Any Content … Anywhere … Anytime …

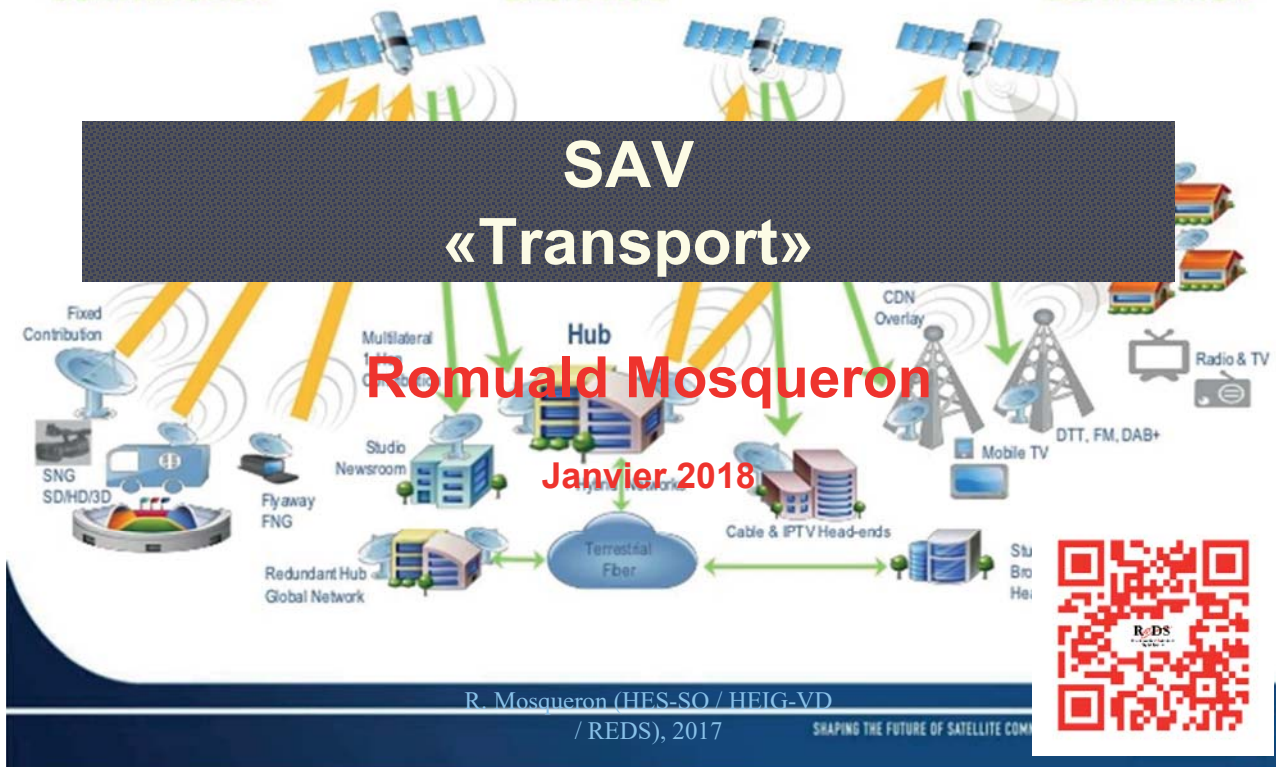CONTRIBUTION   EXCHANGE   DISTRIBUTION

SAV
«Transport»

Romuald Mosqueron

Janvier 2018

Fixed Contribution

Multilateral

Hub

CDN Overlay

Radio & TV

SNG SD/HD/3D

Studio Newsroom

DTT, FM, DAB+

Mobile TV

Flyaway FNG

Cable & IPTV Head-ends

Redundant Hub Global Network

Terrestrial Fiber

SHAPING THE FUTURE OF SATELLITE COM

Plan

ReDS
heig-vd

1- Pourquoi transporter les flux audio-vidéo?

2- ES - Elementary Stream (Audio, Video)

3- PES – Packetised Elementary Stream

4- PS – Program Stream

5- TS – Transport Stream

6- TSoIP

7- IPTV

8- Autres transports

Transport

Connexion uni directionnelle

- Pas de retour sur la qualité

  - Impossible de renvoyer les paquets perdus

  - Utilisation de code correcteur d'erreurs

- Pas de connexion client vers source

  - Informations à embarquer dans le contenu:

  – Configuration de service

  – Descriptions des autres services disponibles

! Tous les utilisateurs reçoivent les même données !

Transport

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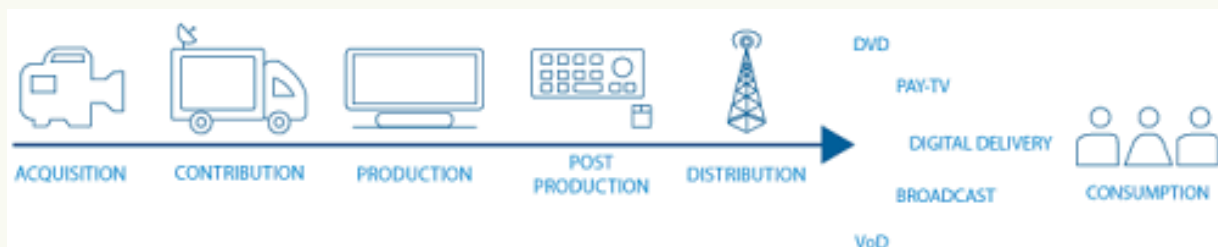 – Descriptions des autres services disponibles

! Tous les utilisateurs reçoivent les même données !
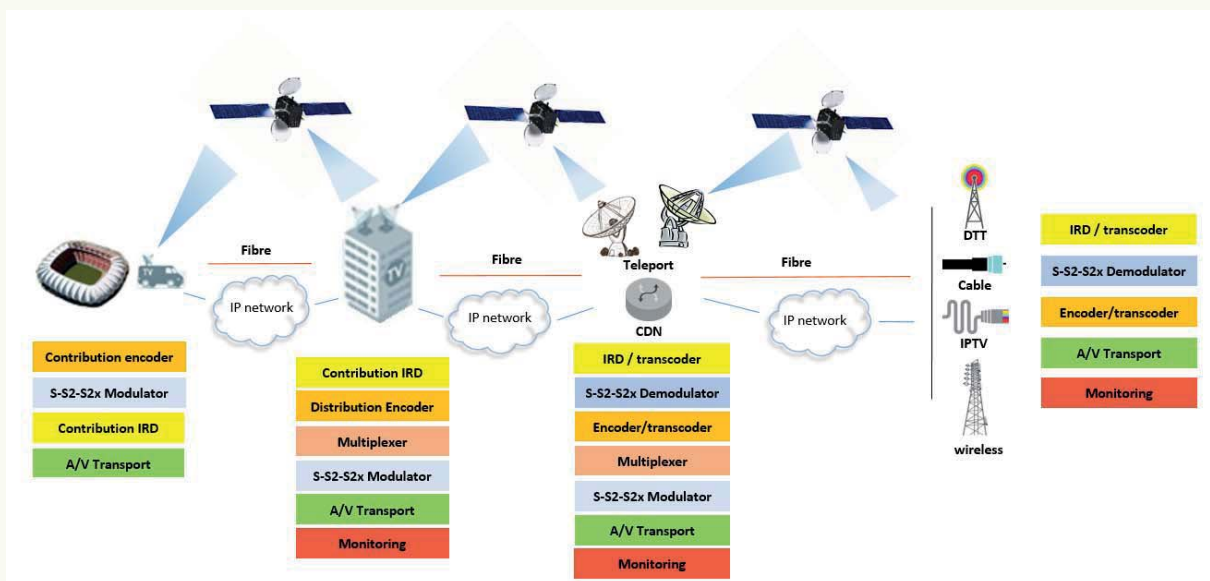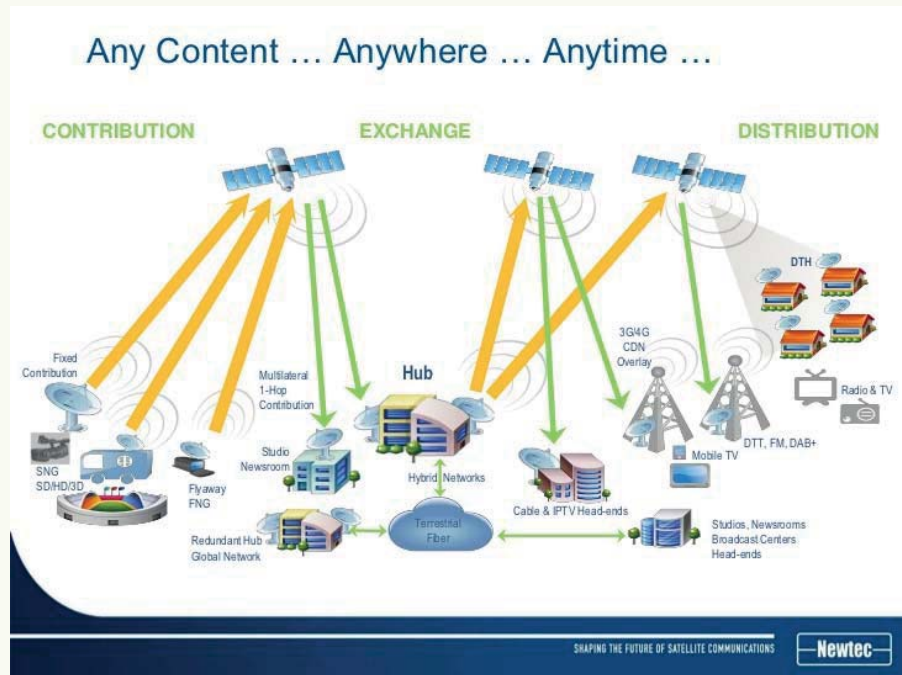
Transport

Gestion des points d'accès

- Permettre l'accès aux flux « à tout moment »
    - Insérer régulièrement les données de configuration
    - Si besoin, remettre les contextes de décodage à zero régulièrement
- Pouvoir mettre à jour la configuration
    - Notion de « version » des données
- Sans perturber les utilisateurs déjà présents
    - Règles sur l'interprétation de la version

Pourquoi?

Quels sont les différents éléments pour la diffusion?

ACQUISITION   CONTRIBUTION   PRODUCTION   POST PRODUCTION   DISTRIBUTION   DVD   PAY-TV   DIGITAL DELIVERY   BROADCAST   VoD   CONSUMPTION

Transport

1- Contribution

2- Distribution

3- Exchange

4- Delivery

Contribution
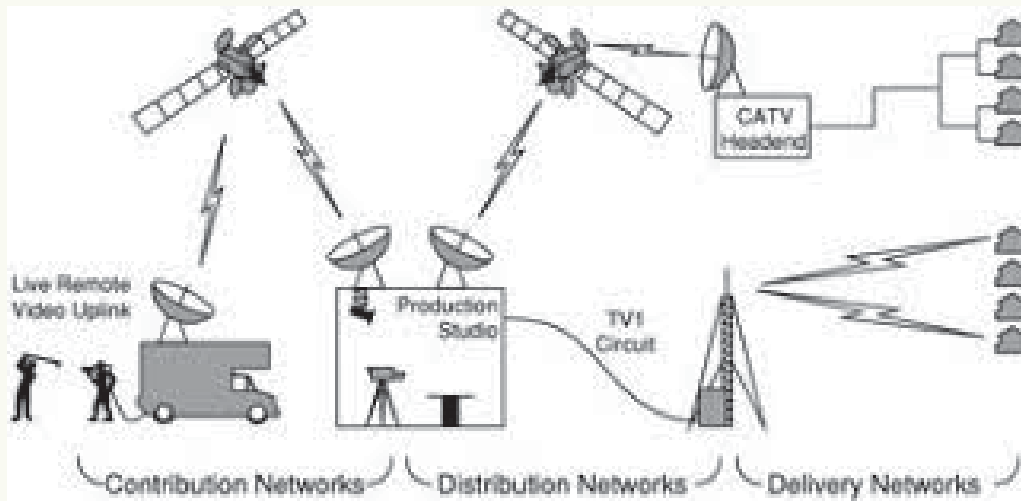
WIRELESS PRODUCTION

CATEGORY I / RF Studio Systems

For this category, under the name RF Studio Systems, we hear operations inside (in studio) or outside (outside broadcast) of RF systems installed on studio cameras.

Generally, such RF systems are used to increase the mobility of certain cameras which then are carried to the shoulder or installed on steadicams.

RF Camera carried to the shoulder

RF Camera installed on a steadicam

Examples of application

The examples of application presented here are not exhaustive, so much there are varied types of production of television programs.

Generally, one can say that RF Studio Systems are more and more often engaged in this kind of production, this in order to bring dynamism and movement in the images, which is difficult to make with cabled cameras.

✓ **Entertainment :**   **The Voice, Eurovision Song Contest,**
outside concerts, soap operas, series theater plays,
games, etc…
(steadicam to turn around the interpreters on
the scene, interventions from back stage,
interviews in slides, etc…).

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WIRELESS PRODUCTION

✓ **Sport :**   **Practically each sporting retransmission implies one or more RF Studio Systems. (camera along, the presentation touchlines of the candidates, cover of the starting and arrival zones, SpeedCam to follow the 100 m, podium ceremony, etc…).**

Car racing (cover of stand and the starting grid, podium ceremony, etc…).

Alpine skiing, cross-country skiing, ski jump, etc… (cover of the starting and arrival zones, presentation of the runners, SpeedCam to follow the arrivals, etc…).

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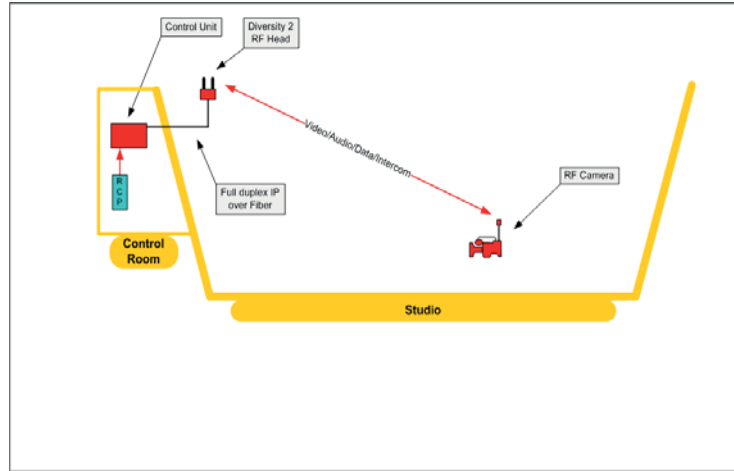Celtic-Plus
Smart Connected World

WIRELESS PRODUCTION

✓ **Event-driven :**   **Historical, politic, cultural events, etc… (accompaniment of the guests, speeches, presentation of sites, interviews various, etc…).**
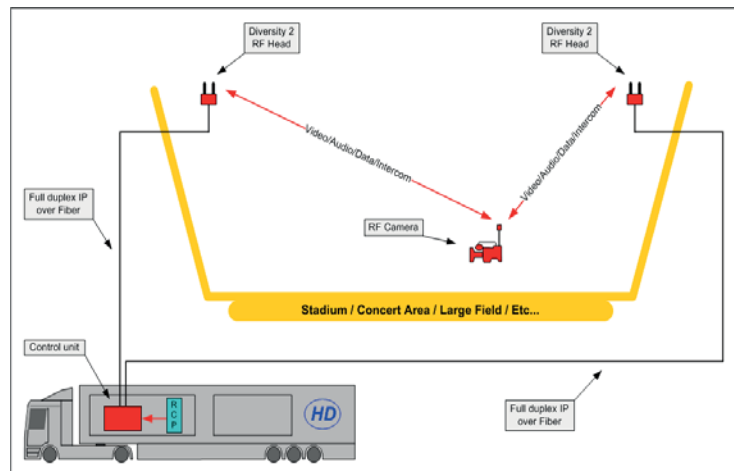

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WIRELESS PRODUCTION

✓ **Studio setup**

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WIRELESS PRODUCTION

✓ **Outside setup**

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✓ **Very Large Outside setup**

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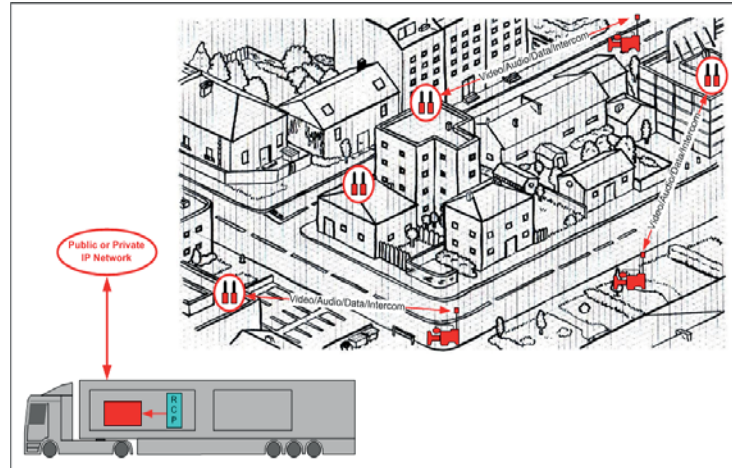
CATEGORY II / RF Mobile Systems

For this category, under the name RF Mobile Systems, we hear operations using all kinds of RF Mobile Systems associated with various types of equipment :

✓ News cameras (Camcorder).
✓ On-board mini-cameras.
✓ Cineflex helicopter.
✓ Moto-cameras.
✓ Aerial relay equipments installed on helicopters and aircraft.
✓ Receiving station (with or without Tracking System)
✓ Etc…

Two kinds of production are realized :

✓ Operations using simple terrestrial reception systems or combined in network (Diversity Network).
✓ Operations using mobile air relays (helicopters and/or planes).

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WIRELESS PRODUCTION

RF Camcorder carried to the shoulder

RF Mobile System installed in a racing car

RF Mobile System installed in a relay helicopter

RF Mobile System installed on a Cineflex helicopter

RF Mobile System installed in a relay aircraft

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Examples of application

The examples of application presented here are not exhaustive, so much there are varied types of production of television programs.

Generally, one can say that the RF Mobiles Systems are more and more often engaged in this kind of production, this in order to transmit live moving events which require a great mobility of the cameras.

✓ **Entertainment :**   **Plays**
                           (Koh Lanta, Hunting for the Treasury,
                           Reality TV,
                           Ushuaia live, etc…)

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✓ **Sport :**   **Cycling, marathon, sailing, power boat, car rally, races of cars and motor bikes in circuit, horse shows, etc…**

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✓ **Event-driven :**   **Historical, cultural and political events, etc… (procession of July 14th in France, visits of the Pope, presidential elections, etc…)**
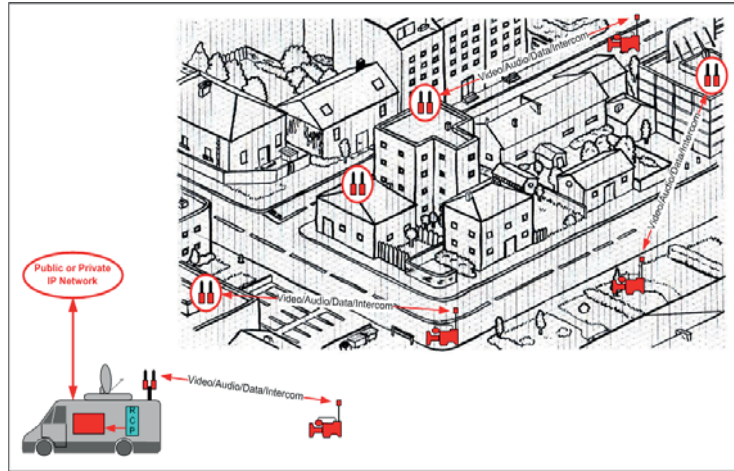

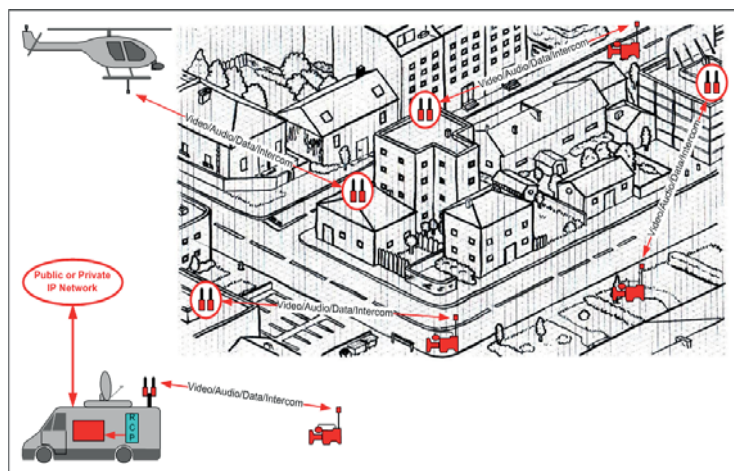✓ **News:**   **Sporting events Political Summits, demonstrations in the streets, various catastrophes, etc…**

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WIRELESS PRODUCTION

✓ **News setup**

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WIRELESS PRODUCTION

✓ **News setup with Cineflex helicopter**

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WIRELESS PRODUCTION

✓ **On-board setup (Ring network)**

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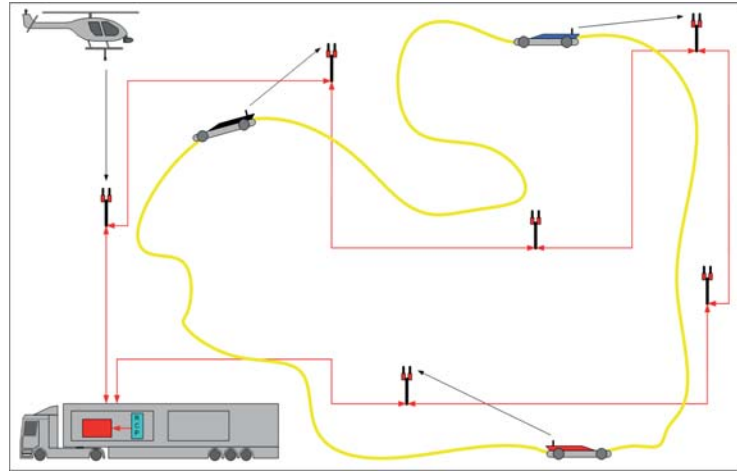
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✓ **On-board setup (Star network)**

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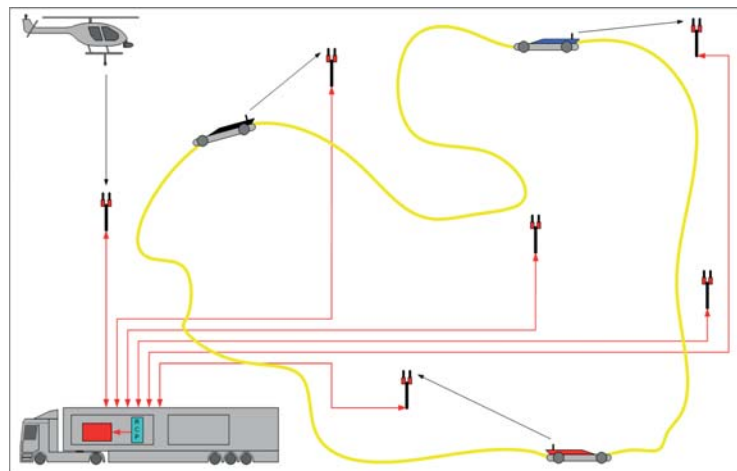
WIRELESS PRODUCTION

✓ **Road cycling setup**

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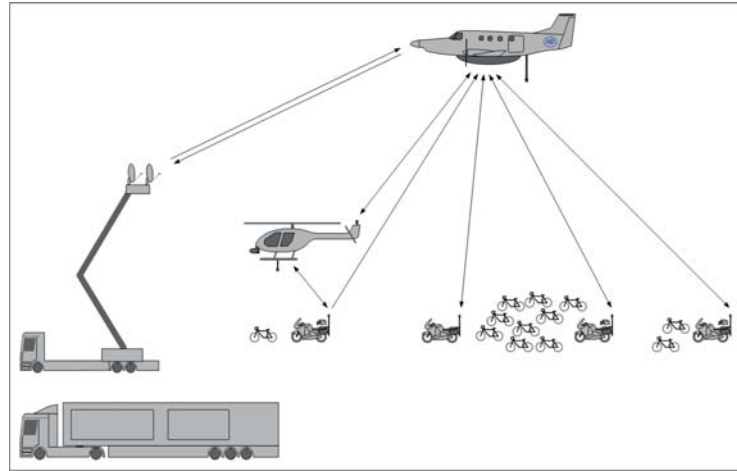
WIRELESS PRODUCTION

CATEGORY III / RF Contribution Systems

For this category, under the name RF Contribution System, we hear operations outside of RF systems dedicated to provide a link between two (or more) fixed points.

We also include in this category satellite link, because the MPEG compression/decompression hardware can be the same as for the other wireless applications.

News van equipped with point to point RF Contribution System

Satellite Van equipped with up-link antenna

Point to point RF Contribution System

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General setup of the applications

✓ **In case of Terrestrial Contribution setup, the News Van equipped with the RF Contribution System will transmit its image, audio, data and intercom towards the RF Head installed on top of buildings, high towers, platforms, pylons, cranes, dedicated masts, etc…**
Then, the signal will be transported by IP over fiber directly to the Control Unit installed in the final studio through a national and/or international IP network on fiber.
Image (return video), audio, data and intercom from the Control Unit will be transported by IP over the same national and/or international IP network on fiber to the RF Head which will transmit all these information towards the News/OB Van on the same frequency.

✓ **In case of Satellite Contribution setup, the News Van equipped with the RF Contribution System will transmit its image, audio, data and intercom towards the satellite.**
Then, the signal will be retransmitted from the satellite to the receiving station and transported by IP over fiber directly to the Control Unit installed in the final studio.
Image (return video), audio, data and intercom from the Control Unit will be transported by IP over the same fiber to the receiving station which will transmit all these information towards the satellite which will retransmit all these information back to the News Van.

✓ **The same setup is used for Satellite Contribution from an OB Van (through a connected Satellite Van or directly from the OB Van if equipped with a satellite station).**

✓ **In case of Terrestrial Point to Point Contribution setup, a point equipped with the RF Contribution System will transmit its image, audio, data and intercom towards the RF Head of the other point installed on top of buildings, high towers, platforms, pylons, cranes, dedicated masts, etc…**
Then, the signal will be transported by IP over fiber directly to the Control Unit installed in the final studio through a local IP network on fiber.
Image (return video), audio, data and intercom from the Control Unit will be transported by IP over the same local IP network on fiber to the RF Head which will transmit all these information towards the other point on the same frequency.
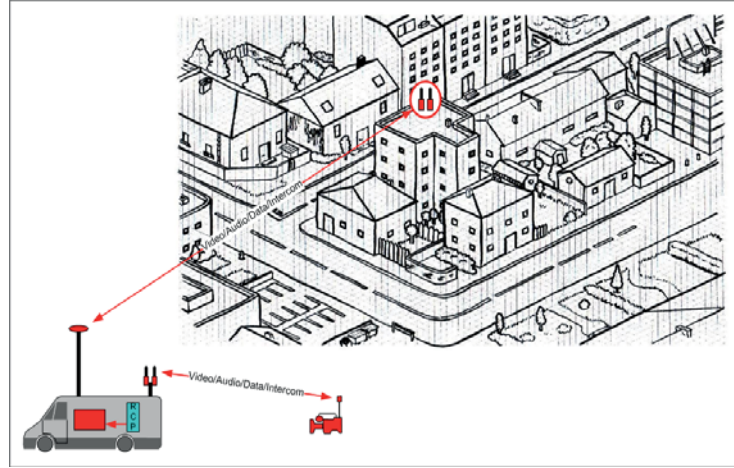
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✓ **Terrestrial Contribution for News Van**

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✓ **Satellite Contribution for News Van**

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WIRELESS PRODUCTION

✓ **Satellite Contribution for OV Van**

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WIRELESS PRODUCTION

✓ **Terrestrial Point to Point Contribution**

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CATEGORY IV / RF Distribution Systems

For this category, under the name RF Distribution System, we hear operations inside (in studio) or outside (outside broadcast) of RF systems dedicated to distribute various TV programs and data information :

- **On stage, back stage**
- **In back training courses**
- **In commentator cabins**
- **In VIP zones**
- **In spectator zones**
- **In restaurants / bars / etc…**
- **In VIP areas**
- **Etc…**

If there is always a 230 VAC power pack available near as of places where these TV monitors must be installed, hundreds of meters (as it is not kilometers !) of coaxial cables must be drawn to connect all these equipments.

Examples of application

The examples of application presented here are not exhaustive, so much there are varied types of production of television programs.

Generally, one can say that the RF Distribution Systems are more and more often engaged in various productions, this in order to transmit live programs and data information to a large number of various terminals.

✓ **To TV monitors :**

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✓ **To Mobile phones, tablets :**

✓ **To giant video screens**

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✓ **To Mobile terminals moving in mobile events :**

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REMOTE PRODUCTION

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CATEGORY I / Remote Production Network Systems

For this category, under the name Remote Production Network Systems, we hear the remote management of local, national and international Production Networks over Fiber optic.

Network Router with
integrated HEVC encoder/
decoder
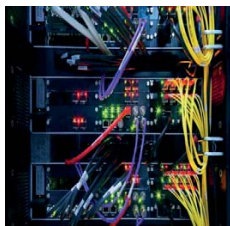
Network Control Room

TELCO

Local, national and international Fiber optic
network furnished by different TELCO

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Examples of application

The examples of application presented here are not exhaustive, so much there are varied types of production of television programs.

Generally, one can say that Remote Production Network Systems are more and more often engaged in all kinds of production.

✓ **Entertainment :**   **Between concert stadiums, opera arenas, theater, etc… and studios of TV channels broadcasting the show.**

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✓ **Sport :**   **Between football, ice hockey, basket ball, swimming, athletic stadiums, Formula 1 circuits, etc… and studios of all TV channels broadcasting the events.**

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REMOTE PRODUCTION

✓ **Event-driven :**   **Between parliament houses, official buildings,
state infrastructures, etc... and studios of
all TV channels broadcasting the events.**

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REMOTE PRODUCTION

General setup of the applications

✓ **In all cases of Remote Production Network Systems, the equipments related to the network used and installed
at all locations :**

  ▪ **Video/Audio/Data/Intercom interface**
  ▪ **MPEG-4 , HEVC, JPEG-2000, and TICO encoder/decoder**
  ▪ **Optical modulator/demodulator**
  ▪ **Network control software**

  are remote controlled through the Fiber optic network from a main Control Center.

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REMOTE PRODUCTION

✓ **Remote Production Network Systems**

● Production location (Sydney) / Network remote controlled from Geneva
● Network Remote Control Center (Geneva)
● Broadcasting locations (Roma, Madrid, London, Stokholm) / Network remote controlled from Geneva

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REMOTE PRODUCTION

✓ **Remote Production Network Systems**

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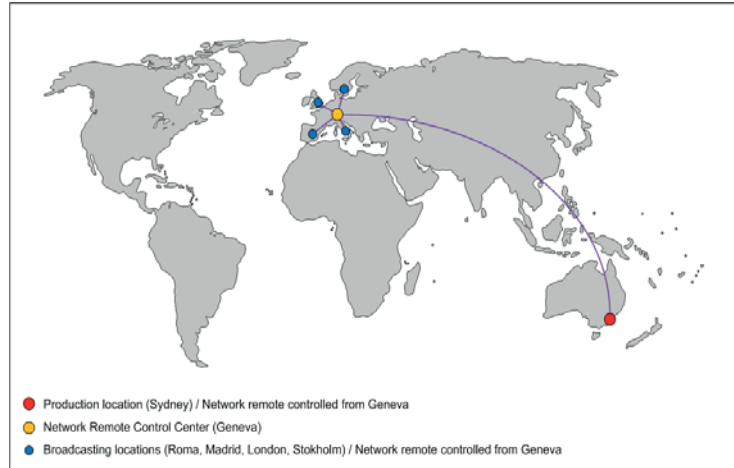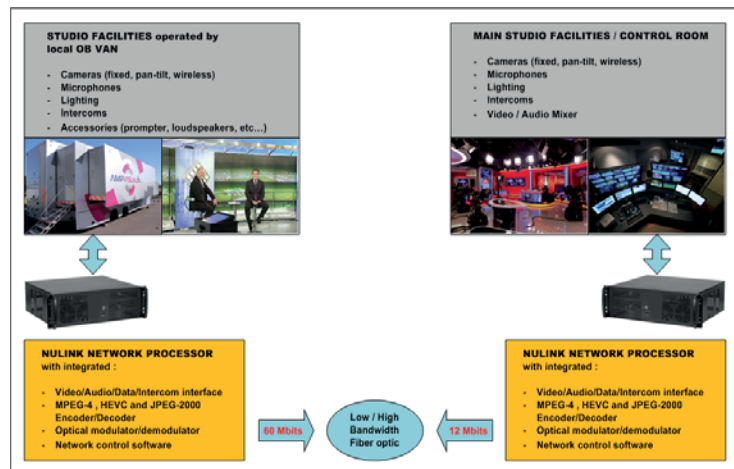
CATEGORY II / Remote Production Facilities Systems

For this category, under name Remote Production Facilities Systems, we hear the remote management of local, national and international Production Facilities over Fiber optic.

TV studio in Brazil remote controlled from the main TV studio in Paris

Main TV studio in Paris

TELCO

Fiber optic network between Brazil and Paris furnished by different TELCO

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Examples of application

The examples of application presented here are not exhaustive, so much there are varied types of production of television programs.

Generally, one can say that Remote Production Facilities Systems are more and more often engaged in all kinds of production.

✓ **Entertainment :**   **Between studio installed in film festivals, music festivals, art festivals, etc… and main studios of TV channels broadcasting the show.**

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REMOTE PRODUCTION

✓ **Sport :**   **Between studio and commentator post installed in football stadiums, ice hockey stadiums, basket ball arenas, swimming arenas, athletic stadiums, Formula 1 circuits, etc and main studios of TV channels broadcasting the events.**

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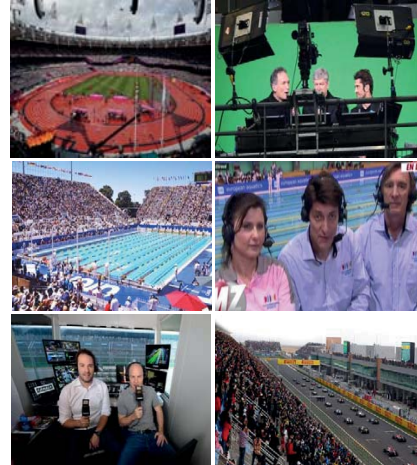
REMOTE PRODUCTION

✓ **Event-driven :**   **Between studio installed in parliament houses, official buildings, state infrastructures, etc… and main studios of TV channels broadcasting the events.**

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REMOTE PRODUCTION

✓ **Remote Production Facilities Systems**

● Production location (Rio Football Stadium) / Studio facilities remote controlled from Stokholm
● Network Remote Control Center (Geneva)
● Broadcasting location (Stokholm) / Main studio facilities / Network remote controlled from Geneva

REMOTE PRODUCTION

✓ **Remote Production Facilities Systems**

Message   Signal   Receiver   Destination

Information Source   Transmitter   Received Signal   Message

Noise Source

MPEG-2 TS   IP

Cable, Satellite
(DVB-C, DVB-S)

IPTV ADSL

Terrestre
(DVB-T, ATSC, ISDB)

Mobile 3G/EDGE

Broadcast Mobile
(T-DMB, 1Seg, S-DMB, DVB-H, MBMS)

- ISO/IEC 13818 – 1994

- Codage source
• Vidéo (Partie 2)
• Audio (Partie 3)
• Audio avancé (AAC, Partie 7)

- Transport
• Sans erreurs (PS)
• Avec erreur (TS)
• Contrôle (DSM-CC)

■ **Flux élémentaires empaquetés (PES)**
  • Média: audio, vidéo
  • Data: services interactifs, guide de programmes
■ **2 modes de multiplexage:**
  • Multiplexe de programme (MPEG-2 PS)
  • Multiplexe de transport (MPEG-2 TS)
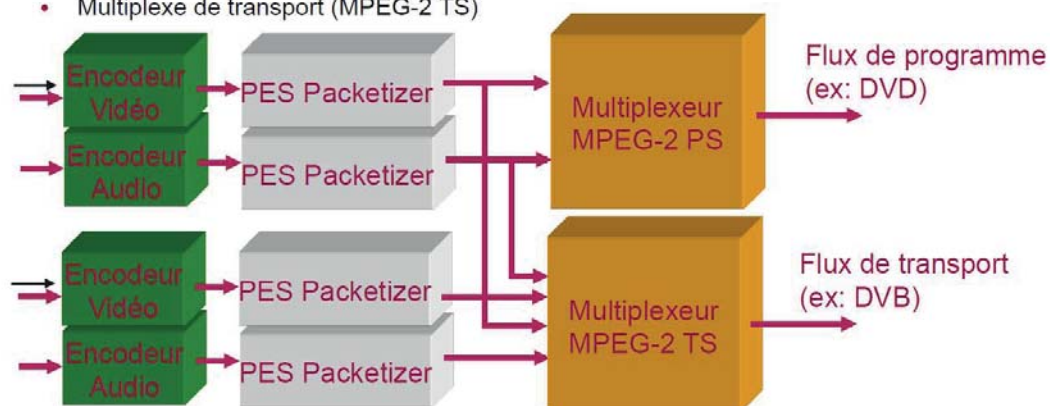
- **Taille variable**
- **Types différents**
  - Entête commune (6 octets)
  - Dont un identifiant de flux pour distinguer
    - Audio/vidéo
    - Bourrages
    - Data, …
- **Pour les paquets AV, d'autres info sont disponibles:**
  - Timing (PTS/DTS)
  - Horloge (ESCR)
  - Scrambling
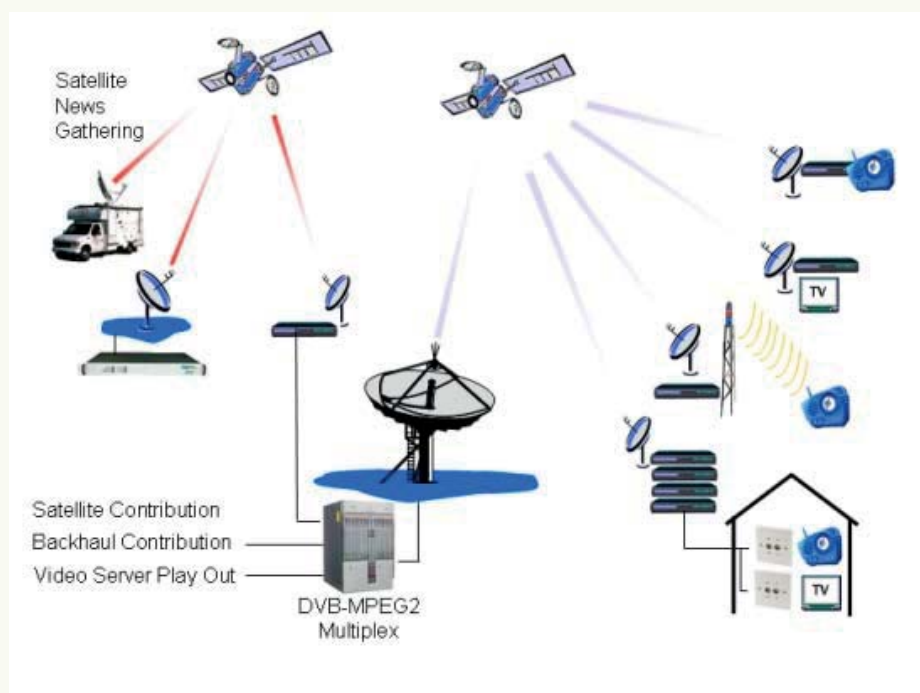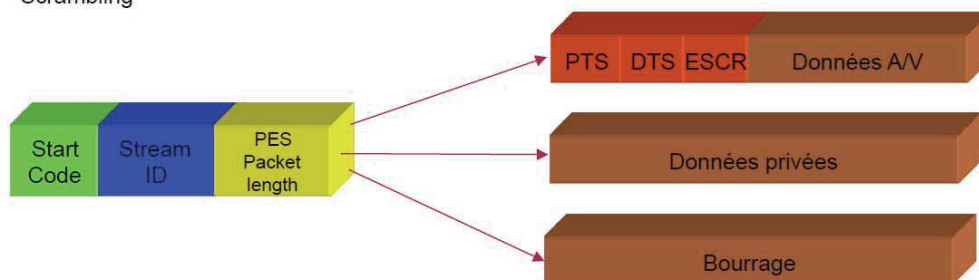
Some history: Communication problems (Shannon)

1. Problème technique:

Quelle est la précision avec laquelle les signaux / symboles de communication peuvent être transmis?

2. Problème sémantique

Quelle est la précision avec laquelle les signaux / symboles transmis transportent (représentent) l'information désirée

3. Problème d'efficacité

Quel est le succès de la transmission du sens désiré?

Analog signals

2	1	2
Acquisition	Transmission	Reproduction

Digital signals

2	2	1	2	2
Acquisition	Coding or Compression	Trasmission	Decoding	Reproduction
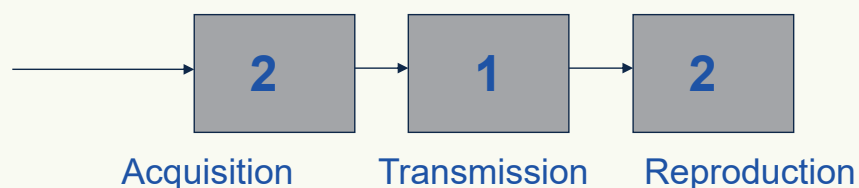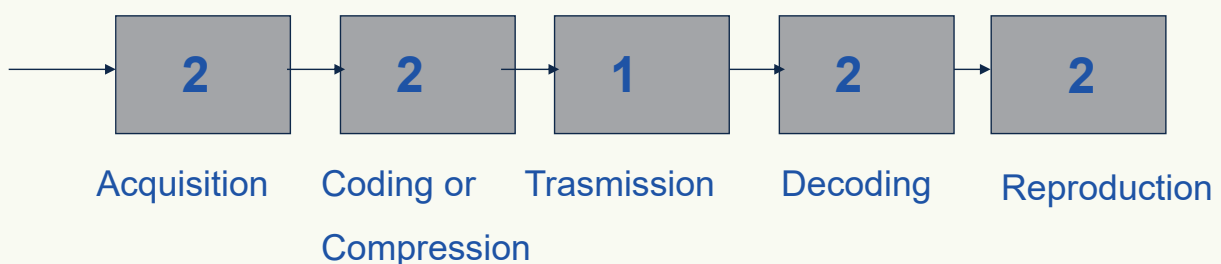
1. **Comment la quantité d'informations est-elle mesurée?**
2. **Comment la capacité d'un canal de transmission est-elle mesurée?**
3. **Le passage d'un message à un signal implique un codage. Quelles sont les caractéristiques d'un codage efficace?**
4. **Quand le codage est-il optimal?**
5. **Si le codage est le plus efficace, quelle est la vitesse à laquelle un canal peut transmettre l'information?**
6. **Quels sont les effets du bruit et de ses caractéristiques? Comment ces effets peuvent-ils être minimisés?**

MPEG-2 Syntax Hierarchy
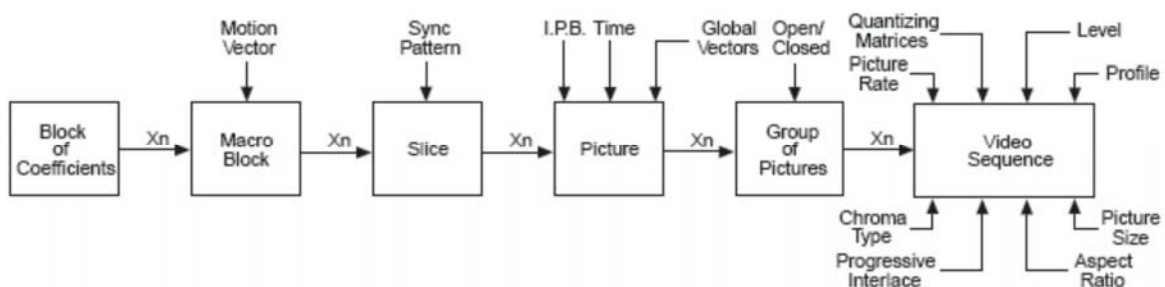
● **Objectif des systèmes MPEG-2:**

Comment les flux de données vidéo et audio compressés au format MPEG peuvent-ils être multiplexés avec d'autres données pour former un flux de données unique adapté à la transmission ou au stockage numérique.

● **Trois éléments principaux:**

- La structure des multiplexes (Elementary et Program Stream),

- Les informations de service éventuellement présentes;

- Le système d'horodatage et de référence d'horloge utilisé pour synchroniser les composants associés d'un programme au décodeur

MPEG-2 Systems Multiplexer
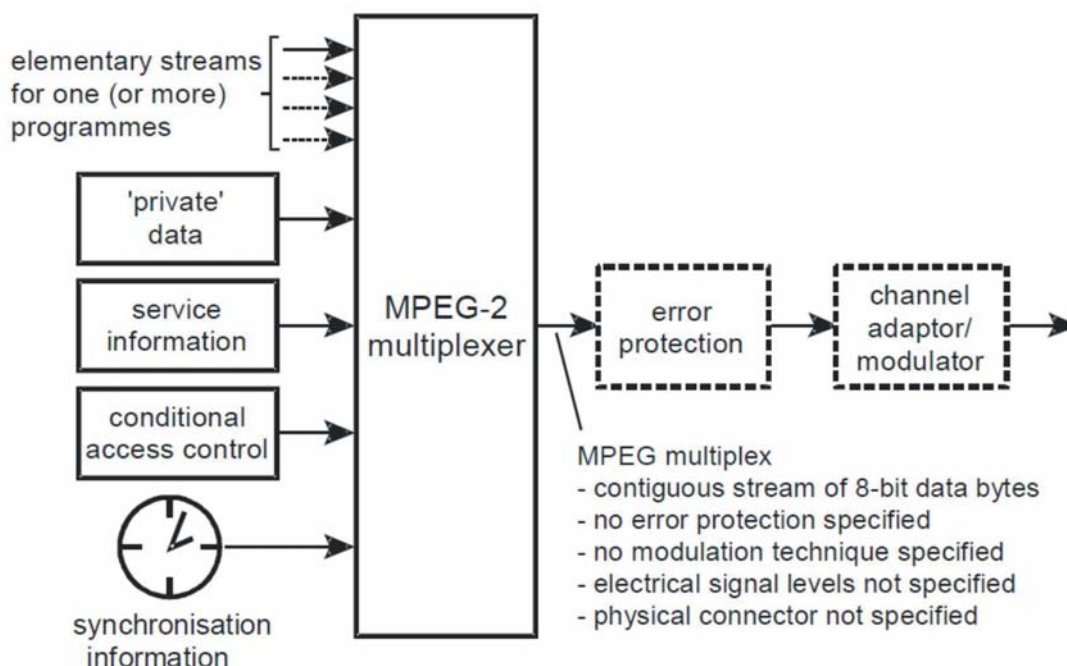
- **Program:**
  - a single broadcast service or channel.
- **Elementary Stream:**
  - a program comprises one or more elementary streams. An elementary stream is a single MPEG-compressed component of a program (i.e. coded video or audio).
- **The output of an MPEG-2 multiplexer:**
  - a contiguous stream of 8-bit-wide data bytes. The multiplex may be of fixed or variable data rate and may contain fixed or variable data rate elementary streams.

Elementary Stream
REDS
heig-vd

Première couche syntaxique du MPEG, l'ES (Elementary Stream) est le signal brut en sortie de compression. Dans la réalité, on ne travaille jamais directement avec ce type de signal. il reste caché au cœur des codeurs.
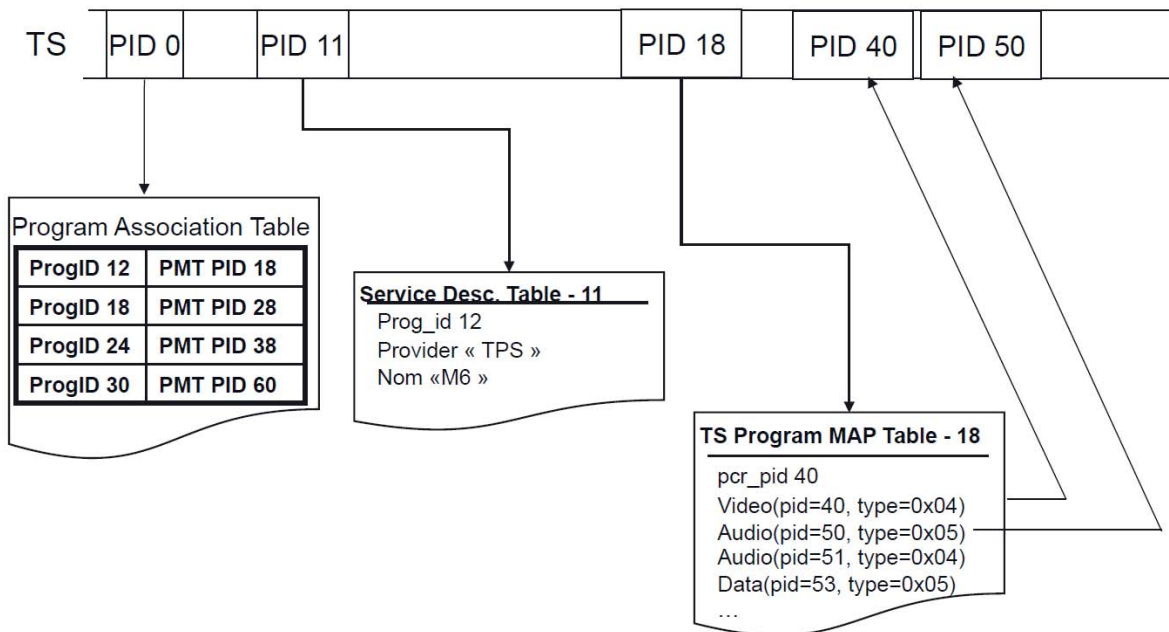
=> Conteneur

Packetised Elementary Stream

REDS
heig-vd
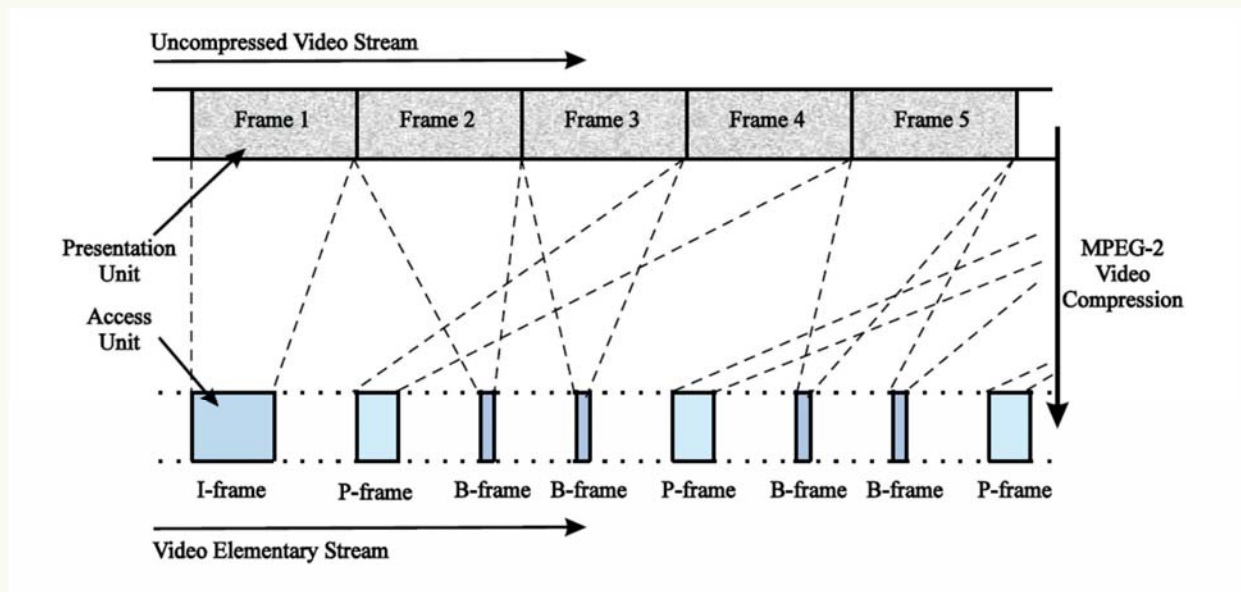
Pour des raisons de commodité, les flux élémentaires continus transportant de l'audio ou de la vidéo en provenance de compresseurs doivent être divisés en paquets. Ces paquets sont identifiés par des en-têtes contenant des marqueurs temporels pour la synchronisation. A partir des PES, on peut créer des Flux de Programme et des Flux de Transport.
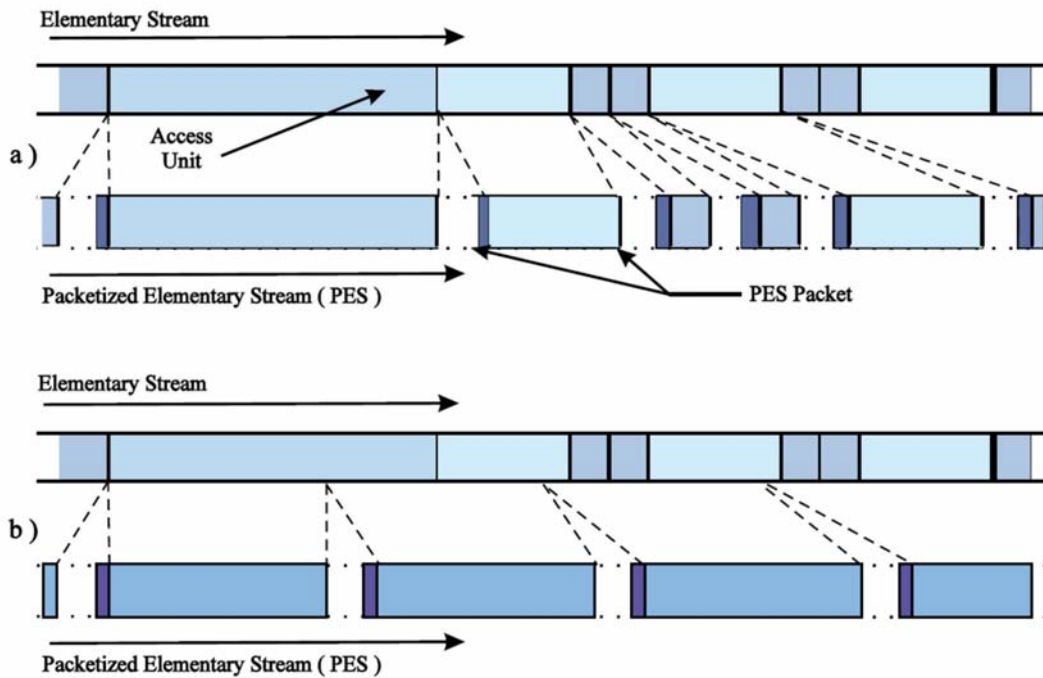
Transport Stream

| TS | PID 0 | | PID 11 | | | PID 18 | | PID 40 | | PID 50 | |

Program Association Table

ProgID 12	PMT PID 18
ProgID 18	PMT PID 28
ProgID 24	PMT PID 38
ProgID 30	PMT PID 60

Service Desc. Table - 11
Prog_id 12
Provider « TPS »
Nom «M6 »

TS Program MAP Table - 18

pcr_pid 40
Video(pid=40, type=0x04)
Audio(pid=50, type=0x05)
Audio(pid=51, type=0x04)
Data(pid=53, type=0x05)
…

Marqueurs temporels

Après la compression, les images sont extraites de la séquence à cause du codage bidirectionnel. Elles nécessitent une quantité variable de données et sont sujettes à un retard variable en raison du multiplexage et de la transmission.

Des marqueurs temporels sont périodiquement incorporés dans chaque image afin de verrouiller la synchronisation entre l'audio et la vidéo.
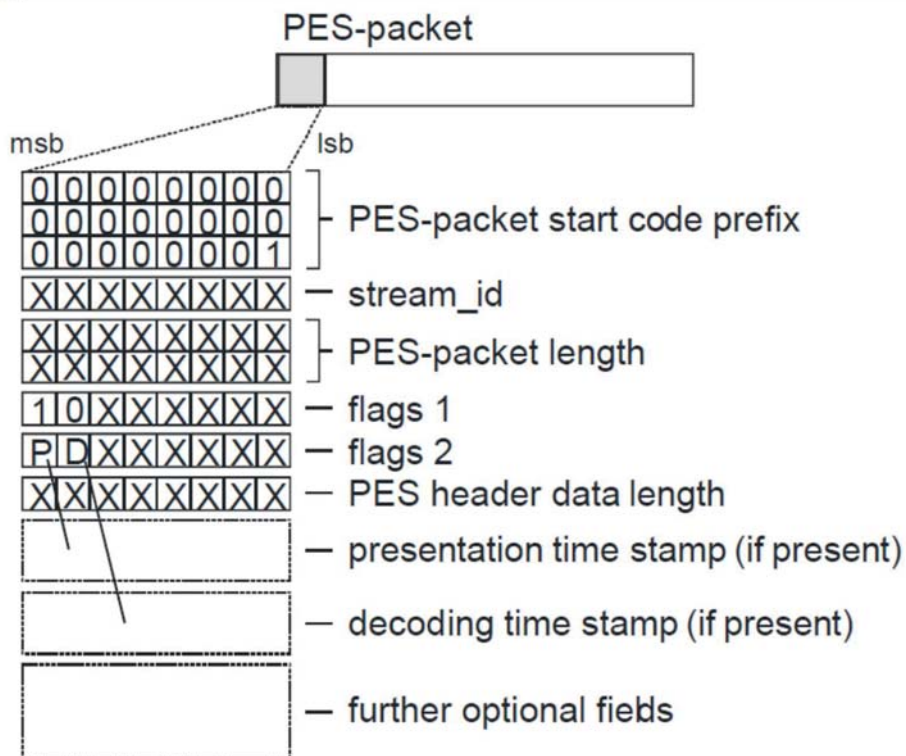
Un marqueur temporel est un nombre de 33 bits constitué par la valeur d'un compteur piloté par une horloge à 90 KHz. Cette horloge est le résultat de la division par 300 de l'horloge de programme à 27 MHz.

NB: Les marqueurs de temps indiquent à quelle référence temporelle une unité d'accès particulière appartient. La synchronisation des mouvements de lèvres est obtenue en incorporant des marqueurs de temps simultanément dans les paquets PES vidéo et audio.
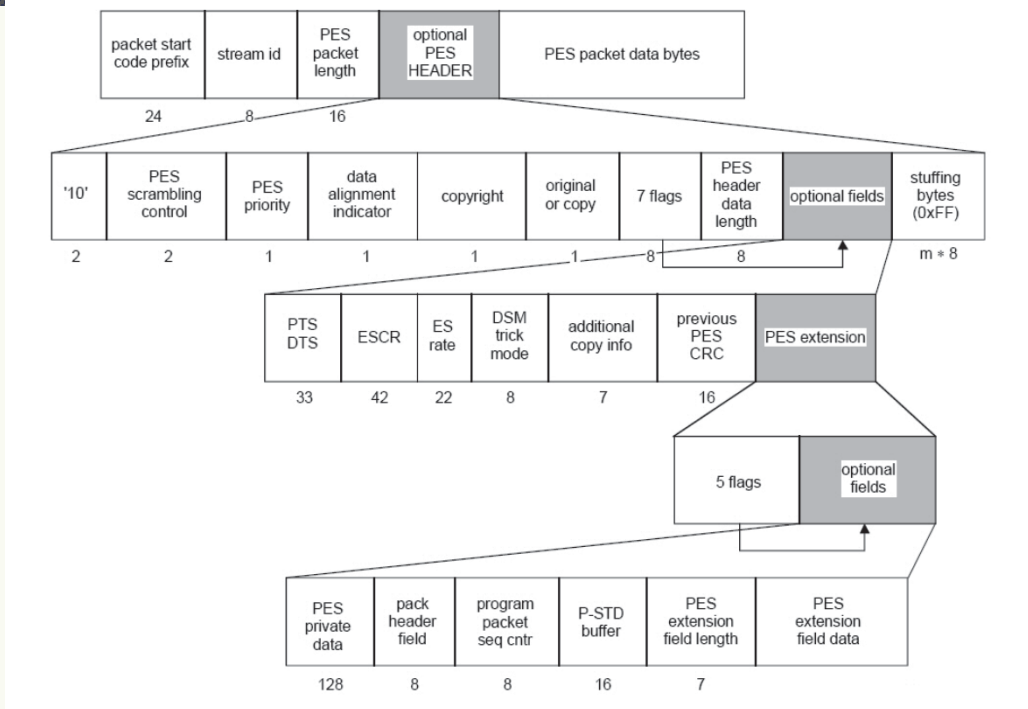
From Elementary Streams to PES

a) Elementary Stream — Access Unit — Packetized Elementary Stream (PES) — PES Packet

b) Elementary Stream — Packetized Elementary Stream (PES)

PES Header Information

PES-packet

msb — lsb

- PES-packet start code prefix
- stream_id
- PES-packet length
- flags 1
- flags 2
- PES header data length
- presentation time stamp (if present)
- decoding time stamp (if present)
- further optional fields

| Stream ID	Type de flux
1011 1100	Program Stream Map
1011 1101	Private Stream 1
1011 1110	Padding stream
1011 1111	Private Stream 2
110x xxxx	Flux audio MPEG-1, -2 ou -4
1110 xxxx	Flux vidéo MPEG-1, -2 ou -4
1111 0000	Flux ECM (Entitlement Control Message) – Accès Conditionel
1111 0001	Flux EMM (Entitlement Managment Message) – Accès Conditionel
…	…
1111 1111	Program Stream Directory

- Transport Stream:
  - a multiplex devised for multi-programme applications so that a single transport stream can accommodate many independent programmes. It comprises a succession of 188-byte-long packets called transport packets.
- Program stream:
  - it can accommodate a single programme only, for storage and retrieval of programme material from digital storage media. Intended for use in error-free environments.

Un flux de programme est bien adapté à un unique programme à débit variable dans un contexte d'enregistrement (DVD); un flux de transport conviendra mieux à la transmission de programmes multiples à débit constant (Bouquet satellite et câble). Dans le cas de la transmission, le décodeur doit recréer la base de temps sous peine de devoir supporter un défaut ou un excès de charge. C'est pourquoi un flux de transport utilise comme référence une Horloge de Programme (PCR, Program Clock Reference) tandis que flux de programme n'a pas besoin d'horloge de programme.

Program Stream

- **Flux de programme ~ programme TV**
- **Format de multiplexage**
  - De plusieurs flux élémentaires: 1 vidéo, N audio, N divers
  - Partageant la même base de temps
  - Débit constant ou variable
- **Dédié aux environnements avec peu d'erreurs**
- **1 flux de programme = suite de 'pack'**
- **1 'pack' = entête 'pack' + suite de paquets PES**

Program Stream
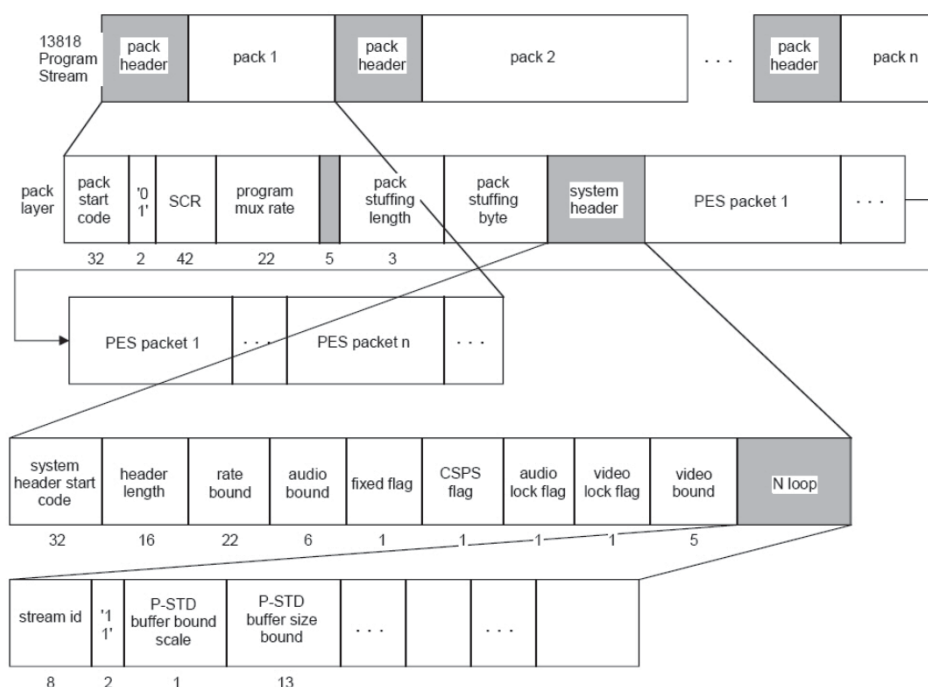
TS Functionality

- **MPEG-2 Transport Stream**
  - **Flexible Multiplexer for multichannel transmission and storage**
  - **Configurable for different application requirements**
  - **Several functionality supported:**
    - **Stream synchronization**
    - **User information on top of video-audio ES**
    - **User information streams**
  - **Stable and well established specification (emulation code are avoided)**

MPEG-2 Transport Stream Packet
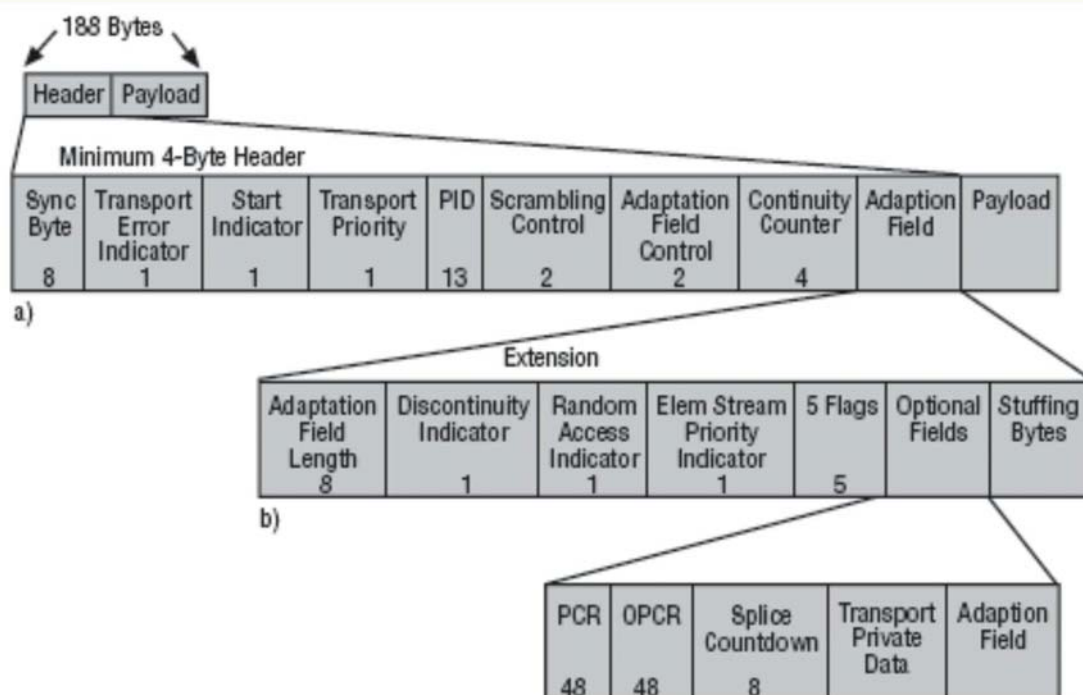
Transport Stream

- ■ **MPEG-2 TS = Format de multiplexage**
  - • De plusieurs programmes TV
    - - N * (Vidéo + Audio(s) + Données) à base de temps différentes
  - • Cas particulier: un programme
    - - Single Program Transport Stream (SPTS)
- ■ **Dédiés aux environnements avec erreurs**
- ■ **1 flux de transport = suite de paquets de transport**
  - • Paquets de taille fixe (188 octets)
    - - Ajout de codes correcteurs d'erreurs facilité
    - - Entrelacement plus facile
  - • Possibilité de détecter les débuts et fins de paquets
  - • Synchronisation possible après une perte de paquets
- ■ **Deux mécanismes de transport des données**
  - • Paquets PES: données audio-vidéo
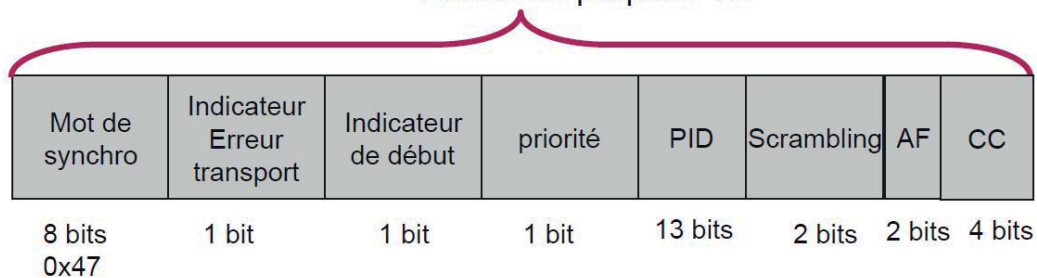 - • Sections: métadonnées, EPG, etc…

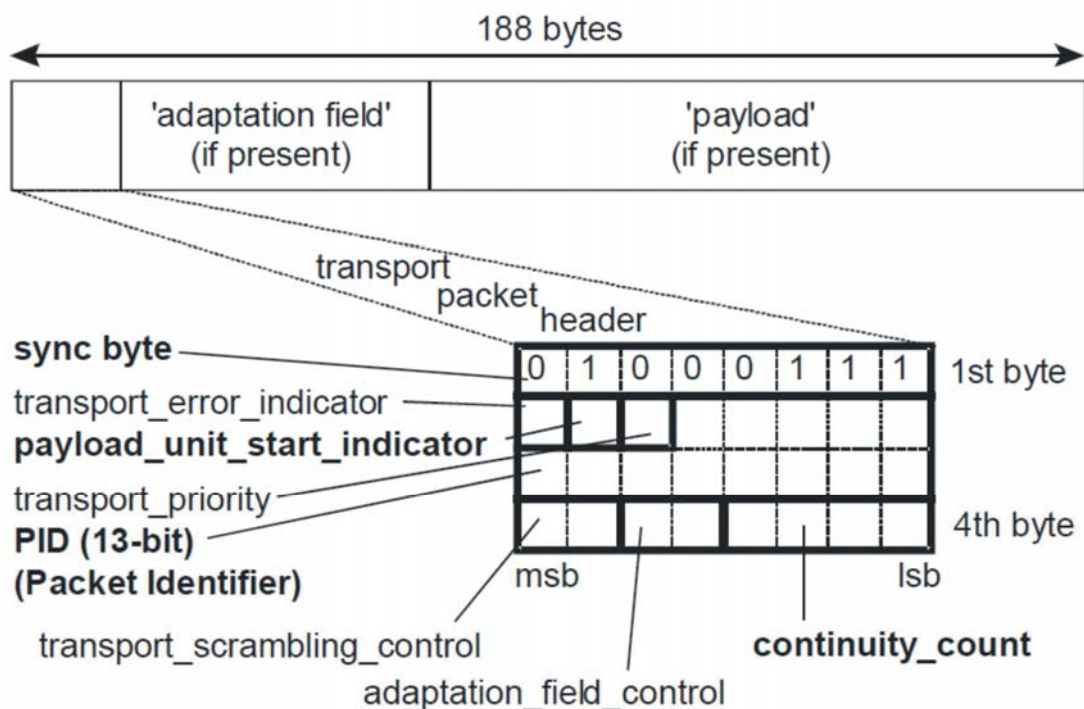# From PES to Transport Stream Packets (188 or 204 Bytes)

Transport Stream
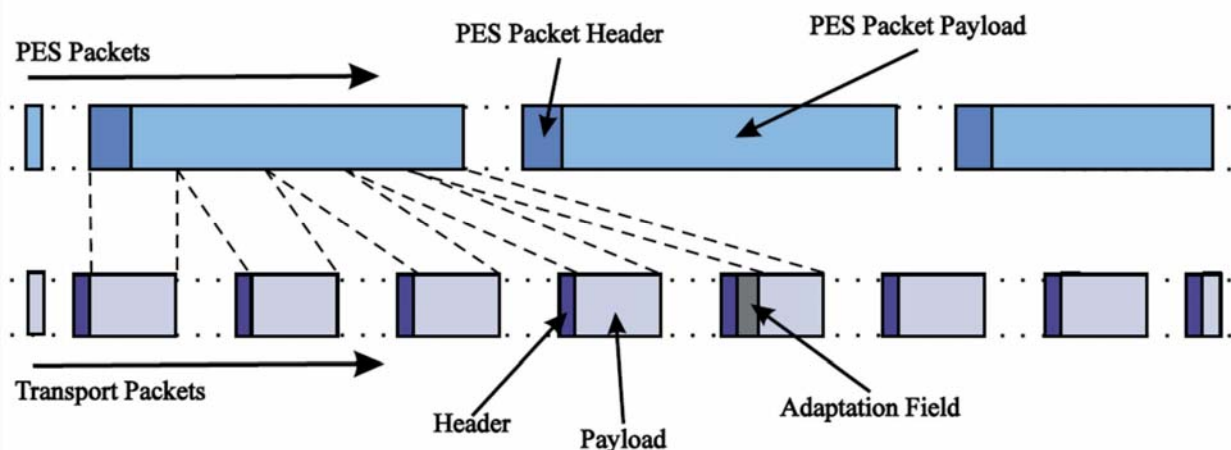
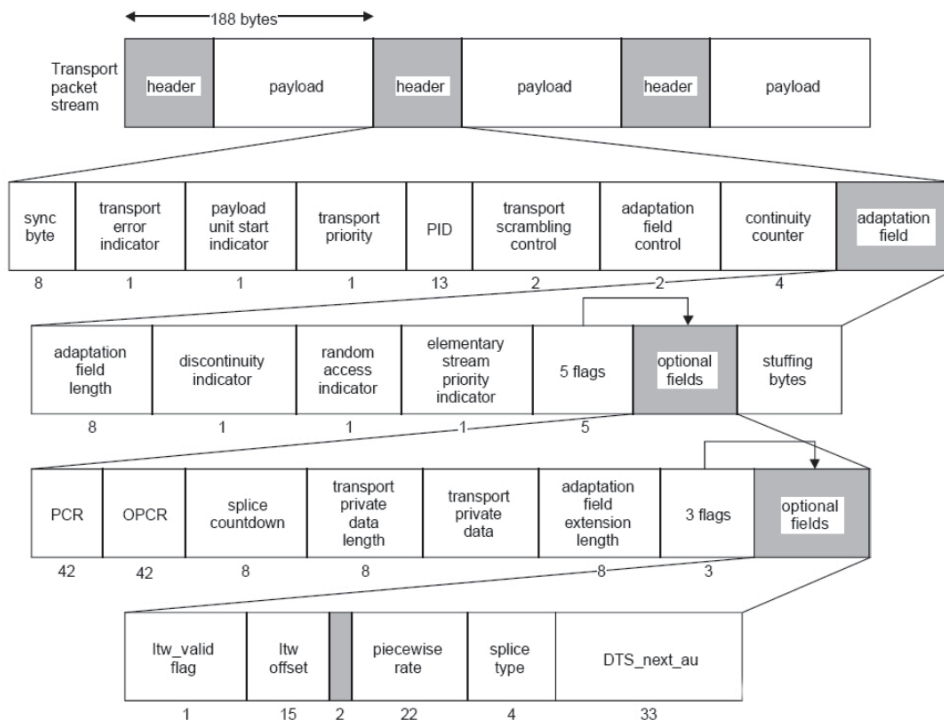- ■ **Paquets de taille fixe (188 octets)**
  - • Entête (4 octets) :
    - - Mot de synchronisation = permet de synchroniser en cas d'erreur
    - - Indicateur d'erreur: si des erreurs ne sont pas corrigées dans le reste du paquet TS
    - - Identifiant de paquet (PID) permet l'identification du type de paquet
    - - Indicateur de début
    - - Indicateur de priorité
    - - Indicateur d'embrouillage
  - • Données
    - - Paquets PES ou Données sections ou bourrage

Entête de paquets TS

Mot de synchro	Indicateur Erreur transport	Indicateur de début	priorité	PID	Scrambling	AF	CC
8 bits 0x47	1 bit	1 bit	1 bit	13 bits	2 bits	2 bits	4 bits

Transport stream Packets Header Information

188 bytes

	'adaptation field' (if present)	'payload' (if present)

transport packet header

```
0 1 0 0 0 1 1 1    1st byte



                   4th byte
```

- sync byte
- transport_error_indicator
- **payload_unit_start_indicator**
- transport_priority
- **PID (13-bit) (Packet Identifier)**
- transport_scrambling_control
- adaptation_field_control
- **continuity_count**

msb   lsb

Transgport Stream

Transport Stream

- **Indique le flux logique de destination des données**
- **PID Réservés**
  - Données de type PSI (Program Specific Information)
    - Program Assocation Table (PAT)
    - Conditional Acces Table (CAT)
    - DVB Tables

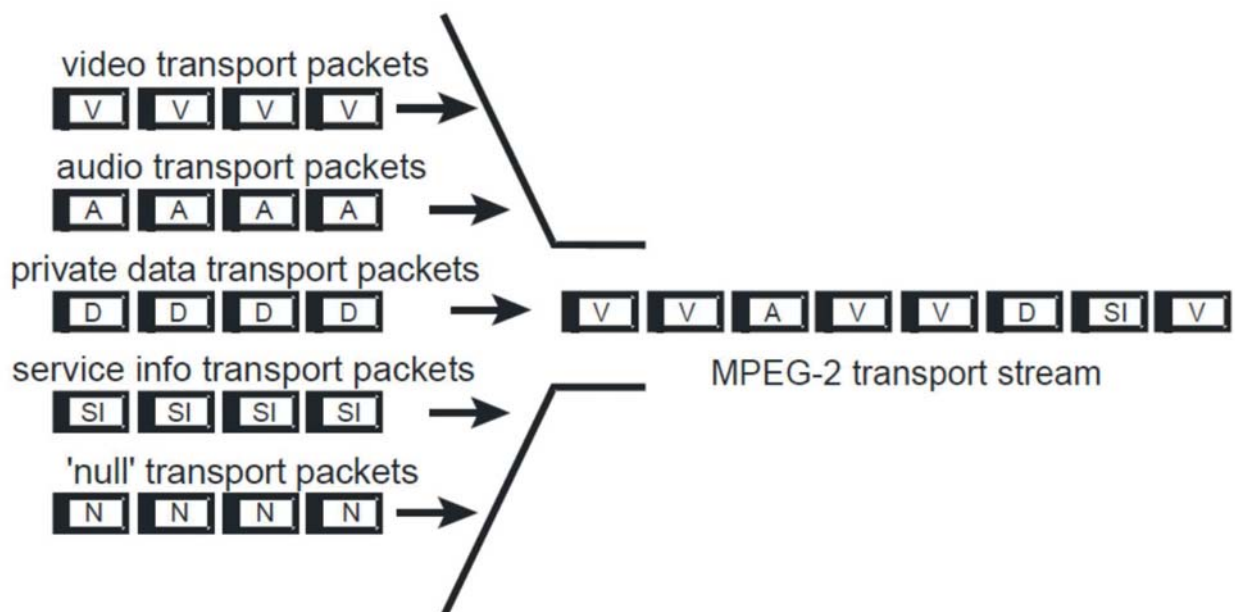| Valeur du PID	Description
0x0000	Program Association Table (PAT)
0x0001	Conditional Access Table (CAT)
0x0002 – 0x000F	Valeurs réservées
0x0010 – 0x1FFE	Valeurs utilisables pour: -Network information table (NIT) -Program Map Table (PMT) -PID des flux élémentaires
0x1FFF	Paquet vide

Transport Stream

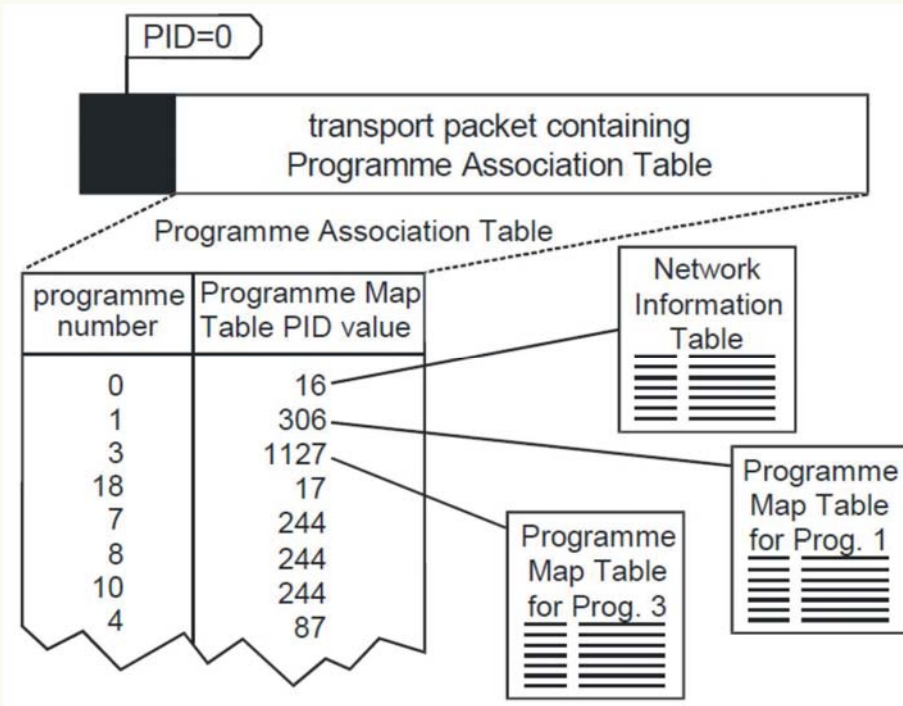Program Association Table (PAT)
- Liste des programmes dans le TS
  - Numéro de Programme, PID de la PMT

Program Map Table (PMT)
- Liste des flux dans un programme
  - Stream Type, PID, méta données
- Méta données du program
- PID du flux portant l'horloge

MPEG-2 Transport Stream Multiplexer

video transport packets
[V] [V] [V] [V] →

audio transport packets
[A] [A] [A] [A] →

private data transport packets
[D] [D] [D] [D] →

service info transport packets
[SI] [SI] [SI] [SI] →

'null' transport packets
[N] [N] [N] [N] →

[V] [V] [A] [V] [V] [D] [SI] [V]

MPEG-2 transport stream

PID=0

transport packet containing
Programme Association Table

Programme Association Table

programme number	Programme Map Table PID value
0	16
1	306
3	1127
18	17
7	244
8	244
10	244
4	87

Network Information Table

Programme Map Table for Prog. 1

Programme Map Table for Prog. 3

Clock Reference Data for Synchronization of ES

incoming transport stream or programme stream

video access units comprising original video elementary stream

admit video PES data

buffer

decode video access unit

admit clock reference data

decoder clock

demultiplexer

audio access units comprising original audio elementary stream

admit audio PES data

buffer

decode video access unit

to further elementary stream decoders

Clock Reference Insertion

Program Clock Reference