# SWITCHING OVERVIEW

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2020

# GENERAL AGENDA 1/2

- Introduction : Justification, quick history, main components ..
- Input ouput
- Transport, TDM technologie
- Switching matrix
- Signaling
- CPU
- Intelligent peripherals
- Traffic calculation

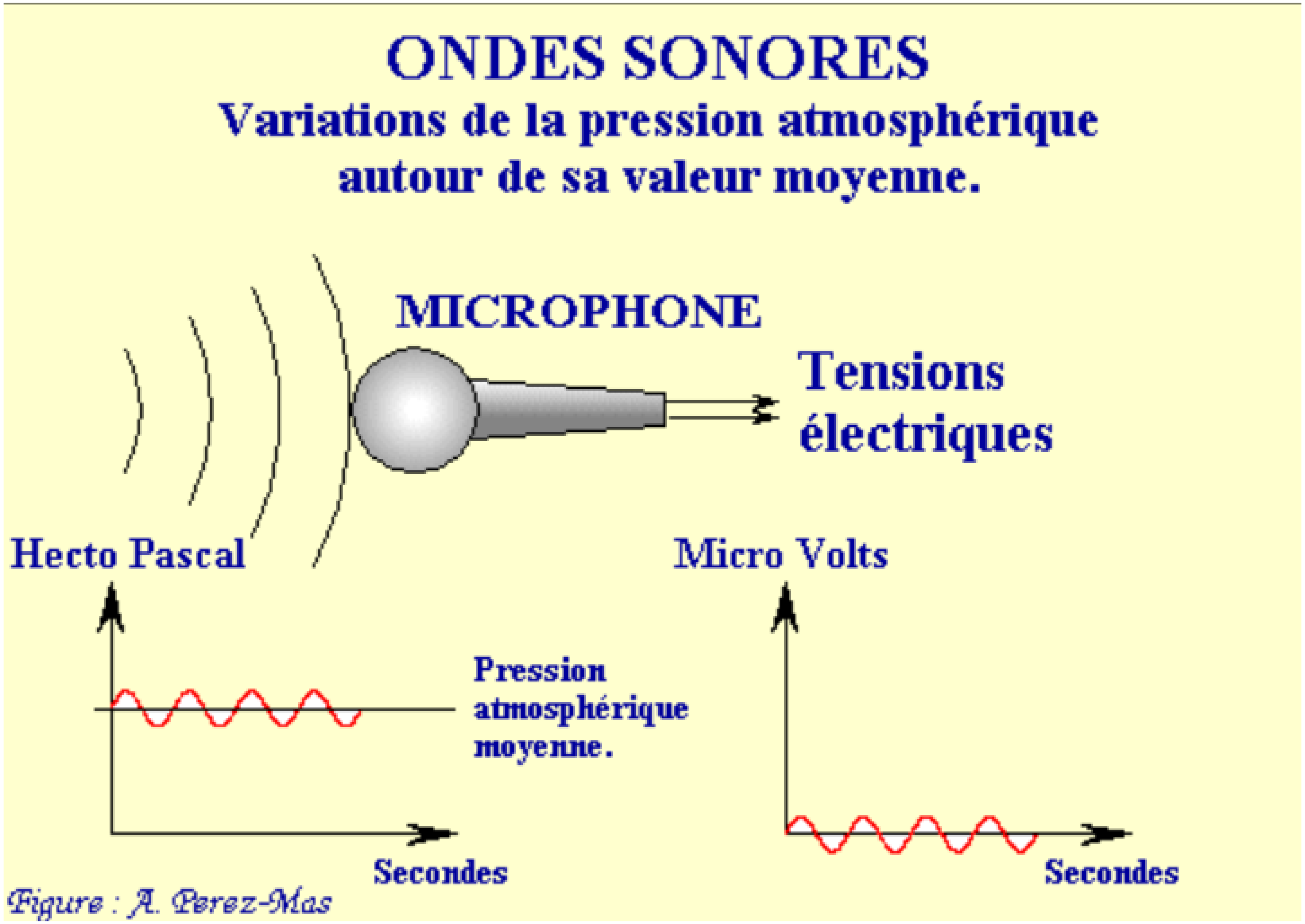
# GENERAL AGENDA 2/2

- Conclusion
- Questions

# INTRODUCTION

Quick history,justification, main components ..

# Quick history



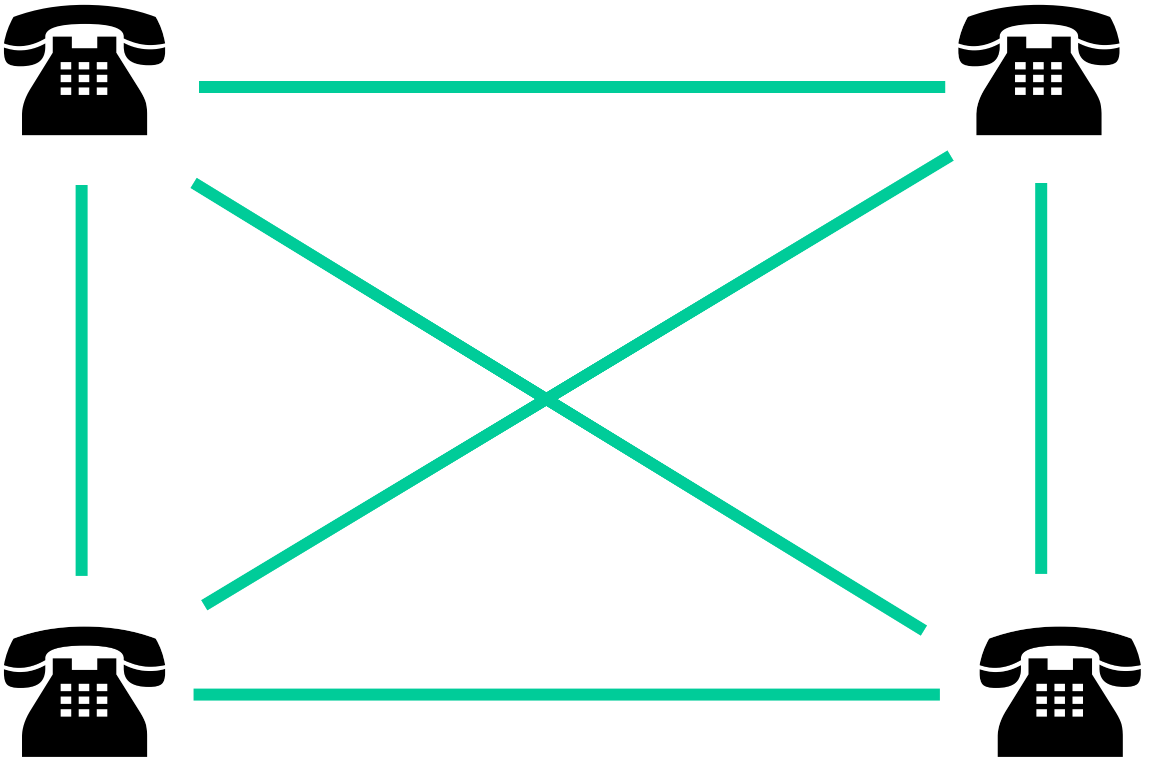
# Quick history Analogic/Digital

| |
|---|
| *Un microphone traduit les signaux sonores - variations de la pression atmosphérique - en variations proportionnelles de tension élecrique,<br>- qui seront appliqués à des amplificateurs puis, finalement, à des haut-parleurs<br>- à moins qu'ils ne soient envoyés sur une ligne de transmission.<br>etc.* |
| D'abord, pourquoi "Analogique" ?<br>Dans les courbes ci-dessus les courbes du signal réel et de sa représentation par une tension électrique présentent une certaine analogie de forme (homothétie).<br><br>Le signal numérique est, lui, une suite de nombres. Aucune analogie visuelle.<br>Une toute autre technique. |

# Quick history

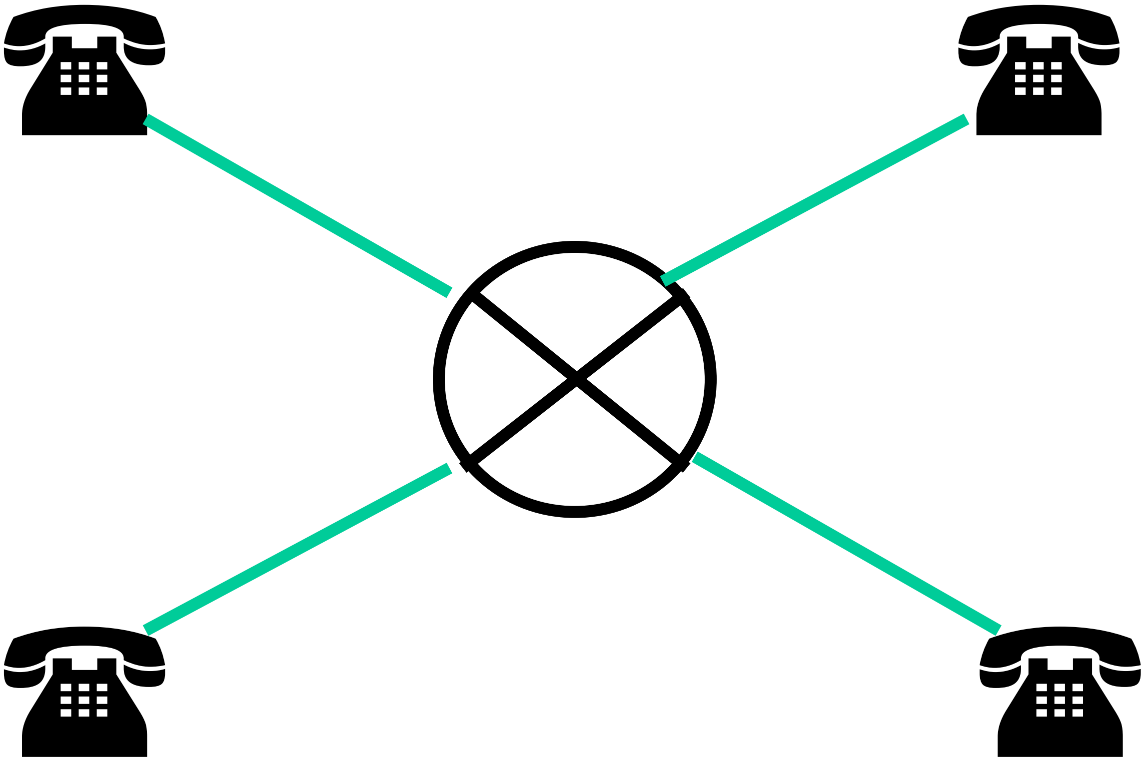
- The transmission was digital at the first step and analog
  - • Morse transmission (Digital)
  - •Voice transmission (Analog)
- Patent regarding the telephone has been registered by A.G Bell in 1876 :
  - •Analog line and modulation,
  - •Reversible Microphone/ Receiver
- The switch introduction came quickly 1878 two years after the A.G Bell patent registration.

# VOICE NETWORK WITHOUT SWITCH



6 links for a full meshed network

# VOICE NETWORK WITH A SWITCH



4 links with a switch

# BENEFIT WITH AN EXAMPLE

- N phones :  NX(N-1)/2 Links for a meshed network
- N phones: N Links and one switch
- Example 100 phones :  100 links instead 4950 links without a switch

# QUICK HISTORY

## The first switches were :

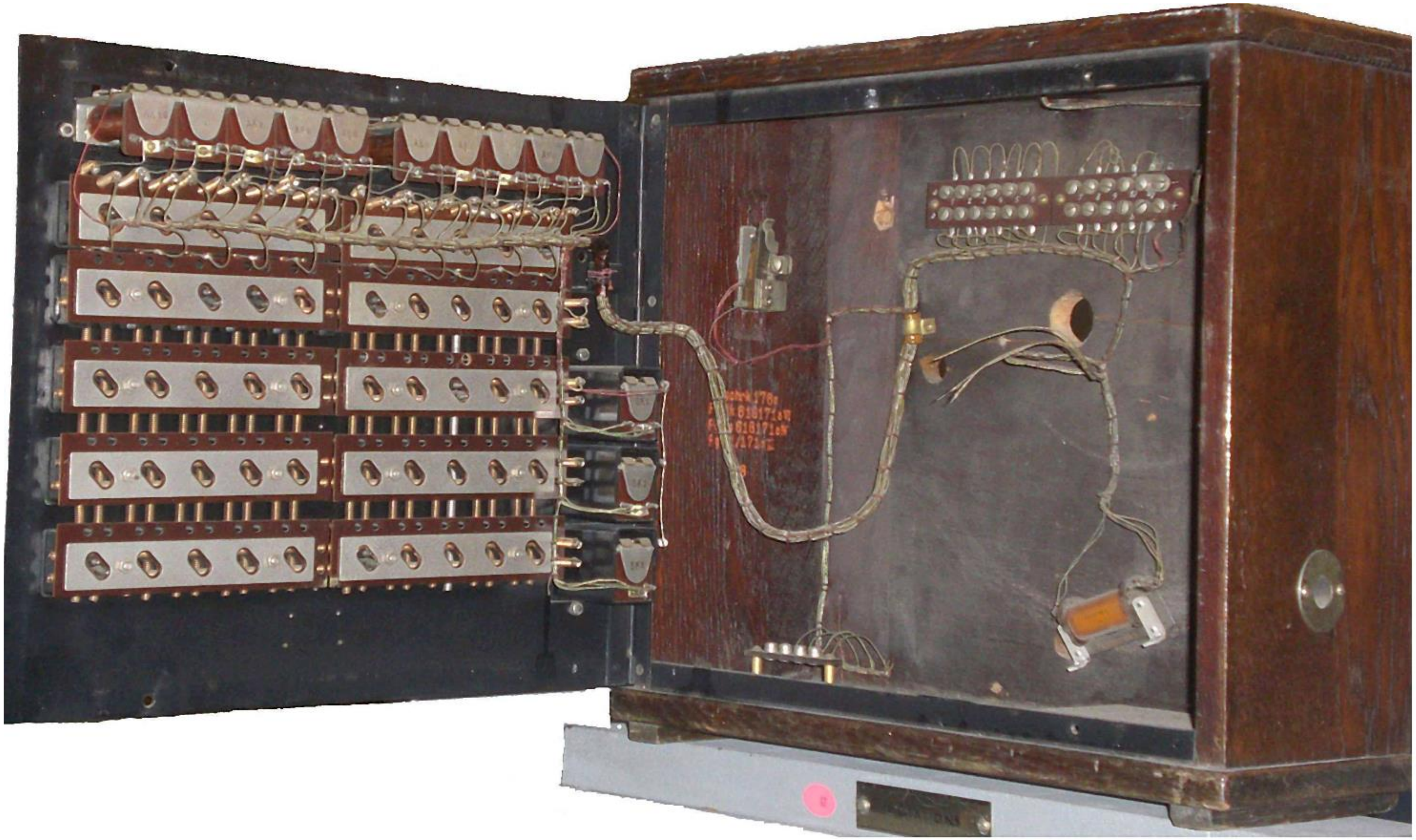
- Manual done by a human operator then,
- Mechanic then,
- Electromechanical and now
- Electronic.

# First type of phone

«Au début du téléphone, l'utilisateur, dit « abonné » car il possède un contrat avec le fournisseur du réseau téléphonique, actionne la manivelle de son poste téléphonique pour « sonner » ou appeler l'opératrice; l'opératrice rentre en contact phonique avec le demandeur pour lui demander qui il veut contacter puis connecte physiquement sa ligne à la ligne de destination pour atteindre le demandé. »

## Subscriber side

# Switch Manual done by a human operator

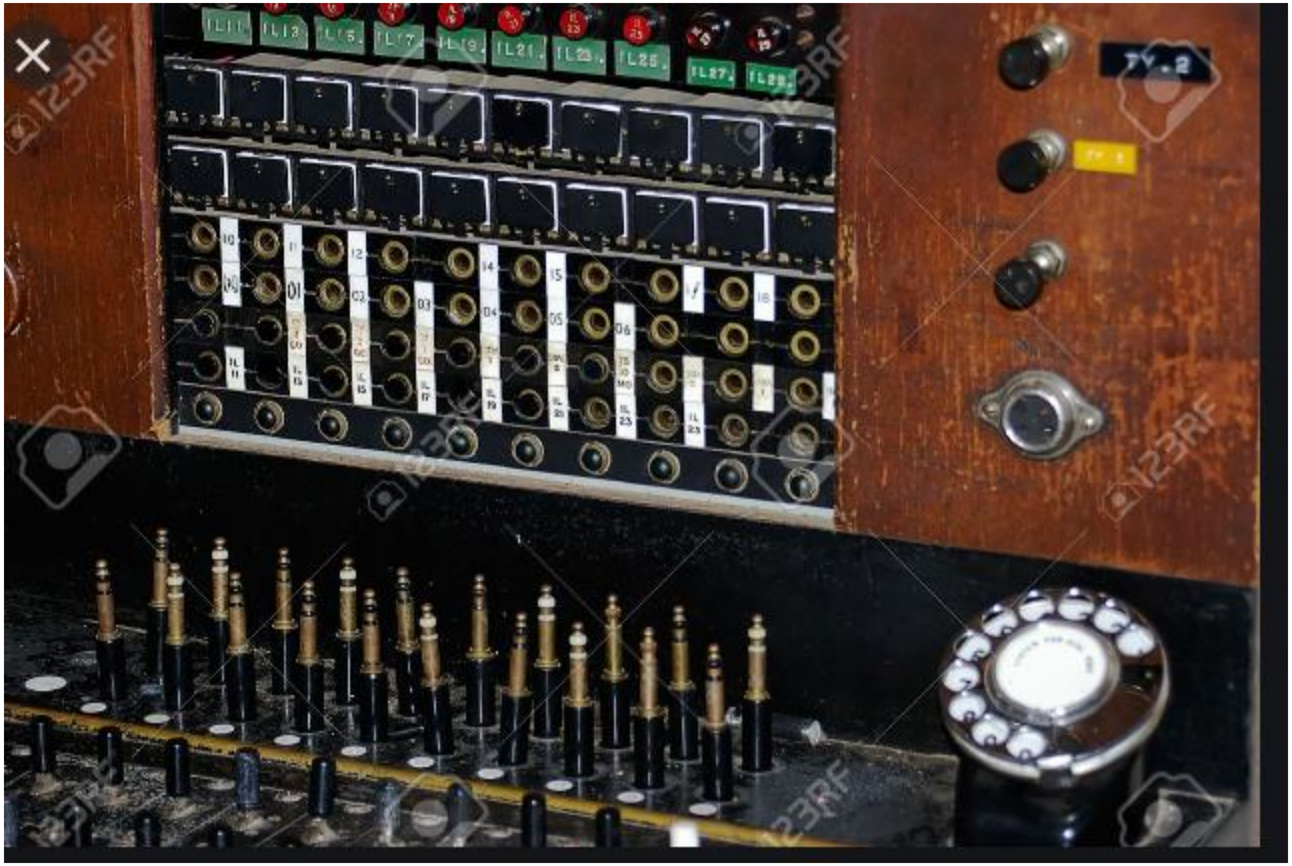


## Switch board Inside View

# Manual done by a human operator


Switch board Inside View

# Manual done by a human operator



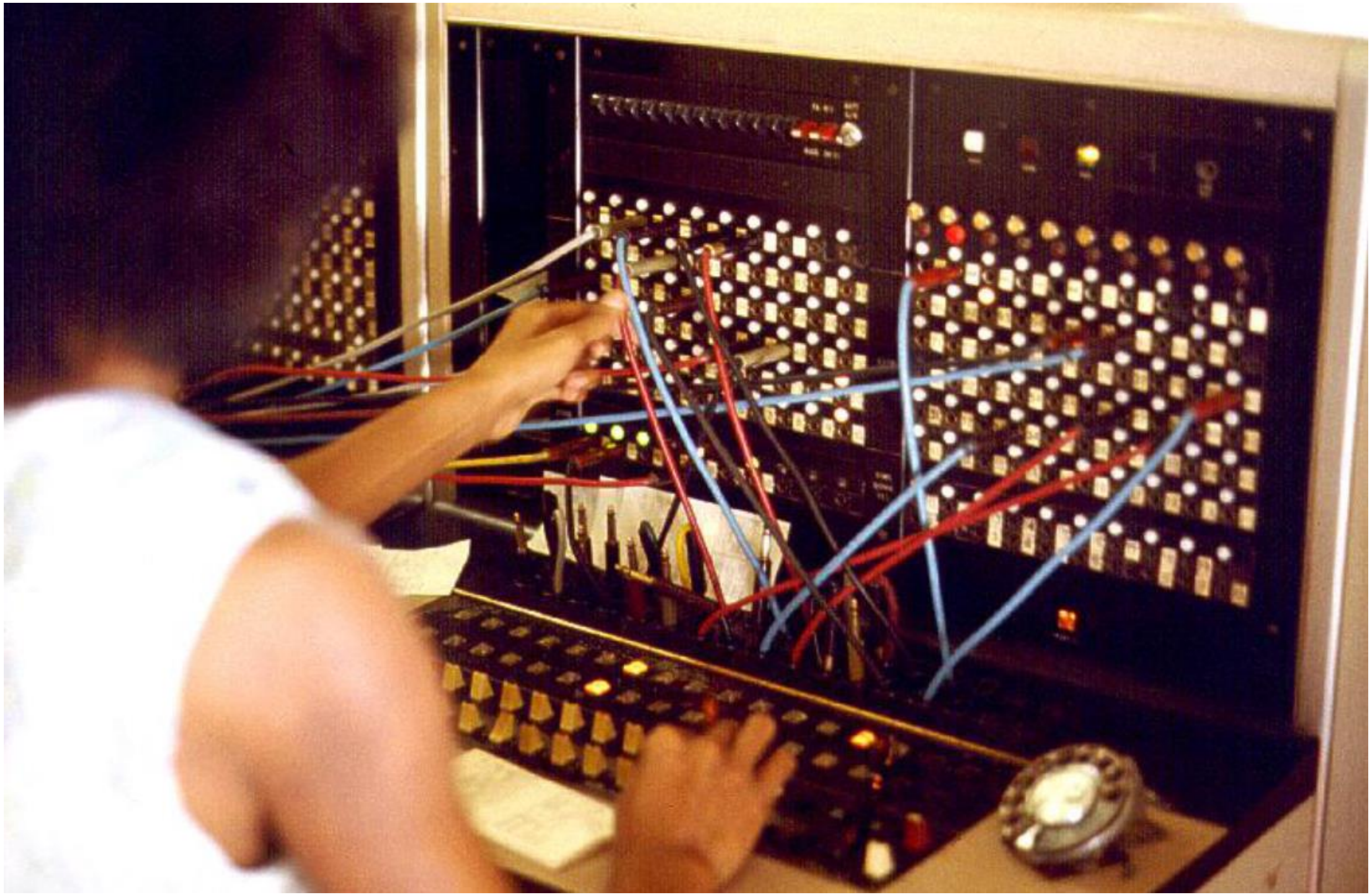

Switch board front View with the jack plug

# Manual done by a human operator

Switch Board operator

# Manual done by a human operator

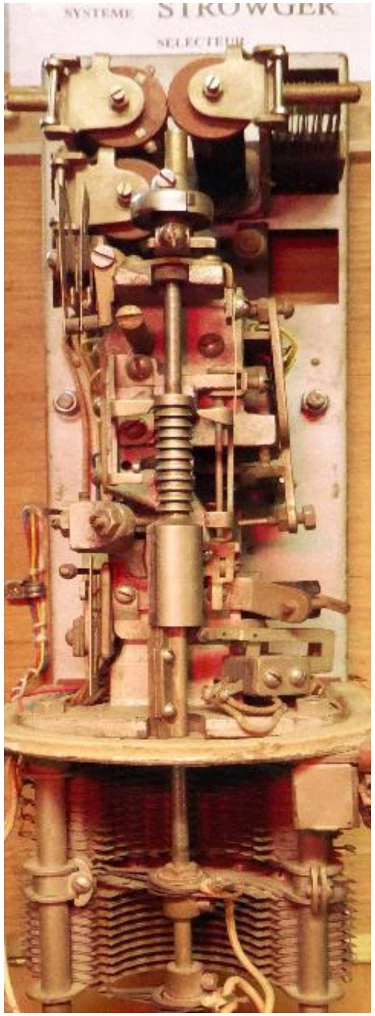
# Manual done by a human operator



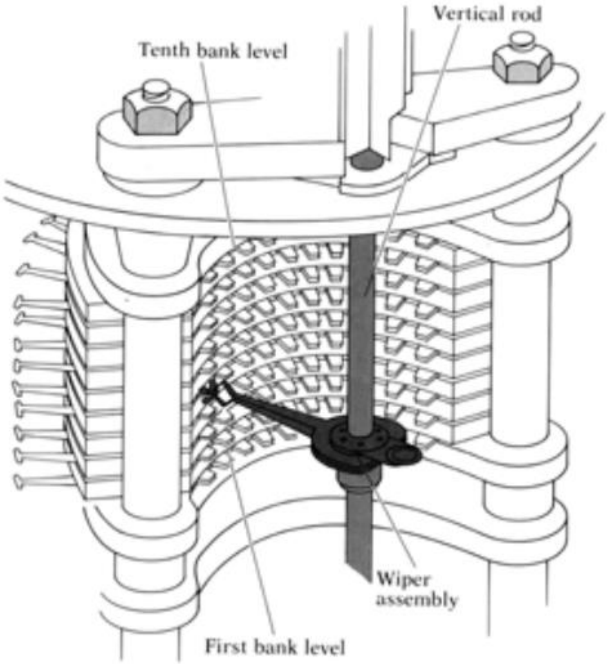
PBX 1975

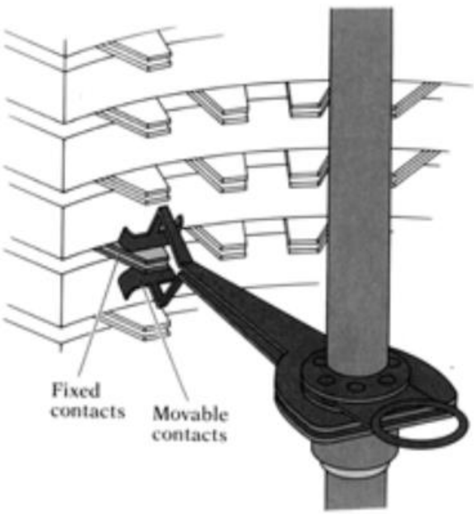
# Mechanic switch

Almon Brown Strowger (1839-1902), was at the begining an undertaker, was motivated to invent an automatic telephone exchange after having difficulties with the local  telephone  operators, one of whom was the wife of a competitor. He was said to be convinced that she, as one of the manual telephone exchange operators, was sending calls "to the undertaker" to her husband.



# Mechanic Strowger step by step switch




*The movable contacts in a step-by-step switch can connect to any of a 100 different pairs of fixed contacts, each leading to a different line.*

https://www.youtube.com/watch?v=xZePwin92cI&feature=emb_title

https://www.youtube.com/watch?v=cNNKLuM8yY8

# Electromecanical switch Pentaconta switch 1950-1970

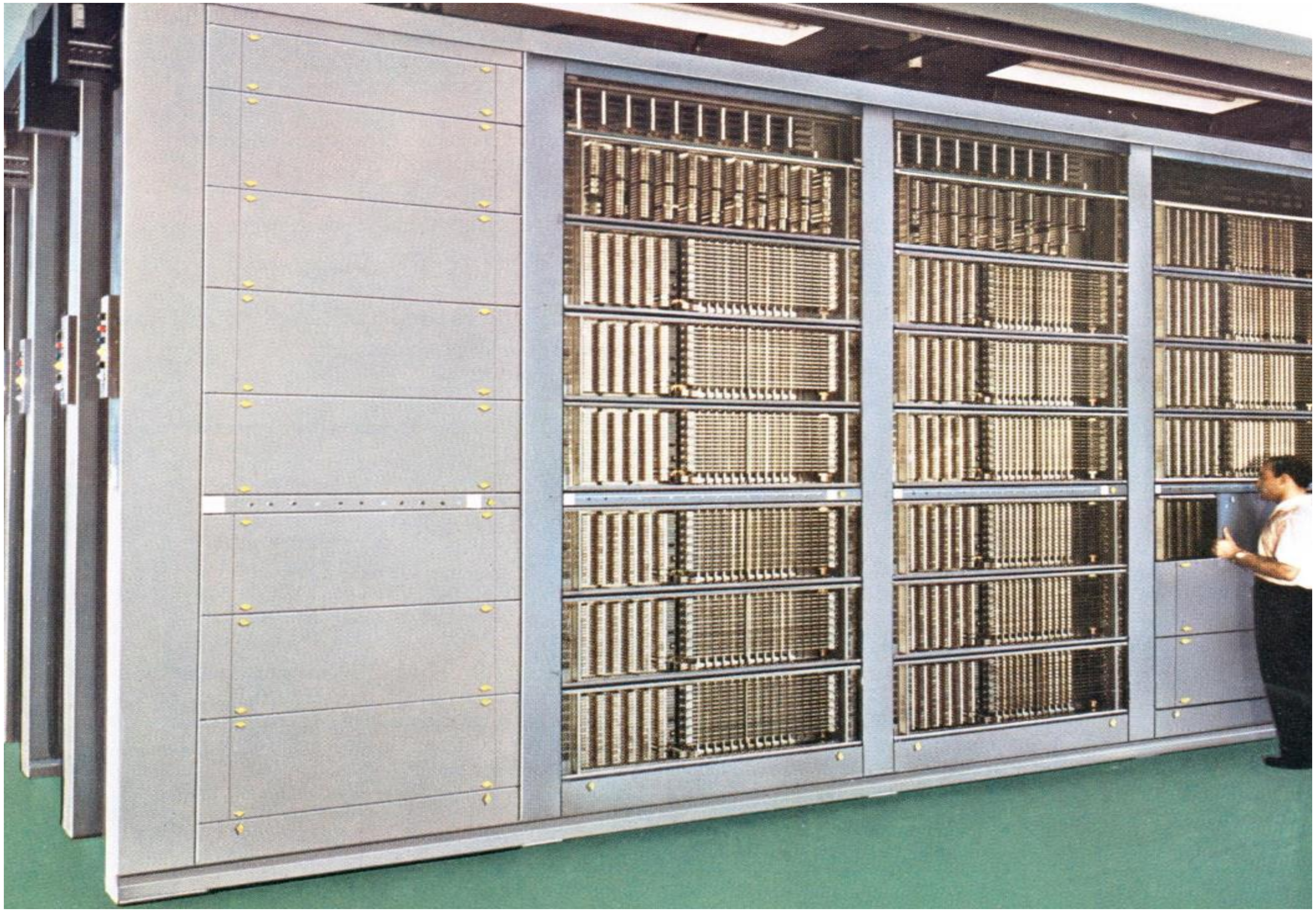
https://www.youtube.com/watch?v=Ahdd-r3Oq_o

https://www.youtube.com/watch?v=oM6OLeGOE6M

PENTA : Subscribers grouped by primary module of 50

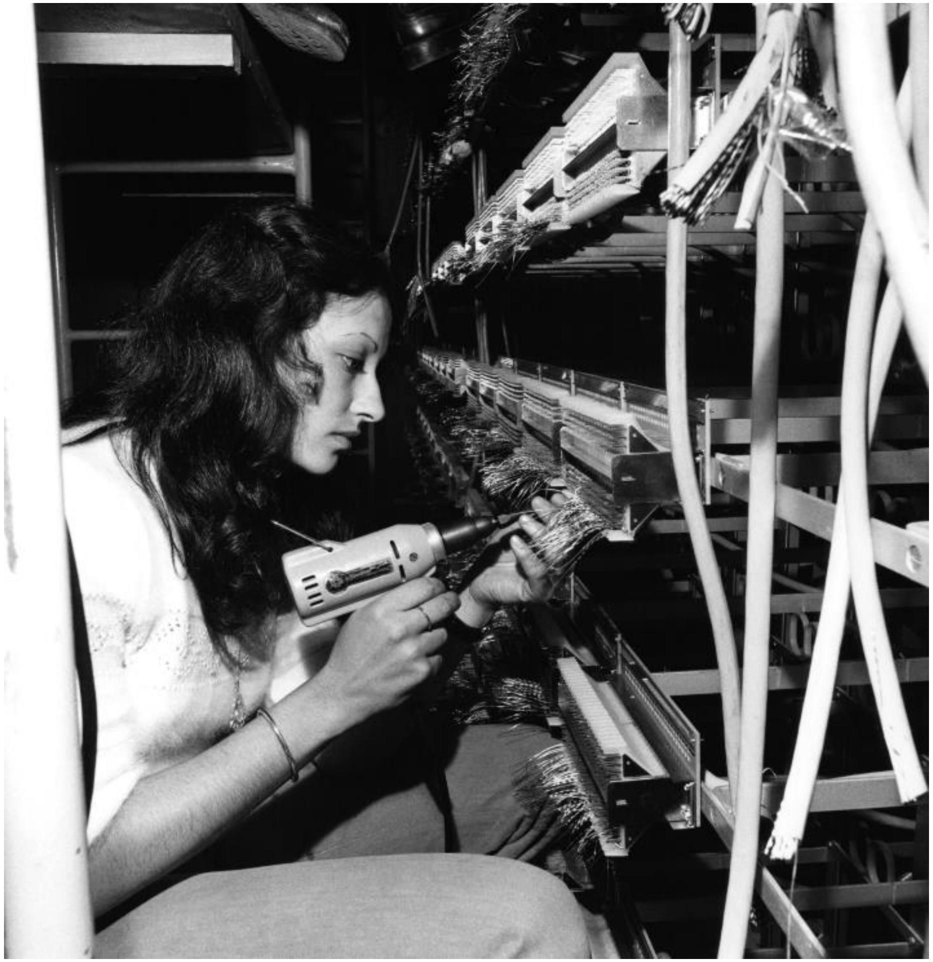
Vendor : LMT & CGCT subsidiaries of ITT (an American company)

# Pentaconta switch 1000A Model Crossbar

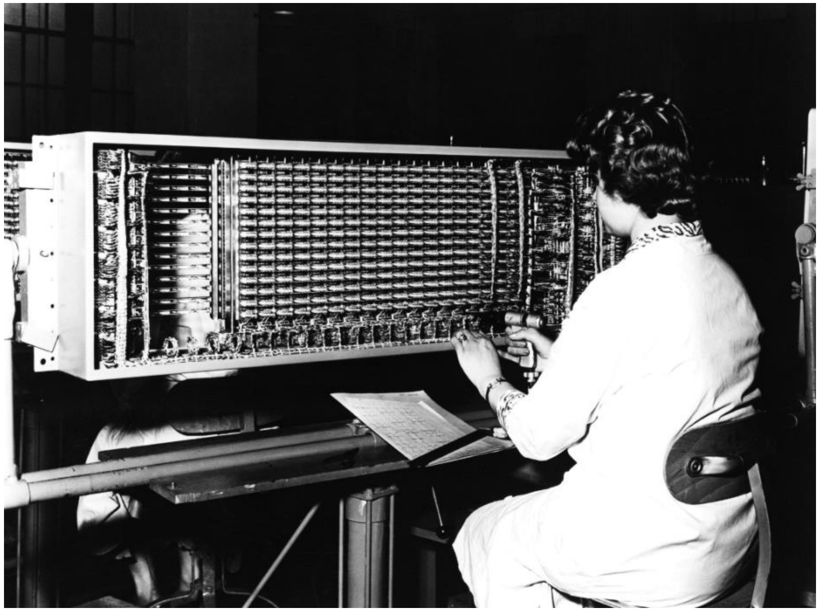


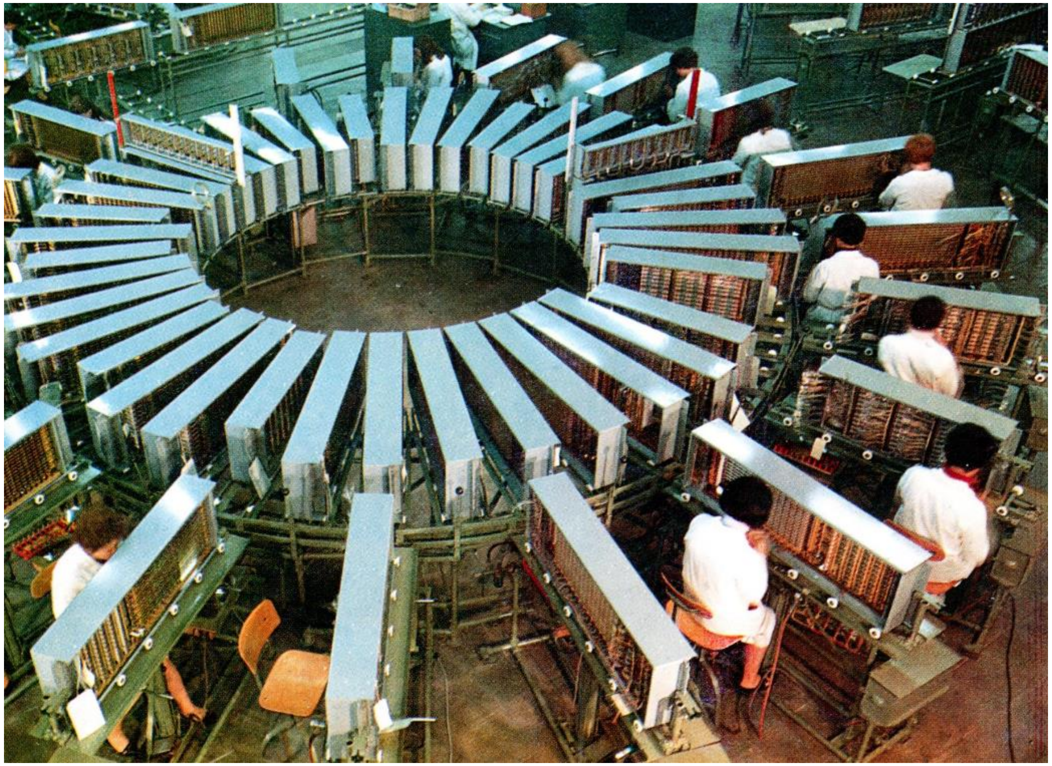
# PENTACONTA GCID Montsouris Transit Switch Crossbar commissioned 1977 - Decommissioned 1993
# Vendor : LMT

# PENTACONTA crossbar wiring phase

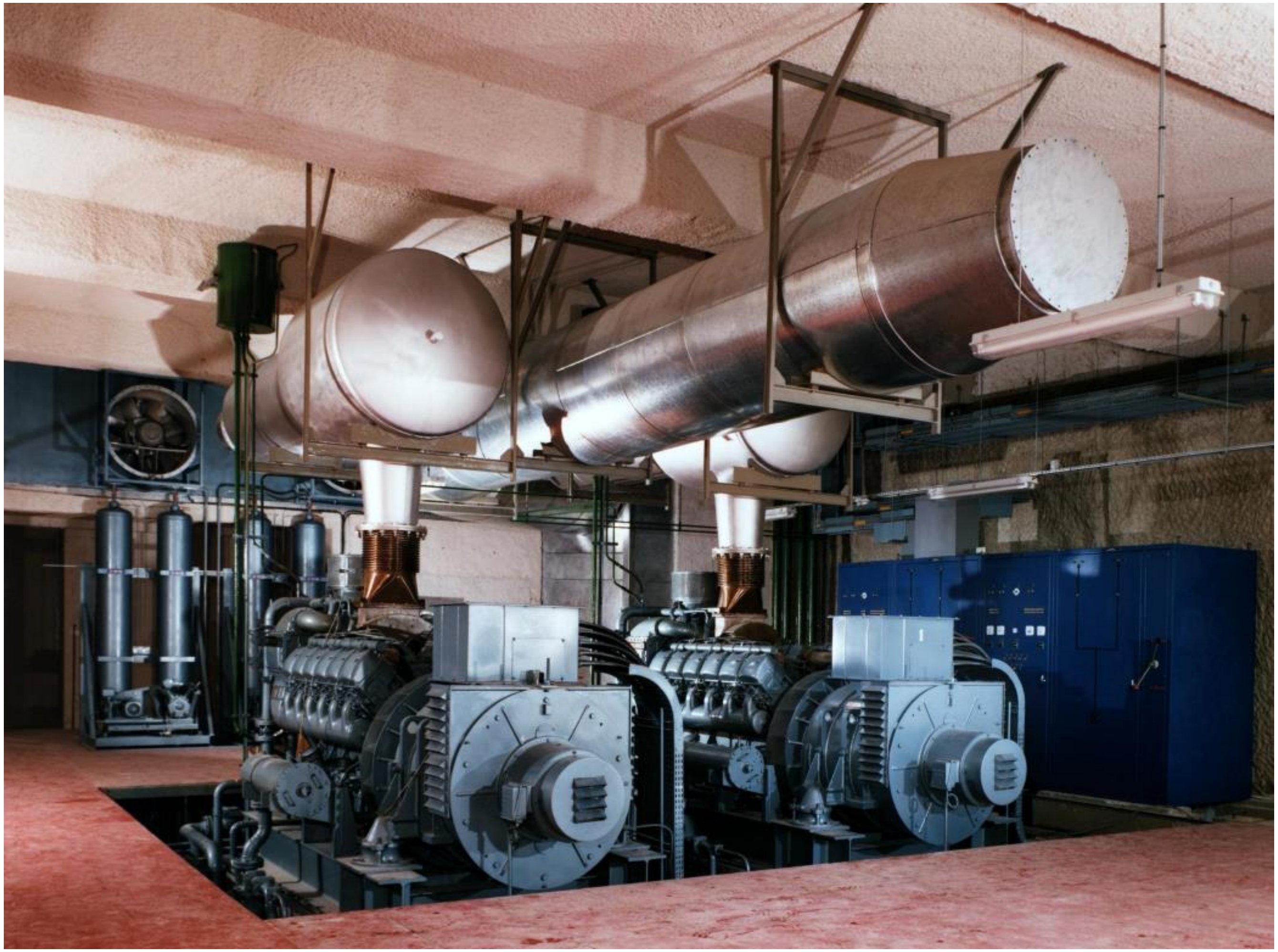


# PENTACONTA wraping phase





# PENTACONTA Stand by Electric Generator



# First Electronic TDM switch in France « The platon » in 1970 for 800 subscribers (Electronic Switch)

# Nortel « DSM 100 » Local Switch (Electronic Switch) 2000 years

# TYPE OF SWITCHES

We could consider that we have two type of switches :

- Private corporate switches (eg. PABX).

- Public Switches used by operators

# MAIN Digital Switching System VENDOR

Today the market is shared by 5 vendors which propose 6 different public switches :

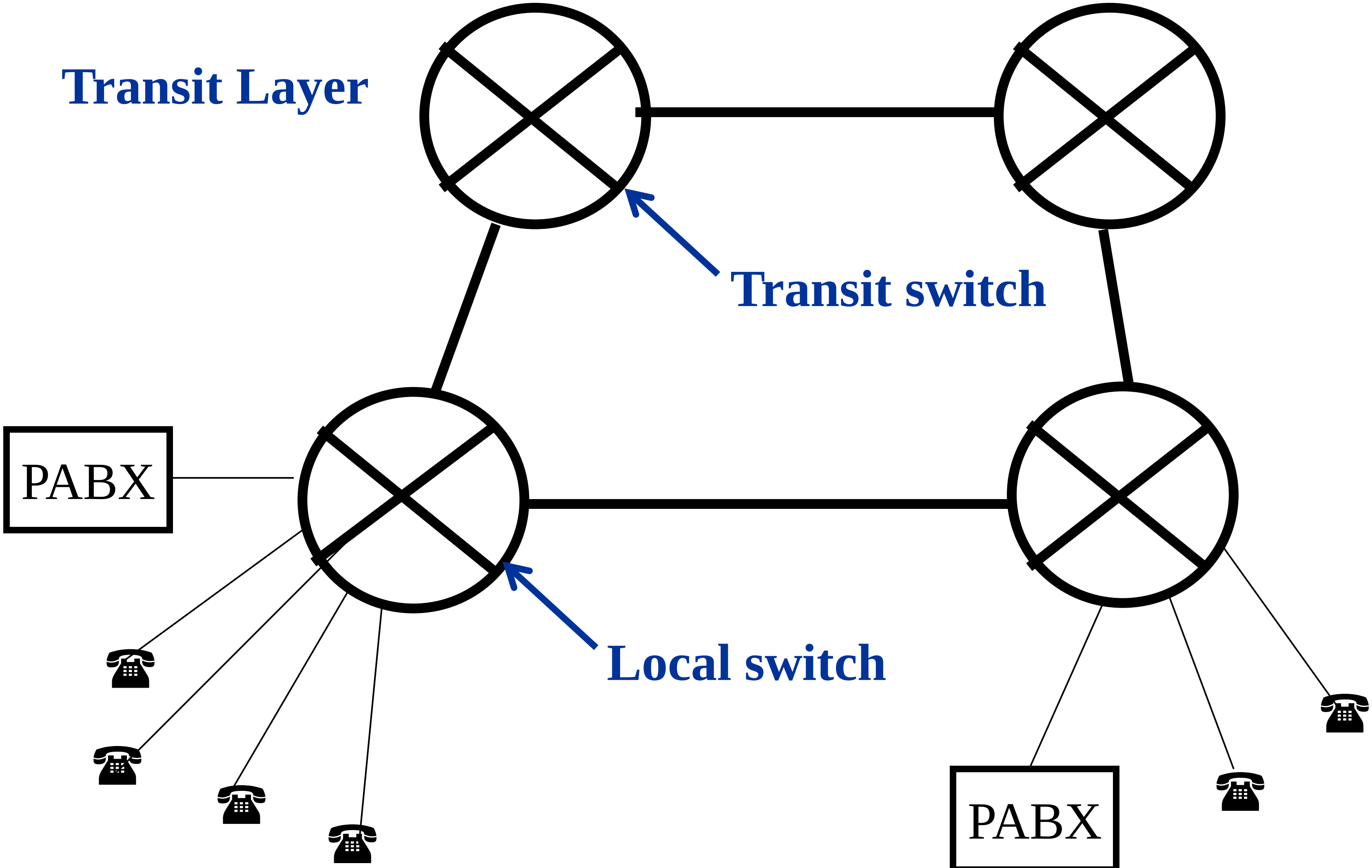
- SIEMENS : EWSD (1975-2017)
- ALCATEL : E10 (1976) ( &CGE product) S12 (ITT product) merge of CGE and ITT.
- LUCENT TECHNOLOGIES : 5ESS Eletronic Switching System 1982-
- ERICSSON : AXE 10 Automatic eXchange Electric (1975 - .
- NORTEL : DMS (1979 – 2010)

# TYPE OF PUBLIC SWITCHES

## There is 3 family of  public switches

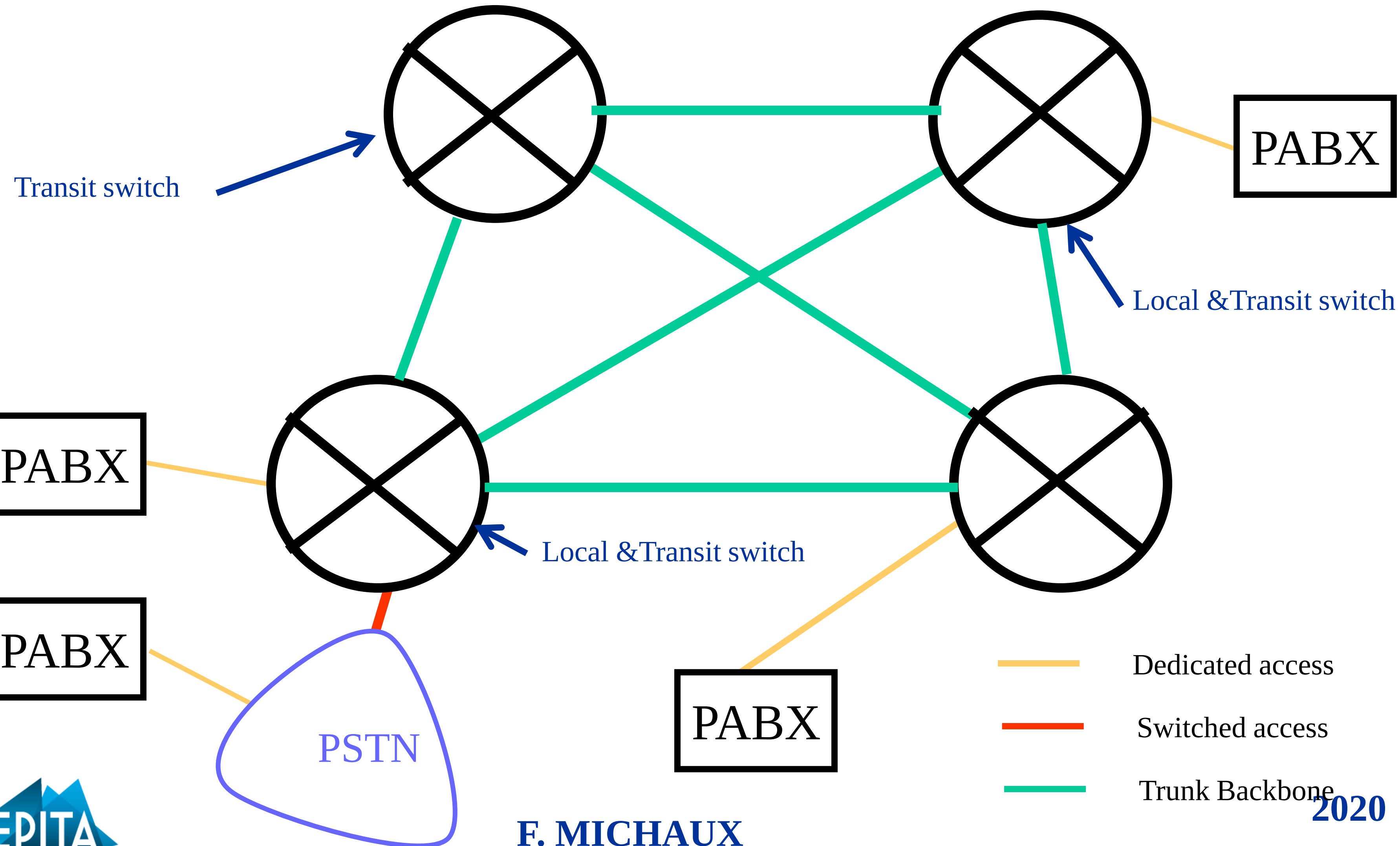
- LOCAL: used to connect customers and others switches
- TRANSIT : Used to interconnect switches
- “TRANS-LOCAL” : Which as the both functions generally used alternate operators which have not enough traffic for having a transit network.

# PUBLIC VOICE NETWORK ARCHITECTURE

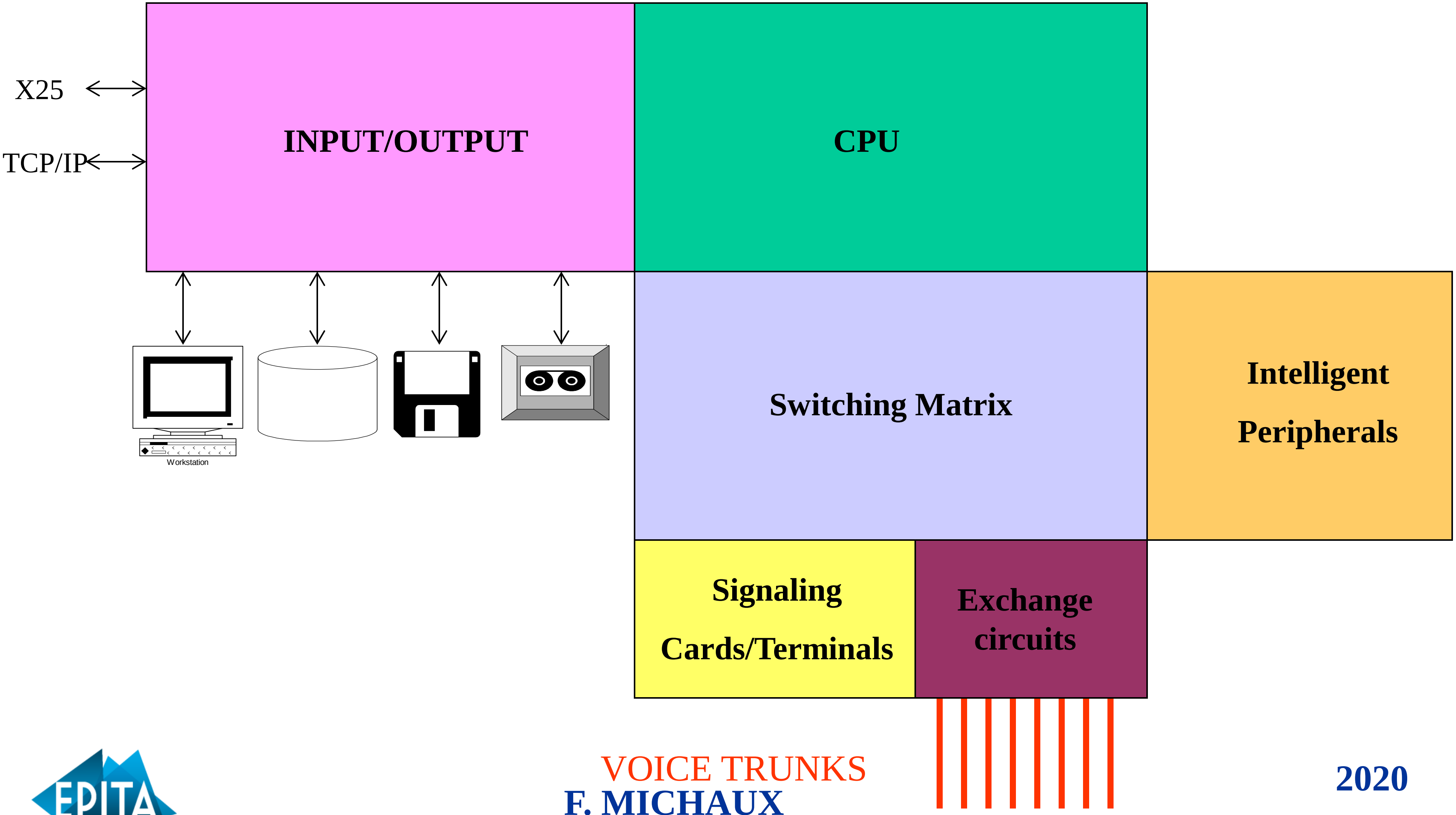


# VOICE NETWORK ARCHITECTURE

**The voice network architecture is flat no transit layer**

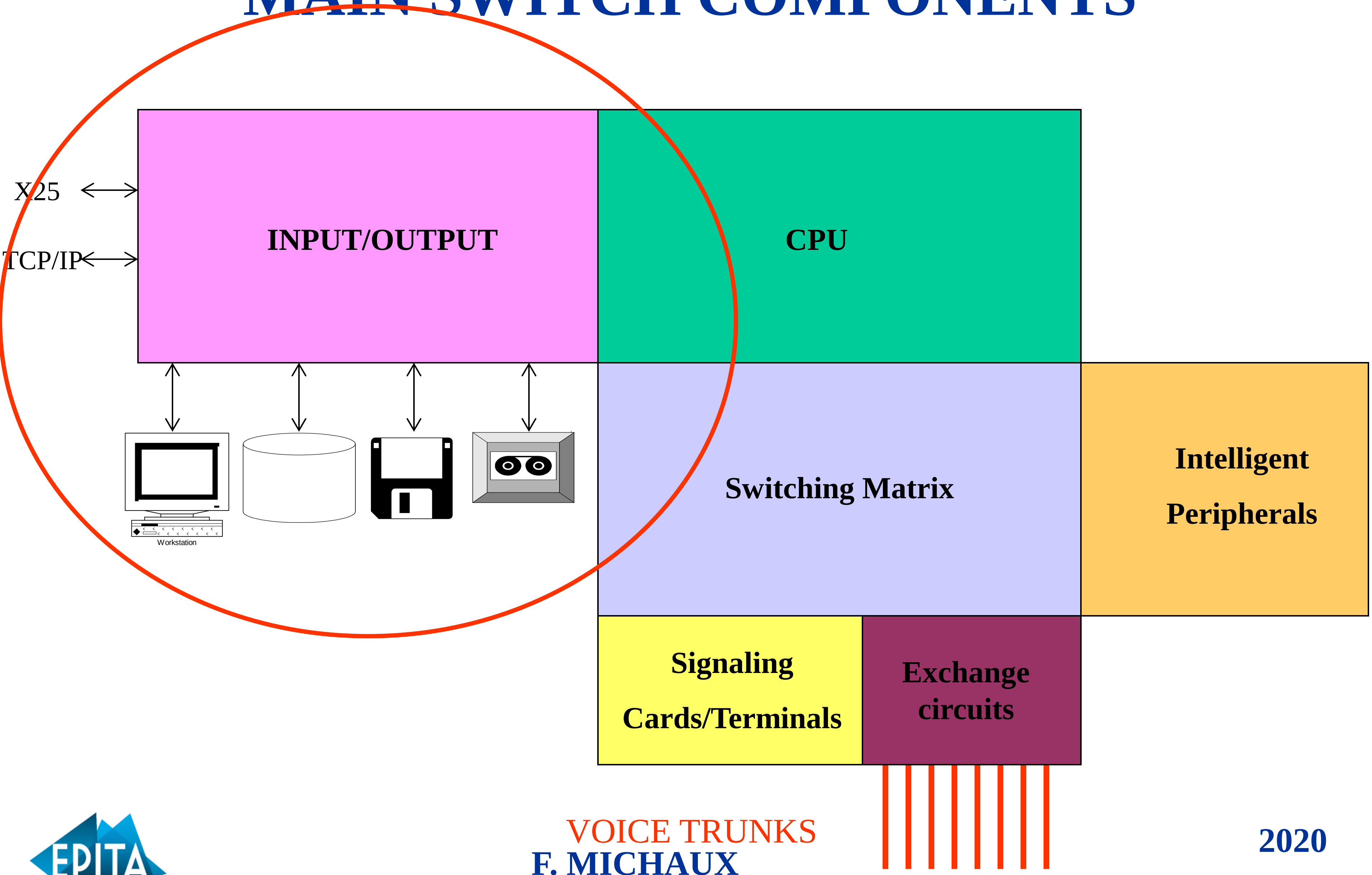


# MAIN SWITCH COMPONENTS



# INPUT/OUPUT

# MAIN SWITCH COMPONENTS



# INPUT/OUTPUT

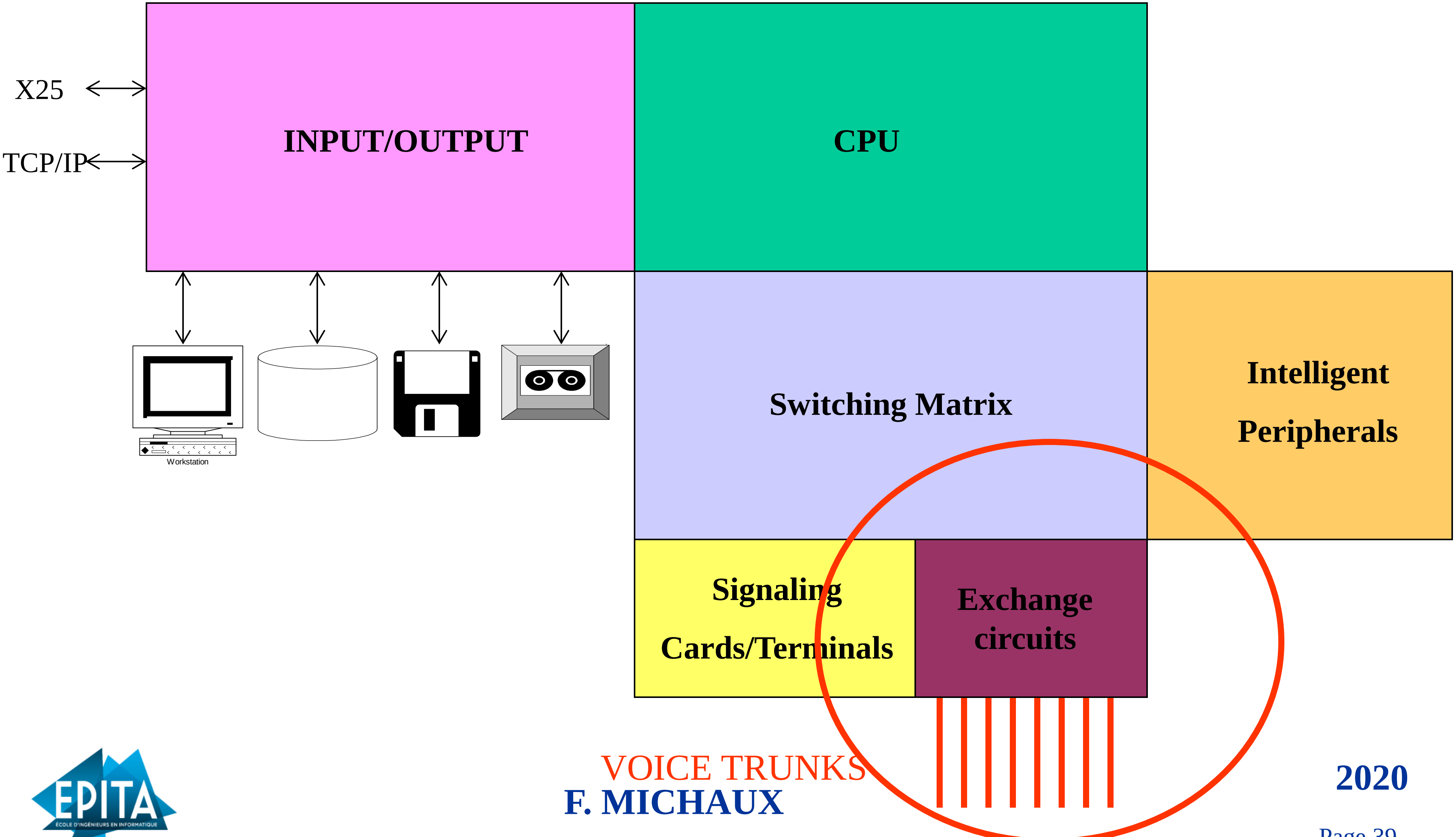
This device is the interface equipment between the switch and

- The billing system X25 or/and TCP/IP.
- Monitoring system remotely and locally.
- Saving system (Call detail records, translations ….
- The disks

# TDM TECHNOLOGIE

Transport, PCM...

# MAIN SWITCH COMPONENTS



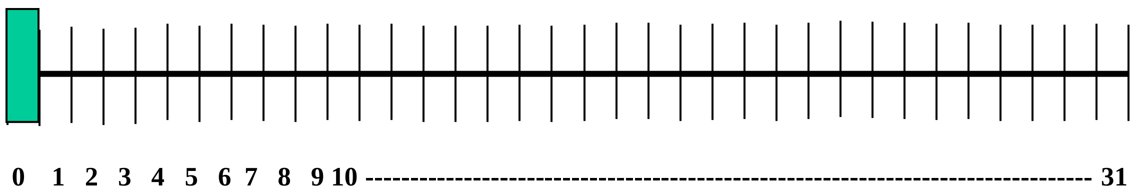
# TDM TECHNOLOGIE

TDM means Time Division Multiplexing

This technologie :

- is known for more than 60 years, but deployed for 30 years. Patent dated before the second world war.
- Consists of divided the time in order to carry in the same link different trafic stream

# TDM TECHNOLOGIE



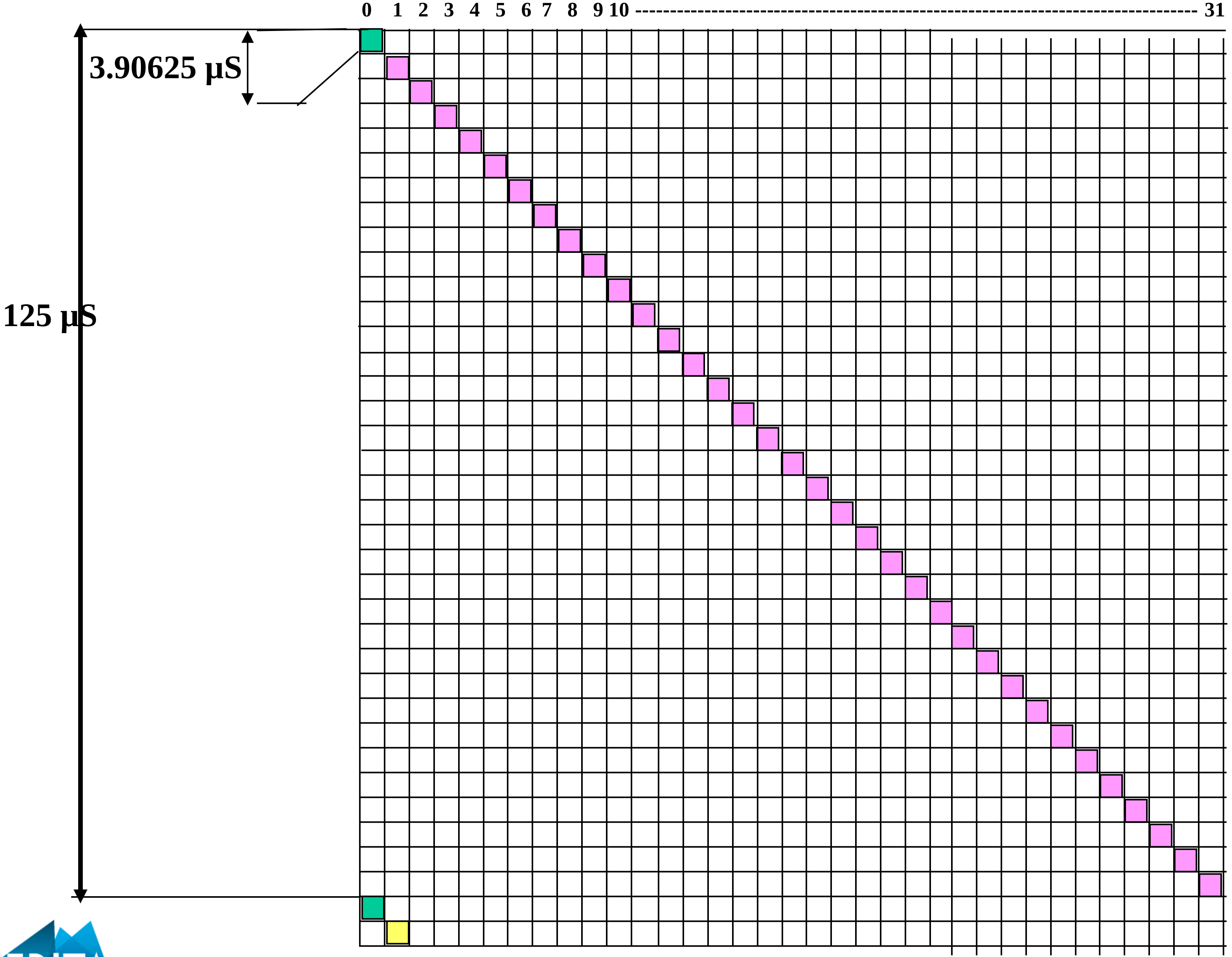

The time is divided in 32 time slots (E1) for the international standart and 24 (T1) for the american standart.

The total rate for the link is 2.048 Mb/s

The rate for the a time slot is 64 Kb/s = 2048/32

The time slot 0 is used for the synchronisation, the paylaod is not 32*64 Kb/s but 31*64 Kb/s

# TDM TECHNOLOGIE



# TDM TECHNLOLOGIE

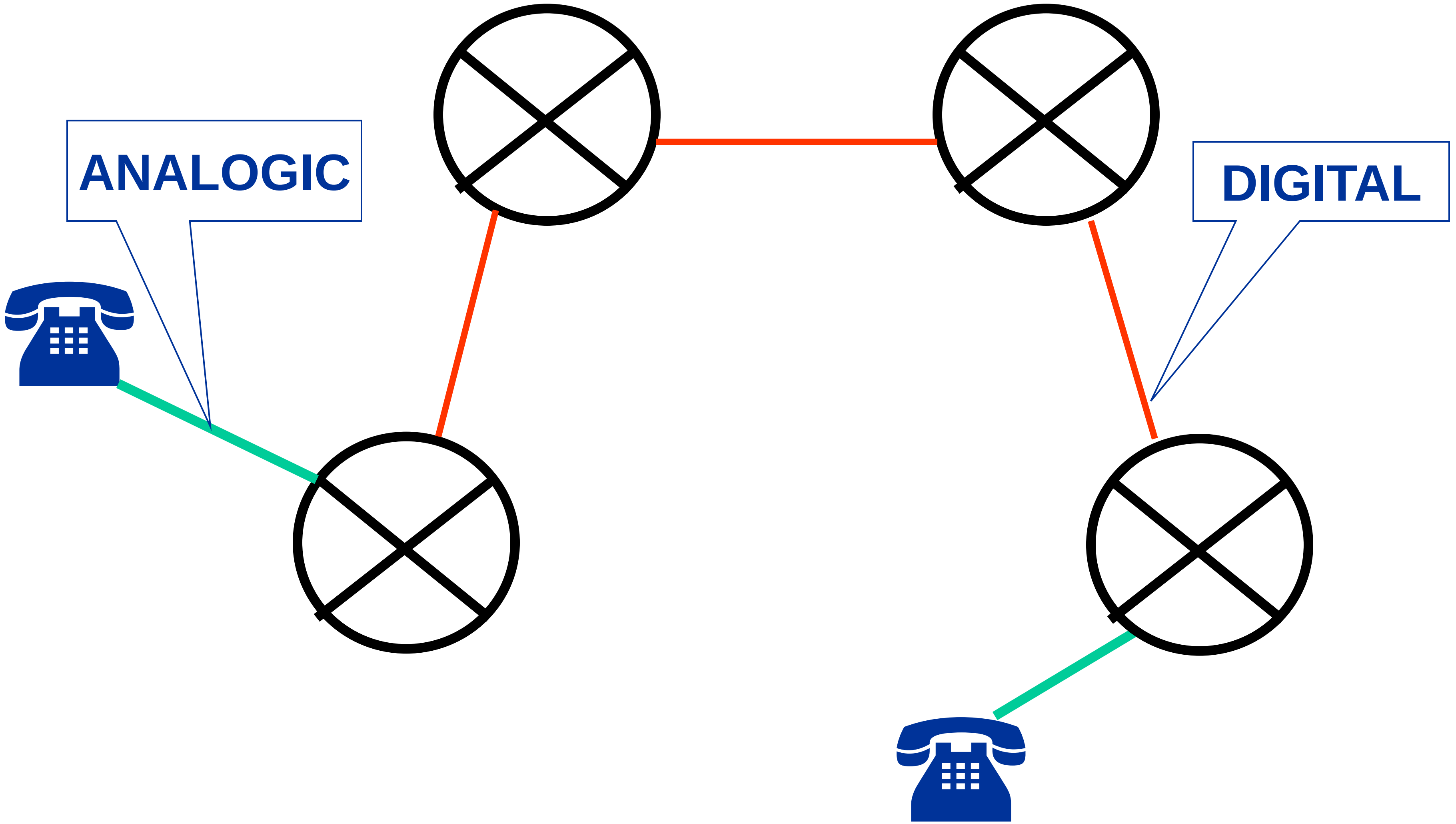
- Every 125 µS each time slot has a window of 125 µS / 32 = 3.90625 µS

- As the total rate of the link is 2.048 Mb/s therefore a time slot sends every 125 µS.

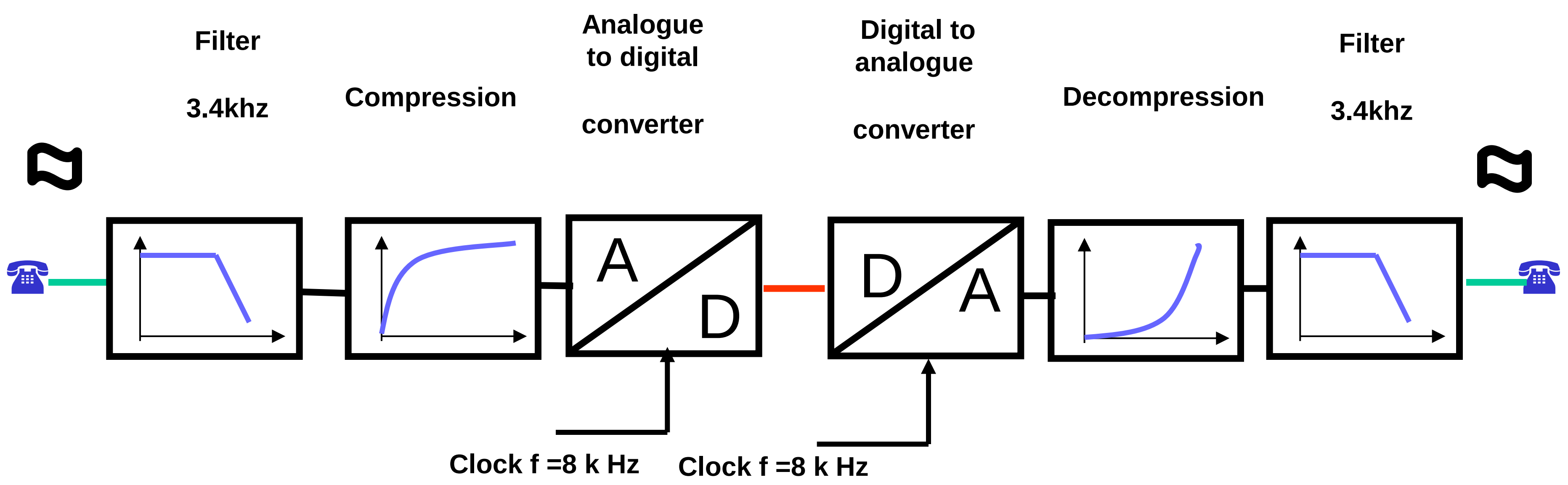
2 048 000 b/s X 3.90625 µS = **8 bits**

**Conlusion:** 1 Byte is sent every 125 µS per time slot. It corresponds of 8000 Bytes/s or 64Kb/s.

# ANALOGIC & DIGITAL LINES



# DIGITALIZATION PRINCIPLE



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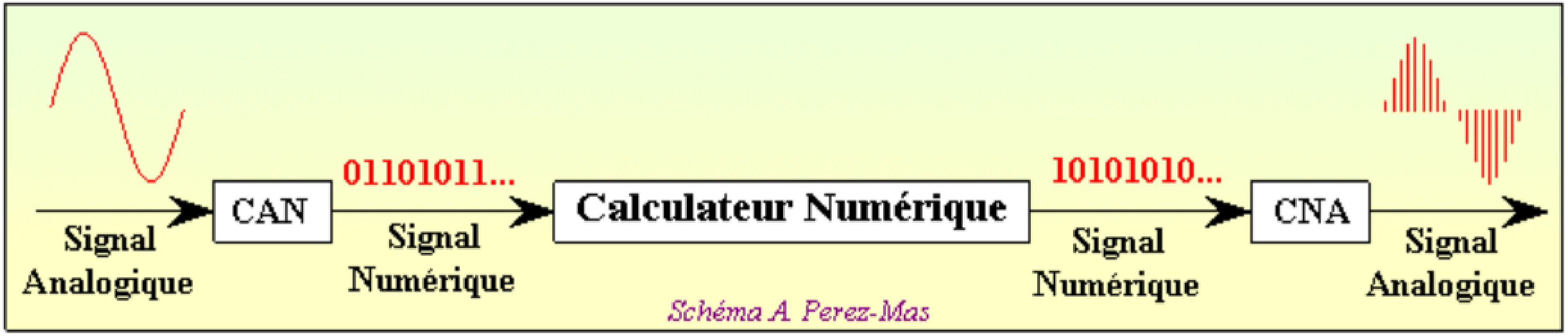
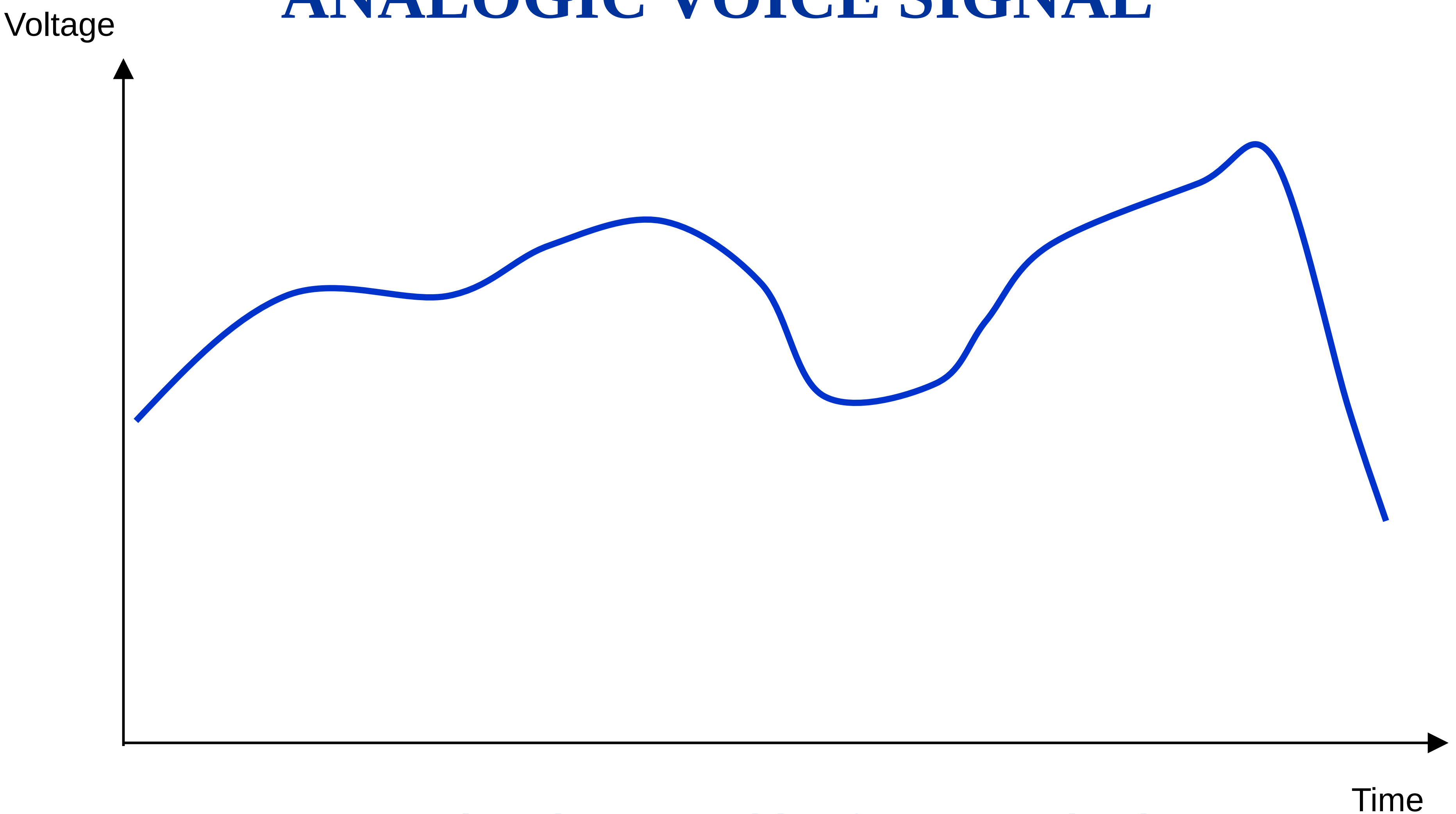
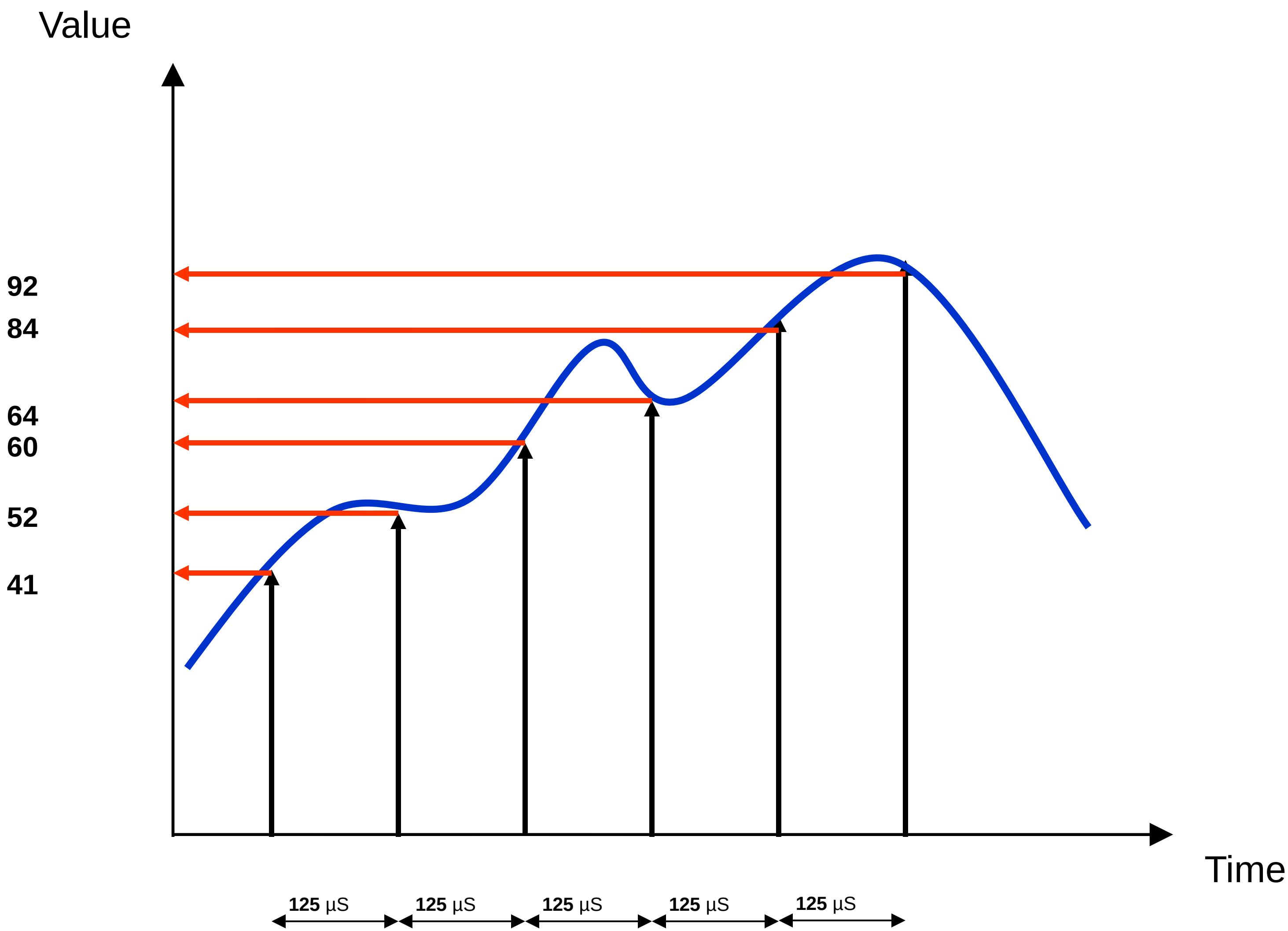


# ANALOGIC VOICE SIGNAL

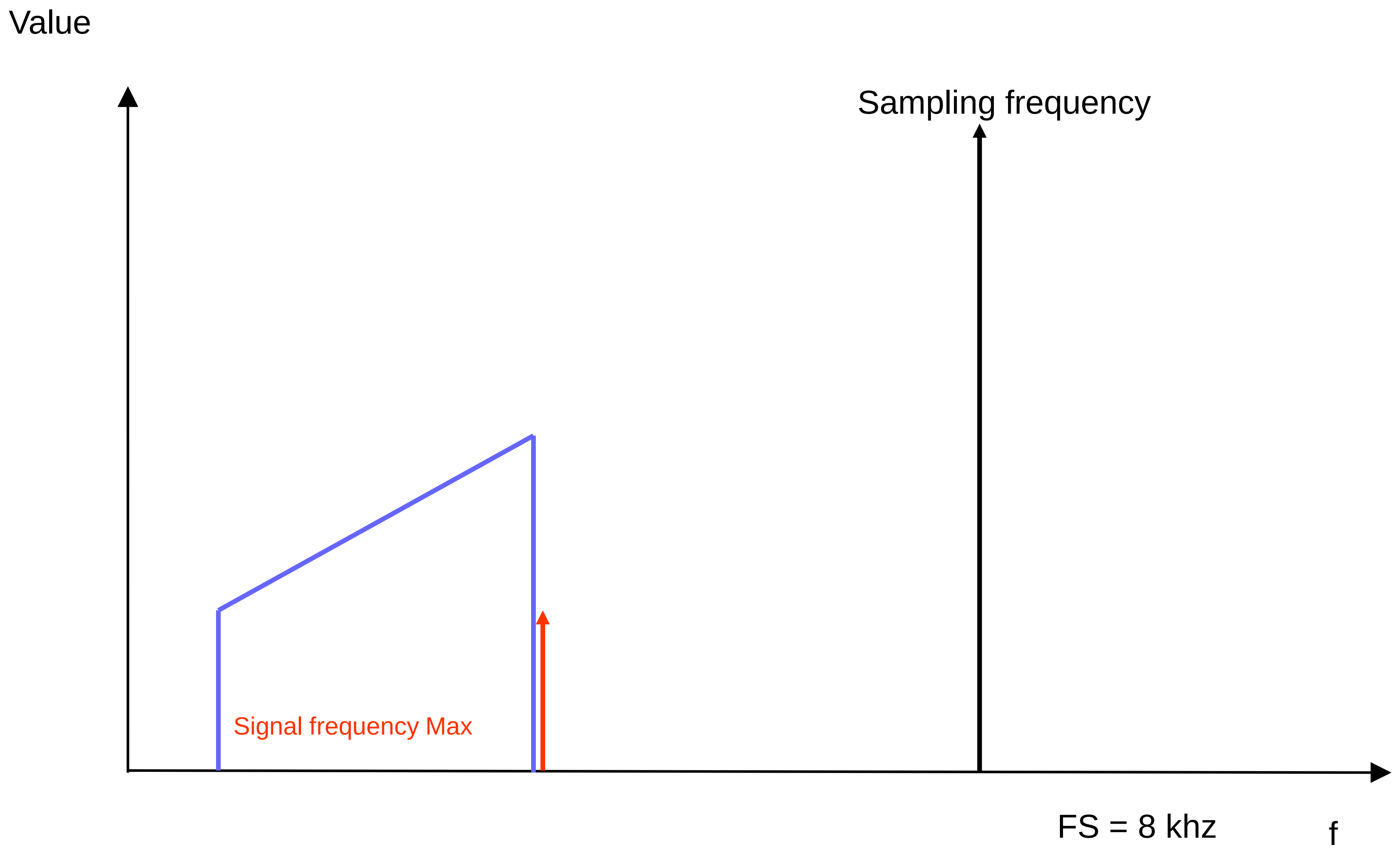



**Voice signal outside of an analogic phone**

# PULSE CODING MODULATION

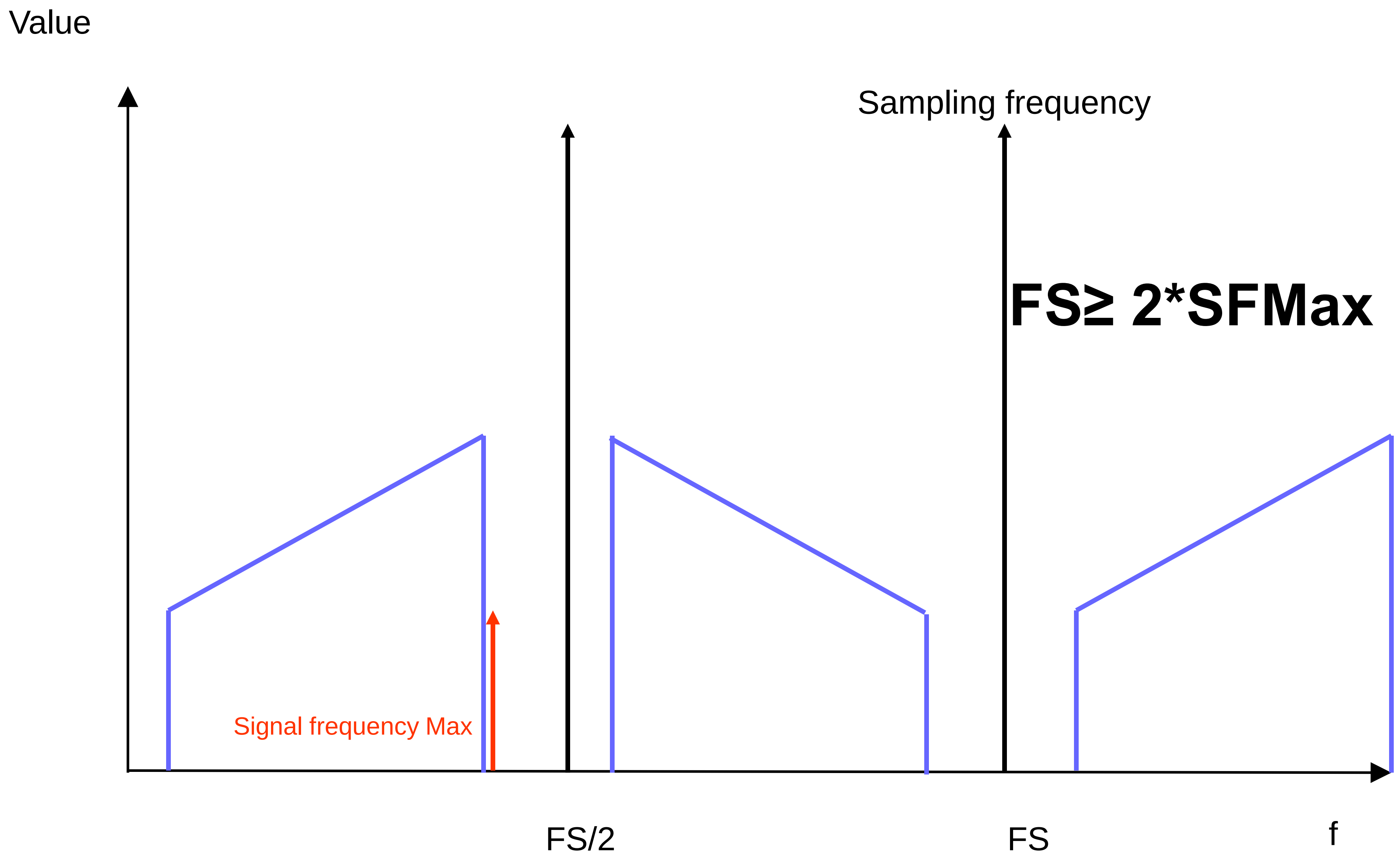


# SIGNAL THEORY



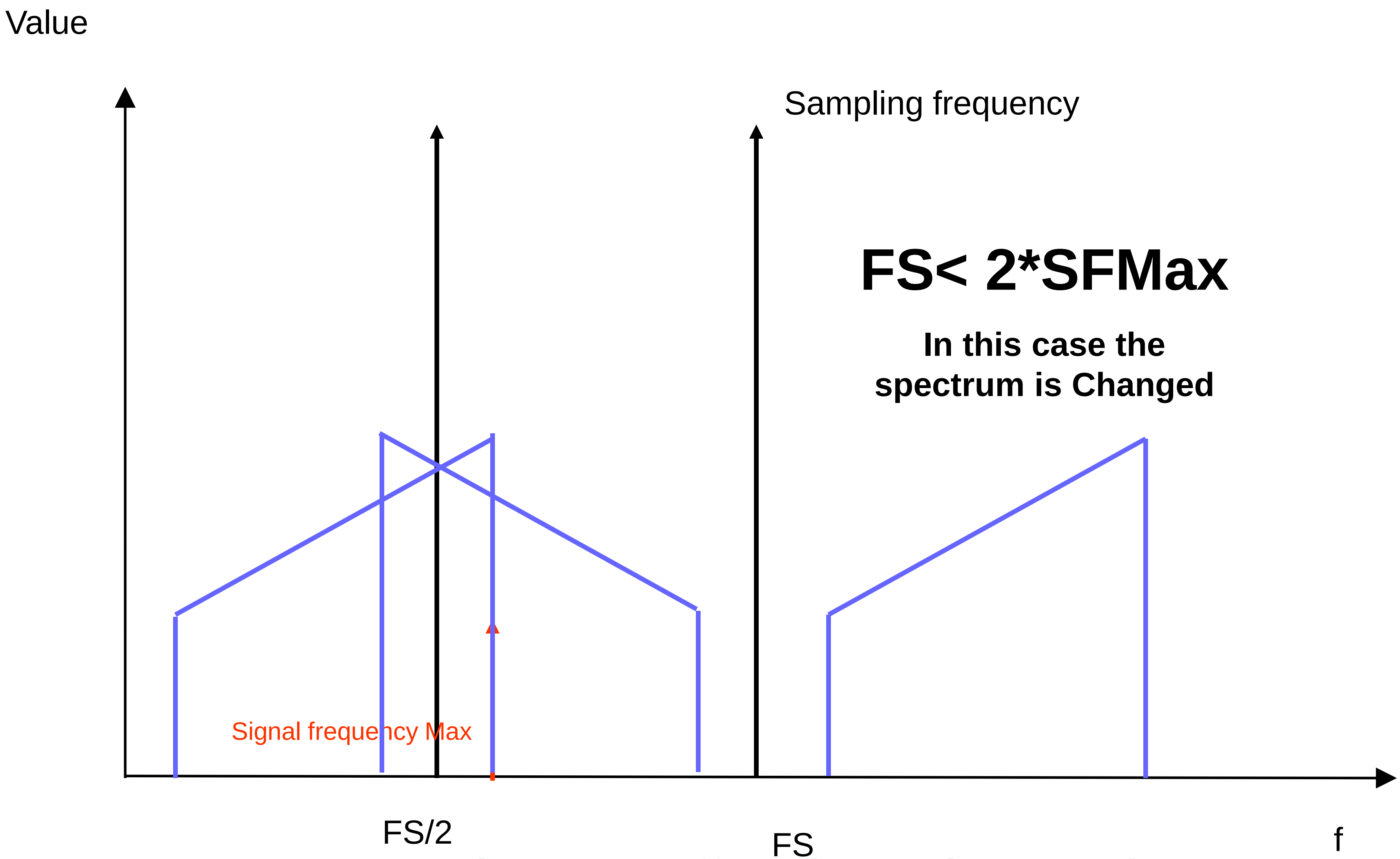

**Voice spectrum**

# SIGNAL THEORY



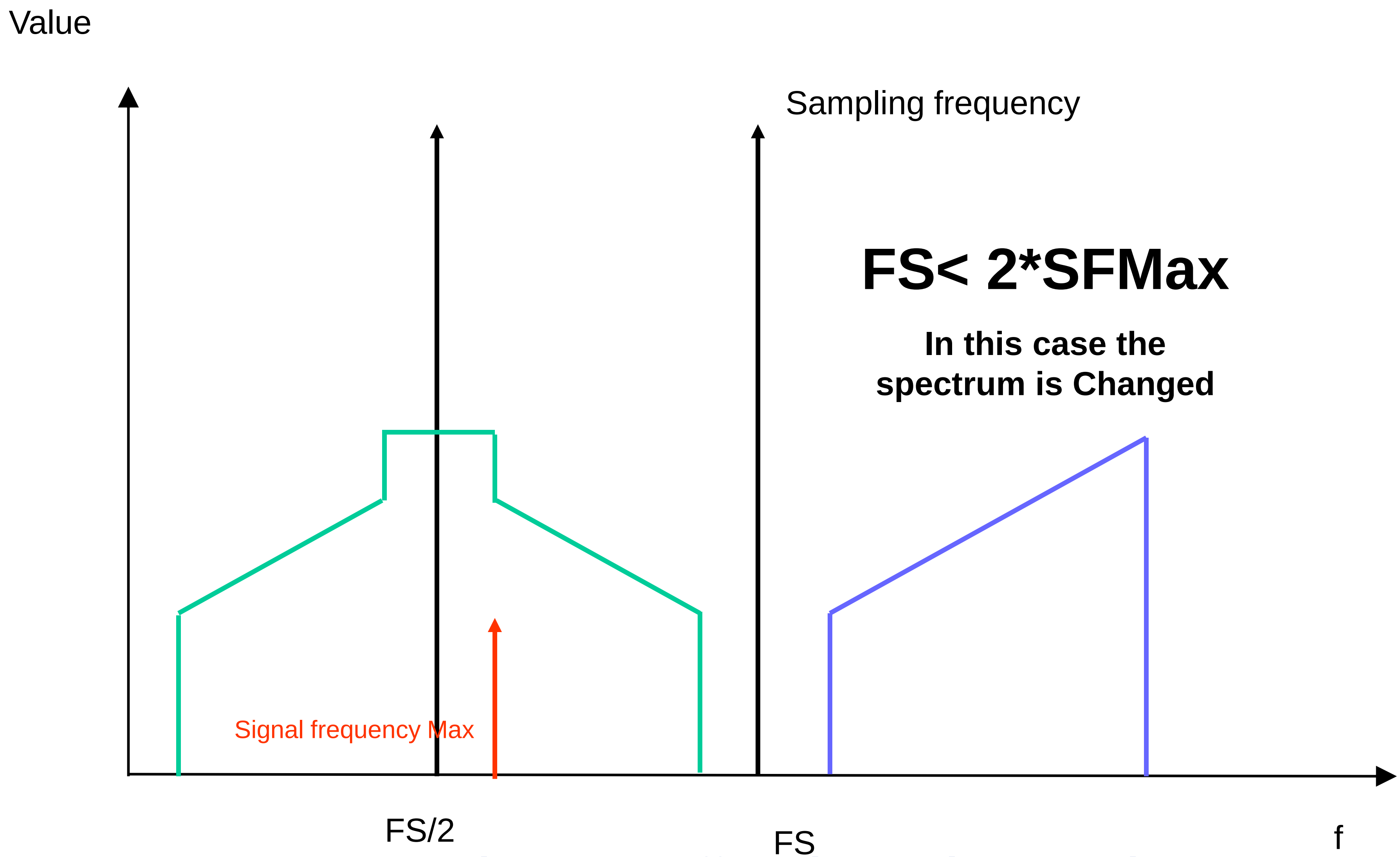

**Spectrum about turn effect due to the sampling**

# SIGNAL THEORY




**Spectrum about turn effect due to the sampling**

# SIGNAL THEORY

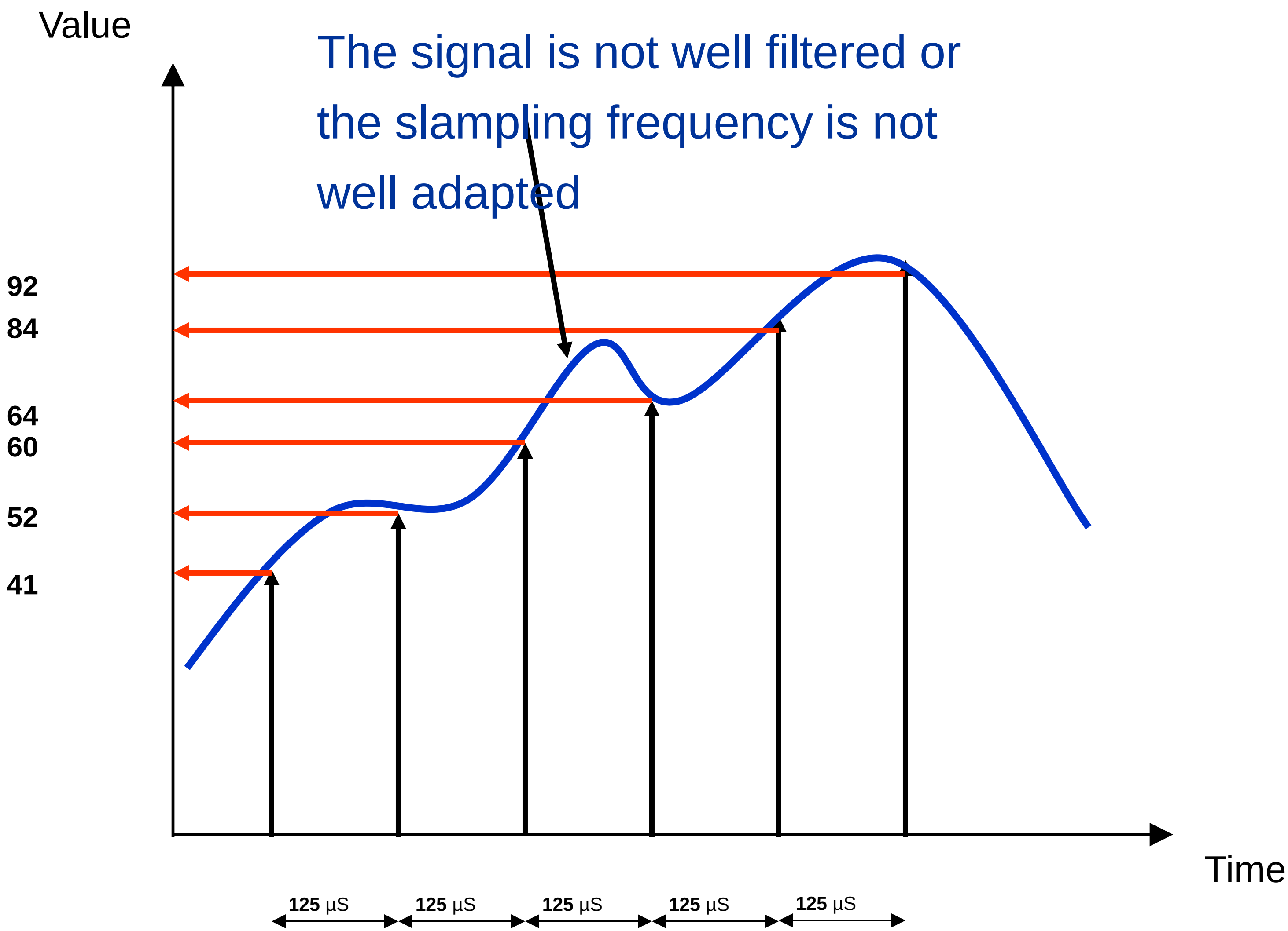



**FS< 2*SFMax**

**In this case the spectrum is Changed**

**Spectrum about turn effect due to the sampling**

# SIGNAL THEORY



# SIGNAL THEORIE

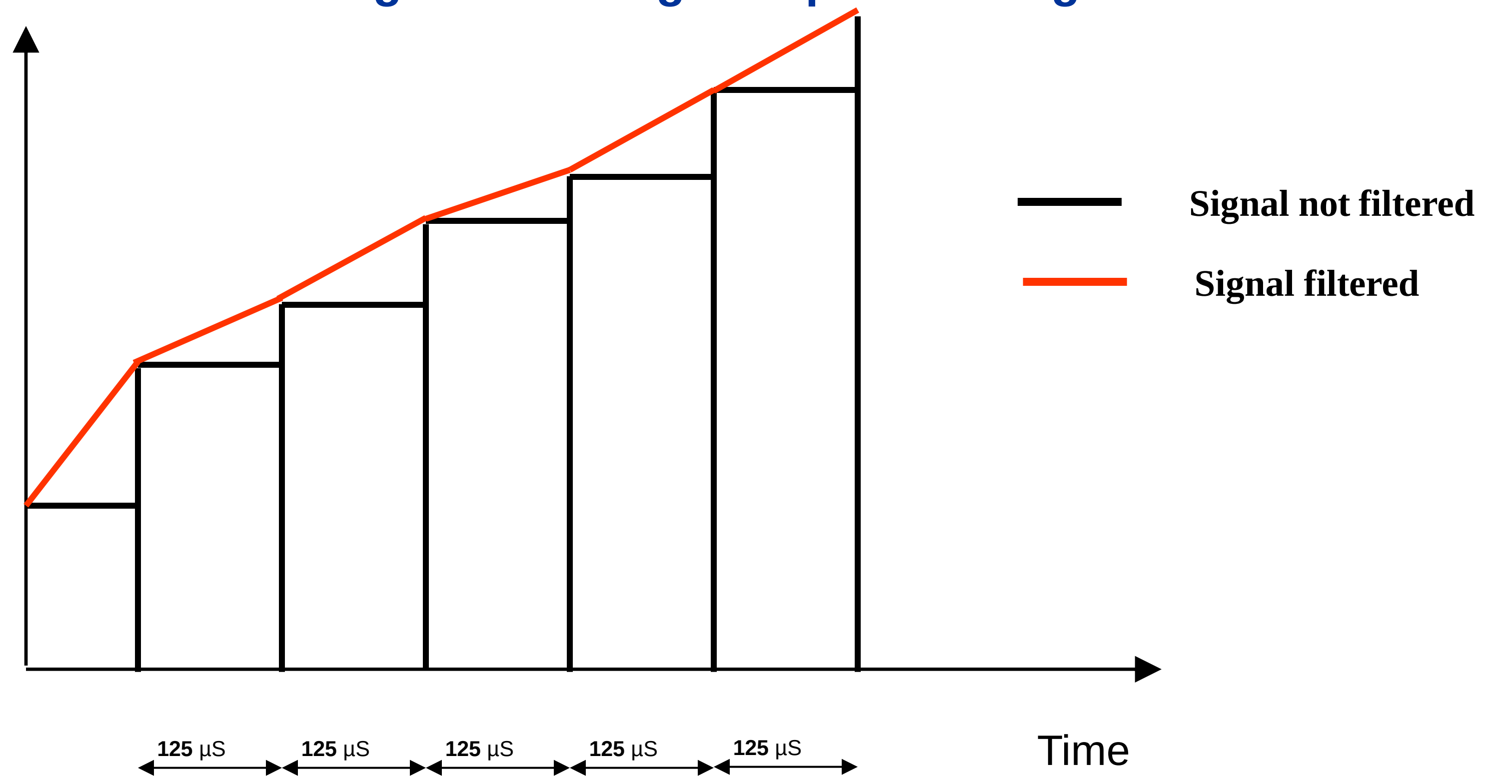
The Shannon theorem : the spectrum will be reproduced identically if the sampling frequency is superior or equal to 2*Fmax (of the voice signal) in telephony :

- The Sampling frequency is 8 KHz
- The voice spectrum is between 300-3400 hz
- Checking : $8000 \geq 2 * 3400 = 6800$
- This the reason why the voice signal is filtered

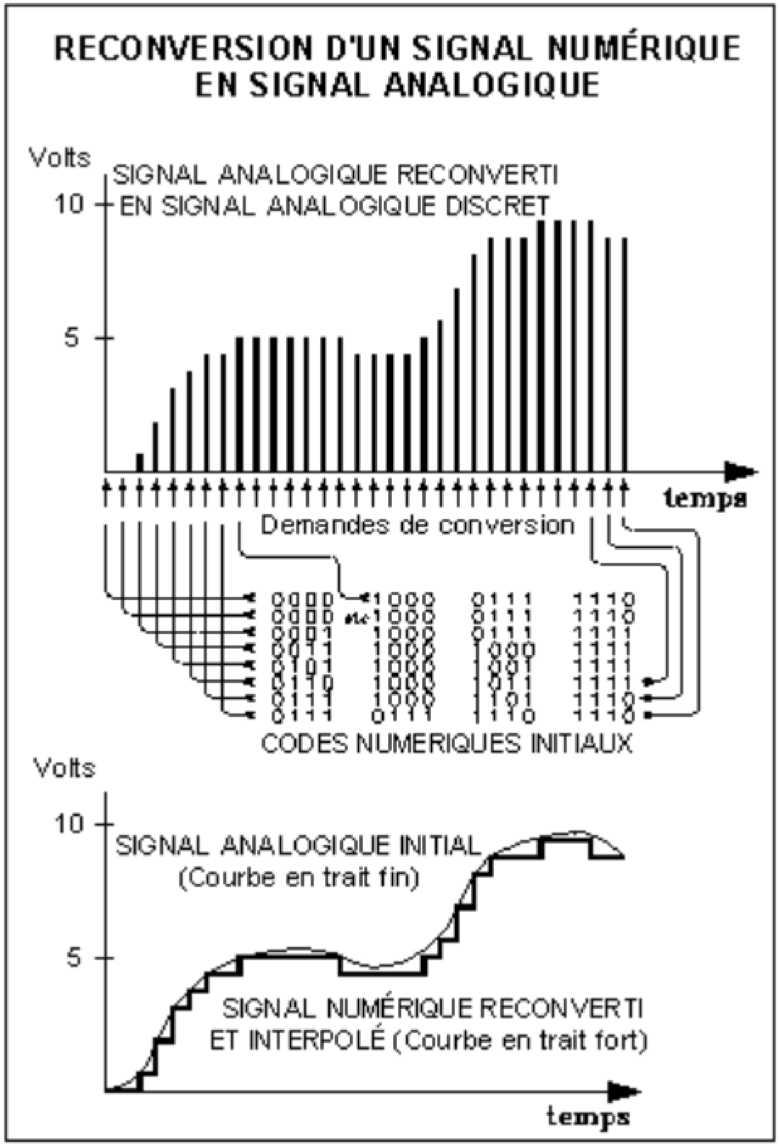
# SIGNAL THEORIE

- The signal has to be filtered after the conversion digital to analog :

**The conversion D to A generates high frequencies signal.**

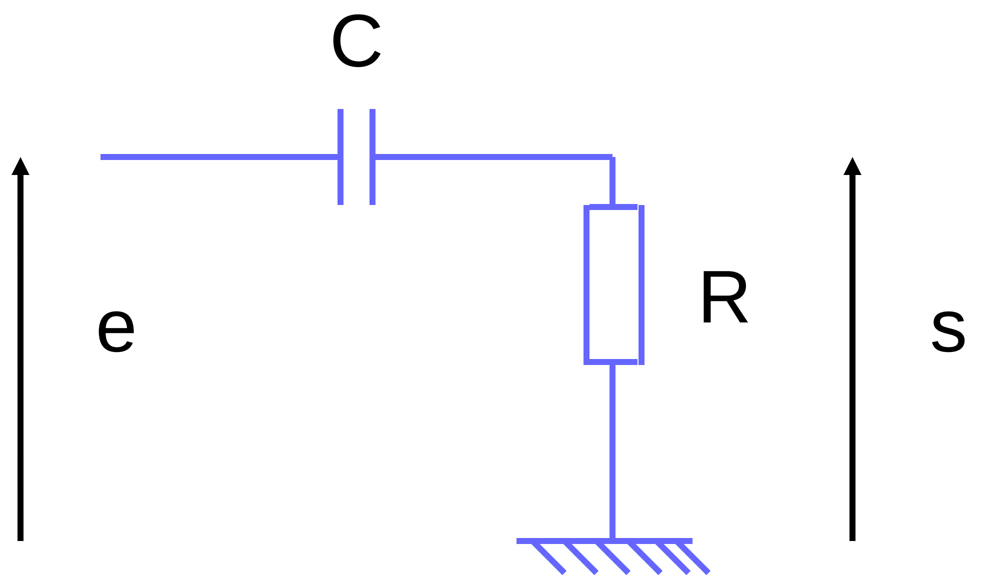


# SIGNAL THEORIE



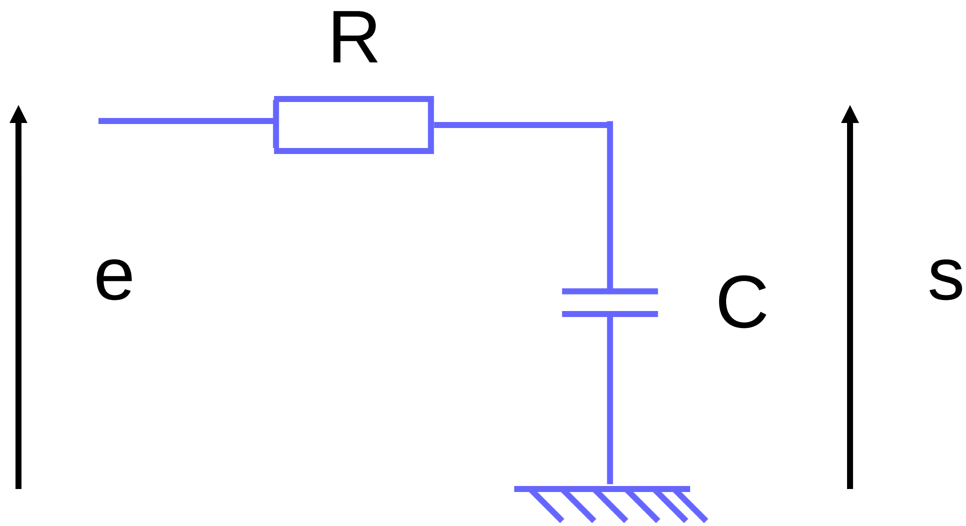
# SIGNAL THEORIE

- Low frequencies suppressor



# SIGNAL THEORIE

- High frequencies suppressor



# COMPRESSION 1/5

### *Résolution d'un convertisseur CAN (ou CNA)*

Nous observons qu'à chaque niveau, un même nombre binaire correspond à toute une plage de valeurs analogiques d'entrée.
La "largeur" commune de ces plages est nommée parfois "**quantum**".

$$\boxed{q = \frac{(V_{max} - V_{min})}{2^n - 1}}$$

Dans le cas de la fig. précédente, n = 4 ; $2^4$=16 ; $2^4$-1=15 ; Mmin=0 V ; Vmax = 10 V
q = 10/15 = 666,6... mV

Il est évident que plus un convertisseur différentie de valeurs pour une même étendue de tensions d'entrée, plus l'information sur la tension mesurée sera précise.
Le mot "**résolution**" est souvent utilisé pour qualifier cette précision.

D'autres appellent "résolution" le quantum lui-même.
Dans ce cas, plus le quantum est petit, plus la résolution serait grande, ce qui est paradoxal !

Pour être plus logique, nous pouvons qualifier de **résolution** le **nombre de bits** du convertisseur.

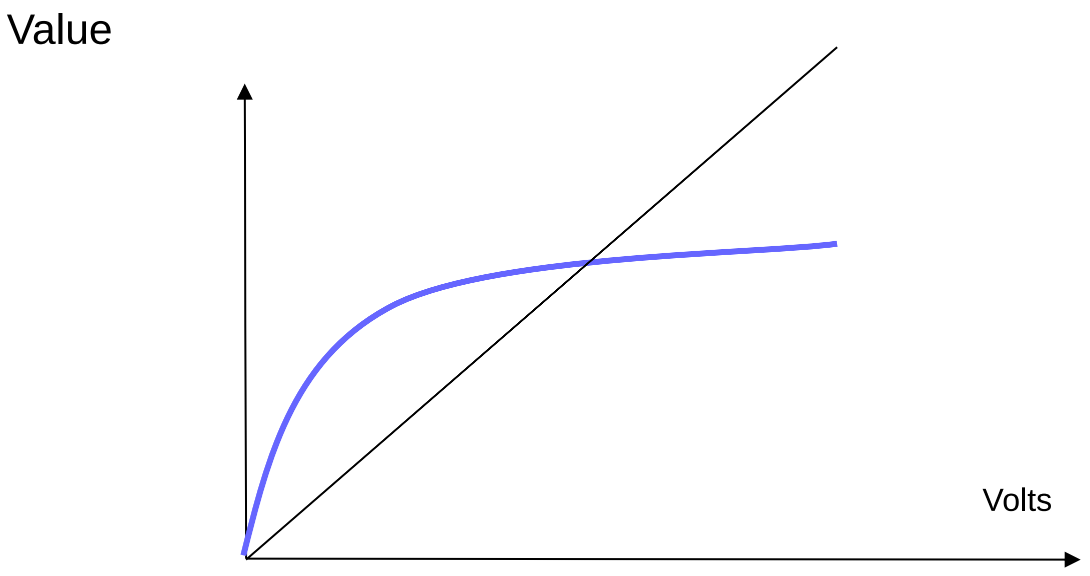
Avec **8** bits, on peut écrire 256 valeurs. D'où la valeur du quantum :
**q = (Vmax - Vmin) / $2^n$-1 = 10/255 = 39,215... mV**

On peut encore évaluer l'incertitude relative de la mesure. q / (Vmax - Vmin)
C'est **1 / $2^{n-1}$**

| Nb de bits | Nb d'échelons | Incert. Rel. |
|---|---|---|
| 8 | 255 | 0,39215 % |
| 12 | 4095 | 0,02442 % |
| 16 | ? | ? |

# COMPRESSION 2/5

The conversion analogic to digital and the conversion digital to analogic is not linear. The reason is to extract the law signal from the noise and also to reduce the quantization noise.



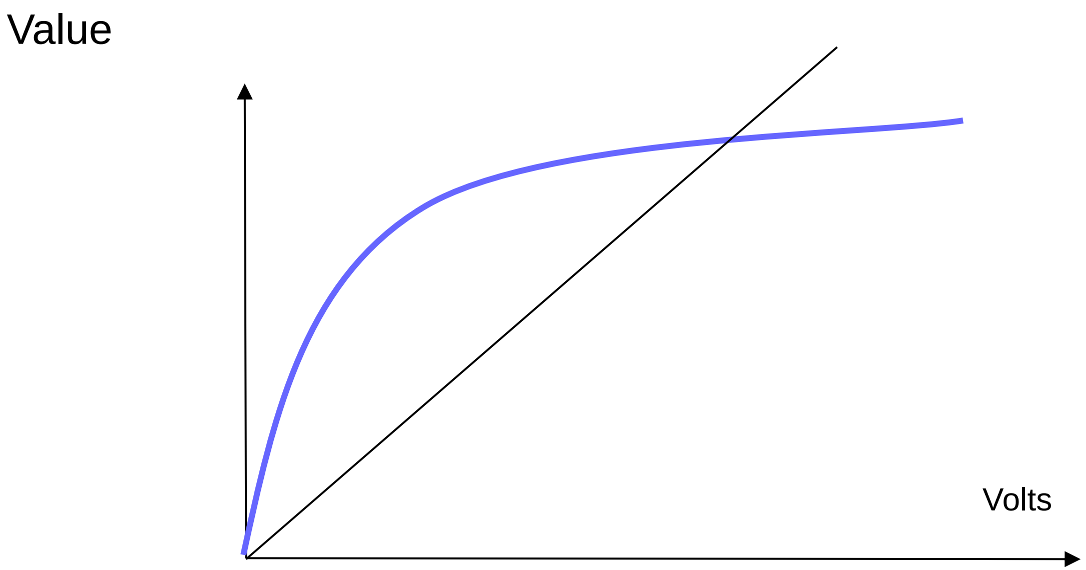
# COMPRESSION 3/5

There is two kind of compression law :

- The law µ used in North America and Japan.
- The law A used for the rest of the world.
- The law A has priority

# COMPRESSION 4/5

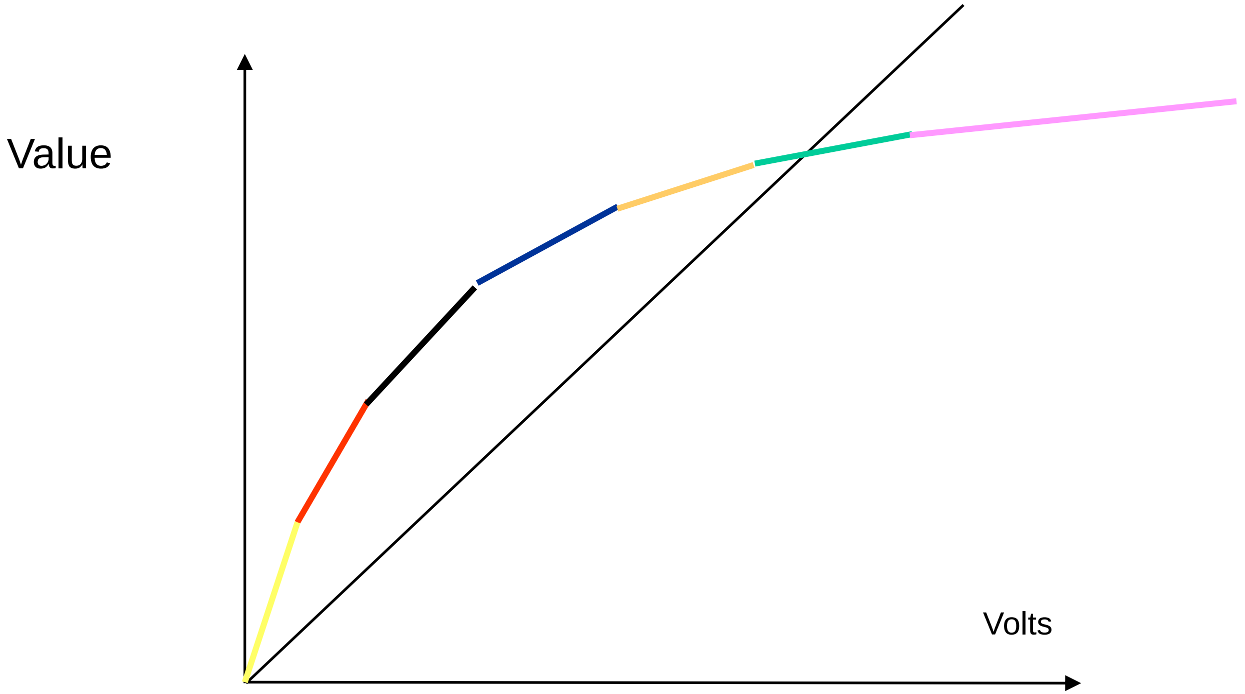
The law μ is a pure logarithmic curve.




The law μ

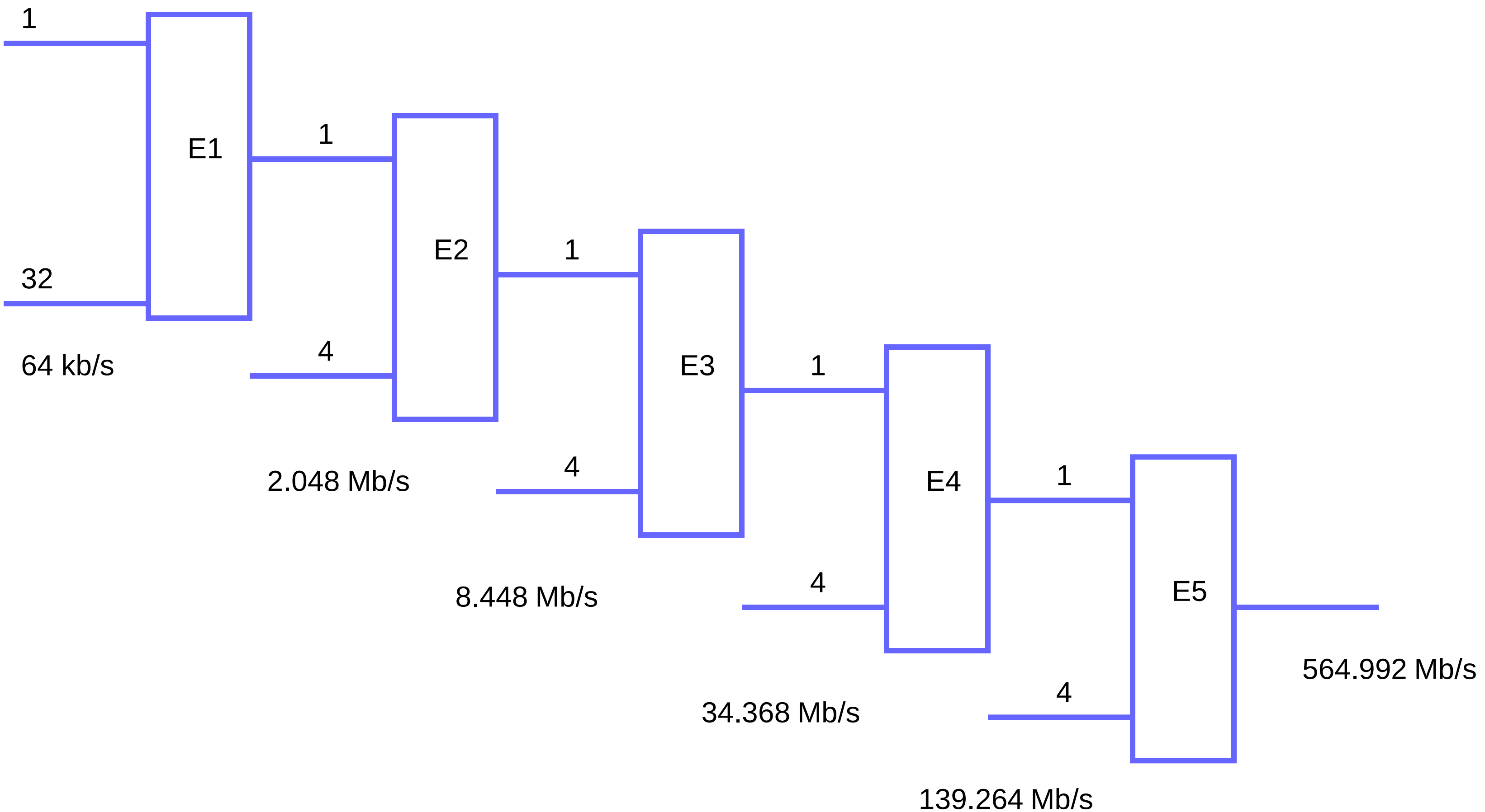
# COMPRESSION 5/5

The law A is a sum of 7 linear segments




The law A

# PLESIOCHRONE DATA HIERARCHY 1/2



# PLESIOCHRONE DATA HIERARCHY 2/2

This technology has some constraints :

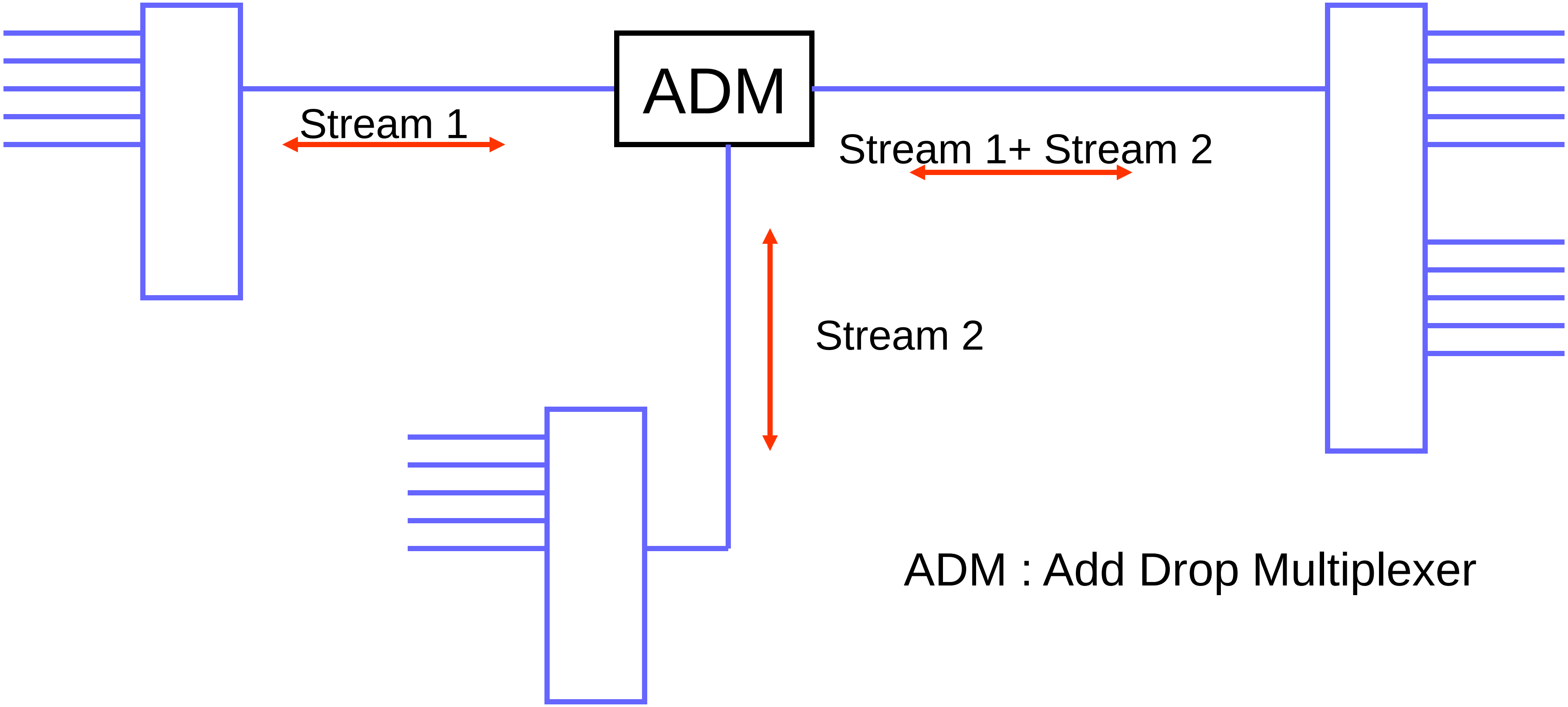
- The links have to be synchronized
- Impossible to drop one time slot or all of the traffic has to be de multiplexed.

Conclusion:

- Interesting for a point to point traffic

# SYNCHRONOUS DATA HIERARCHY 1/6

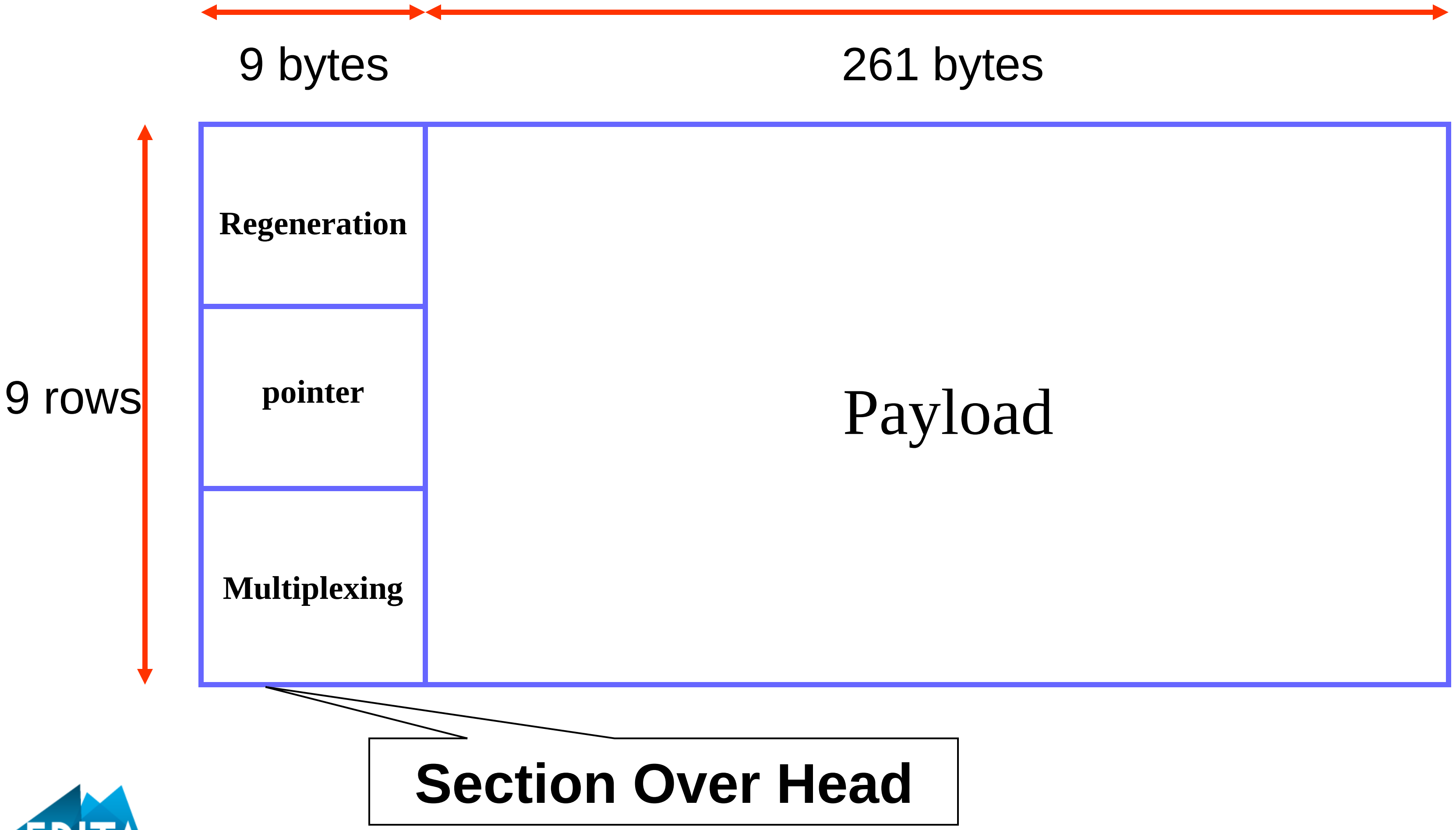
This technology is used in case of ring transport architecture




ADM : Add Drop Multiplexer

# SYNCHRONOUS DATA HIERARCHY 2/6

## STM1 Container description



# SYNCHRONOUS DATA HIERARCHY 3/6

## SOH DESCRIPTION

- Overhead of regeneration : used for error correction
- Overhead of position : used to synchronized the upstream traffic
- Overhead of multiplexing : used to add and drop the traffic at the ADM level.

# SYNCHRONOUS DATA HIERARCHY 4/6

There is 8000 containers per second :

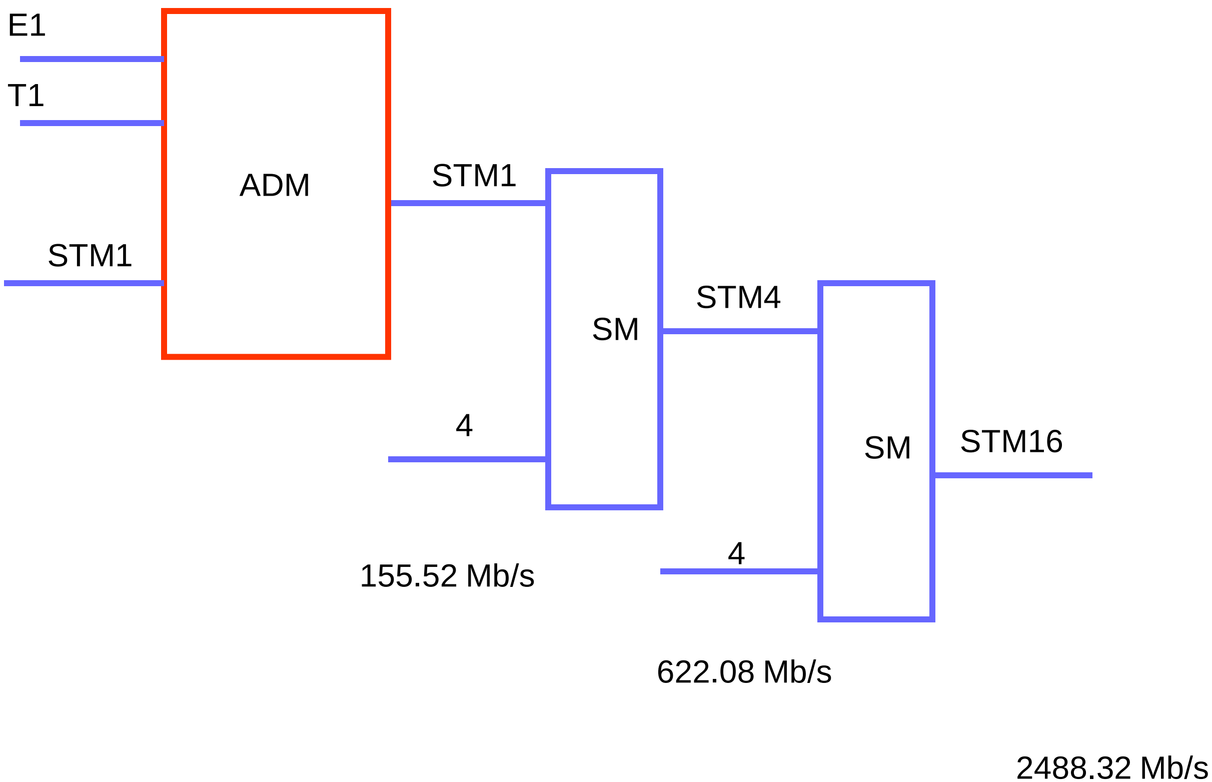
- The total rate is : 270x9X8000X8 = 155.52 Mbit/s
- The payload is 261X9X8000X8 = 150.336 Mbit/s
- STM4 rate is: 622.08 Mbit/s
- STM16 rate is: 2488.32 Mbit/s

# SYNCHRONOUS DATA HIERARCHY 5/6

The benefit is :

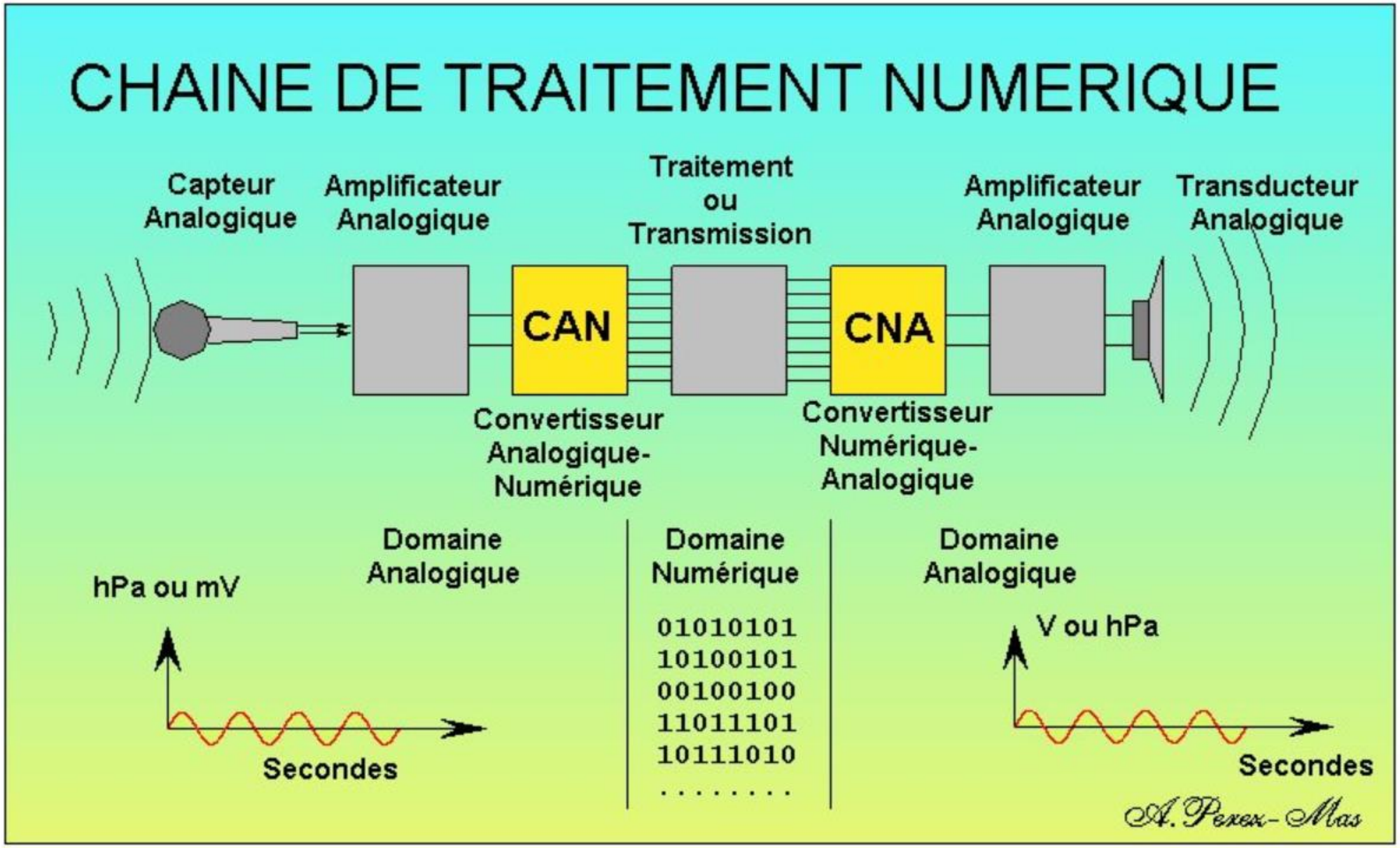
- to multiplex a plesiochronous and synchronous traffic
- to multiplex E1 and T1
- to extract an E1 in a STM16
- Very flexible

# SYNCHRONOUS DATA HIERARCHY



# ECHO EFFECT 1/4

In a long distance network a echo effect appears



# ECHO EFFECT 2/4

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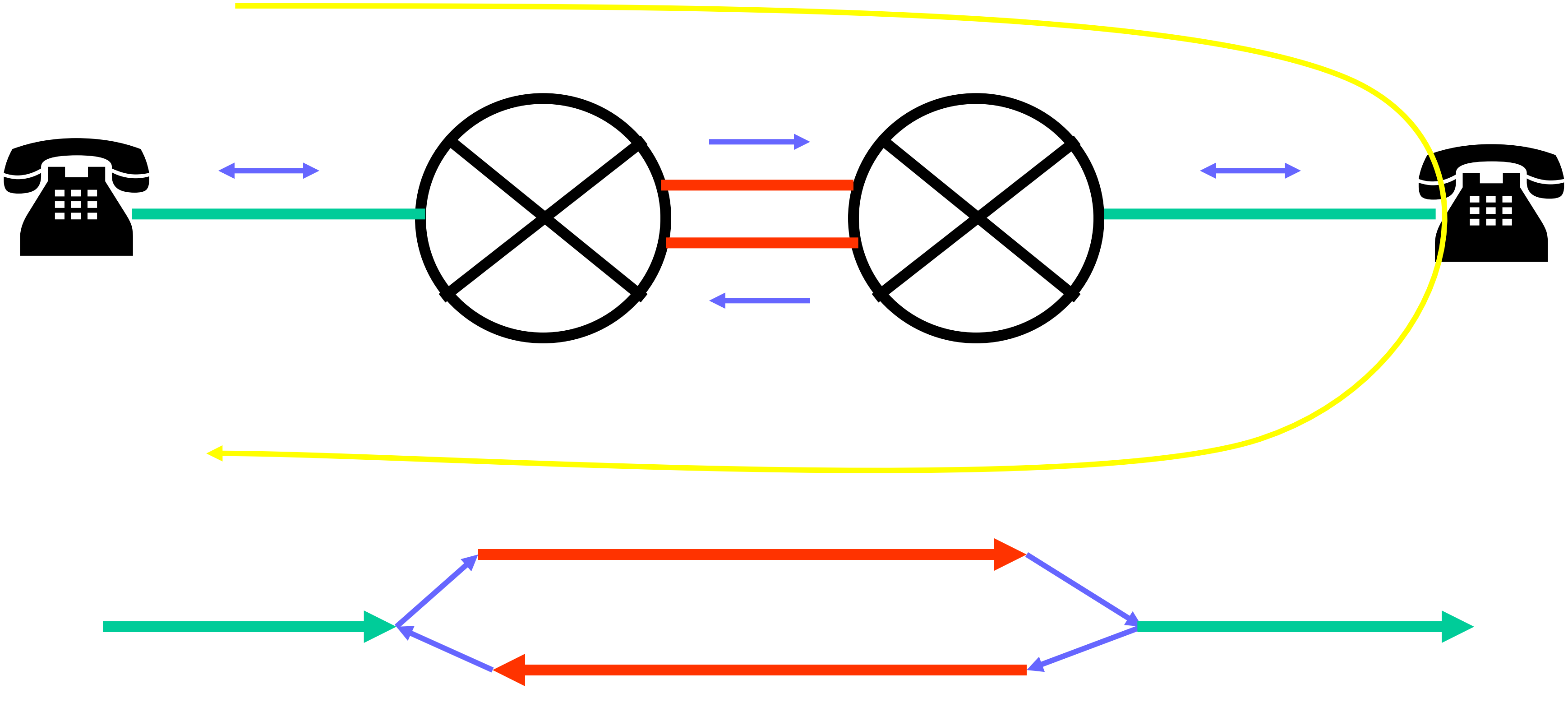
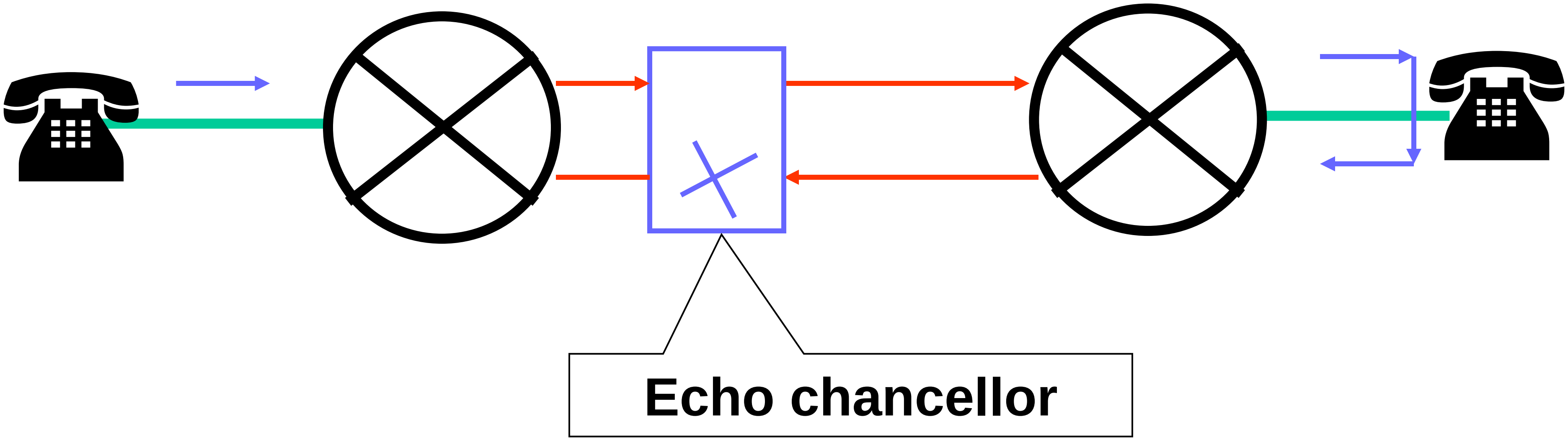


# ECHO EFFECT 3/4

- **The voice signal is on one wire at the phone level**
- **When the voice signal arrives at the destination. It is returned to the origin and overlaid with the “normal” voice signal**

# ECHO EFFECT 4/4

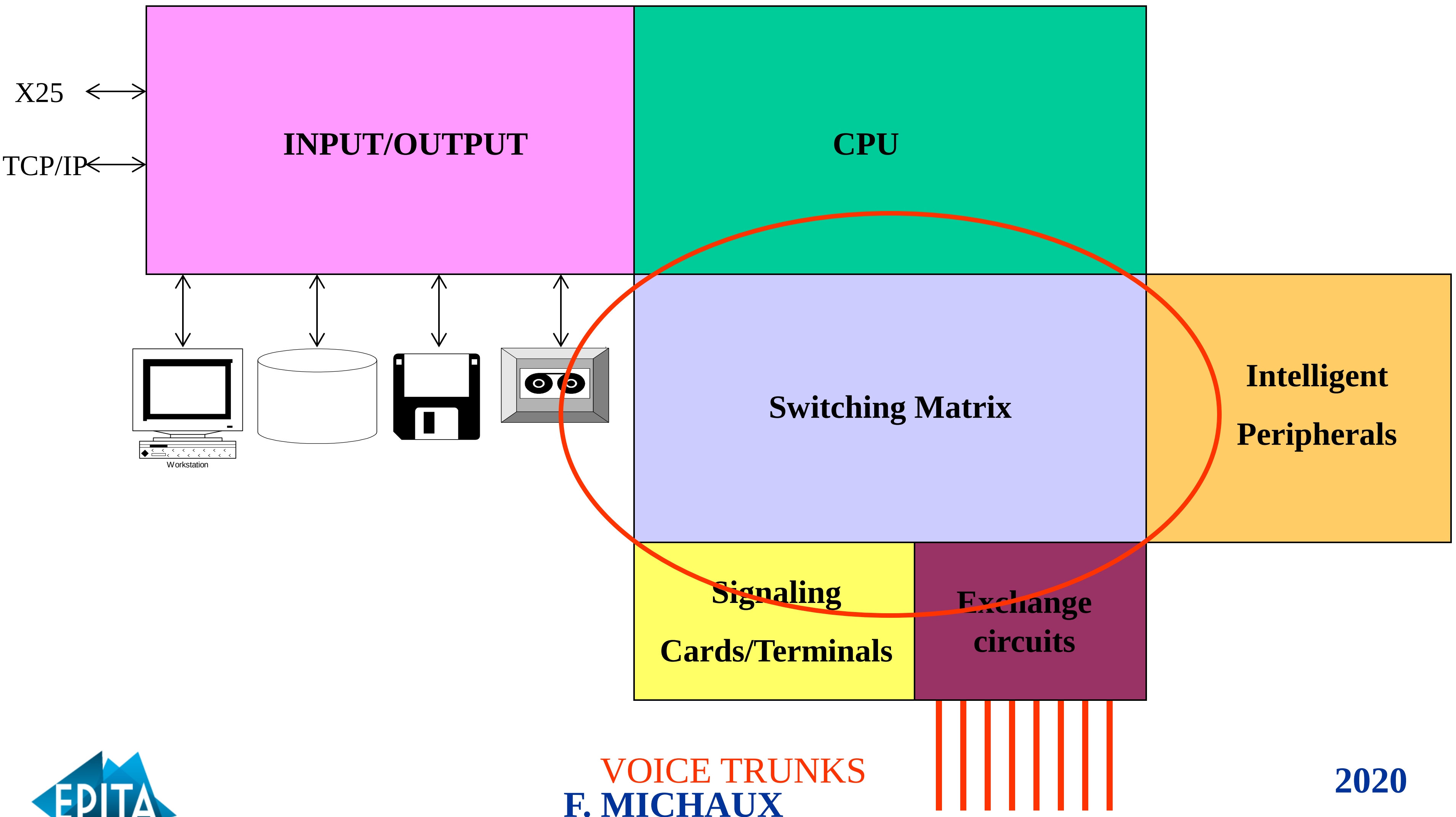
The solution consist of introducing an Echo chancellor



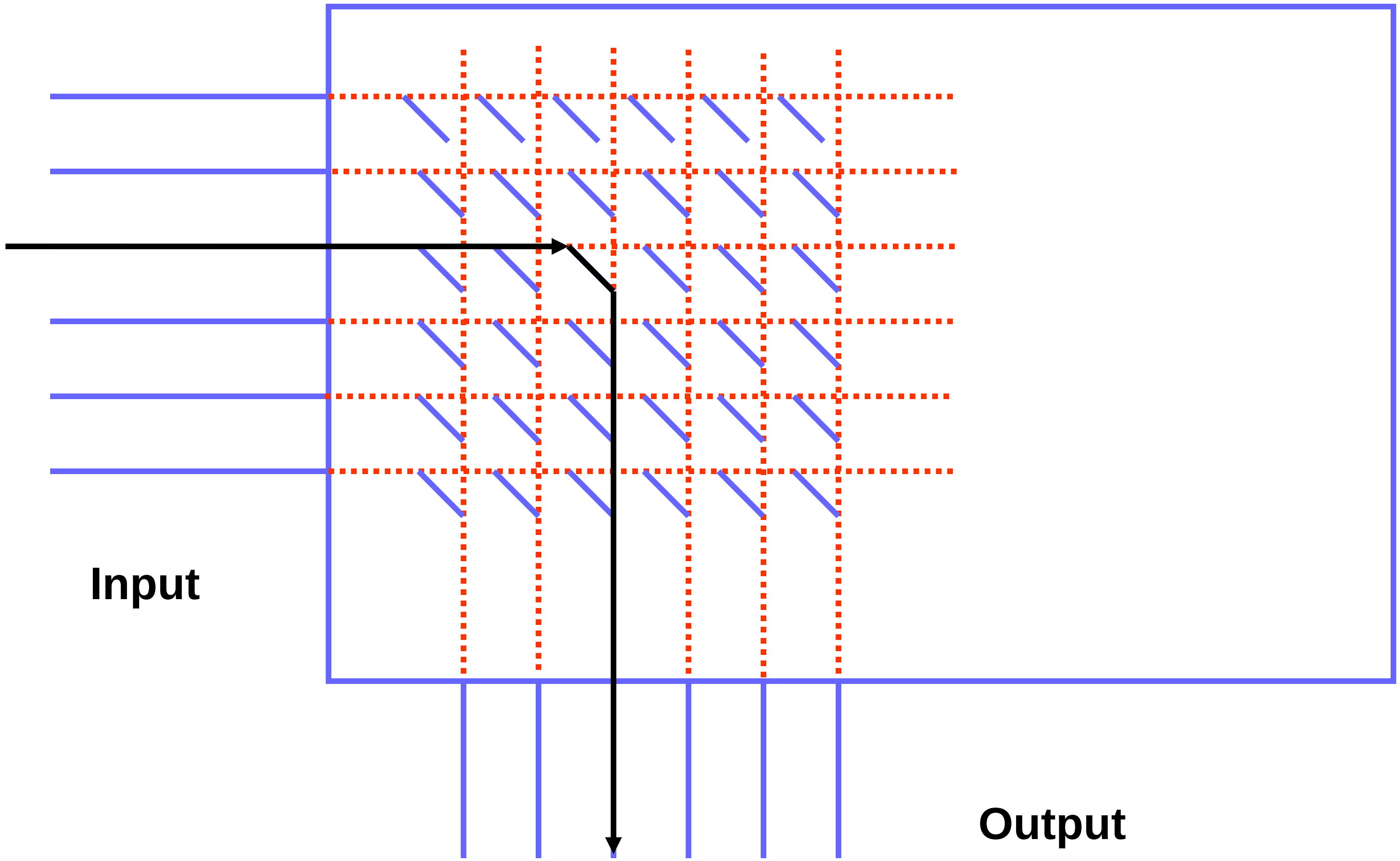

The echo chancellor memories the signal and cancels it at the return

# Switching Matrix

# MAIN SWITCH COMPONENTS



# SWITCHING MATRIX




Switching Matrix Principle

# SWITCHING MATRIX

- The switching matrix is controlled by the CPU

- The switching matrix is named for the DMS “ENET” and “Group Switch or GSS” for the AXE 10.

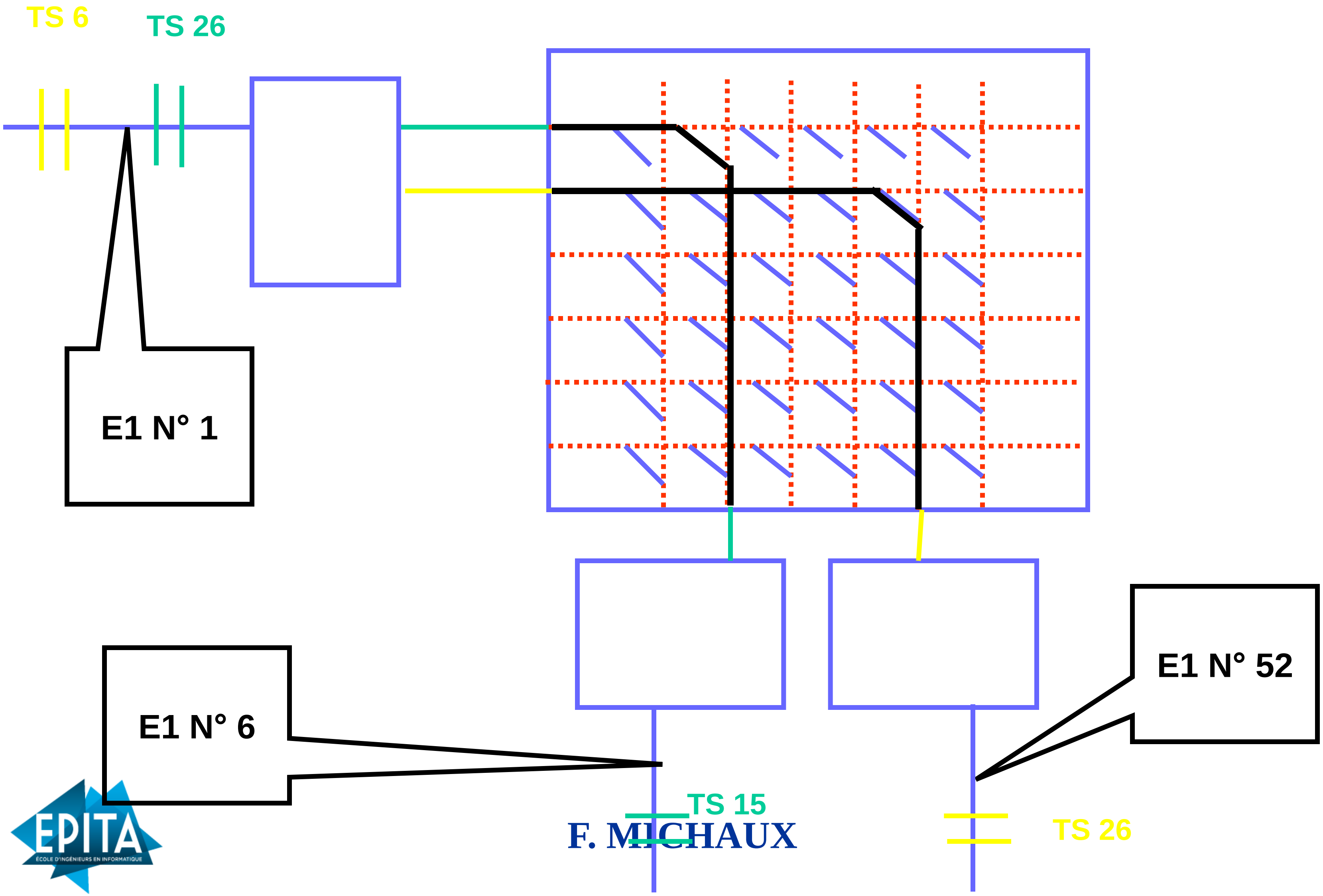
# SWITCHING MATRIX

The size of a switching is calculated as the following:

- 1 E1 = 32 Time slot
- With 32 E1 you have 32*32= 1024 cross connections
- 32 E1 per 1K of Switching Matrix
- Example a switch with 16 k will have a maximum of 16 * 32 = 512 E1.

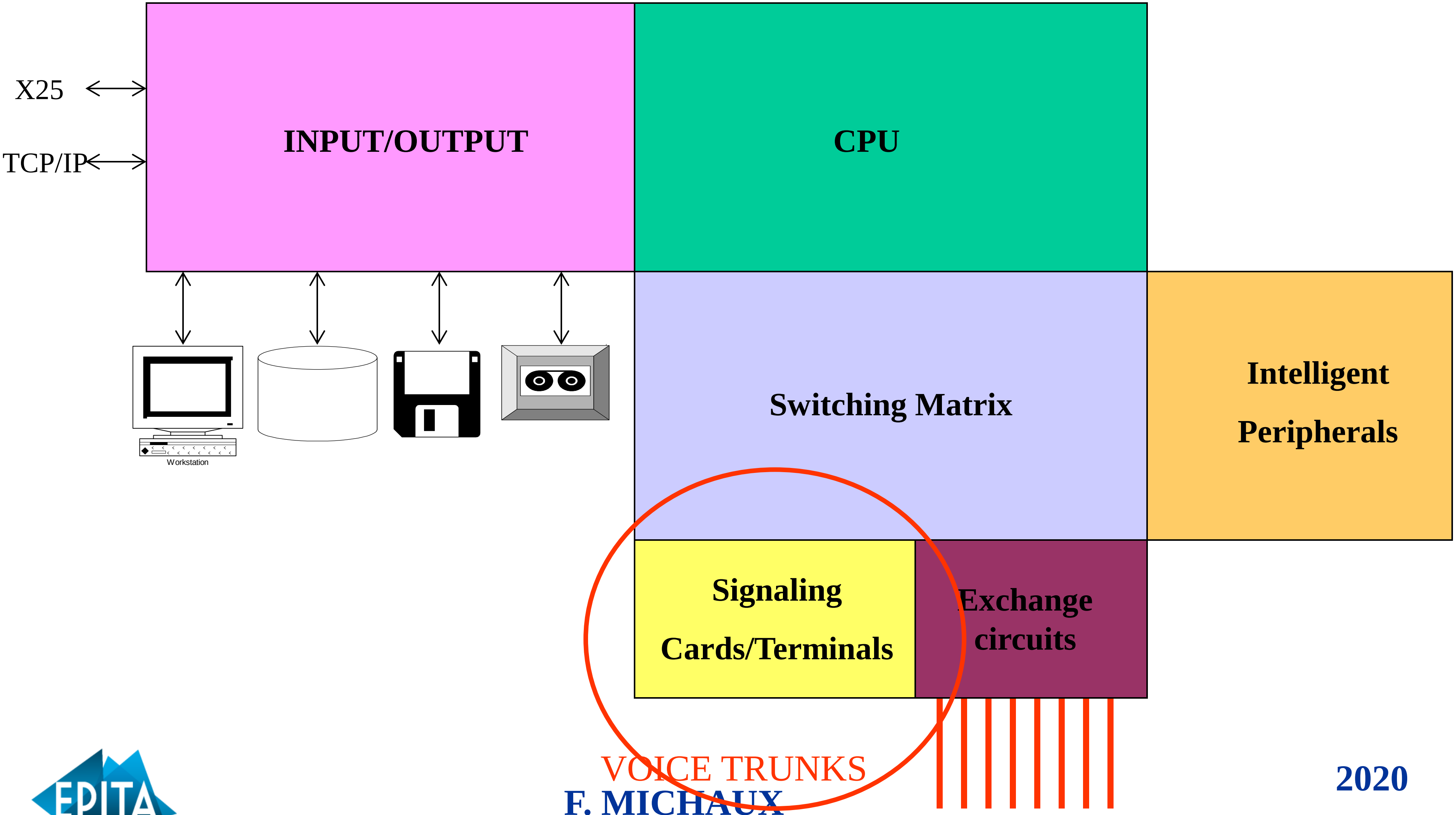
# SWITCHING MATRIX PROBLEMATIC

The E1 links have to be synchronised between them.



# Signaling

# MAIN SWITCH COMPONENTS



# SIGNALING

The signaling allow to exchange information between nodes.

There is several kind of signaling

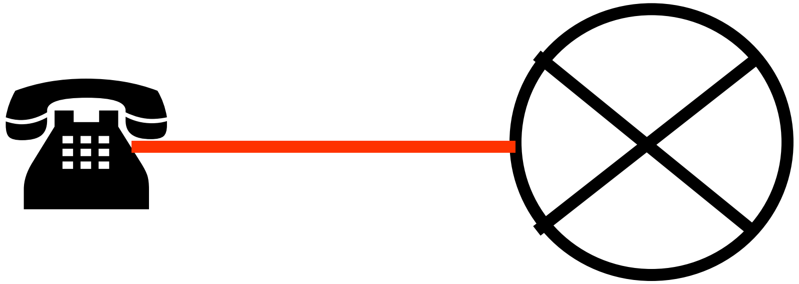
- Signaling circuit associated : eg : ISUP, ISDN, R2...

- Signaling non circuit associated : eg : INAP (for added value services IN), MAP (for mobility GSM or PCS network).

# CIRCUIT SIGNALING ASSOCIATED

## User to Network Interface

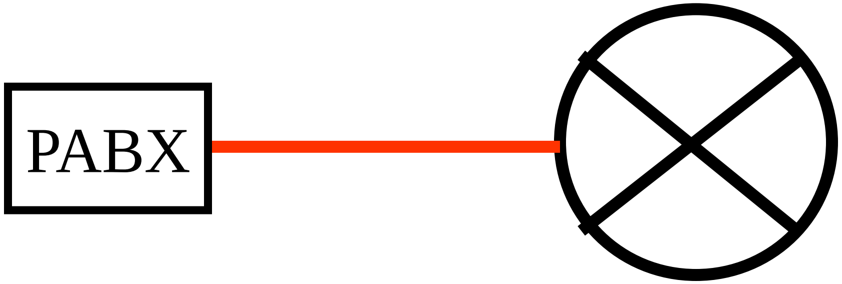
- USER signaling UNI (User to Network Interface) : (eg DTMF) between a analogic phone and a public switch



# CIRCUIT SIGNALING ASSOCIATED

## User to Network Interface

- USER Signaling UNI (User to Network Interface) : between public and private switch PABX e.g. ISDN, R2.



# CIRCUIT SIGNALING ASSOCIATED

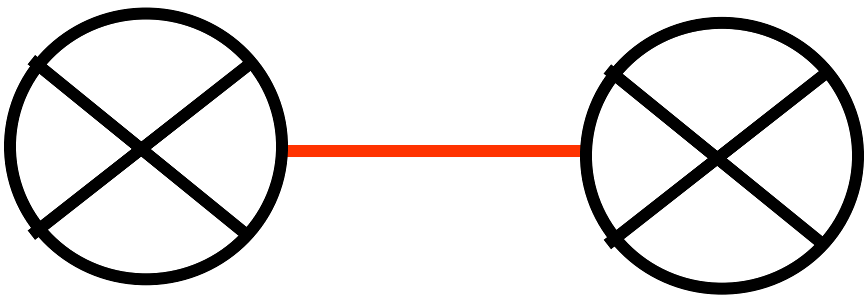
## User to User Interface

- User to User Interface:  (eg QSIG, DPNSS,..) between two PABX.

# CIRCUIT SIGNALING ASSOCIATED

## Network to Network Interface

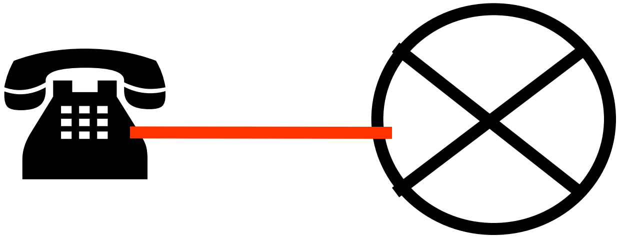
- Network Signaling : NNI (Network to Network Interface) between public switch e.g. R2, TUP, ISUP..



# CIRCUIT SIGNALING ASSOCIATED

## Signaling between an analogic phone and a public switch

- **Two Signaling exists**
  - **by pulse**
  - **by dual tone multi frequency DTMF**



# CIRCUIT SIGNALING ASSOCIATED

## Signaling by pulse

- **Used in the past when the phone was mechanic**

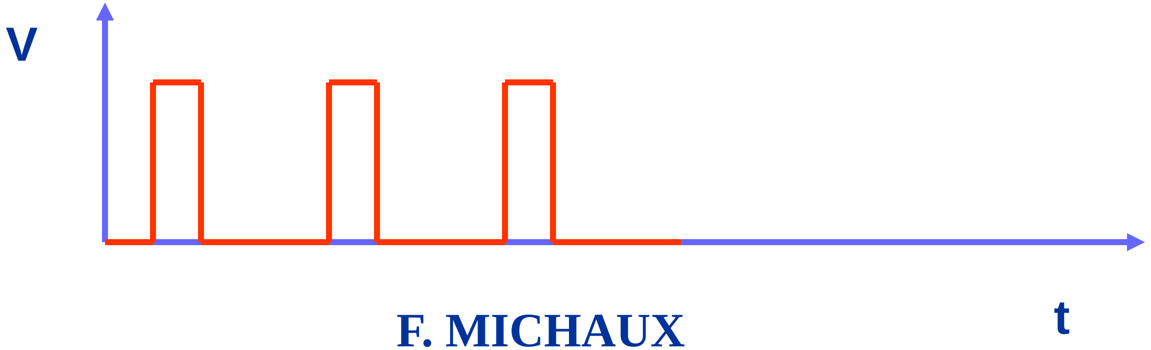
**Dial 10 => 10 pulse on the line**

**Dial 9 => 9 pulse on the line**

**----------------------------------**

**Dial 1 => 1 pulse on the line.**

Example 3 is dialled



# CIRCUIT SIGNALING ASSOCIATED

## Signaling by pulse

- This solution was used when the phones were mechanic

- Very slow 1s per digit

- It was possible to dial only digits and not (*,#,..)

# CIRCUIT SIGNALING ASSOCIATED

## Signaling by Dual Tone MultiFrequency

- **The phone has a kind of modem which is able to generate 8 different frequencies. 2 among 8 are chosen to dial a digit**

| | 1 209 Hz | 1 336 Hz | 1 447 Hz | 1 633 Hz |
|---|---|---|---|---|
| 697 Hz | 1 | 2 | 3 | A |
| 770 Hz | 4 | 5 | 6 | B |
| 852 Hz | 7 | 8 | 9 | C |
| 941 Hz | * | 0 | # | D |

# CIRCUIT SIGNALING ASSOCIATED

## Signaling by Dual Tone MultiFrequency

- **The both frequencies are sent simultaneously**

Example 3 is dialled

# CIRCUIT SIGNALING ASSOCIATED

## Signaling by Dual Tone MultiFrequency

- **This solution is quicker than the previous one**

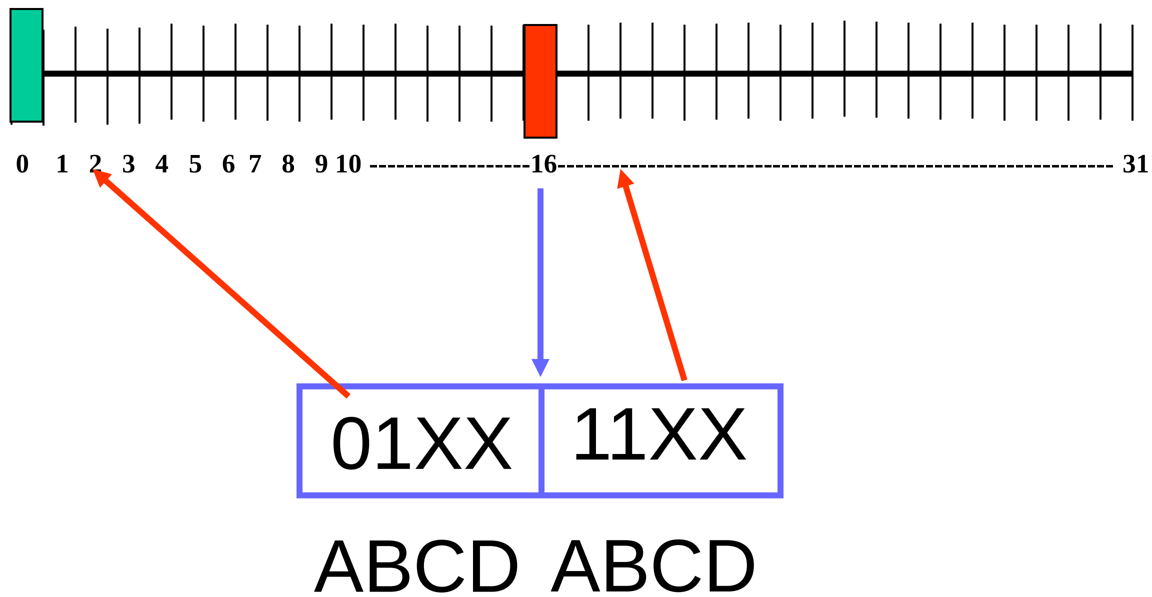
- **It’s possible to dial other character (*,#,A,B..)**

- **This solution is better but is still very poor**

# CIRCUIT SIGNALING ASSOCIATED
# CAS Signaling

- **CAS Means Channel Associated Signaling**

**The most popular CAS signalling is the MFC/R2 (Multi Frequency Compelled R2)**



# CIRCUIT SIGNALING ASSOCIATED

## CAS Signaling

- **The 4 highest bits of the time slot 16 are used for signaling the time slot 1 to 15**
- **The 4 lowest bits of the time slot 16 are used is used for signaling the time slot 17 to 31**
- **At the time the TS 16 give the signaling of the TS 1 and TS 17. 125 µs later the TS 16 give the signaling of the TS 2 and TS 18 ……………..**

# CIRCUIT SIGNALING ASSOCIATED

## CAS Signaling

- **The TS 16 give the sate of the circuit e.g. : sleep, hang up..**

- **The numbering is sent by frequencies inside the circuit as the DTMF but the frequencies are different.**
  **Signalling IN Band**

# CIRCUIT SIGNALING ASSOCIATED
# Below is sample of the MFC/R2 state transition

| Direction | Signal Type | Transition |
|---|---|---|
| **Forward** | Seizure | A,B: 1,0 to 0,0 |
| **Forward** | Clear-forward | A,B: 0,0 to 1,0 |
| **Backward** | Seizure Acknowledgment (ACK) | A,B: 1,0 to 1,1 |
| **Backward** | Answer | A,B: 1,1 to 0,1 |
| **Backward** | Clear-back | A,B: 0,1 to 1,1 |
| **Backward** | Release-guard | A,B: 0,1 to 1,0 |

# CIRCUIT SIGNALING ASSOCIATED
# Below is sample of the MFC/R2 call flow


Pick up

Dialing

Answer

Hang up

# CIRCUIT SIGNALING ASSOCIATED

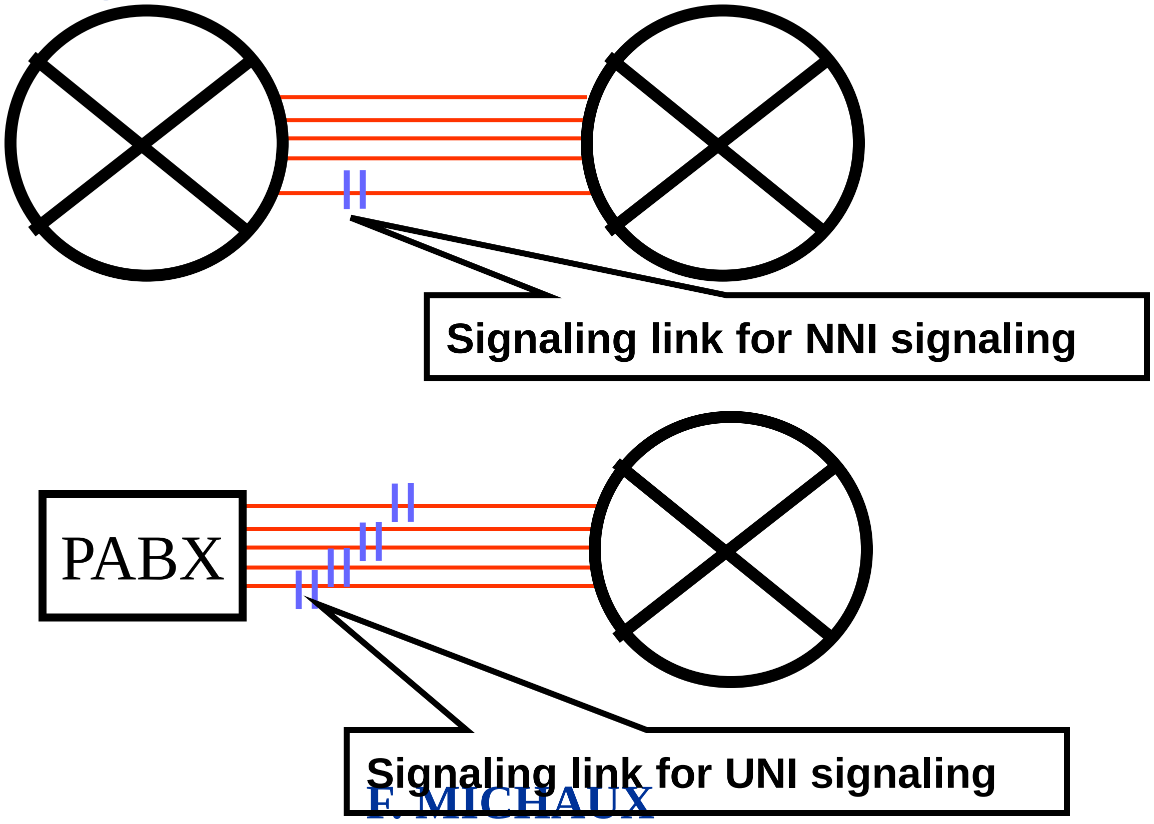
## CAS Signaling conclusion

- This signaling is a UNI and NNI signaling
- This signaling is very rich
- R1, R2 are an example of CAS signaling
- Only one default very slow

# CIRCUIT SIGNALING ASSOCIATED

## CCS Signaling

- CCS Means Common channel signaling
- A signaling link has a rate of 64 Kb/S



# CIRCUIT SIGNALING ASSOCIATED

## CCS Signaling

- The signaling channel is common for several circuit.

- The CCS signaling is in message mode: ISDN for UNI signaling, TUP, ISUP.. For the NNI signaling

- In the UNI signaling one signaling link per E1 in the timeslot 16 named D chanel.

# CIRCUIT SIGNALING ASSOCIATED

## CCS Signaling

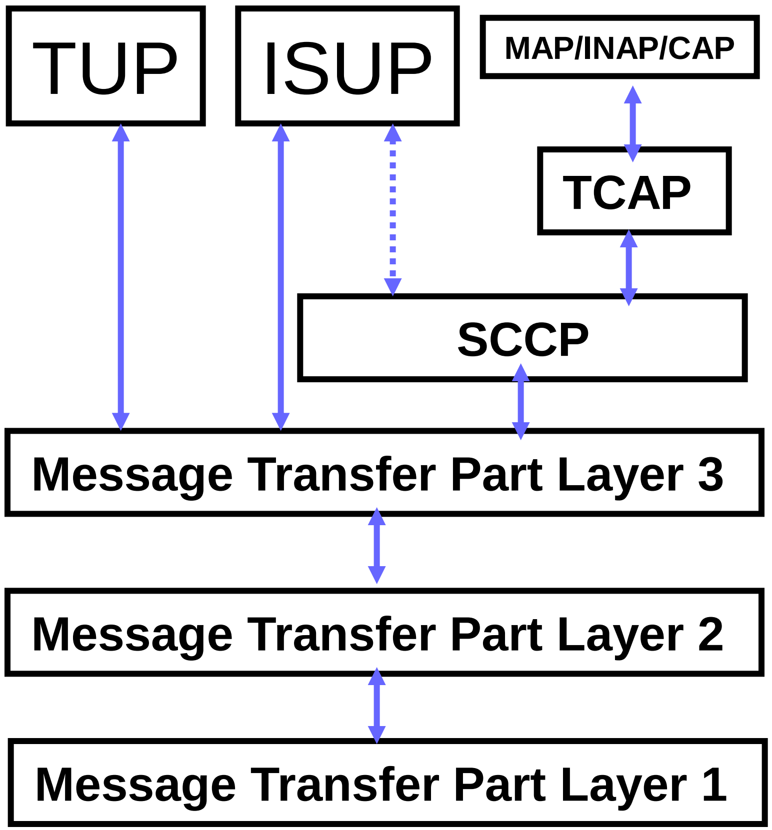
- The CCS Signaling is named signaling N°7, it's a message mode signaling.

- The protocols are different at UNI and NNI level
  UNI : ISDN
  NNI : ISUP

- The benefits of the SS7 signaling are :
  •A better efficiency, the Post Dial Delay (PDD) decreases from 10/20 s in CAS signaling to 2/4 s consequence économy of ressources.
  •Mandatory for added value services and supplementary services.

# SIGNALING SS7

## NNI Signaling N°7 layers description



# SIGNALING SS7
# NNI Signaling N°7 layers description

## Message Transfer Part

## MTP1- Message Transfer Part-1

- MTP1 represents the physical layer, responsible for the connection of SS7 Signaling Points into the transmission network.

## MTP2- Message Transfer Part-2

- MTP 2 ensures exact end-to-end transmission of a message

## MTP3- Message Transfer Part-3

- MTP3 provides routing functionality to transport messages to the destination.

# SIGNALING SS7

# NNI Signaling N°7 layers description

## SCCP

Signaling Connection Control Part

- Network Layer protocol that provides extended Routing, Flow Control, segmentation, Connection orientation and Error Correction facilities in telecommunications networks. SCCP relies on the services of MTP for basic routing and error detection.
- SCCP responsible for GT(Global Title) Routing and Subsystem number (SSN)

## NNI Signaling N°7 layers description

**TCAP**

Transaction Capabilities Application Part

- TCAP facilitate multiple concurrent dialogs between the same sub-systems on the same machines, using Transaction IDs to differentiate these. Similar to TCP multiple sessions on same IP address and port.

# NNI Signaling N°7 layers description

## MAP

Mobile Application Part

- Provides an application layer for the different GSM nodes to communicate with each other to provide services to mobile users. MAP is the application-layer protocol used to access the HLR (Home Location Register), VLR (Visitor Location Register), MSC (Mobile Switching Center), SMSC (Short Message Service Center).

# SIGNALING SS7
# NNI Signaling N°7 layers description

## INAP/CAP

### Intelligent Network Application Part

- Extended form of INAP is Customized Application for Mobile Networks Enhanced Logic (CAMEL). INAP is also application layer protocol to communicate with service control point (SCP).

### CAMEL Application Part

- A signaling protocol used in the Intenrational Intelligent Network architecture.

# SIGNALING SS7

## UNI Signaling N°7 layers description

ISDN

↕

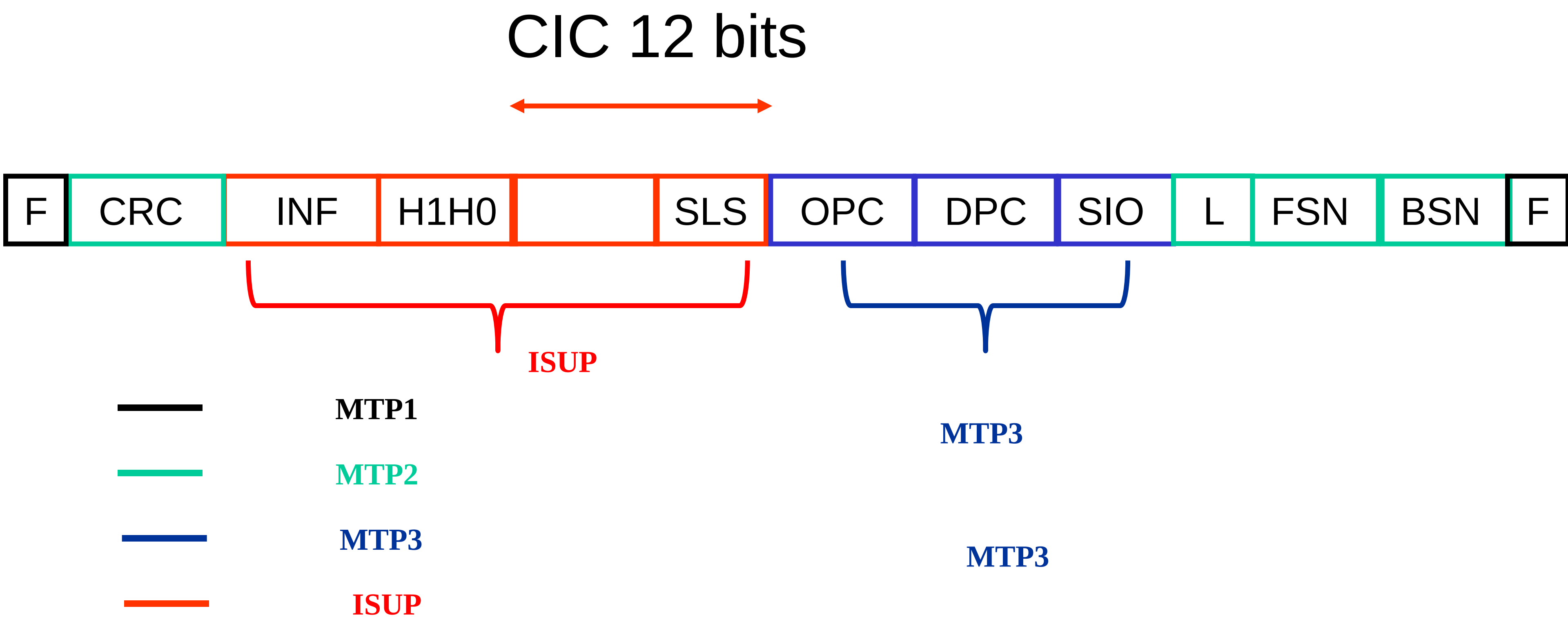
LAP D

↕

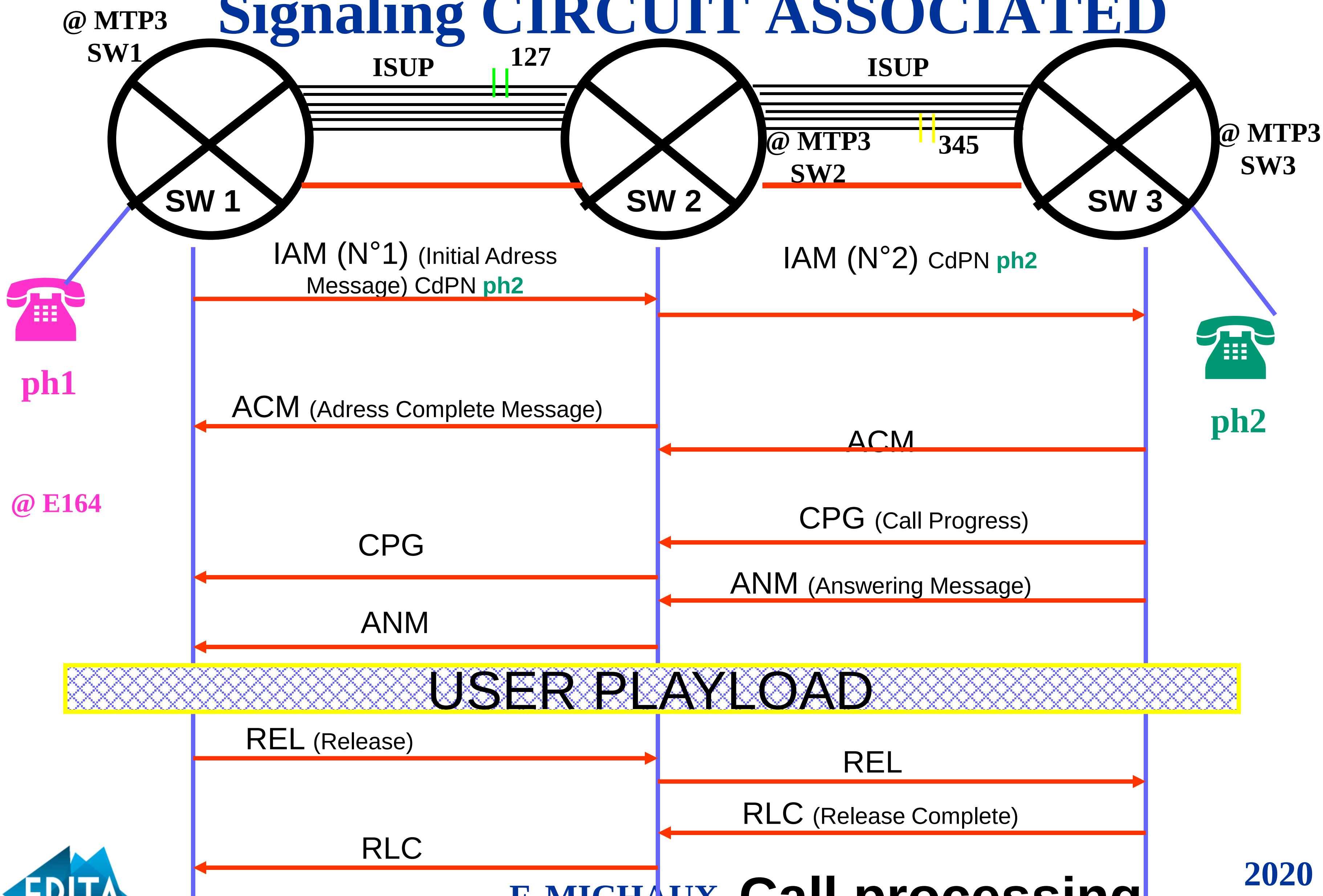
Physical Layer

# SIGNALING SS7

# EXAMPLE OF ISUP MESSAGE



# Signaling CIRCUIT ASSOCIATED

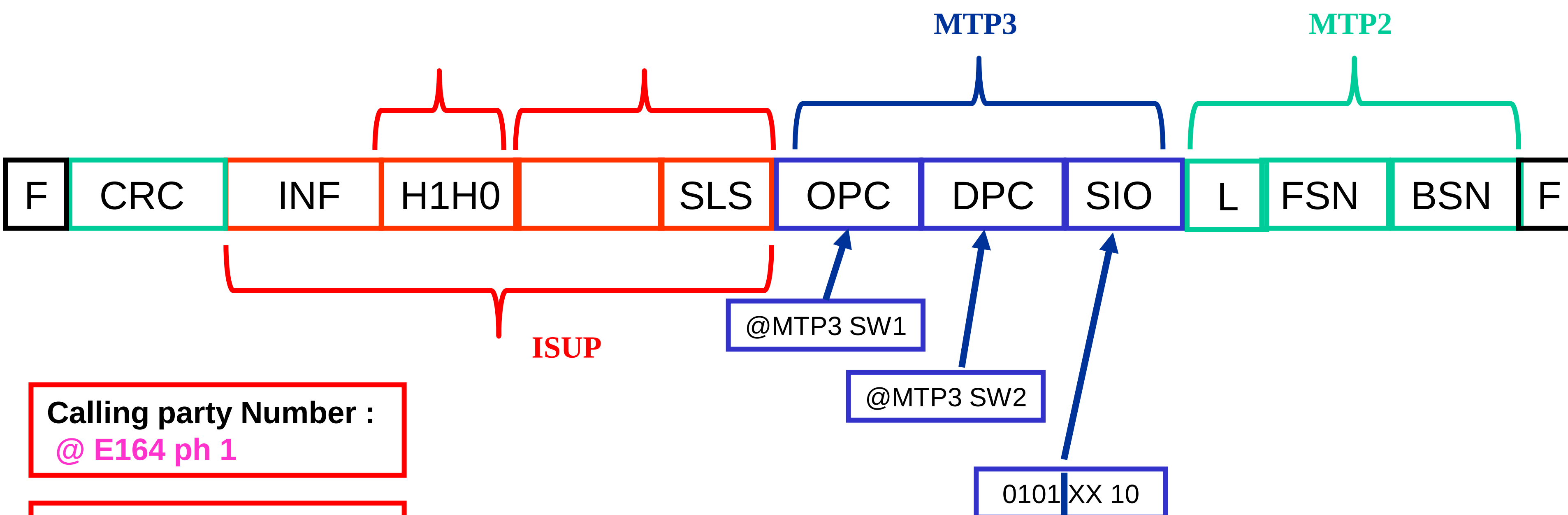


# SIGNALING SS7

## ISUP MESSAGE IAM N°1

**IAM H1HO 0000 0001**

**CIC : ** 12 bits Number of Circuit = 127




**Calling party Number :**
**@ E164 ph 1**

**Called party Number :**
**@ E164 ph 2**

**ISUP : 0101**

**MTP3 : 0101**

**SCCP : 0011**

**INT: 00**
**NAT: 10**

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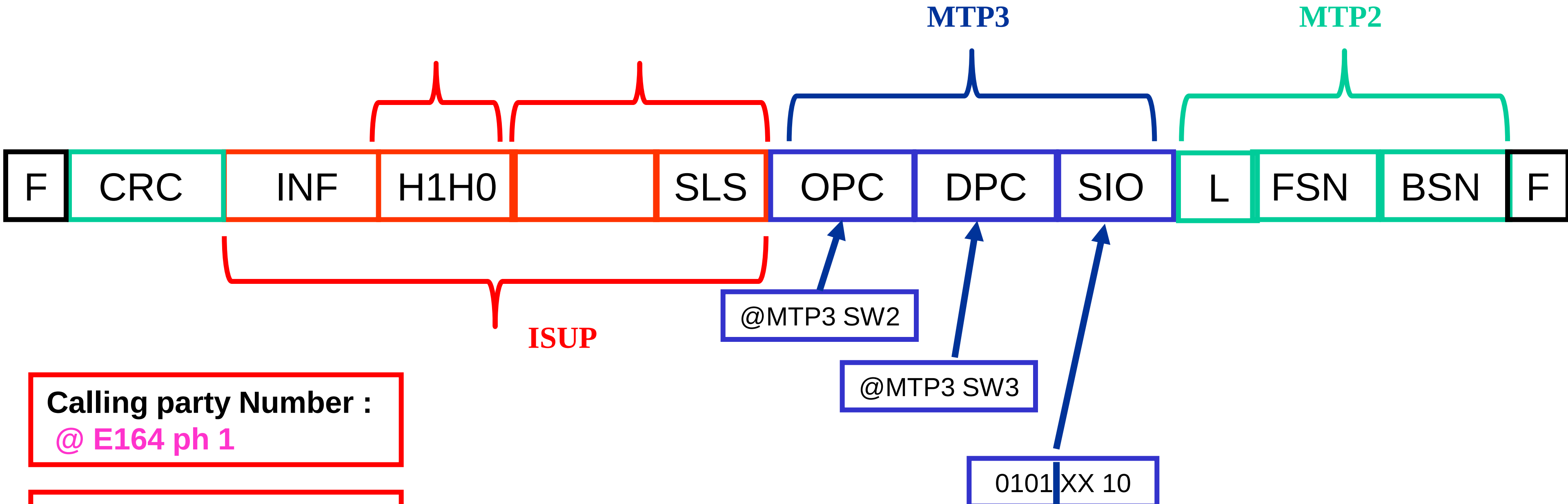
# SIGNALING SS7

# ISUP MESSAGE IAM N°2

**IAM H1HO 0000 0001**

**CIC** : 12 bits Number of Circuit = 345




**Calling party Number :**
**@ E164 ph 1**

**Called party Number :**
**@ E164 ph 2**

**ISUP : 0101**
**MTP3 : 0101**
**SCCP : 0011**

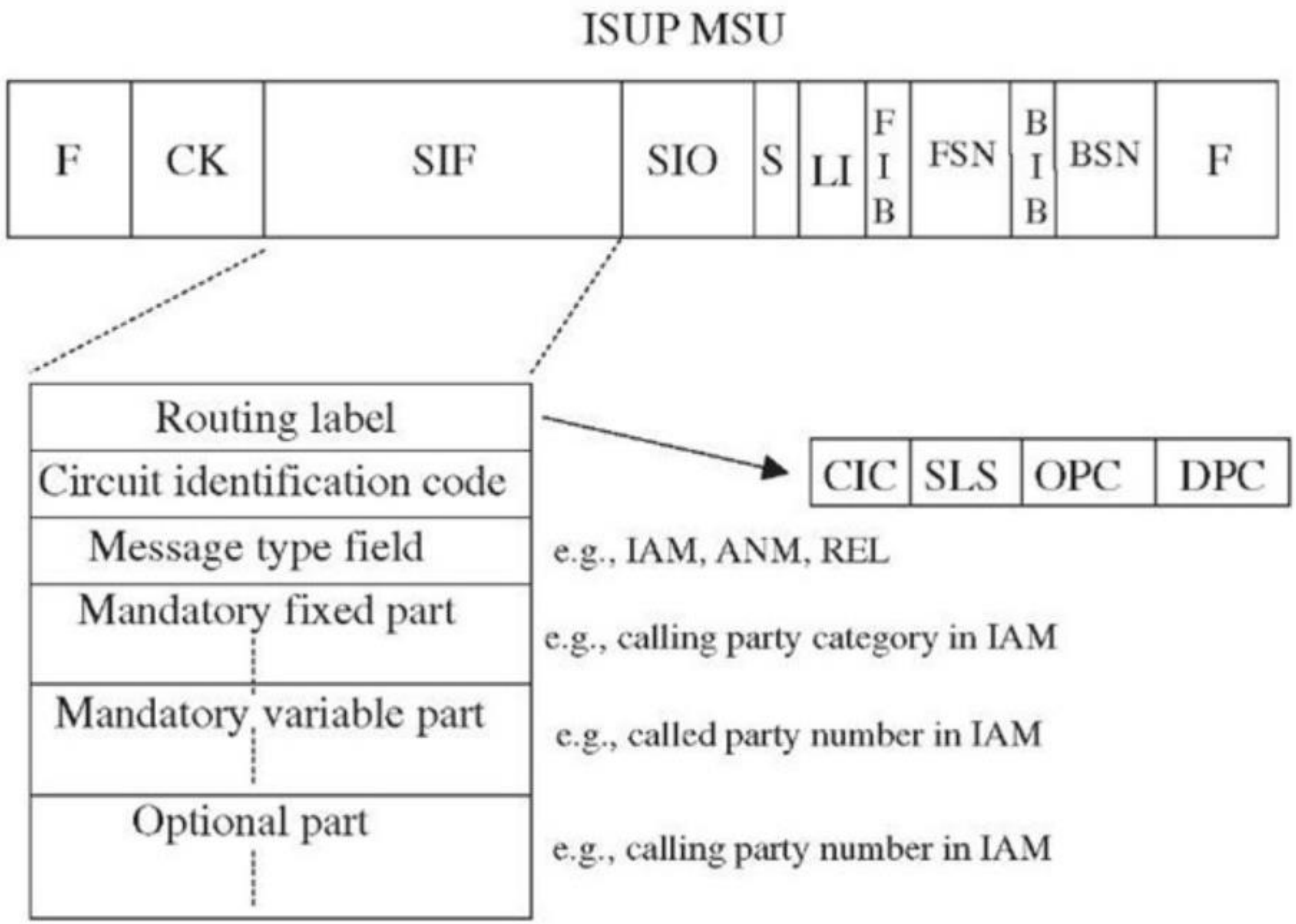
**INT: 00**
**NAT: 10**

# SIGNALING SS7 Type of ISUP Message

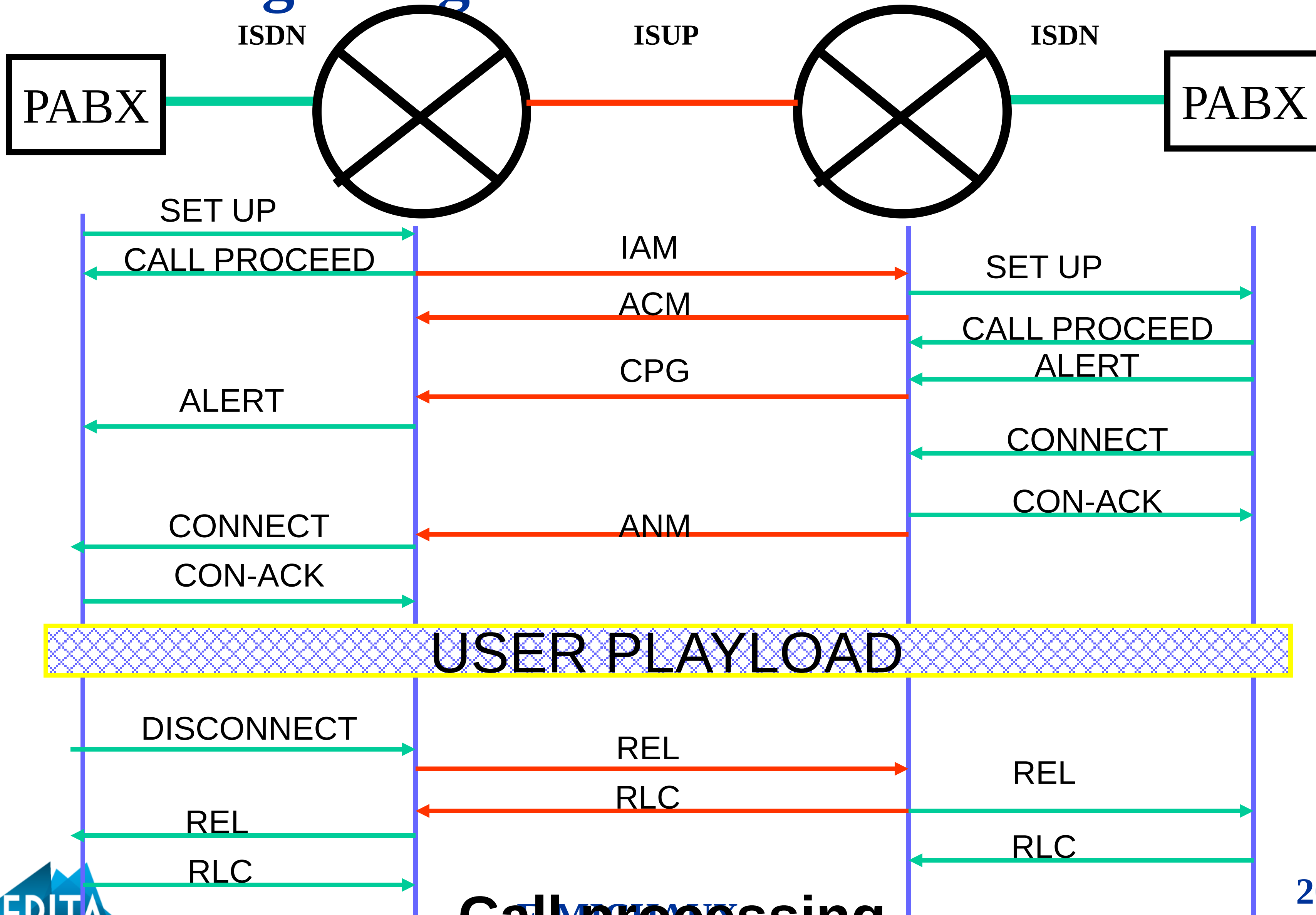
| Mnemonics | Opcode (hex) | Message name |
|---|---|---|
| **ACM** | **06** | **Address complete** |
| **ANM** | **09** | **Answer** |
| BLO | 13 | Blocking |
| BLA | 15 | Blocking acknowledgment |
| CMC | 1D | Call modification completed |
| CMRJ | 1E | Call modification reject |
| CMR | 1C | Call modification request |
| **CPG** | **2C** | **Call progress** |
| CRG | 31 | Charge information |
| CGB | 18 | Circuit group blocking |
| CGBA | 1A | Circuit group blocking acknowledgment |
| GRS | 17 | Circuit group reset |
| GRA | 29 | Circuit group reset acknowledgement |
| CGU | 19 | Circuit group unblocking |
| CGUA | 1B | Circuit group unblocking acknowledgment |
| CQM | 2A | Circuit query |
| CQR | 2B | Circuit query response |
| CVR | EB | Circuit validation response |
| CVT | EC | Circuit validation test |
| CSVR | 25 | Closed user group selection and validation request |
| CSVS | 26 | Closed user group selection and validation response |
| CNF | 2F | Confusion |
| CON | 07 | Connect |
| COT | 05 | Continuity |
| CCR | 11 | Continuity check request |

| Mnemonics | Opcode (hex) | Message name |
|---|---|---|
| DRS | 27 | Delayed release |
| EXM | ED | Exit |
| FAA | 20 | Facility accepted |
| FAD | 22 | Facility deactivated |
| FAI | 23 | Facility information |
| FRJ | 21 | Facility reject |
| FAR | 1F | Facility request |
| FOT | 08 | Forward transfer |
| INF | 04 | Information |
| INR | 03 | Information request |
| **IAM** | **01** | **Initial address message** |
| LPA | 24 | Loopback acknowledgment |
| OLM | 30 | Overload |
| PAN | 28 | Pass along |
| **REL** | **0C** | **Release** |
| **RLC** | **10** | **Release complete** |
| RSC | 12 | Reset circuit |
| RES | 0E | Resume |
| SAM | 02 | Subsequent address message |
| SUS | 0D | Suspend |
| UBL | 14 | Unblocking |
| UBA | 16 | Unblocking acknowledgment |
| UCIC | 2E | Unequipped circuit identification code |
| USR | 2D | User-to-user information |

# SIGNALING SS7 format ISUP Message

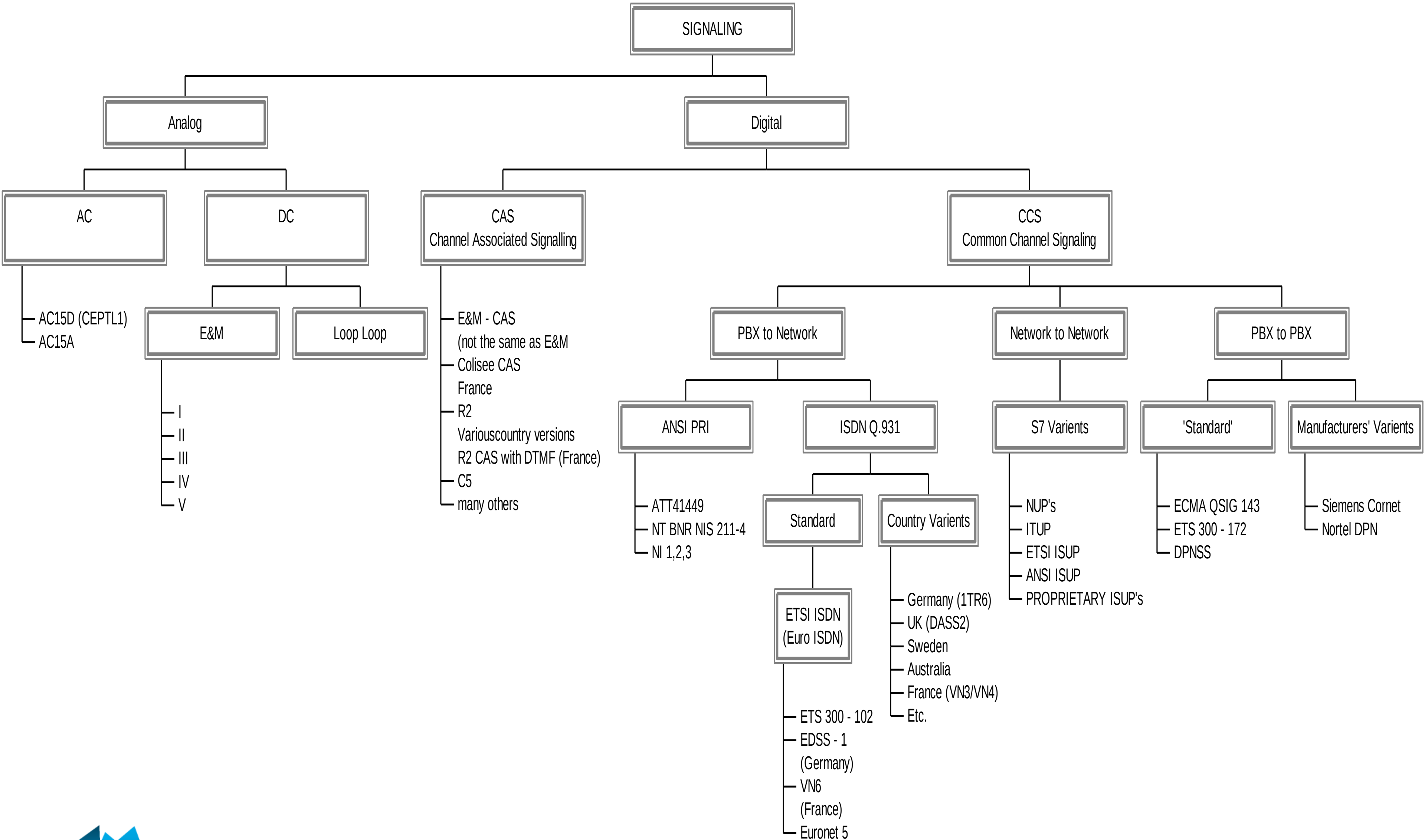


# Signaling CIRCUIT ASSOCIATED

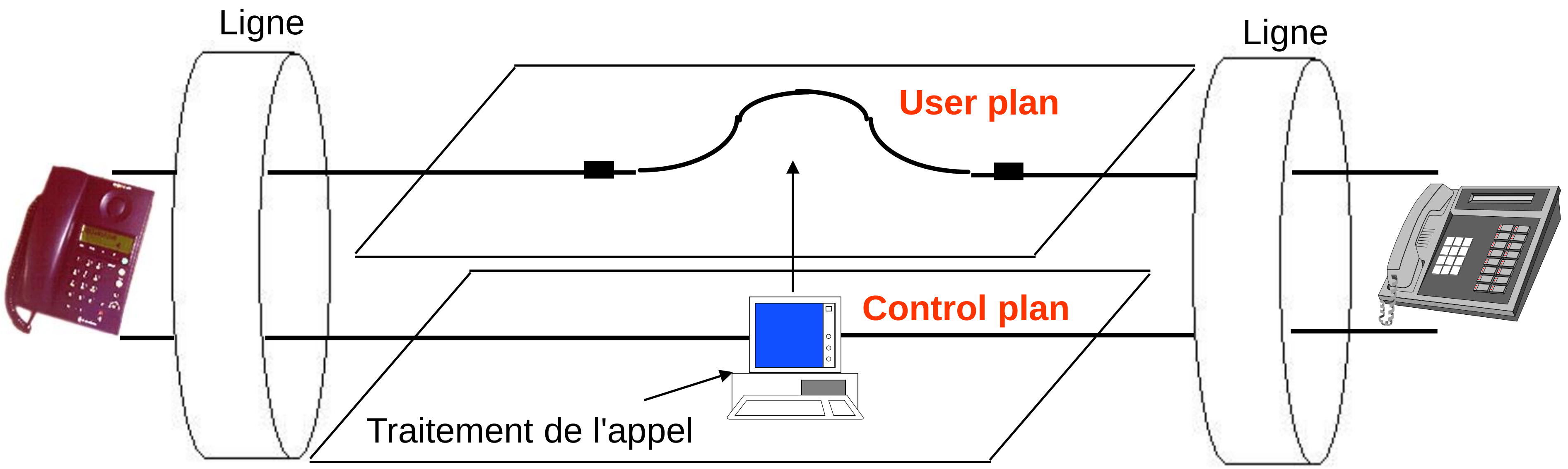



**Call processing**

# Signaling CIRCUIT ASSOCIATED



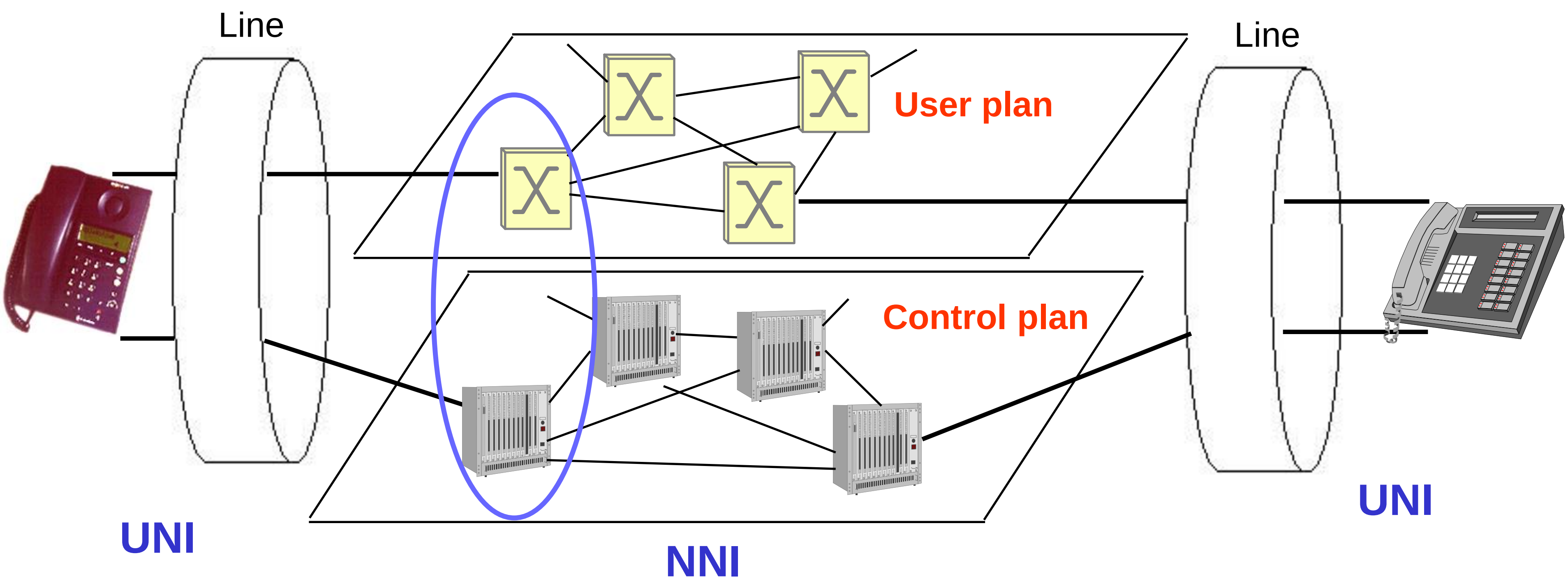
# Control plan / User plan 1/13




Control Plan : In charge to establish the connexion
User Plan : In charge to connect the voice ressources

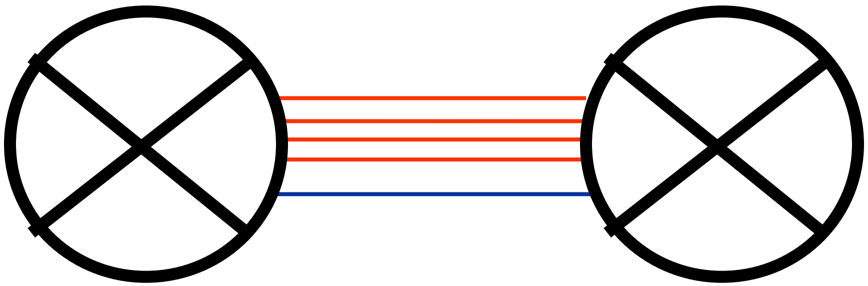
⇨ **the both networks are parrallele**

# Control plan / User plan 2/13




It’s a logical separation which can be also physical with an overlay network

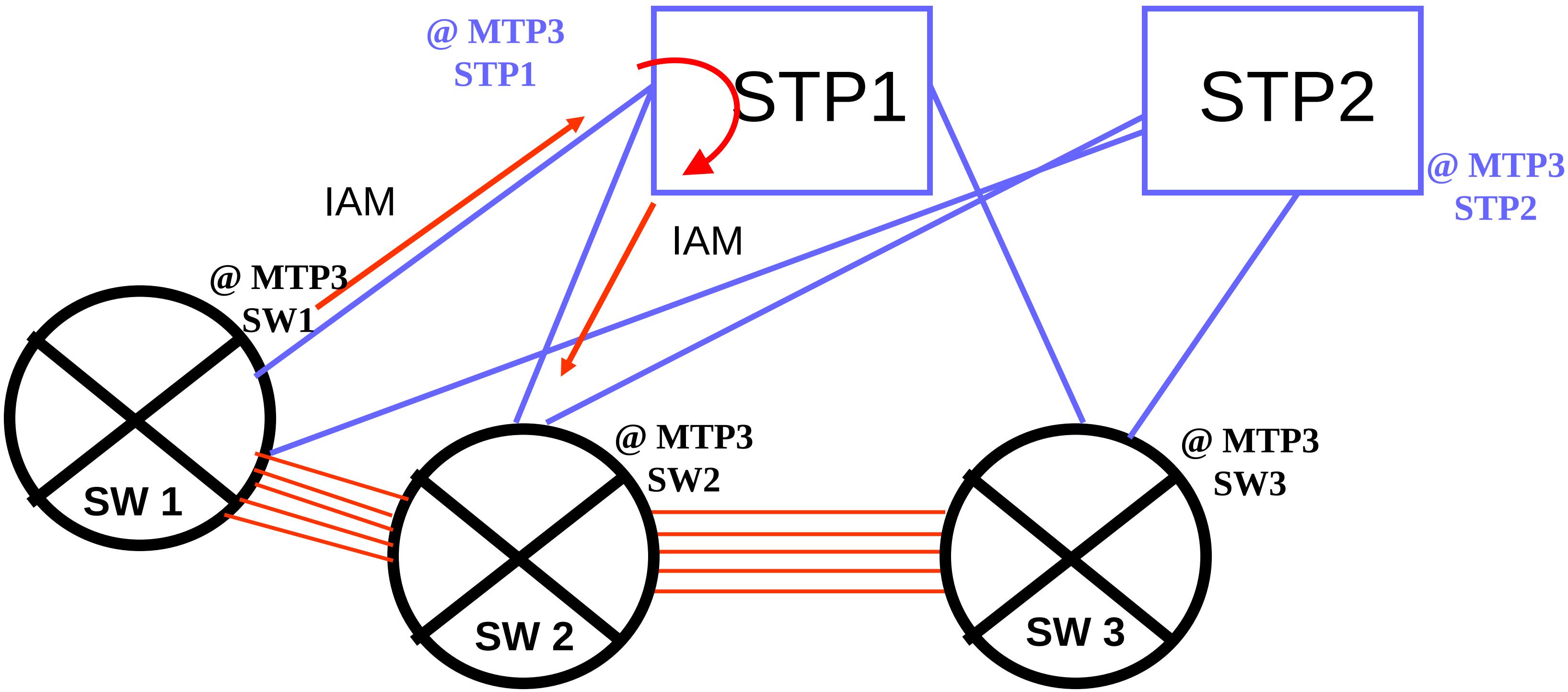
# Control plan / User plan 3/13



**Associated mode**

The Signaling link is dedicated to one voice trunk

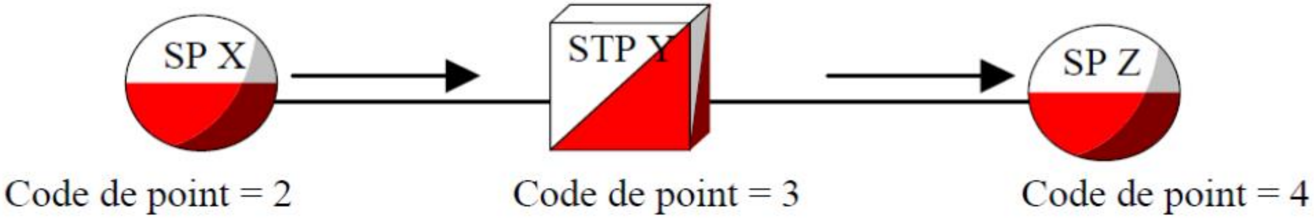
# Control plan / User plan 4/13

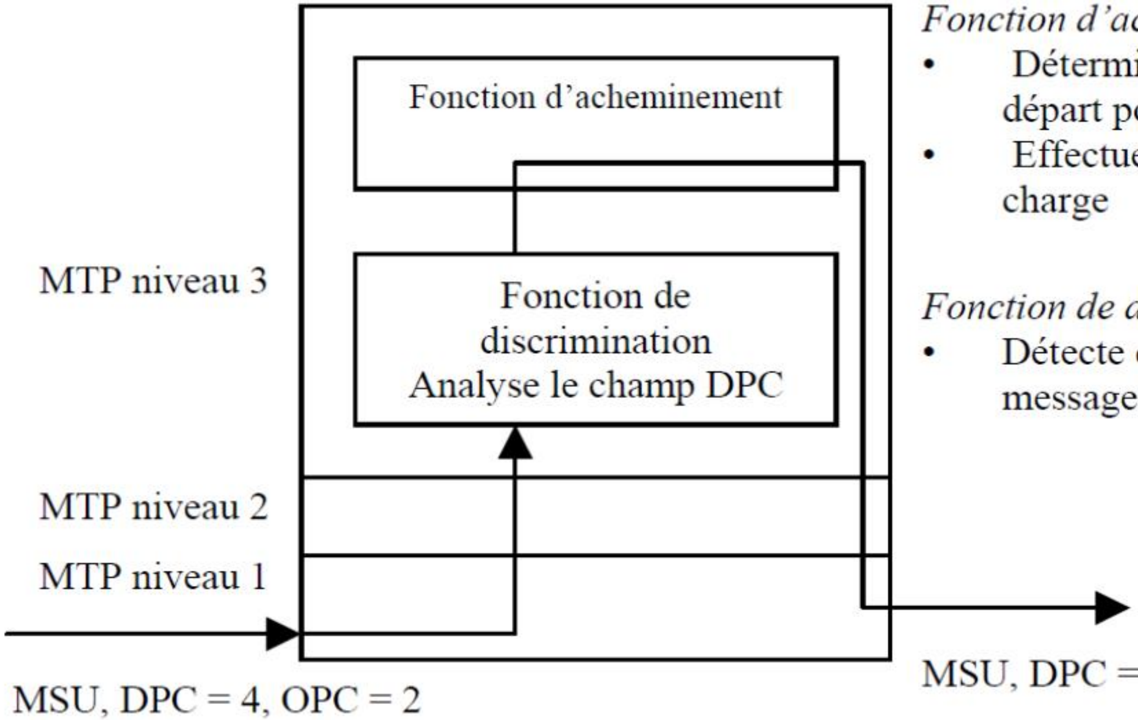



## Quasi Associated mode

The Signaling link is not dedicated to one voice trunk

# Control plan / User plan 5/13
# STP Function




*Fonction d'acheminement*

- Détermine le canal de départ pour le DPC = 4
- Effectue le partage de charge

*Fonction de discrimination*

- Détecte que ce message

# Control plan / User plan 6/13 Location update Translation at the SCCP Layer

HLR : Home location register

MSC : Mobile Switch Centre

SCCP : Signalling Connection Control Part

HLR 4 — @ MTP3 HLR4

HLR 3 — @ MTP3 HLR3

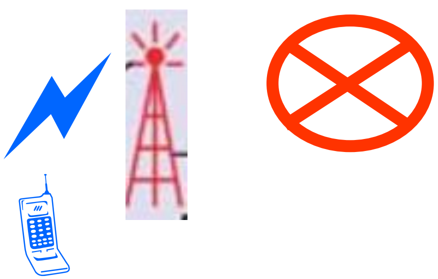
HLR 2 — @ MTP3 HLR2

HLR 1 — @ MTP3 HLR1

Location Uptate

Which HLR is the good one ?

**IMSI Number Z → @ MTP3 HLR ?**



MSC/VLR

@ MTP3 MSC 1

**SCCP Translator**

| |
|---|
| GT IMSI Z |
| SCCP |
| MTP3 |
| MTP2 |
| MTP1 |

Mobile Subscriber IMSI Number

@ MTP3 HLR1

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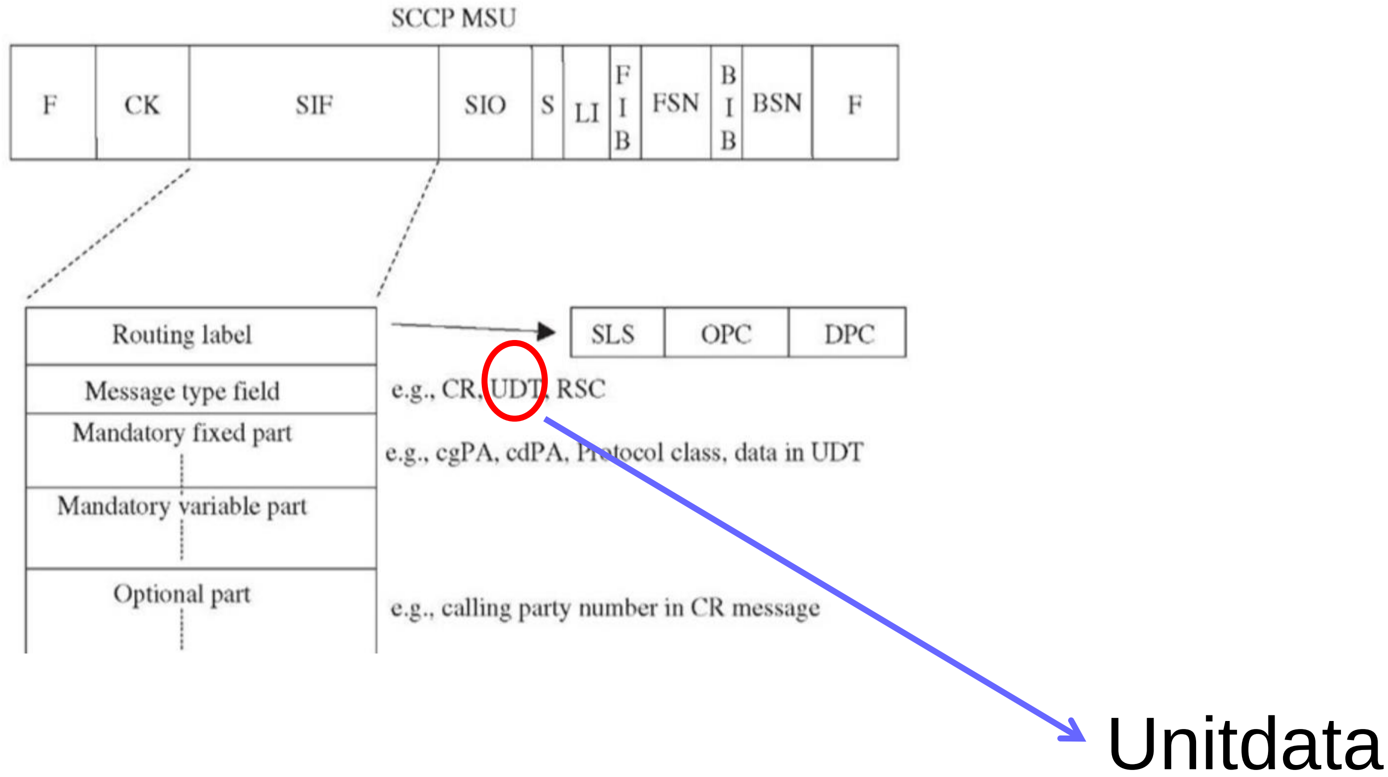
# Control plan / User plan 7/13 SCCP format message

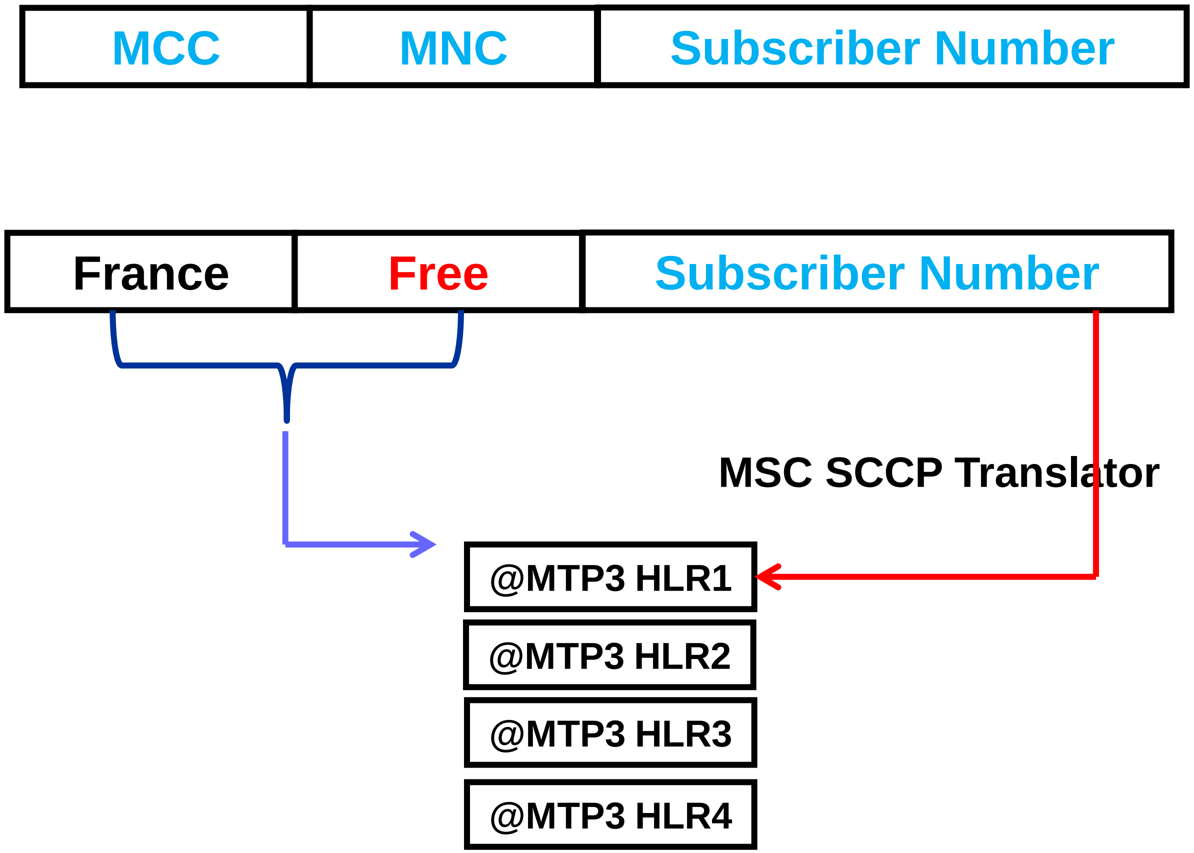
**The structure of SCCP message is shown in Figure 2-13.** The SCCP messages are transferred between nodes in the Level 3 MSU. The SCCP MSU is identified by the SIO value, which is set to 03hex. As shown in the figure, the SCCP message is of variable length. It consists of a routing label, message type, and a few mandatory and optional information elements.



# Control plan / User plan IMSI adress 8/16

MCC Mobile Country Code

**E212 Format IMSI : « SIM card adress »**

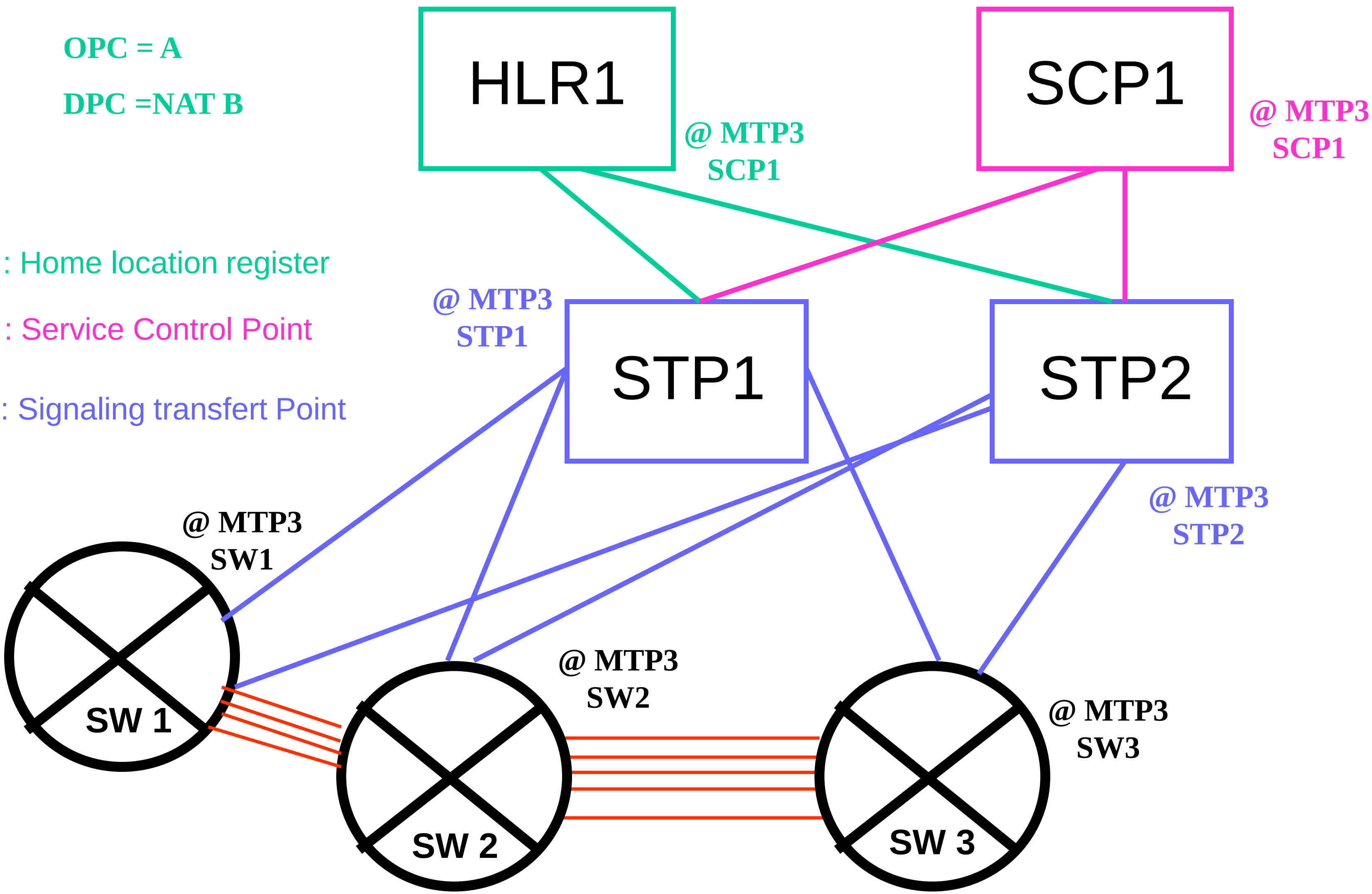


# Control plan / User plan 9/16

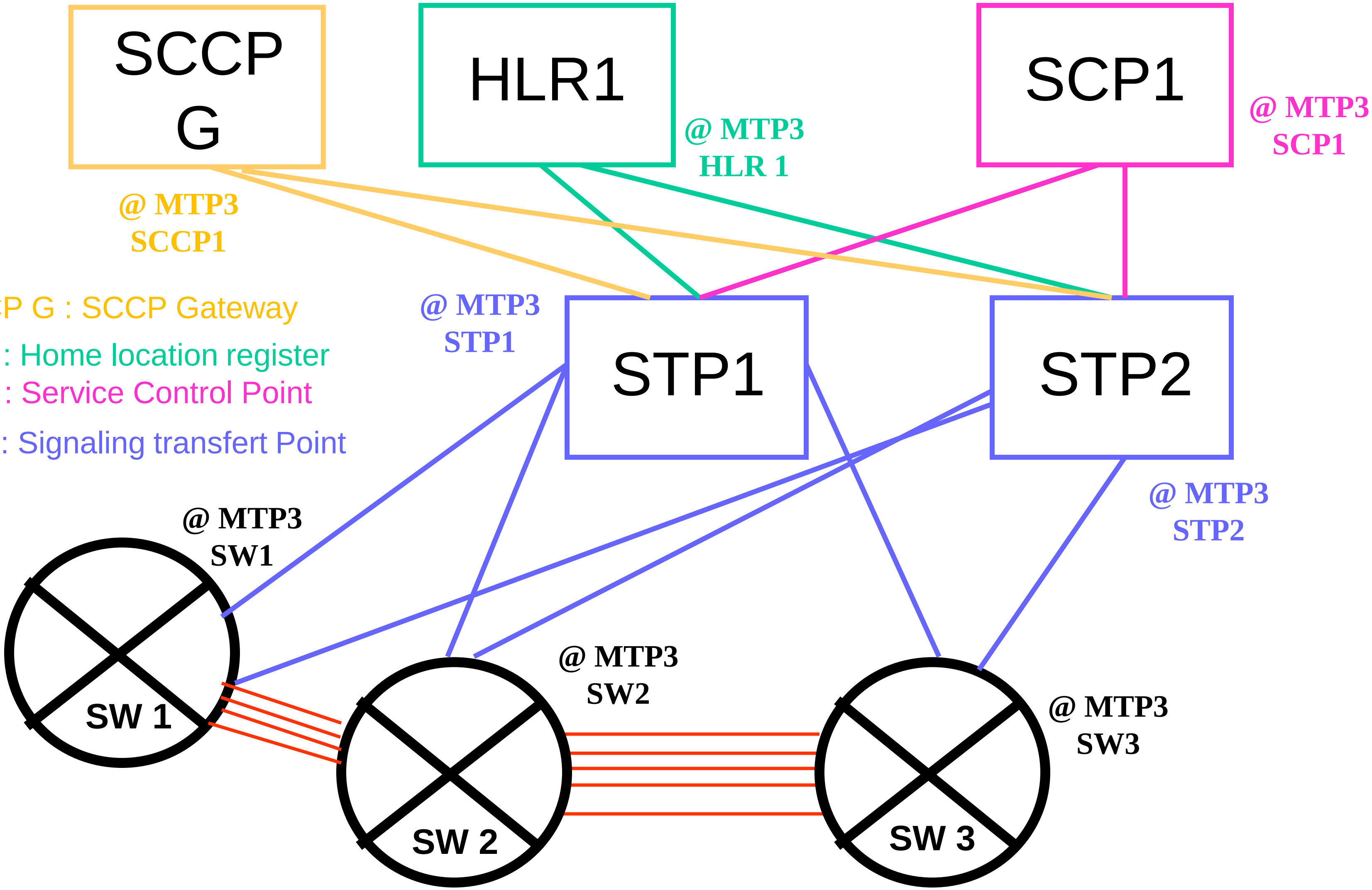
HLR : Home location register

SCP : Service Control Point

STP : Signaling transfert Point



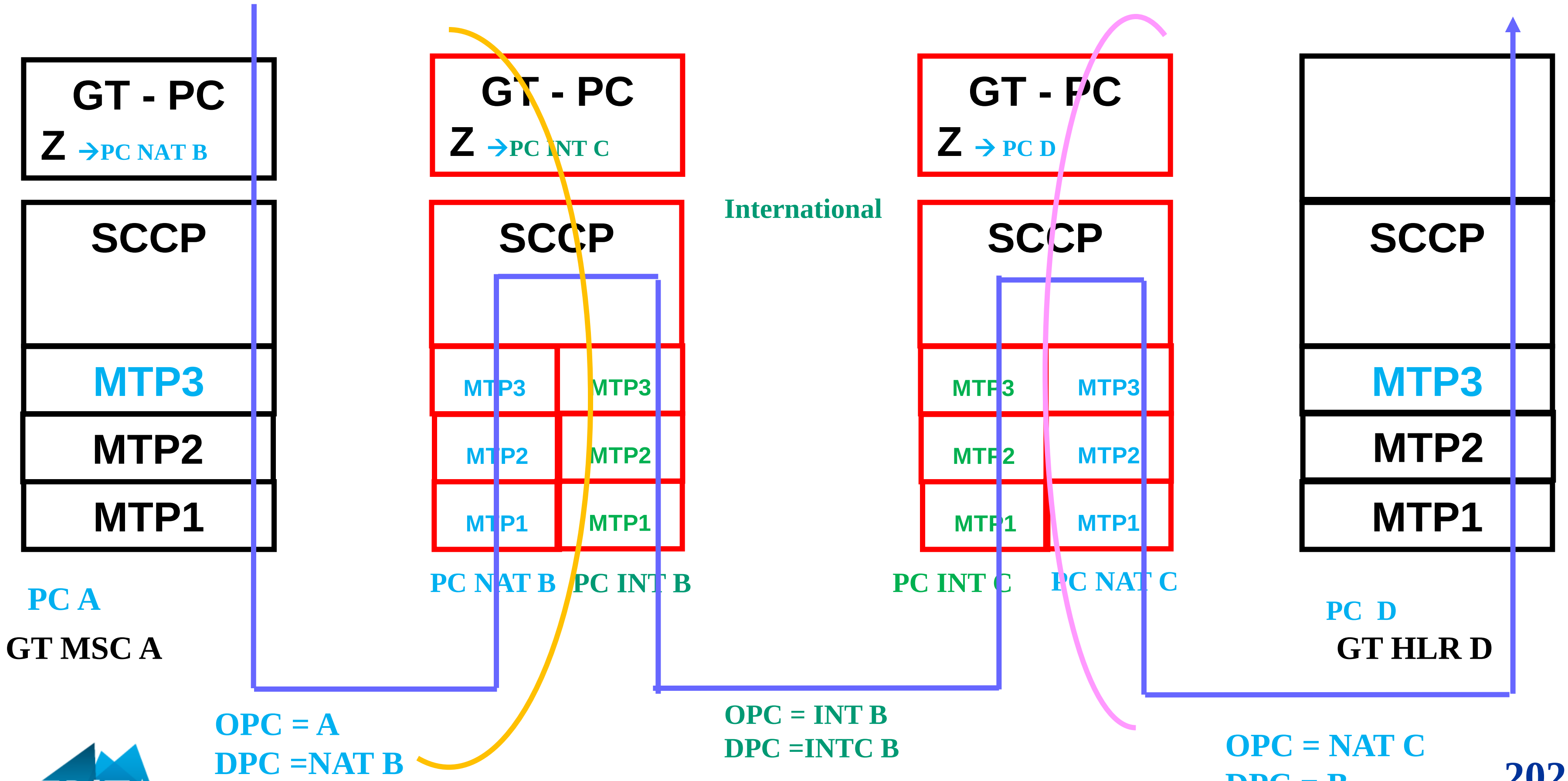
# Control plan / User plan 10/16




SCCP G : SCCP Gateway
HLR : Home location register
SCP : Service Control Point
STP : Signaling transfert Point

# Control plan / User plan 11/16
# SCCP G function

A switch has an @MTP3 and a @GT in order to exchange MAP signalling Messages between 2 nodes for roaming purpose. SCCP layer is in charge to translate GT to an @MTP 3 (**G**lobal **T**itle to **P**oint **C**ode)

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# Control plan / User plan
# Global Tittle Adress 12/16

## Fixe Network Subscriber :

**E 164 address : + 33 (0) 1 45 57 98 18**

## Mobile Network Subscriber :

**E 164 address : +33 (0) 6 07 35 65 15    33 for France 1 for USA, 44 for UK ,.**

## E164 Format

**E 164 : Country Code + Subscriber Number**

## E212 Format

**E212 Format : Mobile Country Code + Mobile Network Code + Subscriber IMSI**

**208 for France, 313 USA, 234 & 235 UK**

**Orange : 01,02**

**SFR : 08, 09,10, 11**

**Free : 15, 16**

**Bouygues : 20,21,88**

**Lyca Mobile : 25**

# Global Tittle Adress 13/16

## Fixe Network Subscriber :

**E 164 address : + 33 (0) 1 45 57 98 18**

## Mobile Network Subscriber :

**E 164 address : +33 (0) 6 07 35 65 15    33 for France 1 for USA, 44 for UK ,.**

## E164 Format

**E 164 : Country Code + Subscriber Number**

## E214 Format mix of E164 and E212

**E214 : CC + XYZ + Subscriber IMSI**

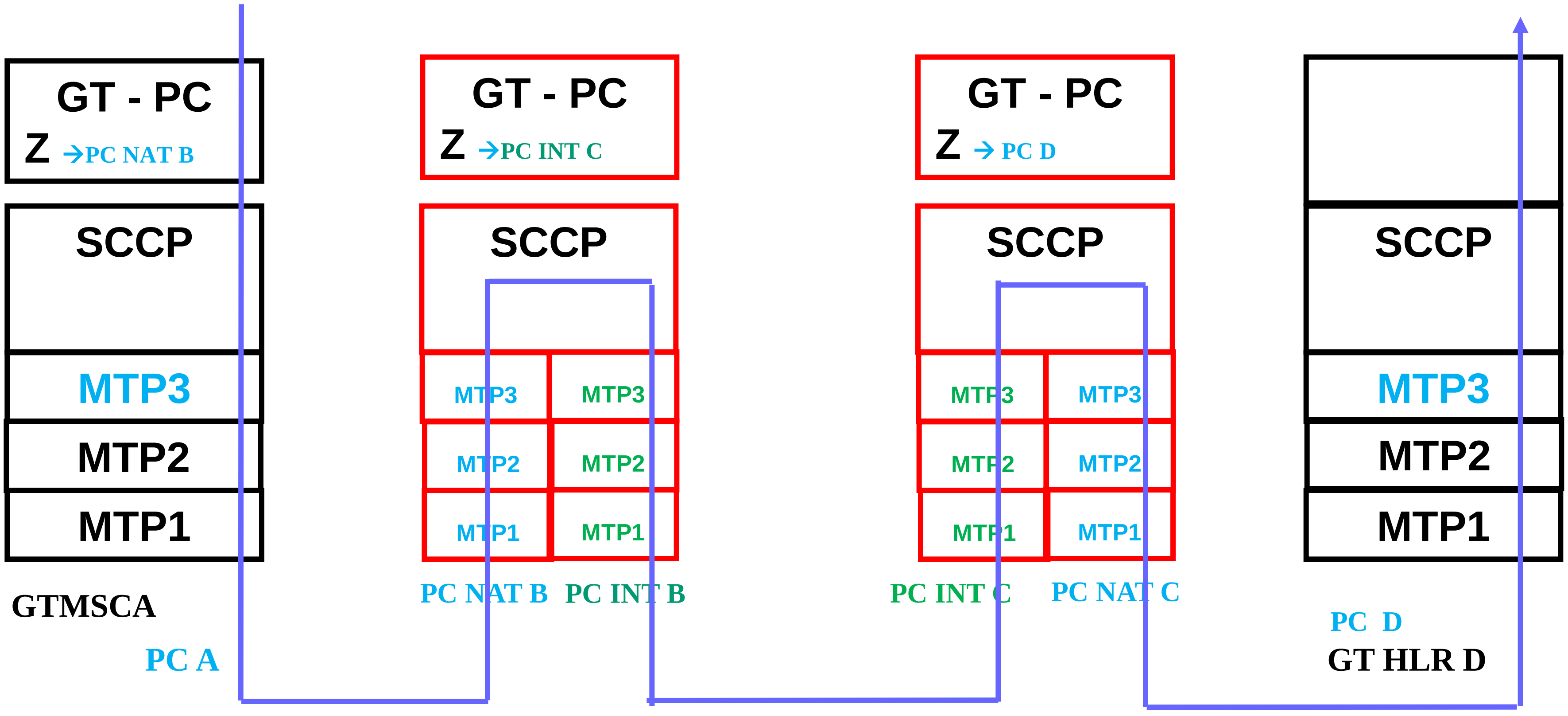
**Orange : 33 607 + Subscriber IMSI**

**SFR :  33 611+ Subscriber IMSI**

**Bouygues : 33 6 60 +Subscriber IMSI**

# Control plan / User plan 14/16
# SCCP G function

Z : E 214 adress
GT MSC A : E 164
GT HLR D : E 164



# Control plan / User plan 15/16

## link set dimensioning

- A link  set dimensioning is a set of signaling links connected to the same signaling adress.

- The link set dimensioning depends of the trunk group size. One signaling per 2000 circuits,  they are duplicated for security reason.

- Example : 2000 circuits 2 signaling links
  1000 circuits 2 signaling links
  4000 circuits 4 signaling links

# Control plan / User plan 16/16

## Signaling link dimensioning

- Signaling link economy.
- The traffic is centralized in the STP interesting for the monitoring.
- Mandatory to plug service added value platforms

# IN call emergency Call «17 » Police Station

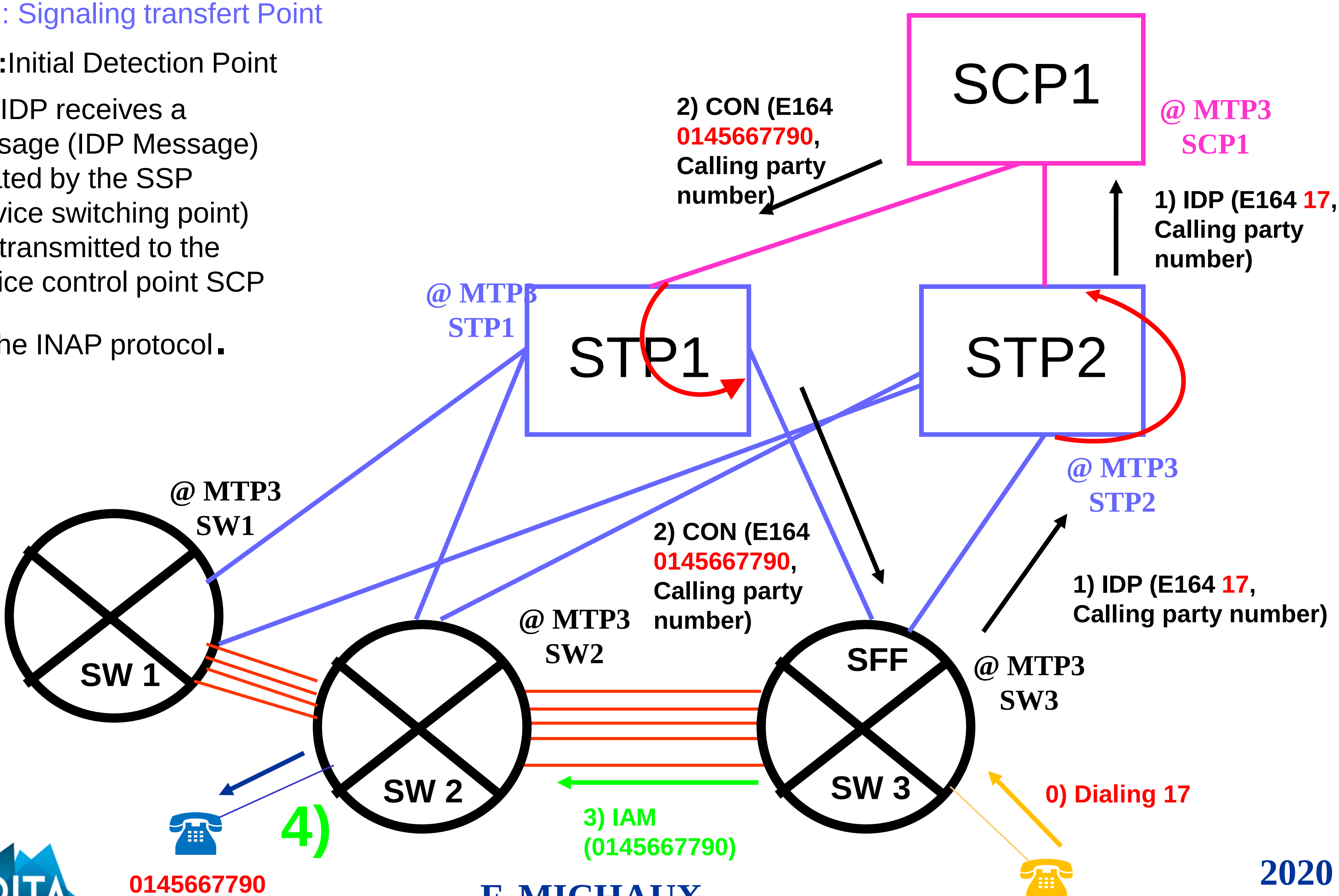
**SCP** : Service Control Point

**STP** : Signaling transfert Point

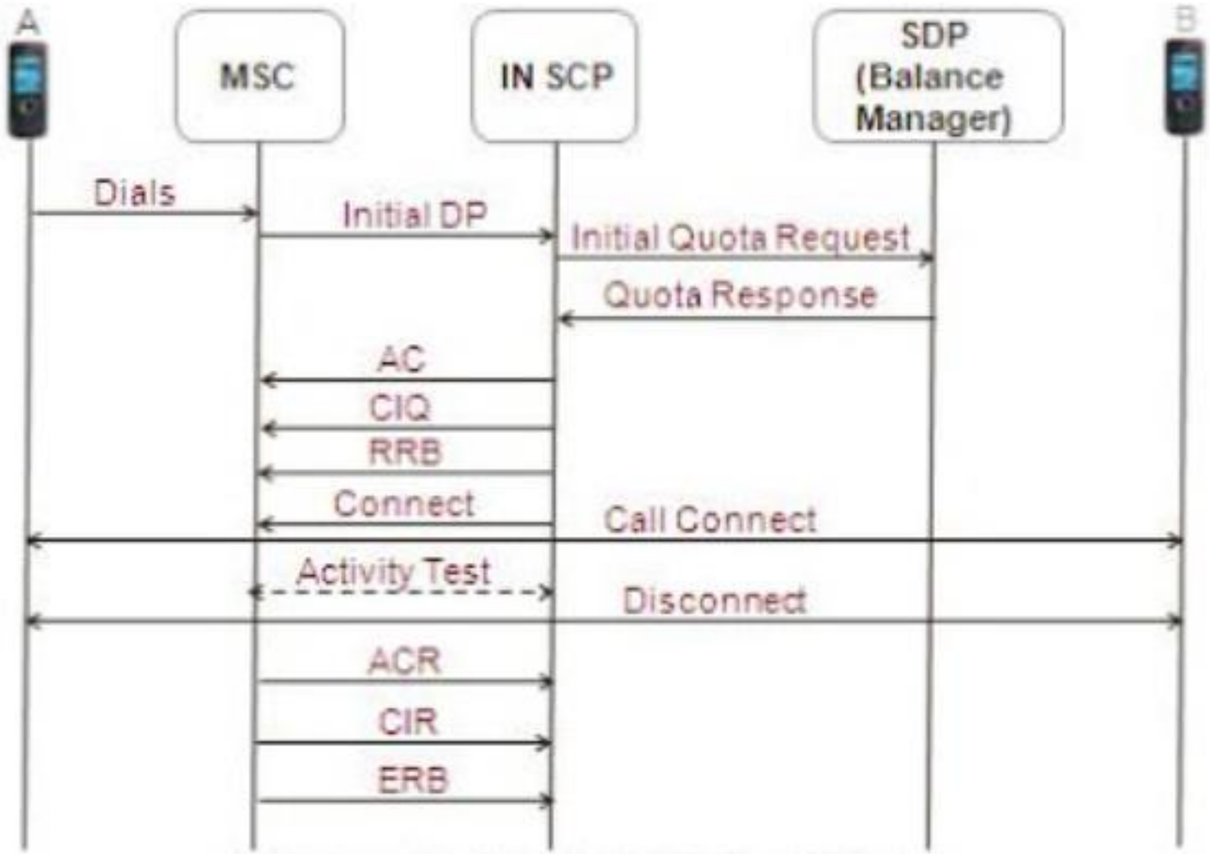
**IDP :**Initial Detection Point

The IDP receives a message (IDP Message) initiated by the SSP (service switching point) and transmitted to the service control point SCP

via the INAP protocol.



# Prepaid Service via IN solution




Normal Prepaid (IN) Call Flow

# Prepaid Service via IN solution

The previous flow describes a basic direct dial call scenario with normal call termination:

1. Mobile A starts a new call by dialing Mobile B.

2. The MSC sends an IDP (Initial Detection Point) event, which notifies the IN-SCP of the new call.
 IDP Message Contains :- A-Party no, B-Party no., Service key=90, A Party Location, Time stamp.

3. The IN SCP processes the request and after authorizing the user, the IN SCP sends 3 IN messages to the MSC -

AC (Apply Charging) :- Check the A-Party Balance / tariff related facilities & provides maximum granted time for a call.

CIQ (Call Information Query) :- IN request from the MSC for call information, like *CAET* - *Call Attempt Elapsed Time* (time between call ringing & user picks the call), CCET - *Call Connect Elapsed Time* (Duration of a call), *CST* - *Call Stop Time* (exact time when call disconnect), RC - *Release Cause* (Exact release cause due to which call got disconnected).

RRBCSM (Request Report Basic Call State Module) :- IN again request from MSC for detailed Release Cause.

4. Connect :- After getting everything OK i.e. all request from IN side have been done then IN sends a Connect message to MSC for further call processing & connect the call.

5. Activity Test :- After IN provides "connect" message to MSC, its a sort of ping message which is unidirectional, sent by IN to MSC, to know the progress of a call.

6. Once the connection is made, an event report (for answer event) is sent to SDP via IN-SCP.for preventing any revenue loss.

# Prepaid Service via IN solution

7. After conversation, when call gets disconnected, a new event report is sent to SDP via IN-SCP, which in turn instructs to release the call.

8. Once the call is released, a new Apply Charging Report (ACR) is sent to IN-SCP, which contains full time usage data of a call. This report is sent to SDP for accurate & final call charging.

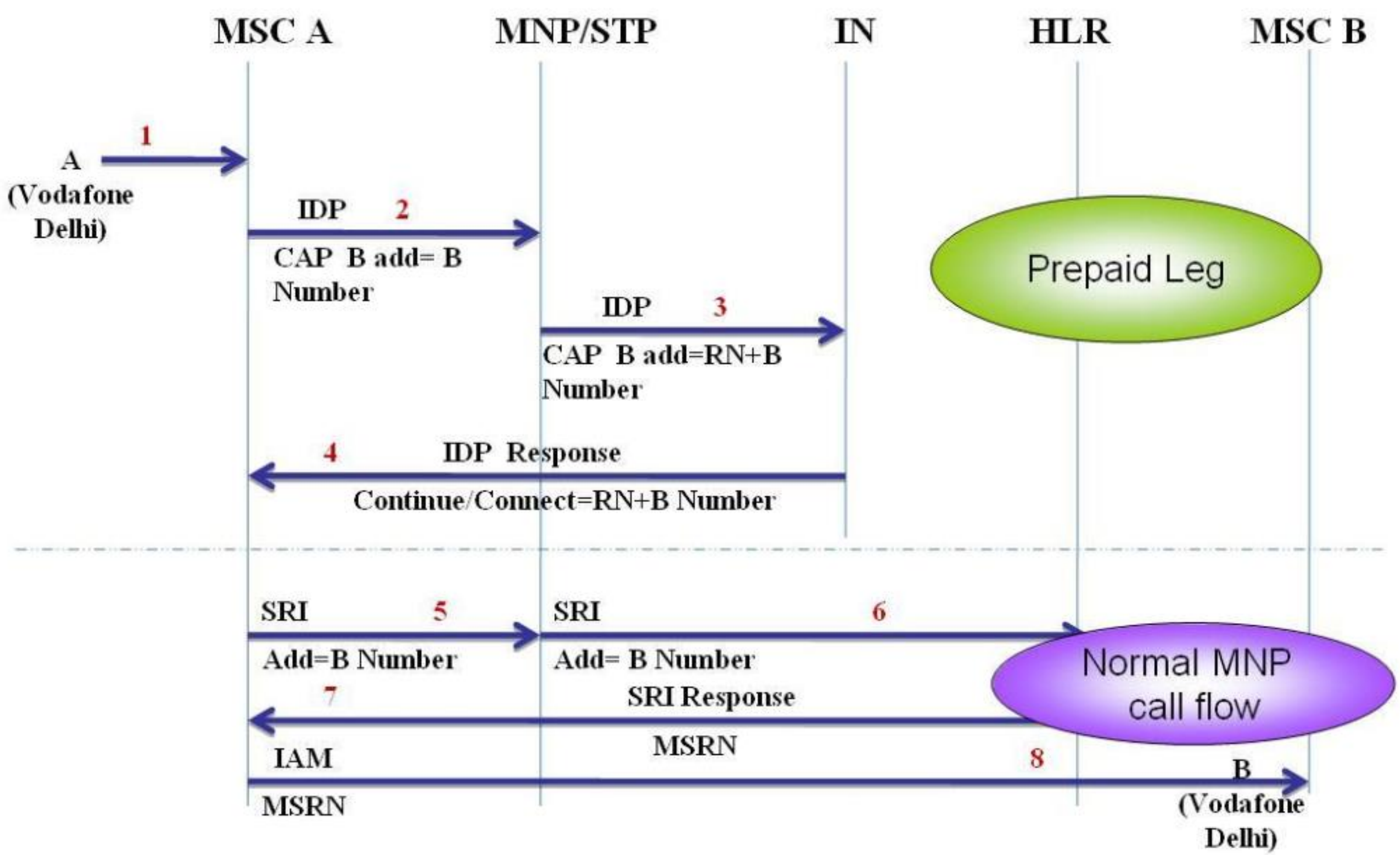
9. CIR (Call Information Report) :- By using the details which was noted in CIQ message, MSC makes a report i.e. CIR (which contains CAET, CCET, CST, RC) & sends to SDP via IN-SCP.

10. ERB (Evert Report BCSM) :- Another report send by MSC to IN, which contains actual release cause in details, which may be - Abandon, B-Party Busy, B-Party no answer, B-Party not reachable, route selection failure, disconnect.

11. Finally signaling terminates, which ends the call.

# Mobile Network Portability Service via IN solution

**A Subscriber calls an B Subscriber (Ported In or Normal Subscriber), Both In Same PLMN (Local)**

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# Basic Mobile Call

HLR : Home location register

MSC : Mobile Switch Centre

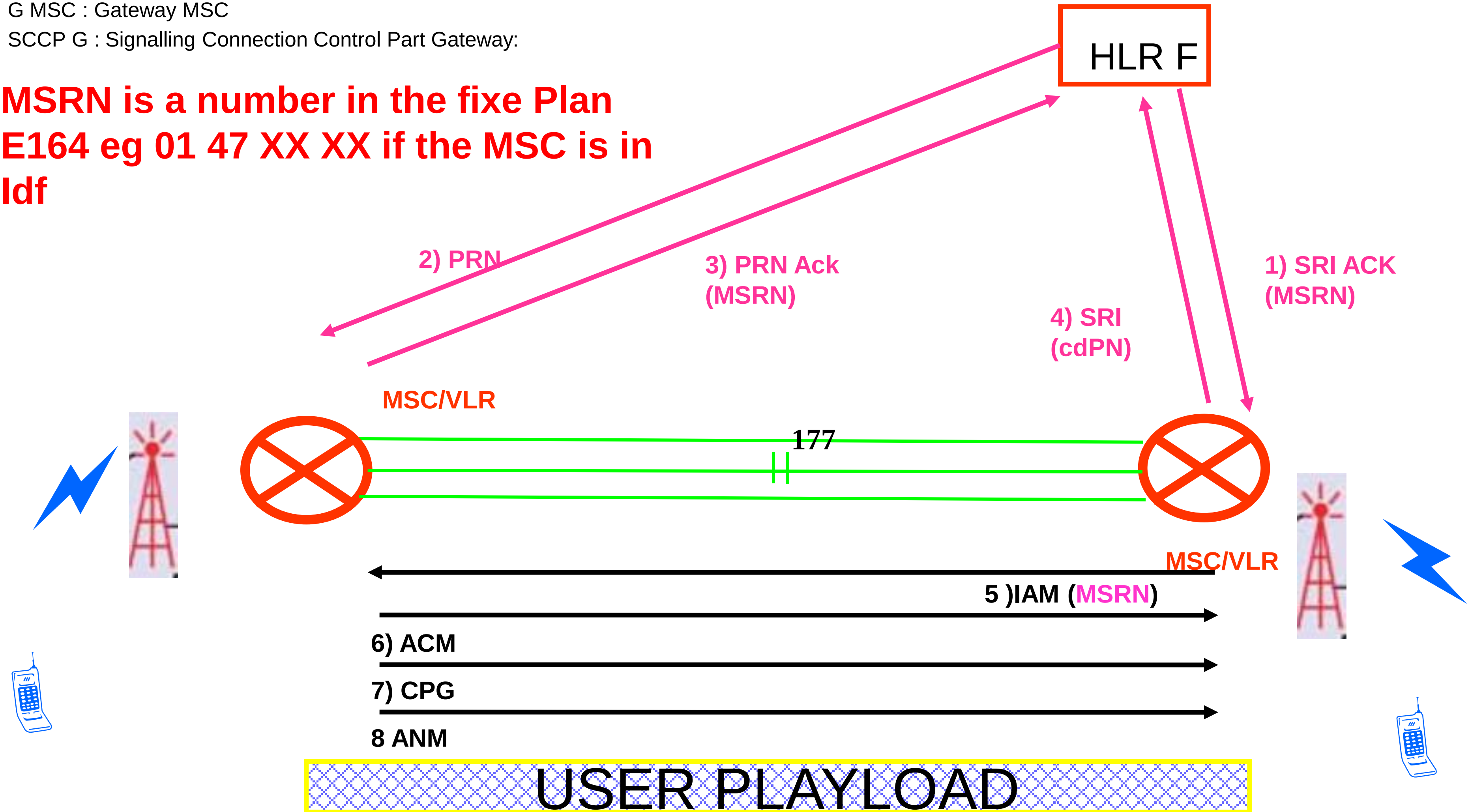
G MSC : Gateway MSC

SCCP G : Signalling Connection Control Part Gateway:

SRI : Send Routing Information

PRN : Provide Roaming Number

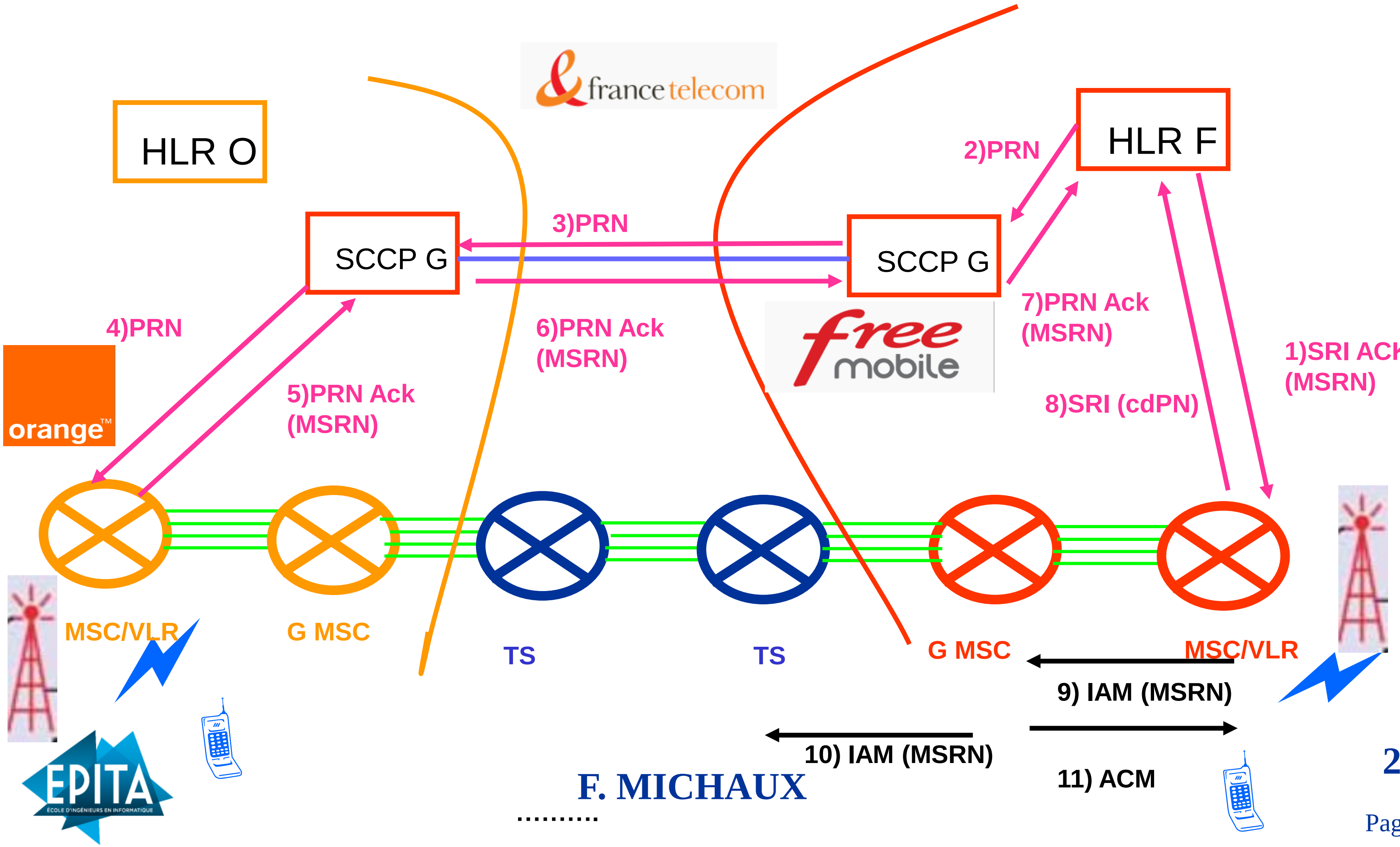
**MSRN is a number in the fixe Plan E164 eg 01 47 XX XX if the MSC is in Idf**



# Free customer call in Roaming

HLR : Home location register
MSC : Mobile Switch Centre
G MSC : Gateway MSC
SCCP G : Signalling Connection Control Part Gateway:
SS7 : Signaling N° 7

SRI : Send Routing Information
PRN : Provide Roaming Number



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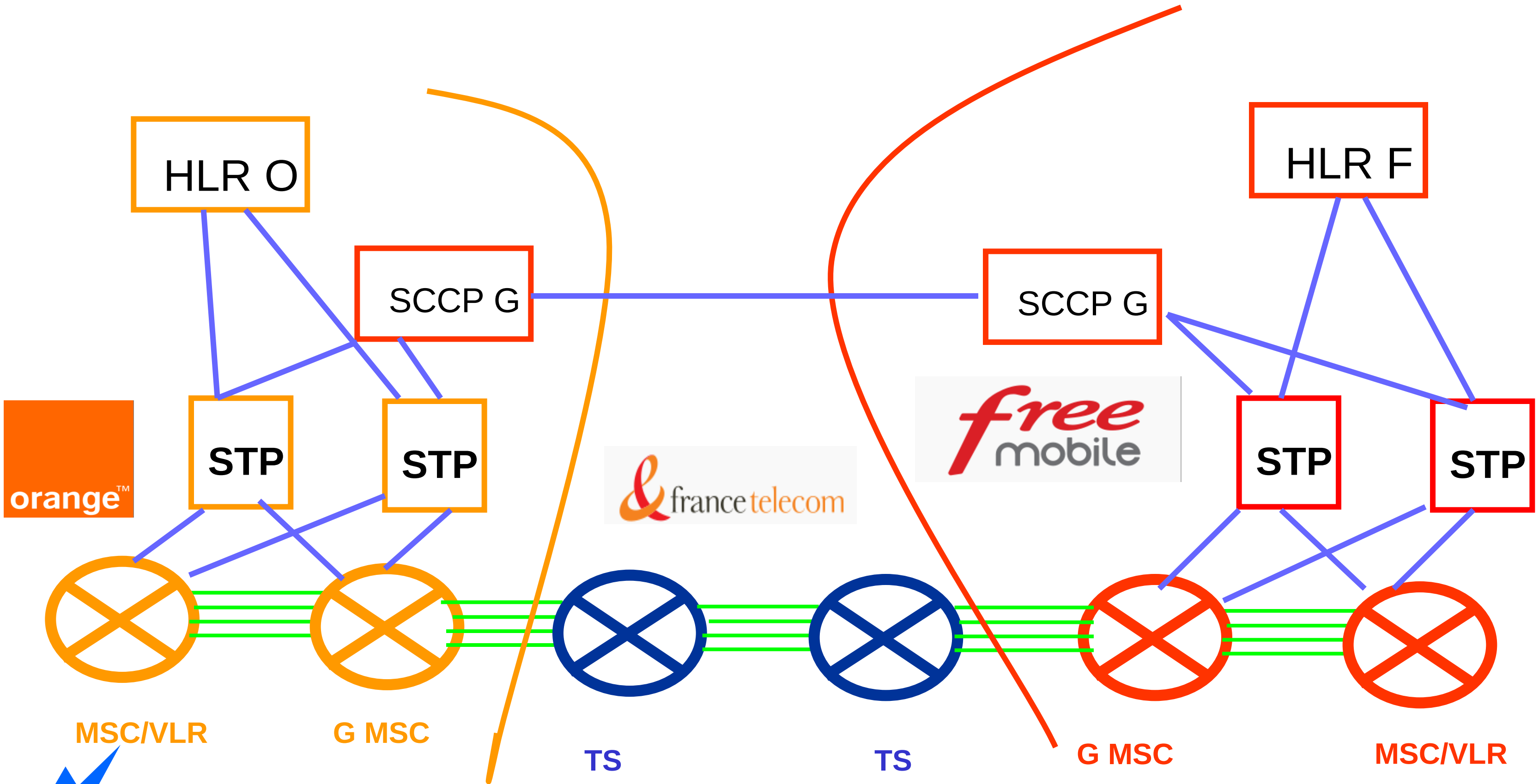

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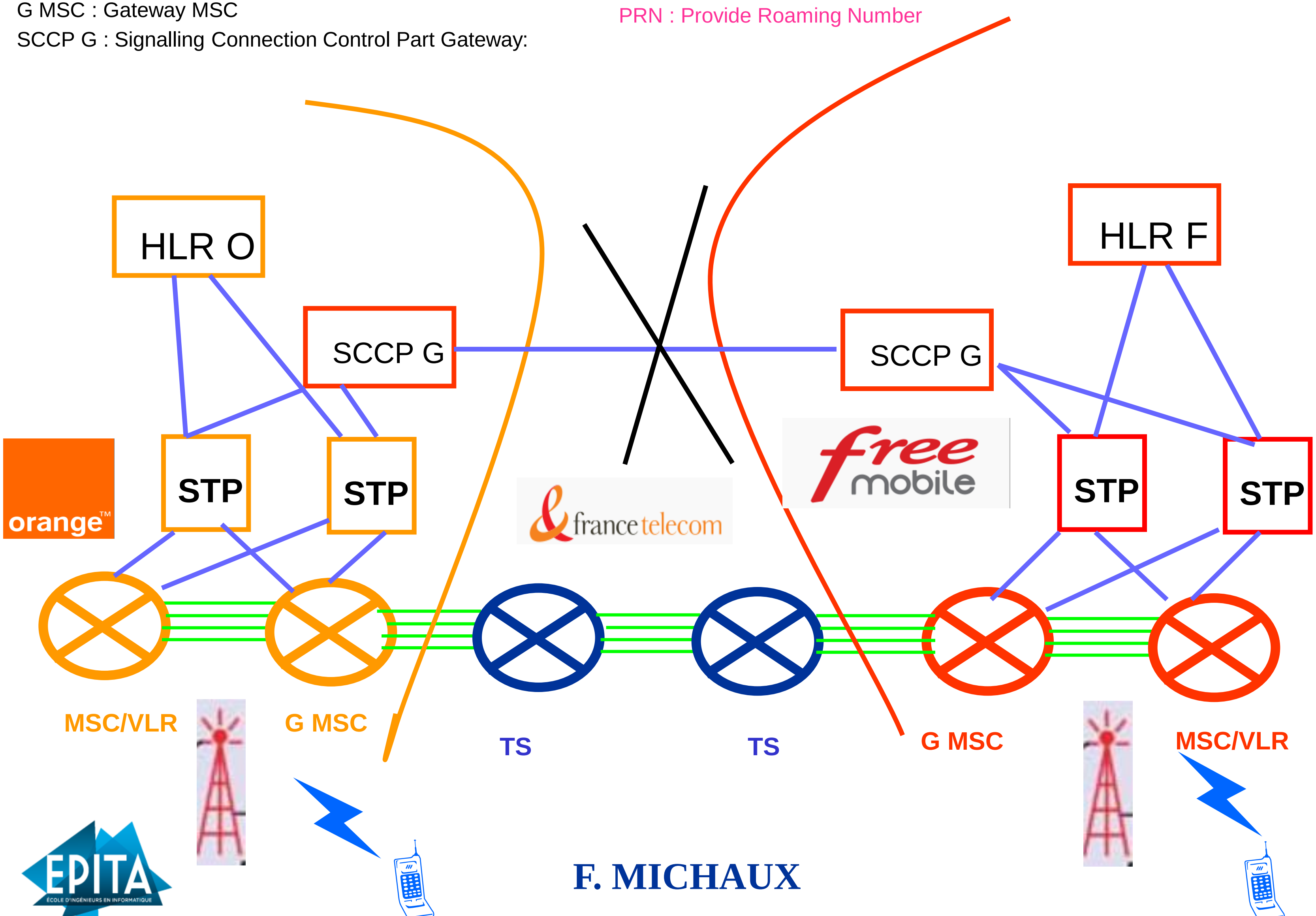


“Les villes de Lyon, Grenoble, Angers et bien sûr Paris ont ont été touchées, entre autres. Hier soir, Orange a tenu à réagir en affirmant ne pas être à l’origine du problème : « Vu de notre fenêtre, tout est au vert. On pense savoir que Free a un problème sur un de ses équipements. Il y a eu un incident il y a déjà trois semaines. Un équipement de signalisation de Free Mobile était en cause. On constate les mêmes symptômes aujourd'hui », a expliqué un représentant de l’opérateur historique à 20 Minutes.”

# Free customer call in Roaming

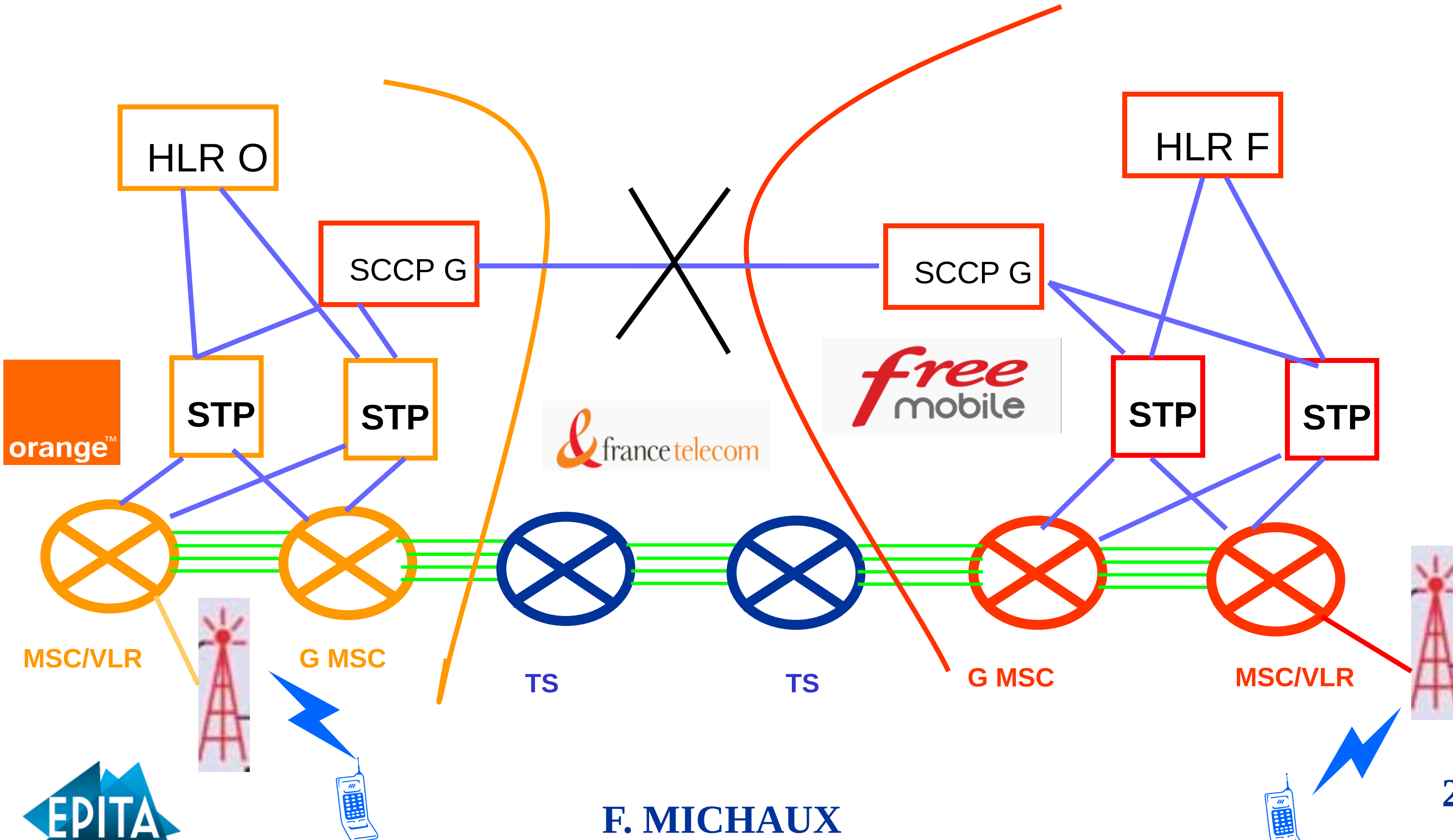
HLR : Home location register

MSC : Mobile Switch Centre

G MSC : Gateway MSC

SCCP G : Signalling Connection Control Part Gateway:

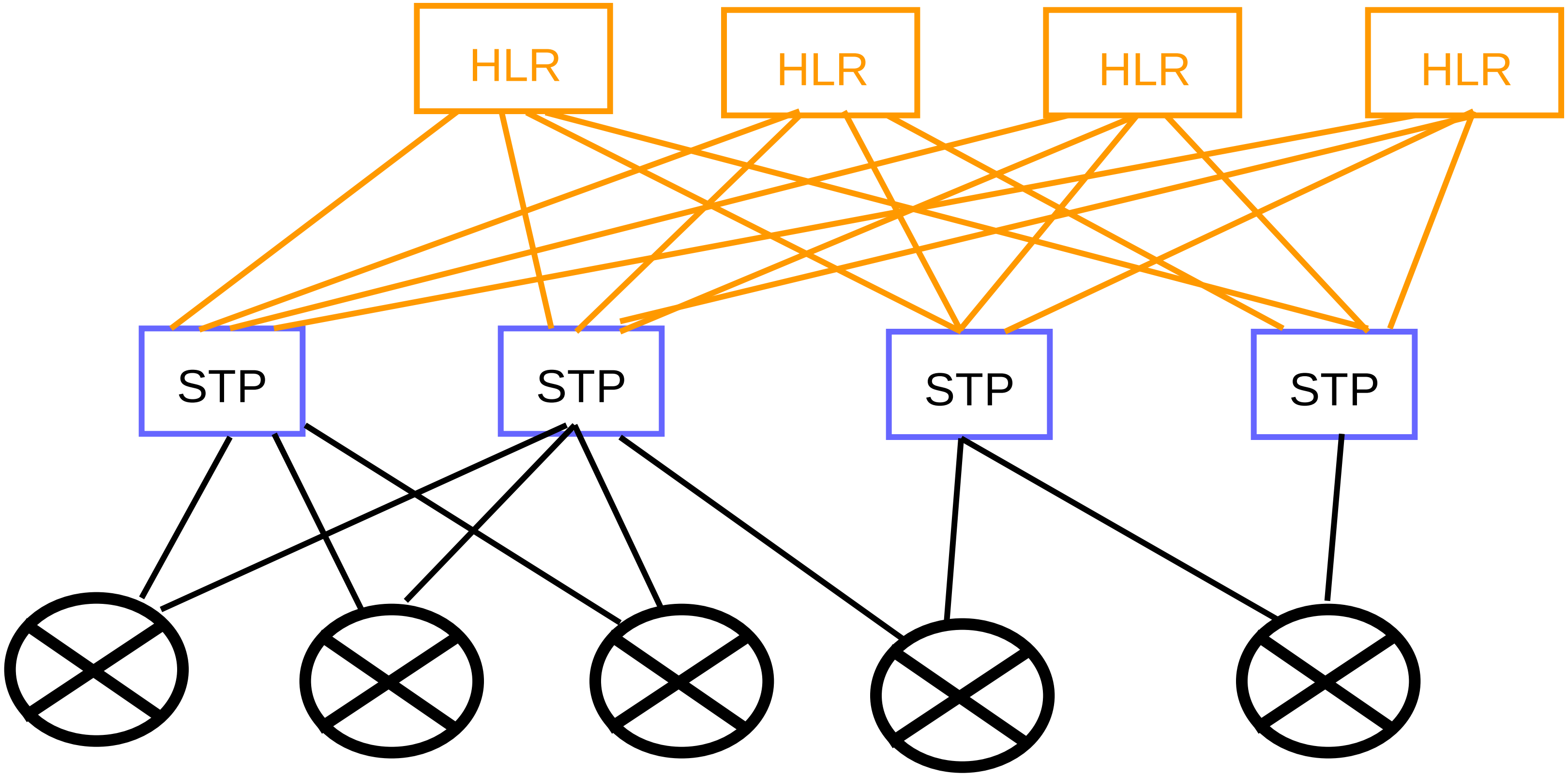
SS7 : Signaling N° 7



# HLR classi connection to the STP 's

HLR : Home location register

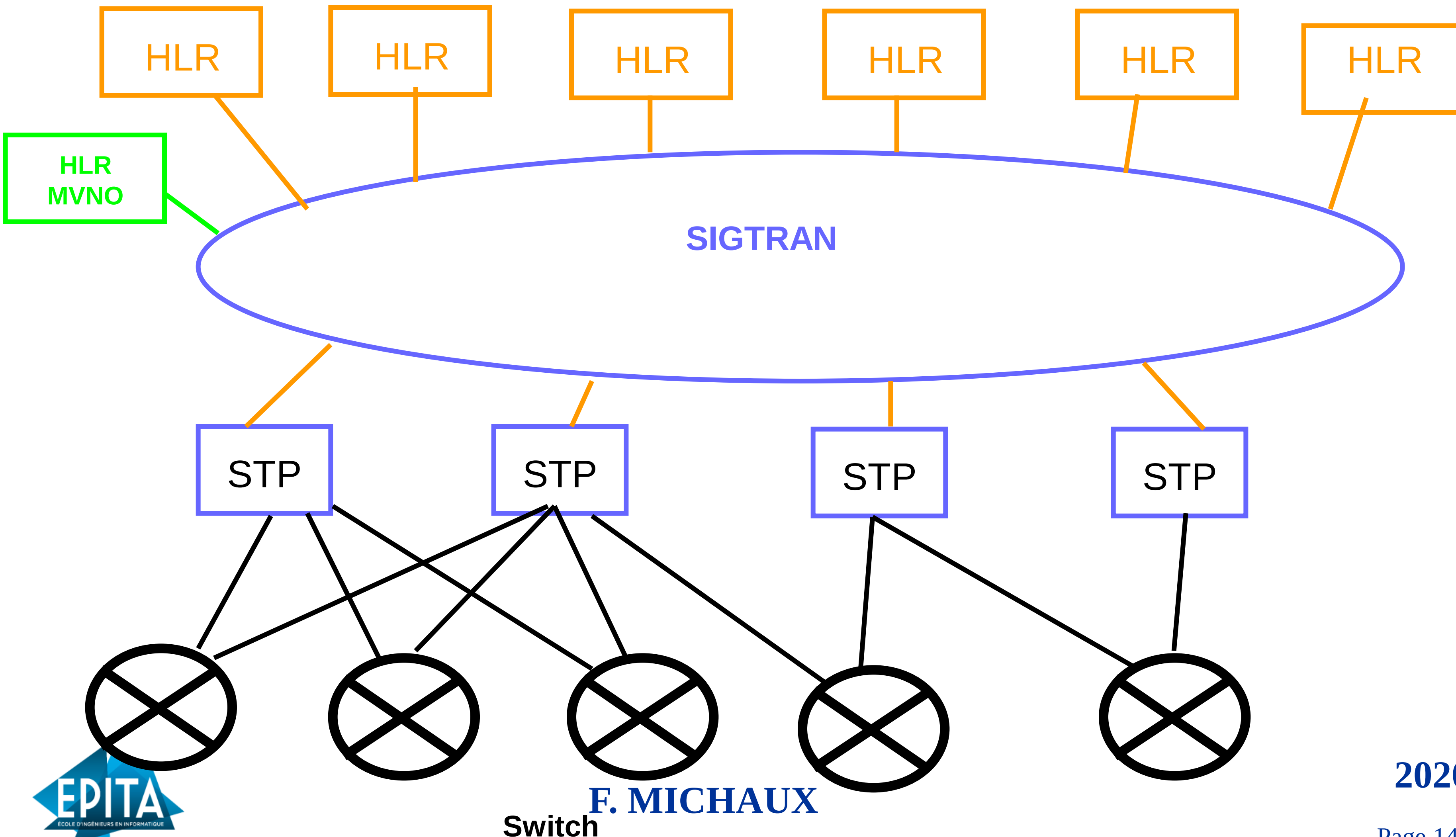
STP : Signalling Transfer Point




Switch

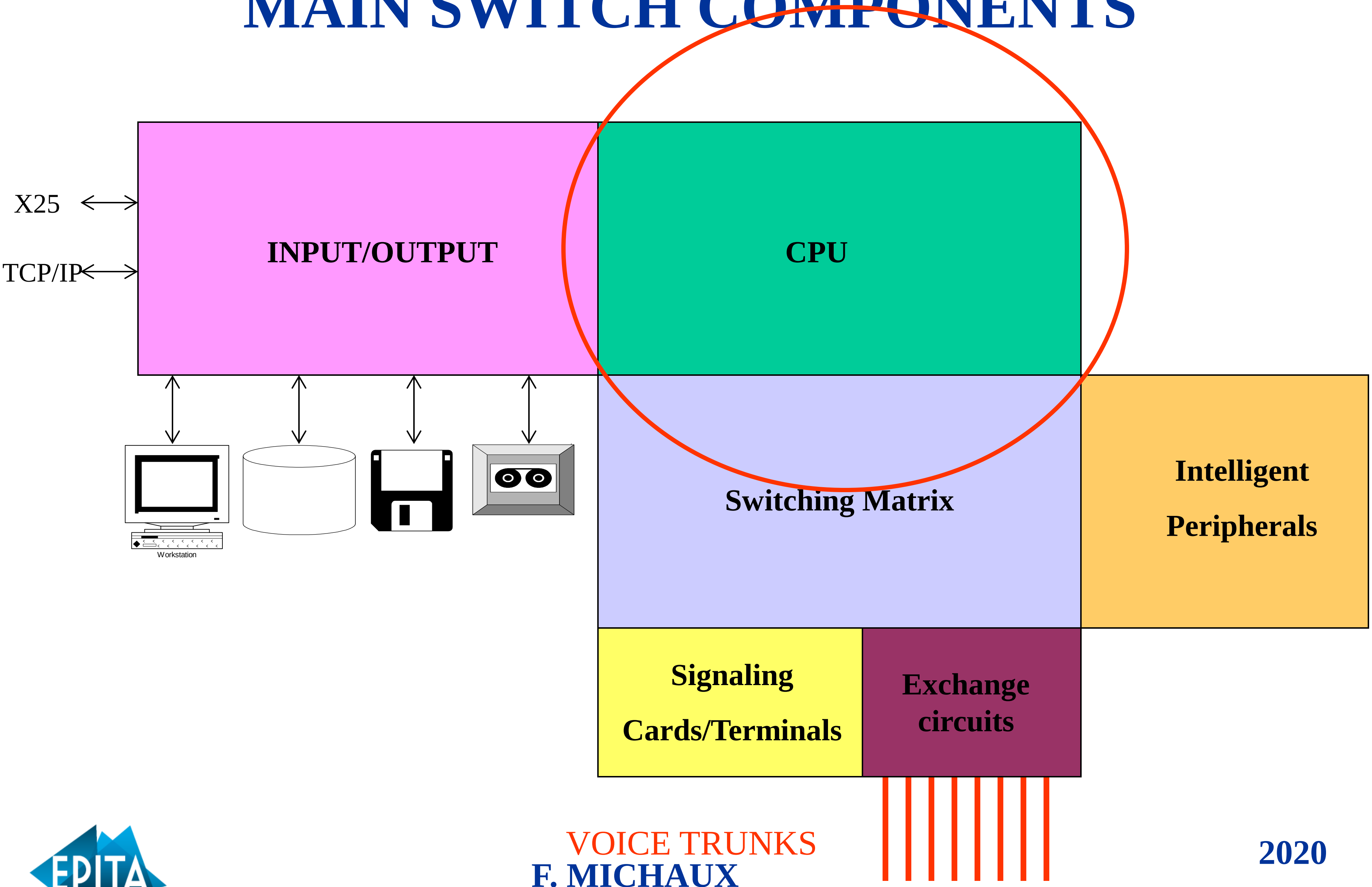
# HLR connection to the STP 's via Sigtran

HLR : Home location register
STP : Signalling Transfer Point
Sigtran : **Sig**naling **tran**sport (infrastrucure to carry SS7 singnaling on an IP network)



# CPU

# MAIN SWITCH COMPONENTS



# CPU

The CPU is the Central Processor Unit. It is the main switch component

The CPU :

- handles the call processing
- Controls the switching matrix
- Controls the intelligent peripherals
- Handles the translations
- Handles the signaling protocol from the network layer to the application layer.

# CPU

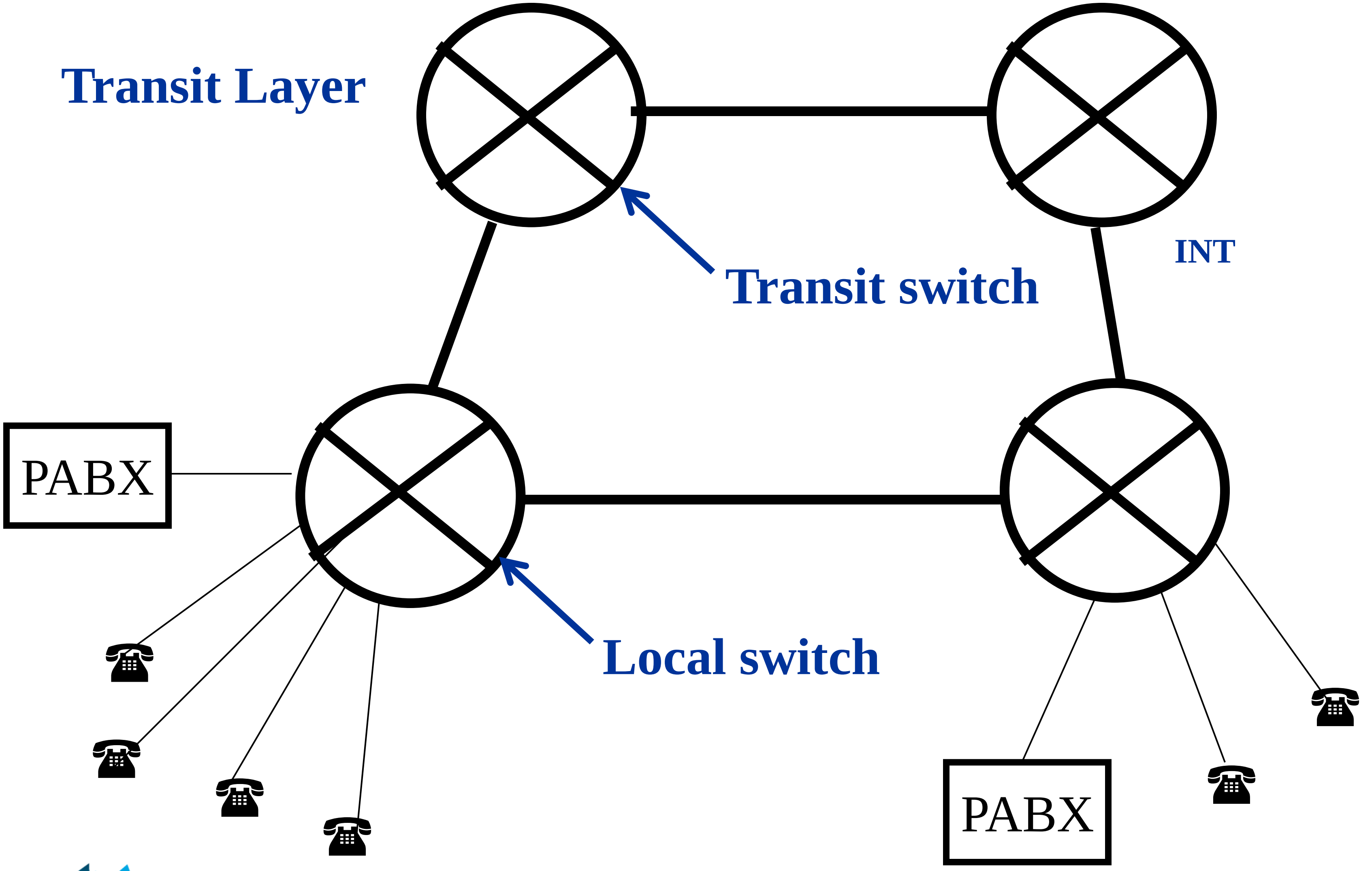
- There is 2 CPU’s in  a switch in order to Increase the reliability.
- One active and one standby in case of failure
- There is no loss of call in case of channel change over from the active to the stand by
- The size of the software is huge
- It’s a real time software each call lauches a task.

# CPU

The CPU is dimensioned by the traffic handles by the switch at the peak hour

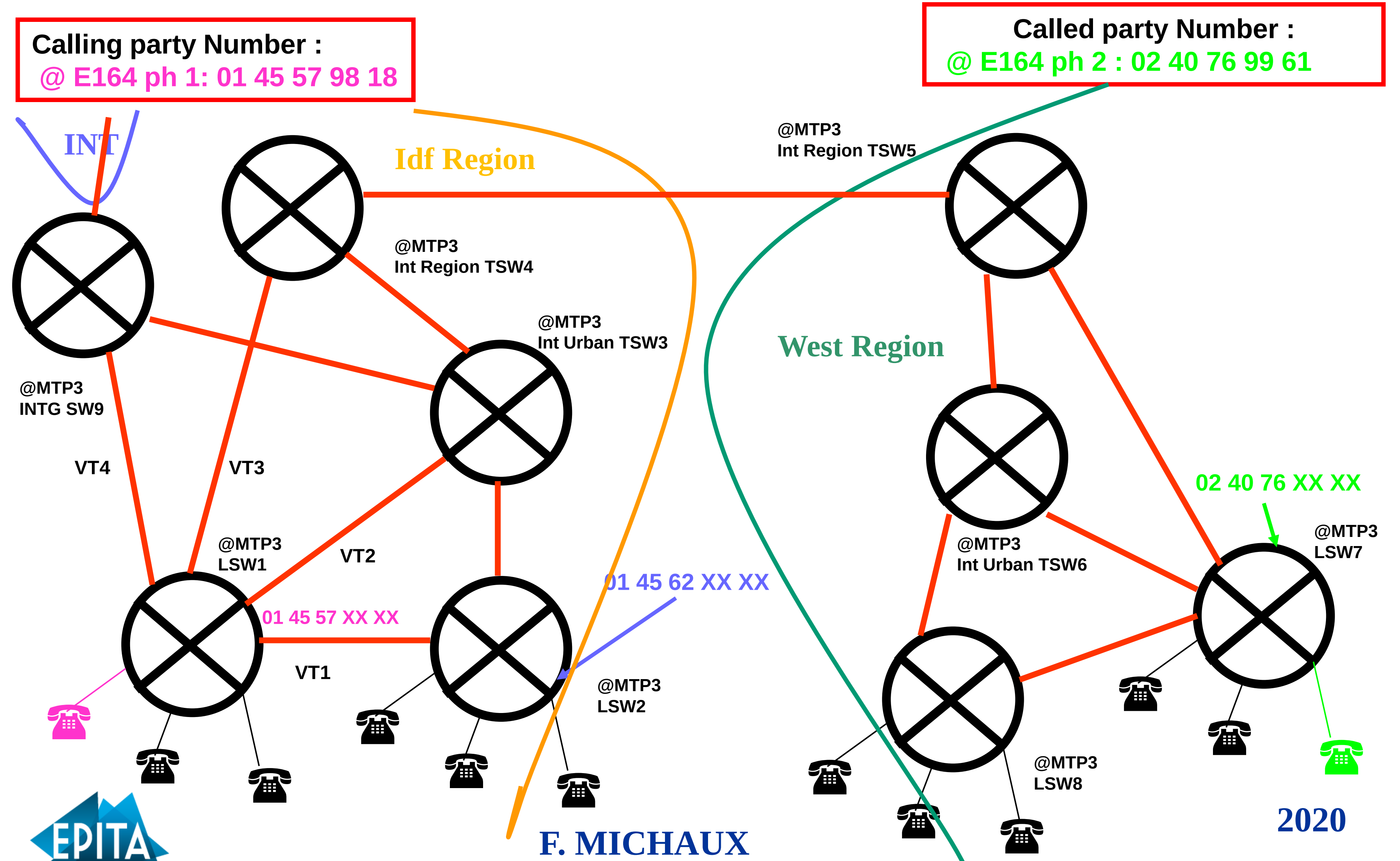
- The BHCA is the unity
- BHCA : Busy Hour Call Attempt
- The CPU size is linked to the switching matrix size and the type of traffic. IN traffic ….

# PUBLIC VOICE NETWORK ARCHITECTURE



# Translation principle

The called party number is analysed by the translation

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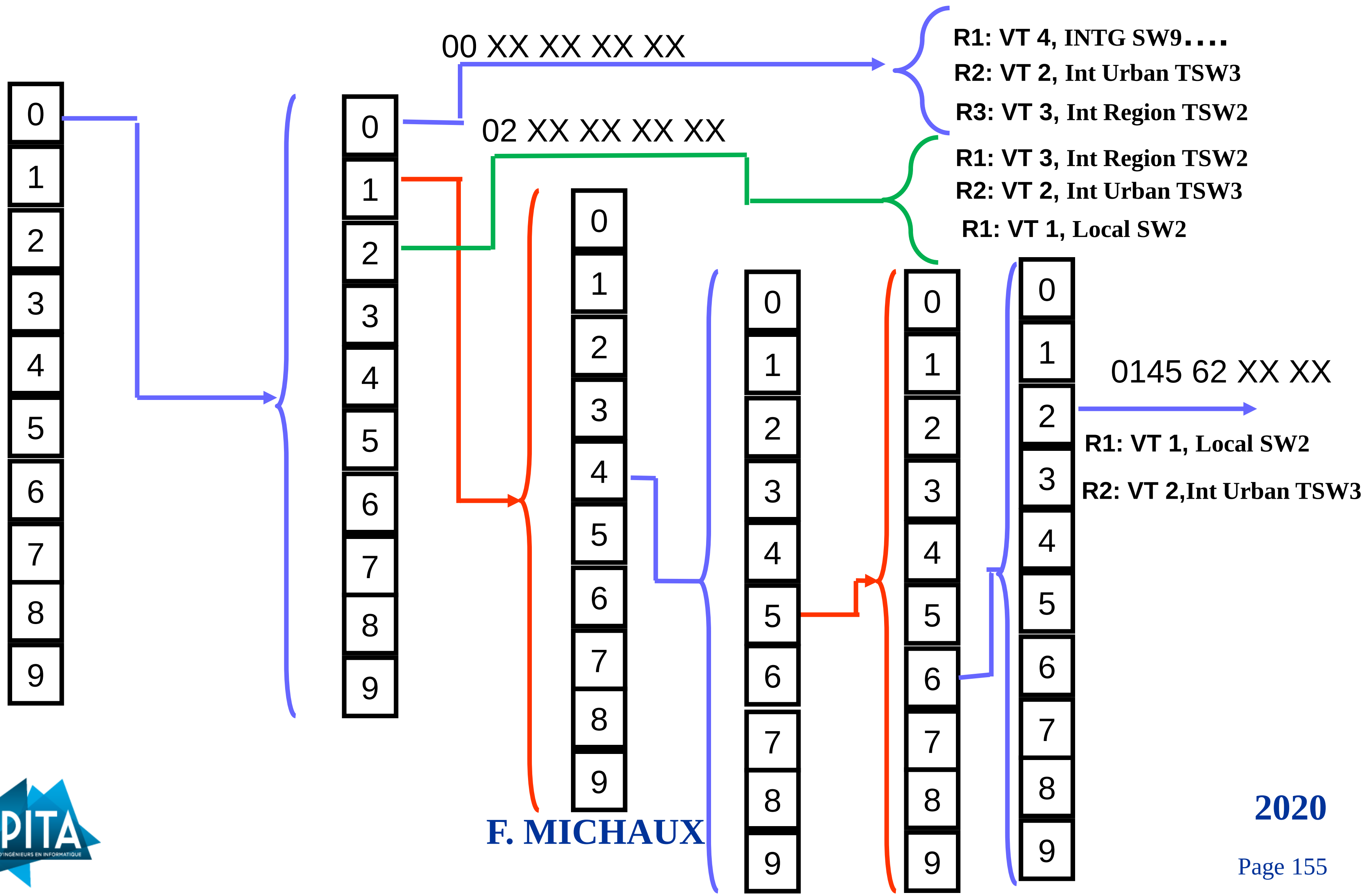
**2020**

# Translation principle LSW1

The called party number is analysed by the translation



# INTELIGENT PERIPHERALS

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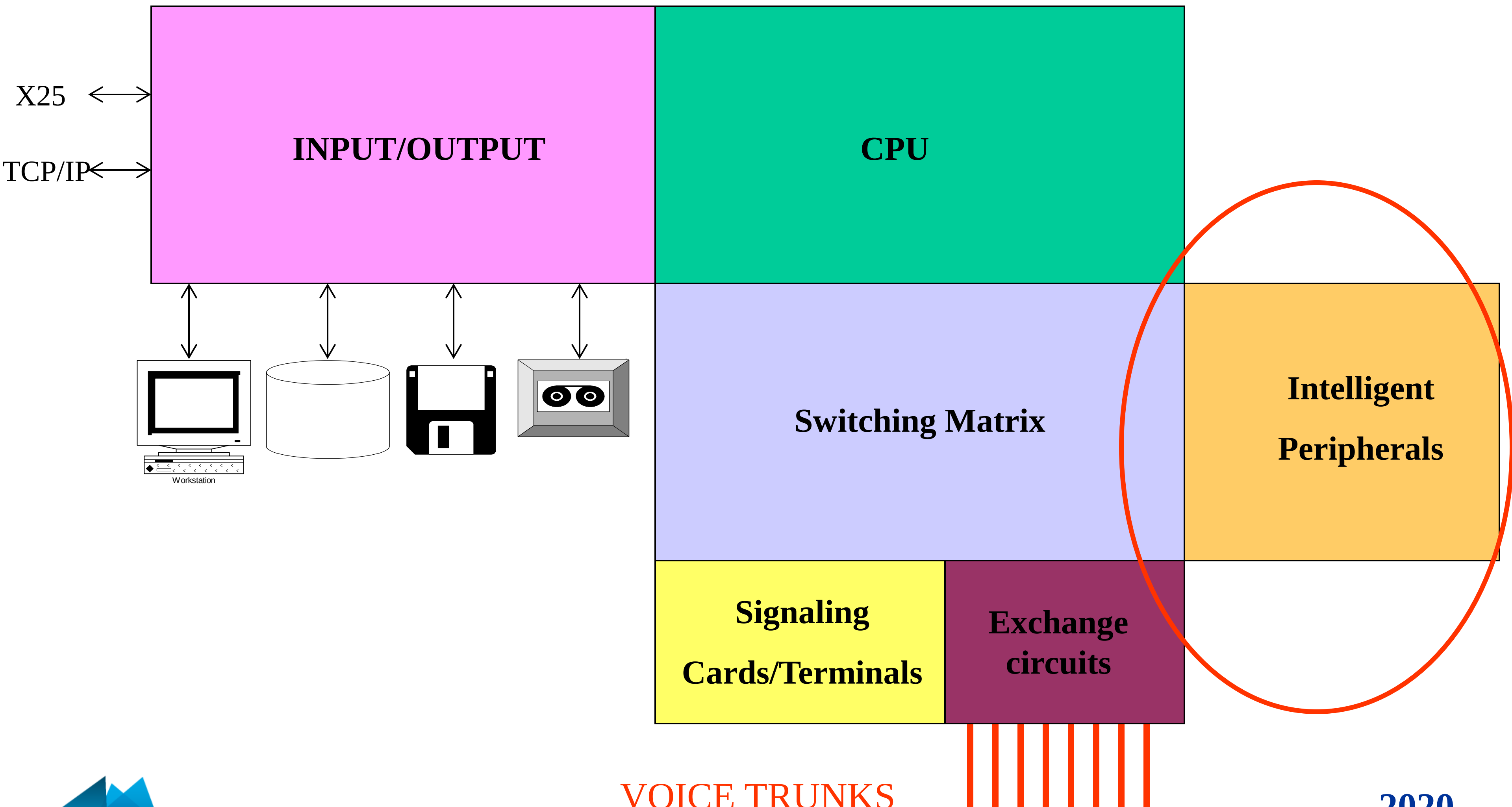
# MAIN SWITCH COMPONENTS



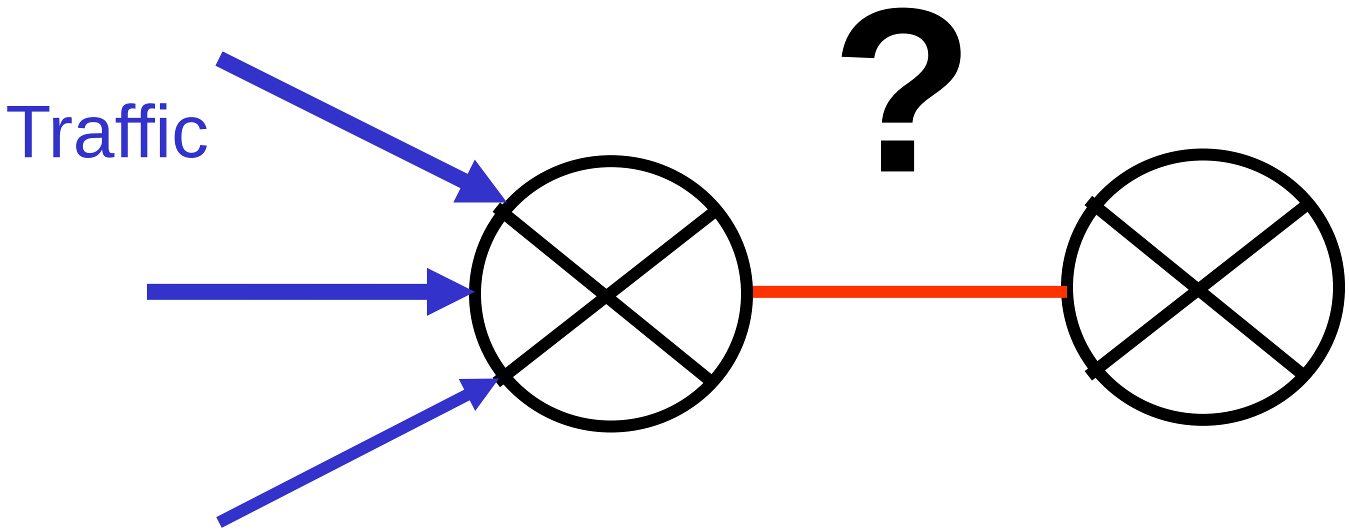
# INTELLIGENT PERIPHERALS

The intelligent peripherals provide additional services for the basic calls :

- DTMF receivers
- Announcement machines

# Traffic calculation

# Traffic calculation




**Problematic :**

**if the trunk group is too small the consequence is an important lost of traffic => lost of Money**

**if the trunk group is too big the capacity is paid but not used => lost of Money**

# Traffic calculation

**The size of the link between 2 switches depends of the traffic between the both switches**

- **it's based on : A stochastic process which means that It's partially due to the luck, that's why it's possible to define a model.**
- **A formula which is named the Erlang law.**
- **The calculation is generally done at the busy hour**

# Traffic calculation

**An erlang (*) is :**

**the utilization of the resources in percentage**

**The resources are the circuits**

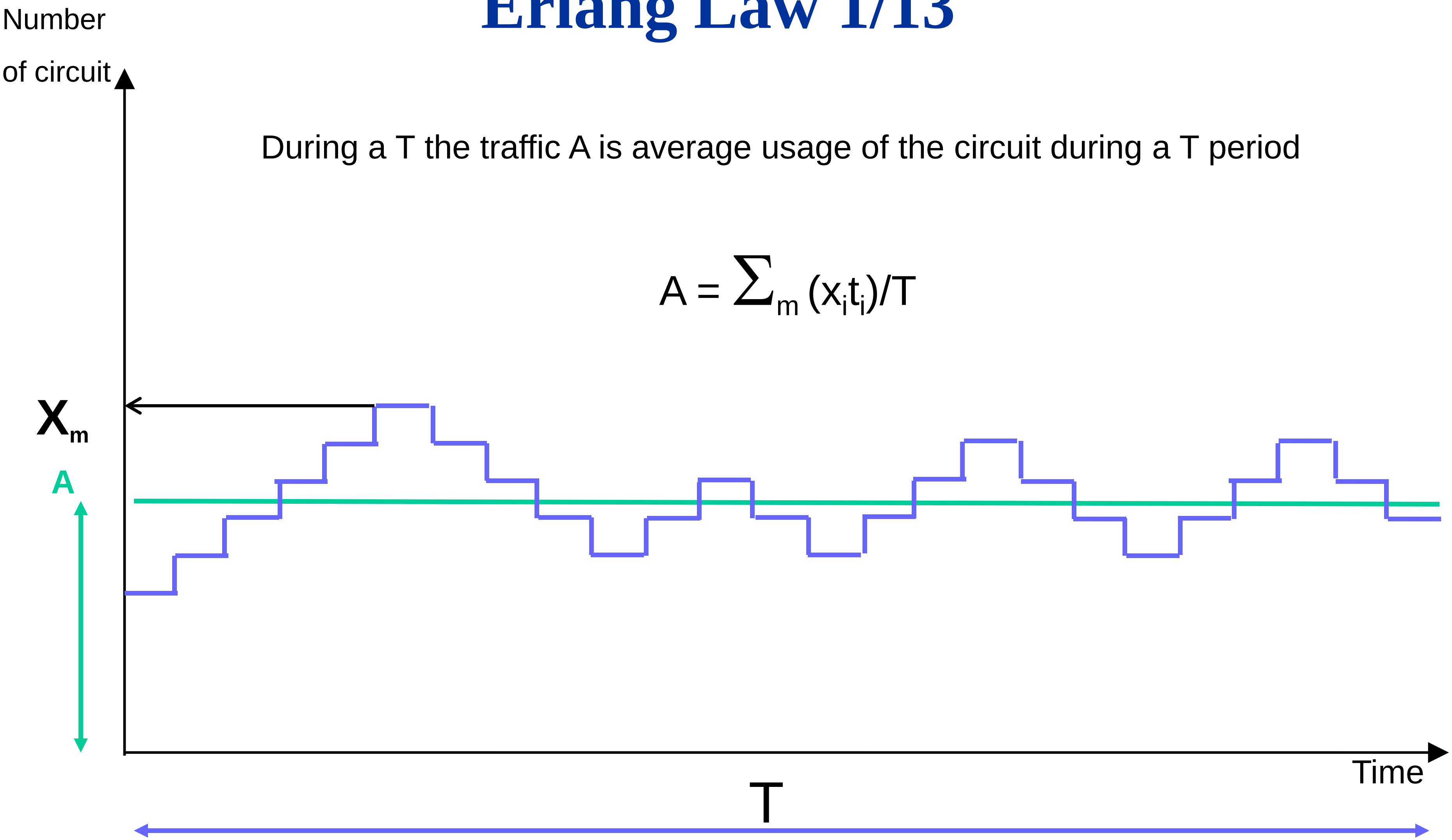
**Example : if the average circuit traffics at 12%. The traffic is 0.12 E / circuit**

**(*) Mister Agner Krarup Erlang (1878-1929) was Danish**

# Erlang Law 1/13

During a T the traffic A is average usage of the circuit during a T period

$$A = \sum_m (x_i t_i)/T$$




**Circuit occupation**

# Erlang Law 2/13

**Generally the traffic is given per minutes**

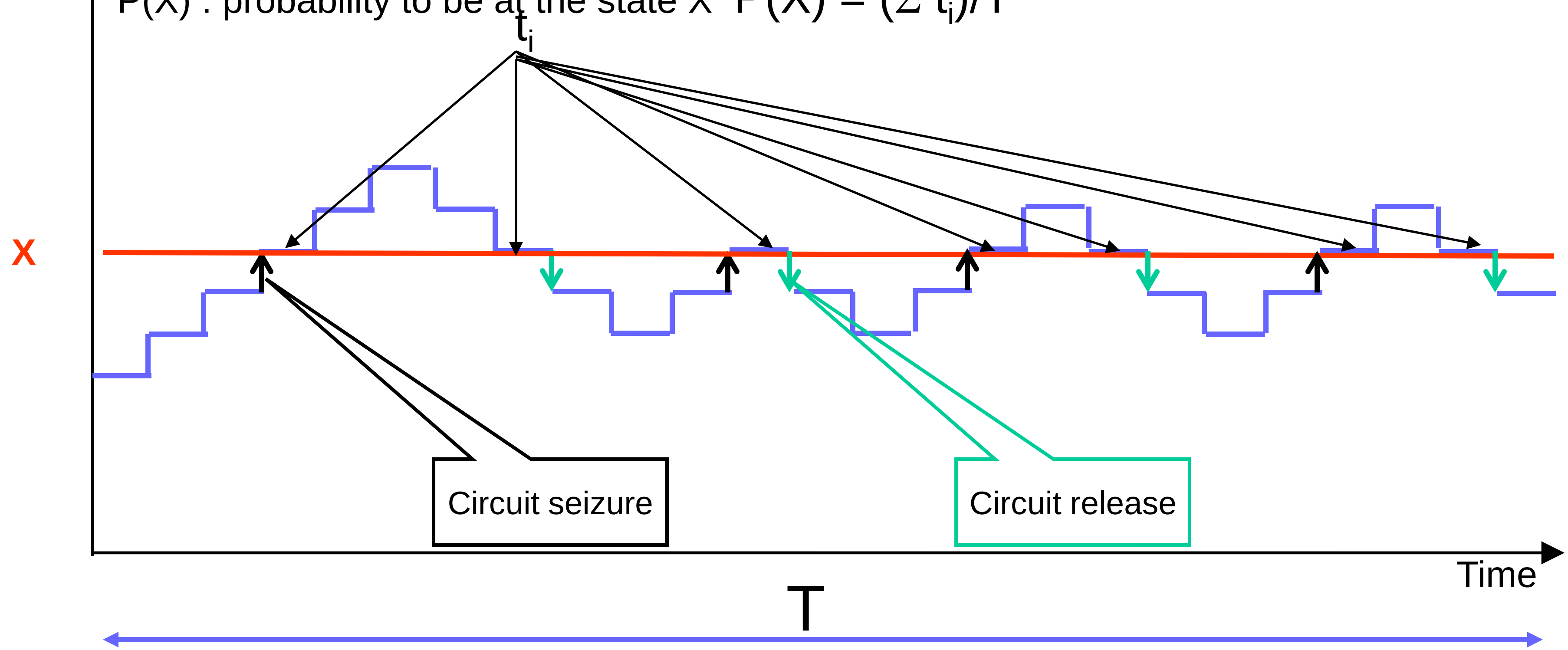
**Example : 20 000 calls / hour and the average time per call is 3 minutes**

**Result : 3/60* 20 000 = 1000 Erlangs**

# Erlang Law 3/13

During a T period the number of transition from the (X-1) state to the (X) state is equal to the number of transition from the (X) state to the (X-1)

P(X) : probability to be at the state X $P(X) = (\Sigma\ t_i)/T$

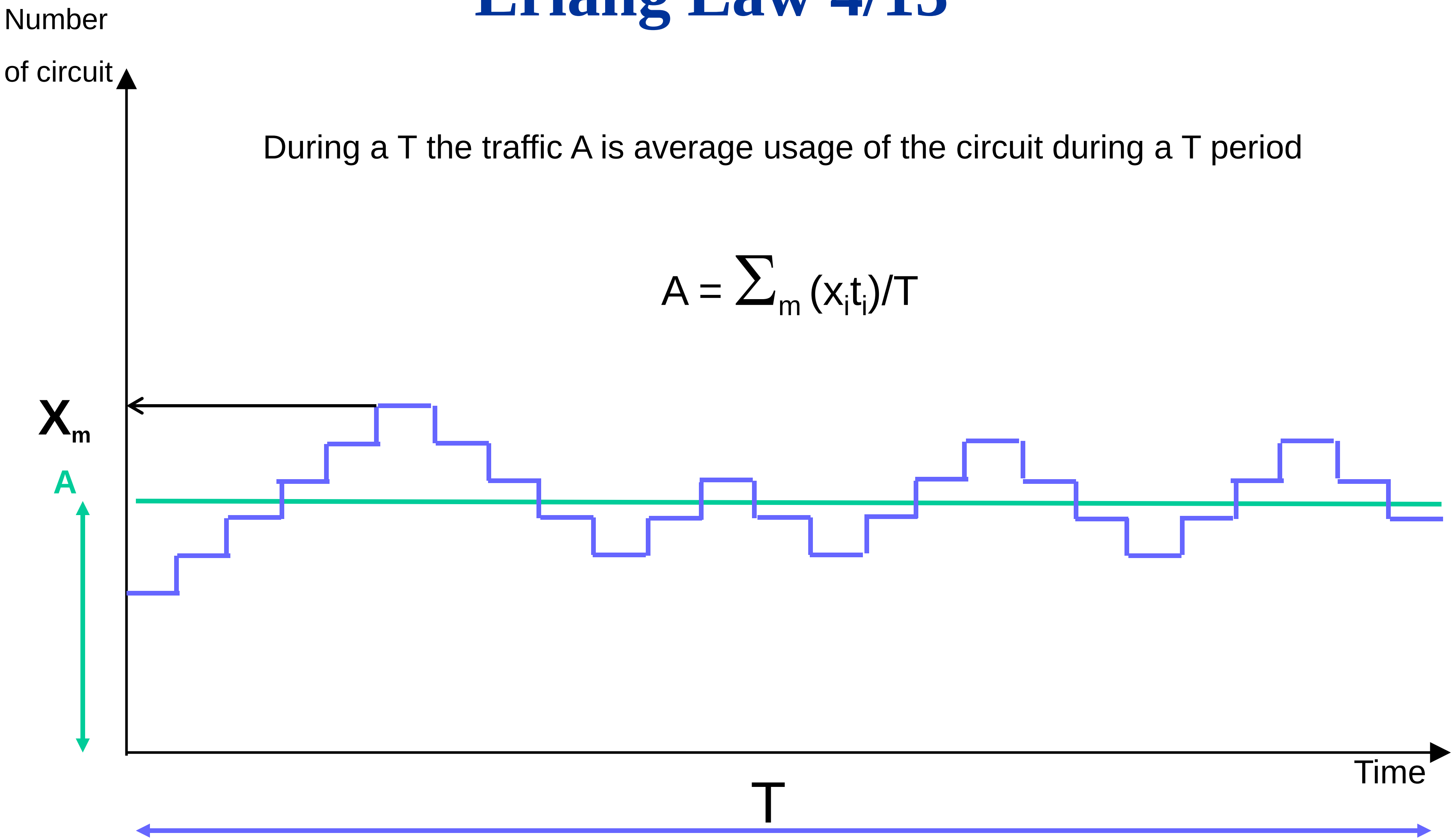



## Circuit occupation

# Erlang Law 4/13

During a T the traffic A is average usage of the circuit during a T period

$$A = \sum_m (x_i t_i)/T$$



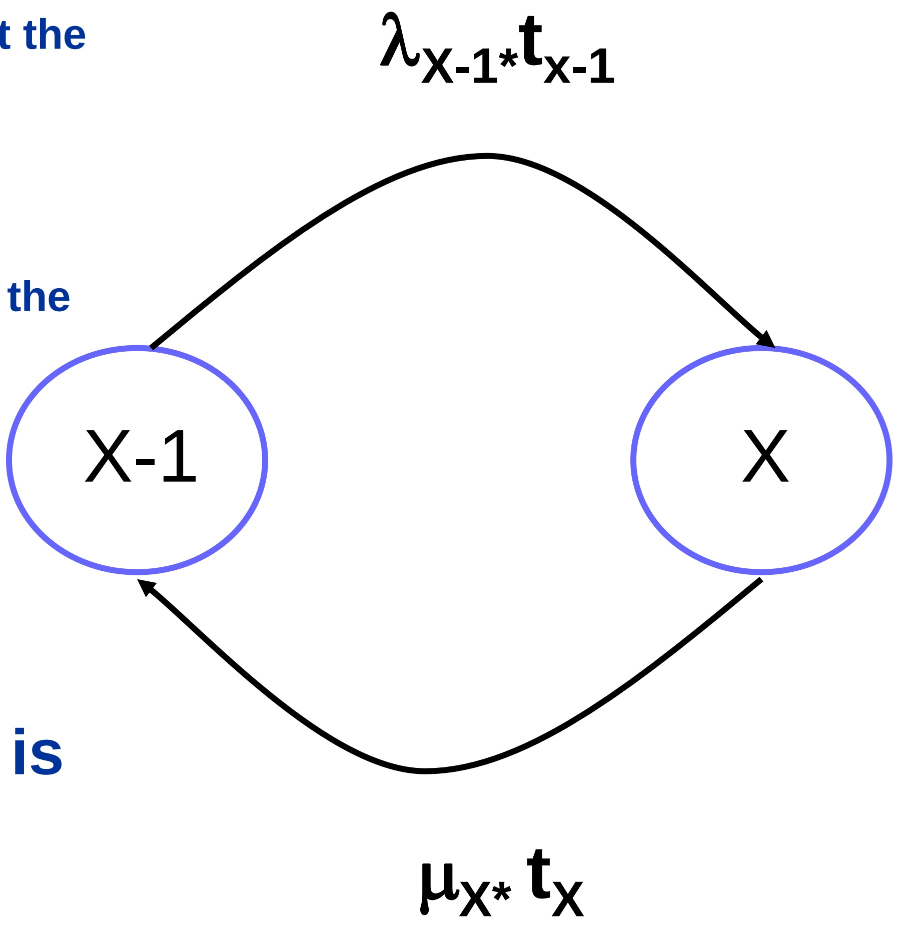

Circuit occupation

# Erlang Law 5/13

- $\lambda_{X-1}$ is the rate of circuit seizure at the (X-1) state

- $\mu_X$ is the rate of circuit release at the (X) state

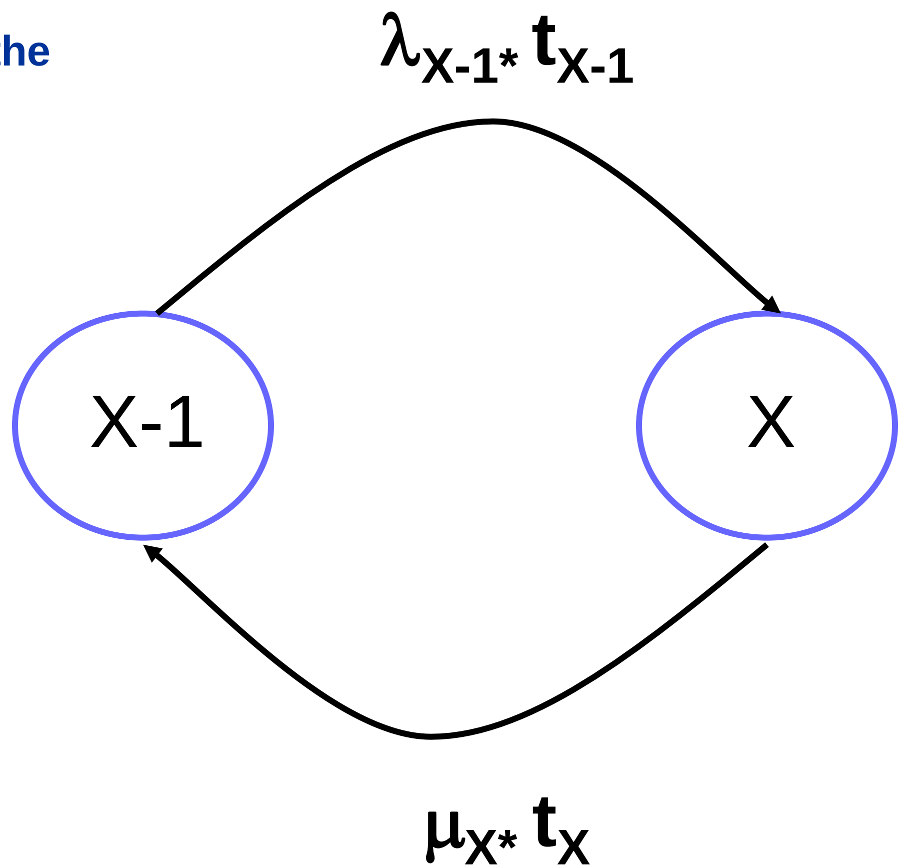
- **The balance equation is $\lambda_{X-1} P(X-1) = \mu_X P(X)$**




Transition between the states (X) and (X-1)

# Erlang Law 6/13

- $\lambda_{X-1}$ does not depend of the circuit already seized but depends only of the traffic A
- $\mu_X$ is proportional to the circuit seized. More the circuit are seized more the circuit could be released
- $\lambda_{X-1} = \lambda = n/T = \mathbf{A/\tau}$
- $\mu_X = \mathbf{X/\tau}$
- The balance equation is $A * \mathbf{P(X-1)/\tau = (X) * P(X)/\tau}$




**Transition between the states (X) and (X-1)**

# Erlang Law 7/13

$P(X) = A/X\, P(X-1) = A/X*A/(X-1)*A/(X-2)*.......*P(0)$

$P(X) = (A^X/X!)*P(0)$

$\Sigma_0^N P(X) = 1$ N is the number of circuit of the trunk

$P(0)*\Sigma_0^N (A^i/i!) = 1 \rightarrow P(0) = 1/\Sigma_0^N (A^i/i!)$

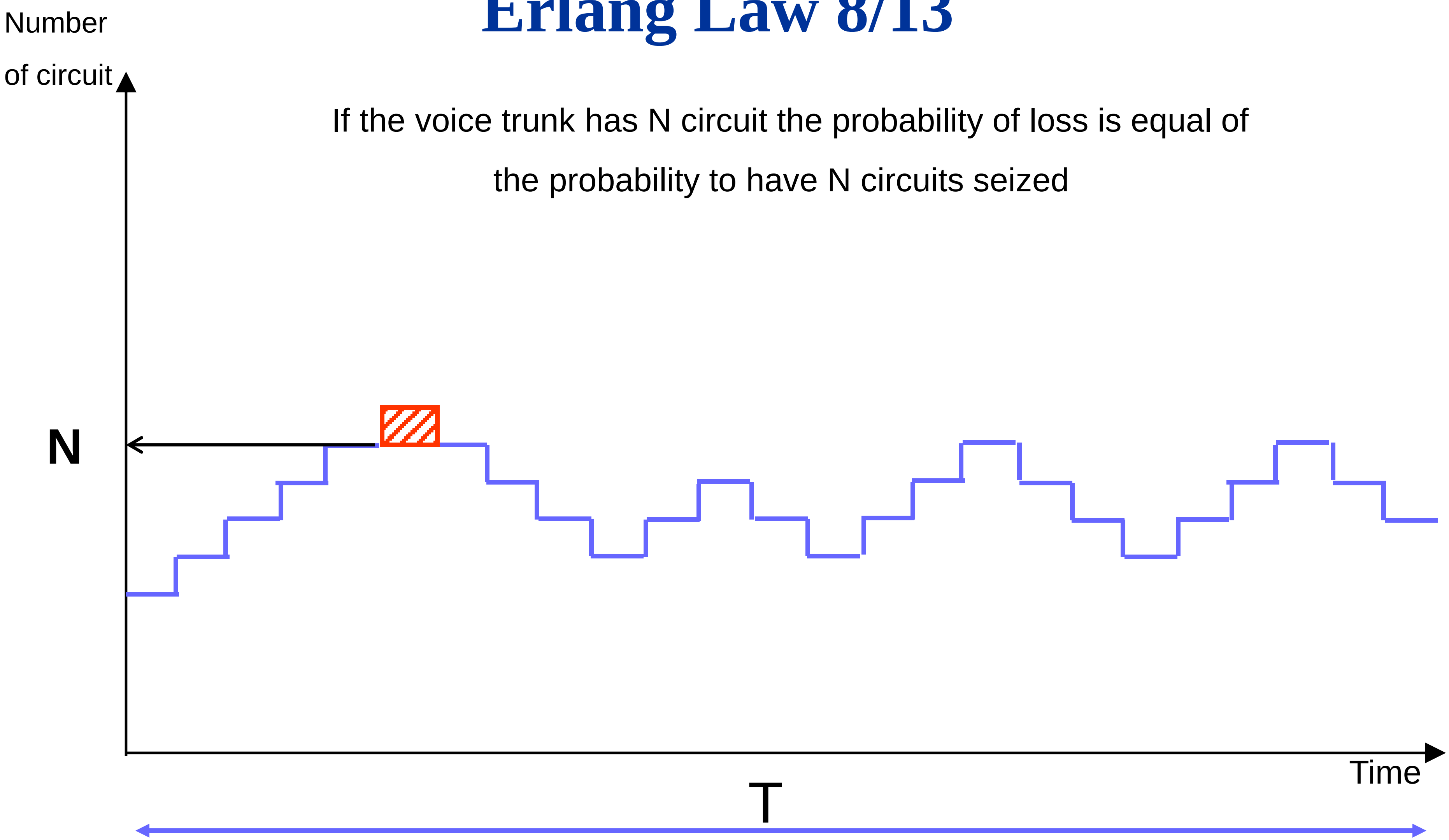
$P(X) = (A^X/X!)/\Sigma_0^N (A^i/i!)$ This is the Erlang distribution probability to have X circuit engaged when the traffic is A and the voice trunk has N circuits.

NOTA : The Erlang Law is very close to the Poisson Law

$\Sigma^\infty P(X) = 1 \rightarrow P(0) = 1/\Sigma^\infty (A^i/i!) = e^{-A} \rightarrow P(X) = A^X/X! * e^{-A}$

# Erlang Law 8/13

If the voice trunk has N circuit the probability of loss is equal of the probability to have N circuits seized




**Circuit occupation**

# Erlang Law 9/13

- $P(X) = (A^X/X!) \,/\, \sum^N (A^i/i!)$

  Probability to have X circuit engaged when the traffic is A and the voice trunk has N circuits.
- $1/P(N) = \sum^N (A^i/i!) \,/\, (A^N/N!)$
- $1/P(N) = (N!/A^N) * ( 1 + A + A^2/2 + \ldots + A^N/N!)$
- $1/P(N) = N/A * ((N-1!)/A^{N-1}) * ( 1 + A + A^2/2 + .. + A^{N-1}/(N-1)! + A^N/N!))$
- $1/P(N) = N/A * 1/P(N-1) + N!/ A^N * A^N/N!$
- $1/P(N) = N/A * 1/P(N-1) + 1$ with $P(0)=1$

# Erlang Law 10/13

**The fist Erlang law is the following :**

**$1/ (E_{(1,N)}A) = 1 + N/A^* \, 1/E_{(1,N-1)} (A)$**

**with $E_{(1,0)}(A) = 1$**

N : is the Number of circuits

A : is the traffic in Erlang

$E_{(1,N)}(A)$ : is the probability of loss with A Erlangs and N circuits

$E_{(1,0)}(A) = 1$ because with 0 circuit the probability of loss is 1

# Erlang Law 11/13

$1/E_{(1,N)}A) = 1 + N/A^* \, 1/E_{(1,N-1)}(A)$ with $E_{(1,0)}(A) = 1$

$E_{(1,0)}(A) = 1.000000$ $A = 100$

$E_{(1,1)}(A) = 0.990099$

$E_{(1,2)}(A) = 0.980200$

$E_{(1,3)}(A) = 0.970303$

$E_{(1,4)}(A) = 0.960408$

$E_{(1,5)}(A) = 0.950515$

----------------------

$E_{(1,100)}(A) = 0.075700$ $1/E_{(1,100)}(A) = 13.209960$

----------------------

$E_{(1,140)}(A) = 0.000028$ $1/E_{(1,140)}(A) = 36185.150291$

**Conclusion : as much as the circuit are important the probability of loss is small**

# Erlang Law 12/13

**Conclusion :**

**As much as the circuit are important as the probability of loss is small.**

**Problematic :**

**Generally the inputs are the probability of loss and the traffic. N has to be found !**

**The probability of loss for n circuits depends the probability of loss for (n-1) circuits.**
**Very long to calculate before the computer the people used Palm table.**

# Erlang Law 13/13

It's not easy to calculate the number of circuit
A formula which gives a good approximation is

$E_{(1,N)}(A) = 10^{-k}$

$k = -LOG_{10}[E_{(1,N)}(A)]$

$$\underline{N \# A + k*A^{1/2}}$$

# CONCLUSION

# Conclusion

**This switching overview shows the experience required is very large as :**

- **Electronic : Modulation, filtering, digitalization**
- **Signal theory, compression,**
- **Protocol (Signaling),**
- **Real time software knowledge,**
- **Probability (traffic calculation).**
- **…………**

# QUESTIONS

# ?

# QUESTIONS

- Questions regarding the presentation ?

- Questions regarding the Telecommunication World ?

  How is the business ?
  What is the future ?

# Thank you for your attention