The American...
25.9 CNN
Tommy Boy
Crossfire
Eat, Drink, ...
28.0 HBO
Titanic
Seinfeld
28.1 SHO
Ellen
Mad About You
The Jerk
28.3 TMC
Home Improvement
One Fine Day

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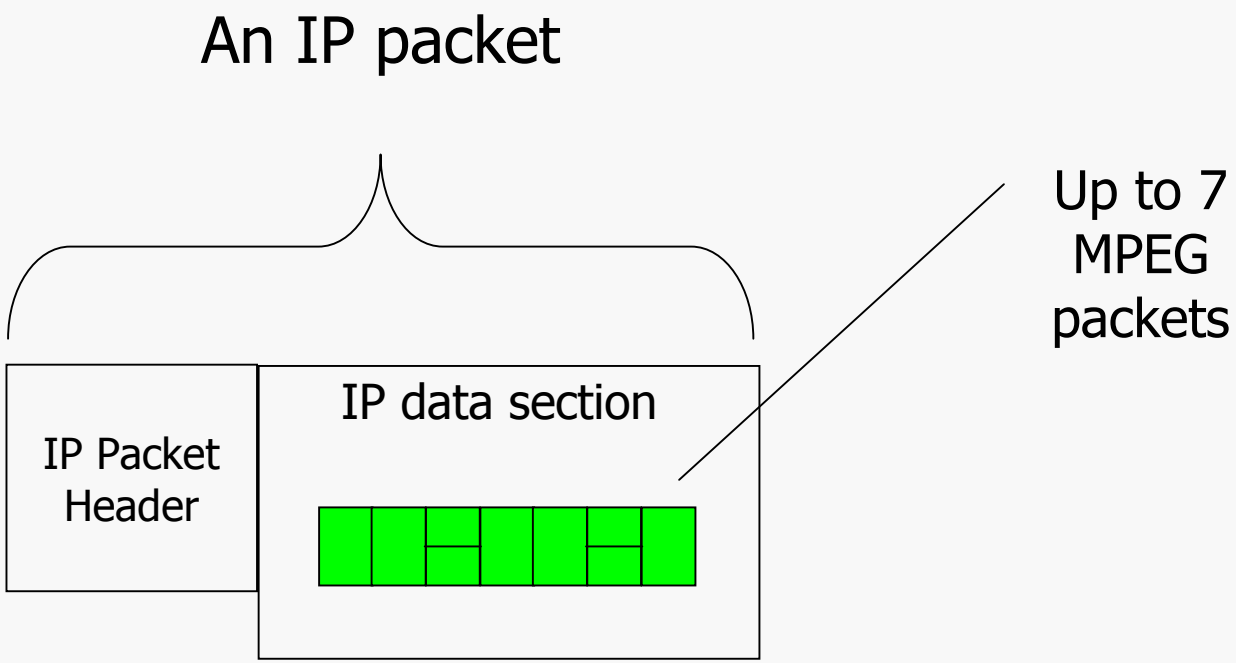
What about IP??

- IP based connectivity spreading widely through Cable and Telco (IPTV) infrastructures
  - Inexpensive
  - Very high bandwidth capability
    - 1Gb/s → 10Gb/s → 40Gb/s
  - Not especially well suited for carrying video
    - Low cost rules!
- Little use so far in broadcast plants
  - BUT
    - Low cost & availability may change this picture
    - IP based technologies spreading into broadcast TV
      - NRT
      - Mobile/Handheld

IP carriage of MPEG packets



A/V carriage over RTP

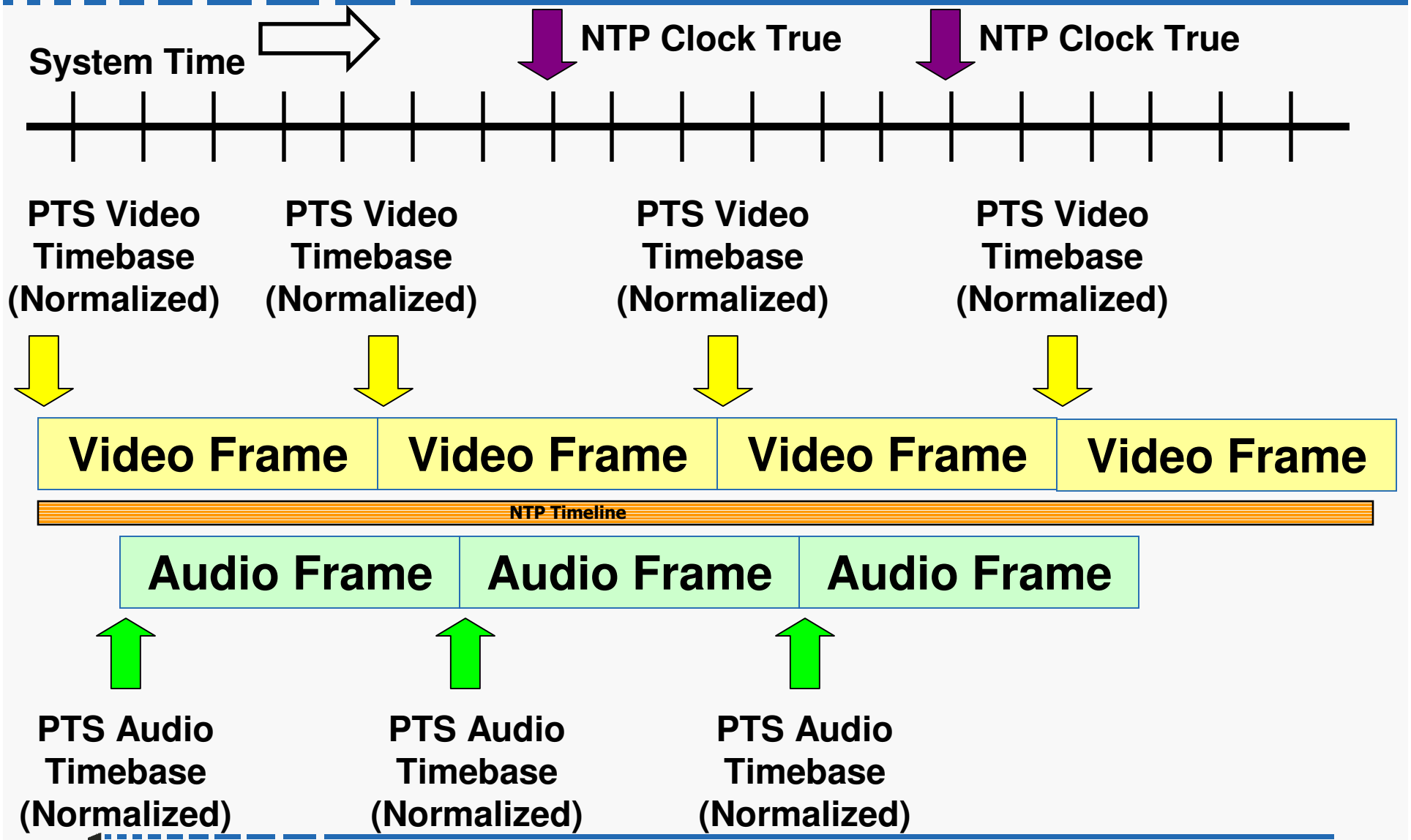
- Emerging broadcast technologies use RTP transport instead of MPEG-2 transport
  - ATSC M/H
  - Real Time Protocol
  - Unidirectional
  - RTP/UDP/IP
- Video and Audio streams carried over RTP
  - RTCP (Real Time Control Protocol) used to provide time base information
  - RFC 3550
- Replicates necessary functionality of MPEG-2 Transport
  - IP address/port replicates PID functionality
- For "Broadcast Quality" a timing/buffer model is necessary

Simple principles of RTP delivery

RTP Packetizes audio and video frames into UDP over IP frames

- RTP headers have timestamps and Stream ID unique to their streams. Note timestamps have a random offset from wall clock (NTP) time
- RTP flag indicates the end of an audio or video frame

RTP Transport Synchronization



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The Future of Broadcasting

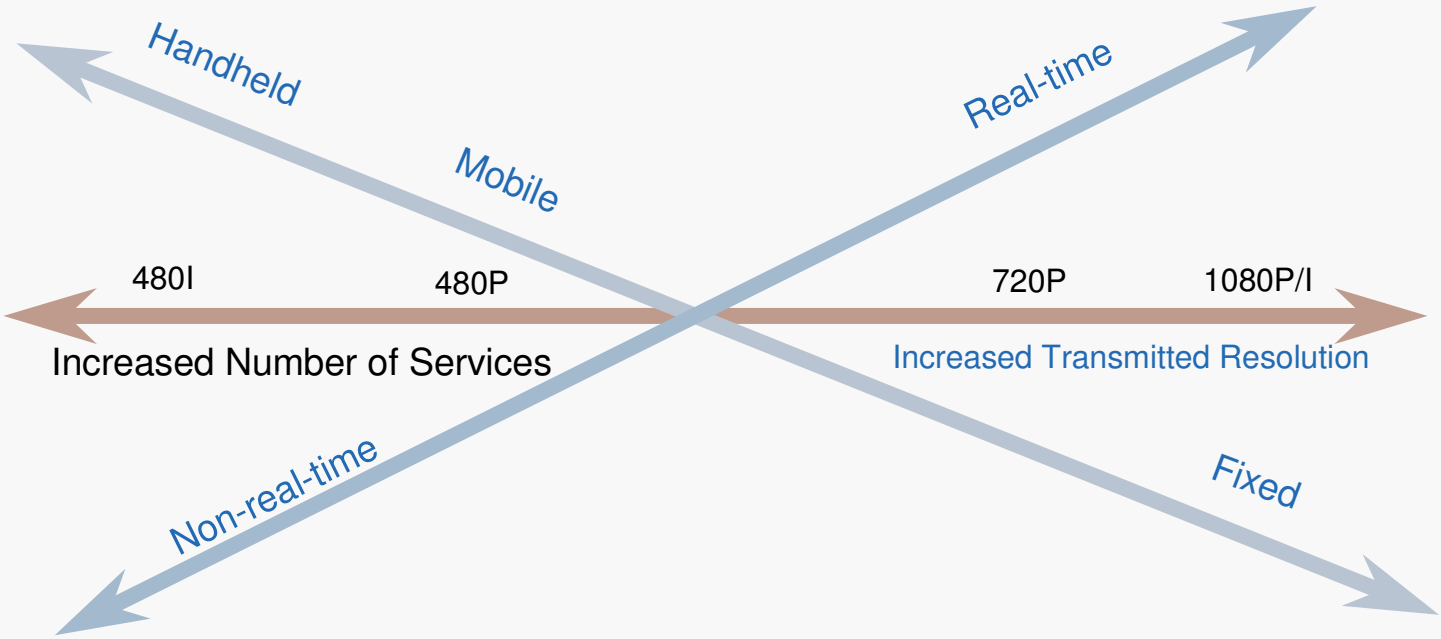
- Going forward, the broadcasting industry must leverage
  - Local
    - Content
    - Brand
    - Sales contacts
  - Un-tethered nature
    - It's wireless (before wireless was cool)!

Leveraging Wireless




Target devices that move!

ATSC Programming Options



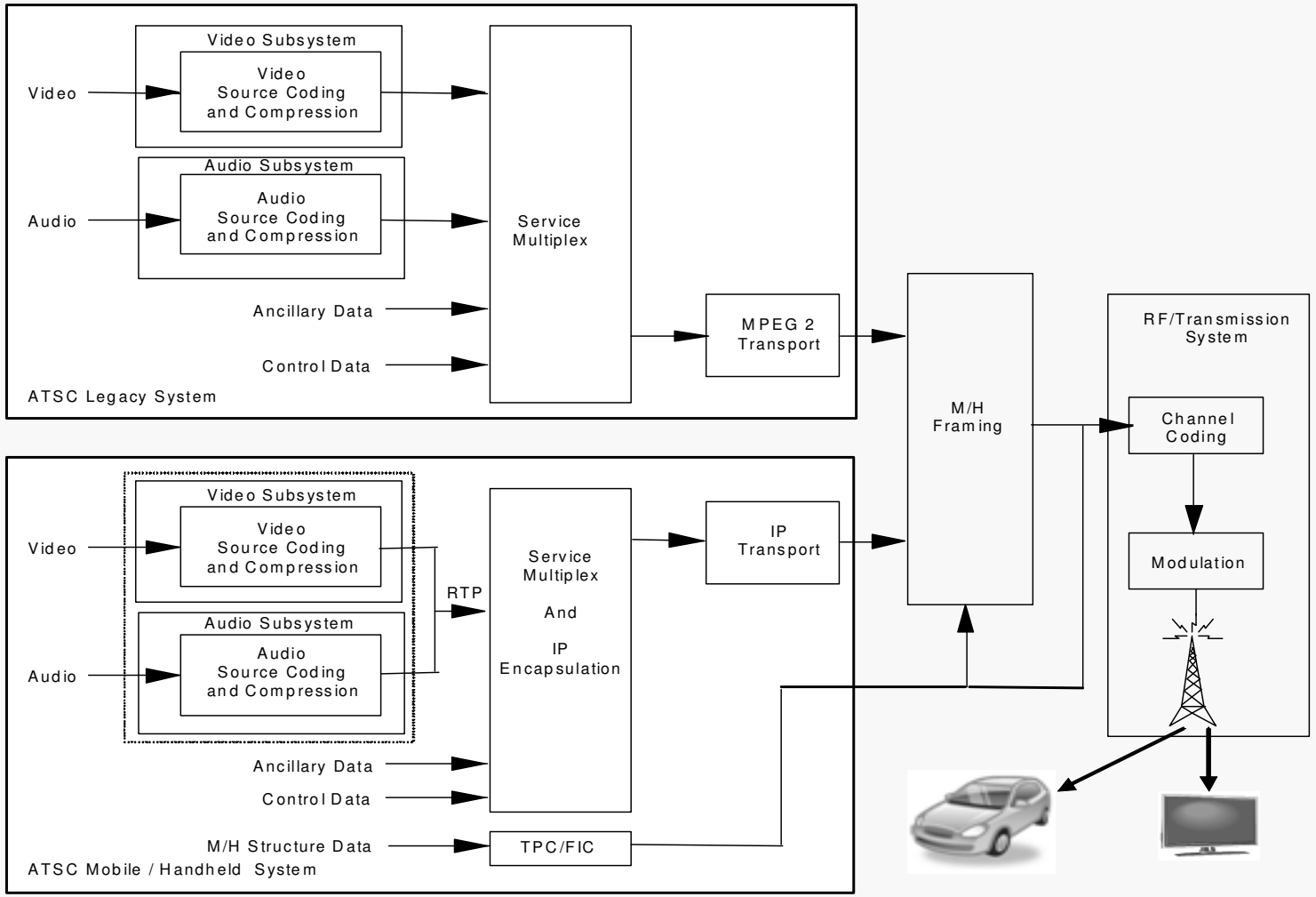
ATSC-M/H

- ATSC has developed a standard for delivery of real-time and non-real-time television content and data to mobile and handheld devices (ATSC-M/H).
  - ATSC-M/H services will be carried in DTV broadcast channels.
  - ATSC-M/H will be backwards compatible.
    - The presence of these services will not preclude or prevent operation of current ATSC services in the same RF channel or have any adverse impact on legacy receiving equipment.

ATSC-M/H Details

- The ATSC-M/H standard specifies:
  - Physical layer (modulation and FEC).
  - Transport, signaling, and announcement (including EPG) optimized for mobile and handheld services.
  - Other parameters as necessary for carriage of video, audio, and data essence and metadata.
- The ATSC-M/H standard references other standards to maximize interoperability, including those from other standards developing organizations.

ATSC M/H Architecture

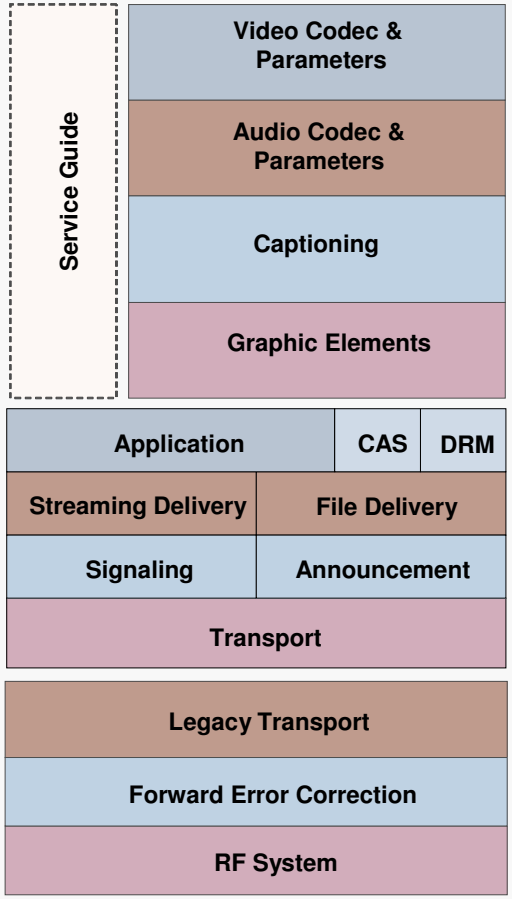


ATSC-M/H Layer Stack

S4-3 Presentation Layer

S4-2 Management Layer

S4-1 Physical Layer



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Summary

- Digital Television is on the move, providing new opportunities – and new challenges.
- PSIP is one of the keys to unlocking the opportunities for increased viewership – and is mandated by FCC.
- Broadcast stream monitoring is increasingly important, to ensure FCC compliance and viewer satisfaction.
- New products and product architectures are appearing to help meet the challenges and take advantage of the opportunities in all these areas.
- IP based technologies are becoming part of the broadcast toolkit
- Mobile capabilities offer new opportunities

Thanks

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