SWITCHING OVERVIEW

F. MICHAUX

GENERAL AGENDA 1/2

▶ Introduction : Justification, quick history, main components ..

▶ Input ouput

▶ Transport, TDM technologie

▶ Switching matrix

▶ Signaling

▶ CPU

▶ Intelligent peripherals

▶ Traffic calculation

2020

F. MICHAUX

GENERAL AGENDA 2/2

▶ Conclusion

▶ Questions

F. MICHAUX

2020
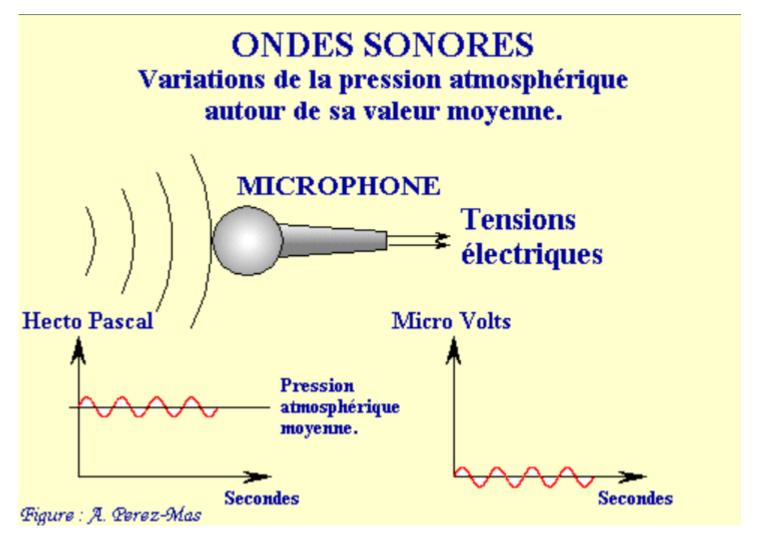
INTRODUCTION

Quick history,justification, main components ..

F. MICHAUX

Quick history

ONDES SONORES
Variations de la pression atmosphérique autour de sa valeur moyenne.

MICROPHONE — Tensions électriques

Hecto Pascal

Micro Volts

Pression atmosphérique moyenne.

Secondes

Secondes

Figure : A. Perez-Mas

Quick history Analogic/Digital

Un microphone traduit les signaux sonores - variations de la pression atmosphérique -
en variations proportionnelles de tension élecrique,
- qui seront appliqués à des amplificateurs puis, finalement, à des haut-parleurs
- à moins qu'ils ne soient envoyés sur une ligne de transmission.
etc.

D'abord, pourquoi "Analogique" ?
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).

Le signal numérique est, lui, une suite de nombres. Aucune analogie visuelle.
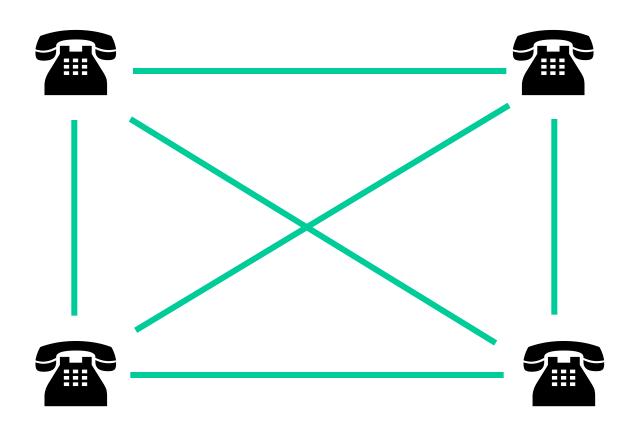Une toute autre technique.

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

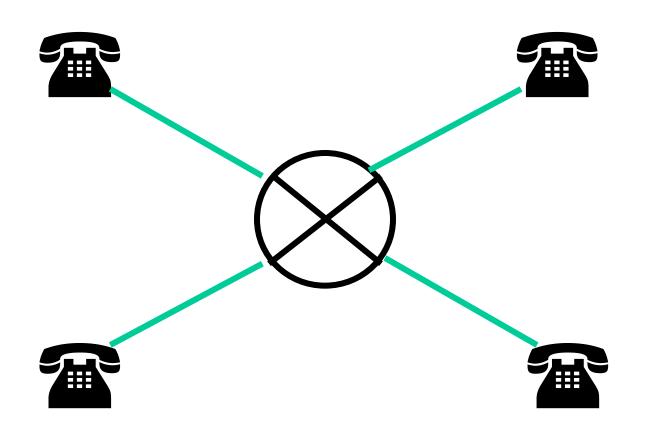▶ The switch introduction came quickly 1878 two years after the A.G Bell patent registration.

F. MICHAUX

2020

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

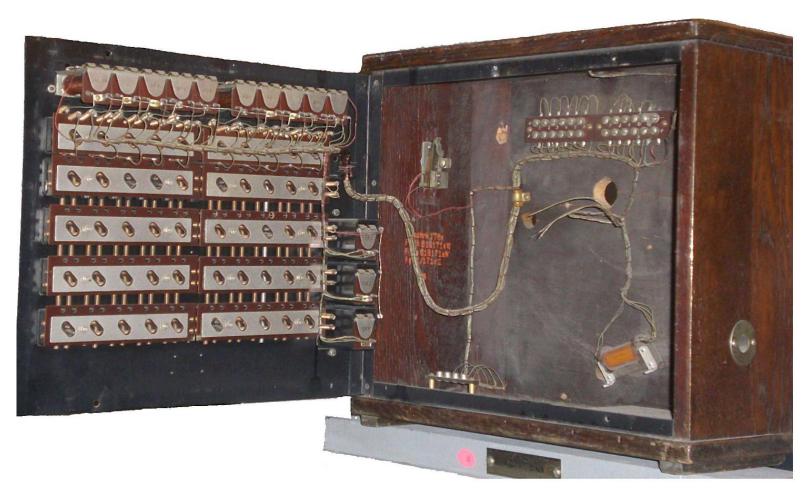▶ Electronic.

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. »
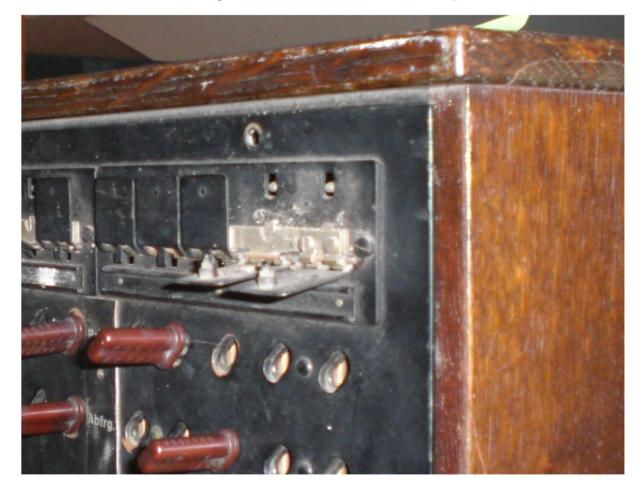
Subscriber side

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
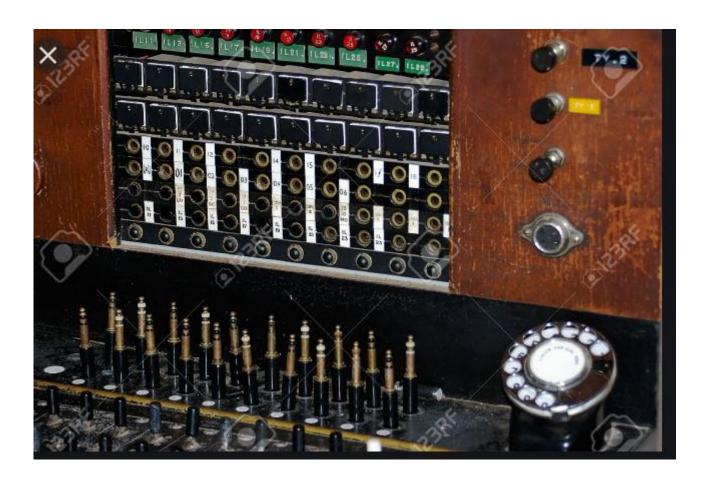
Switch board front View with the jack plug

Manual done by a human operator

Switch Board operator

Manual done by a human operator

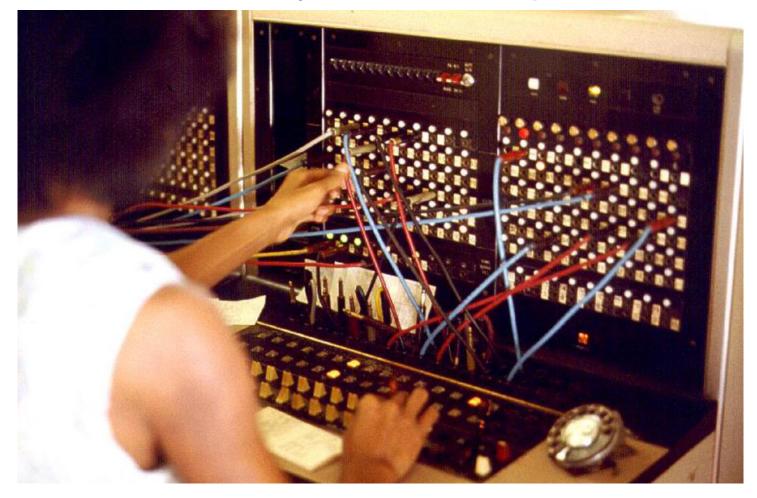# Manual done by a human operator

PBX 1975

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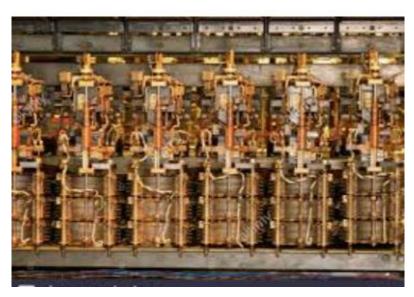
Almon Brown Strowger (1839-1902), was at the begining an undertaker, was motivated to invent an automatic telephone exchange after having difficulties with the local telephone operators, one of whom was the wife of a competitor. He was said to be convinced that she, as one of the manual telephone exchange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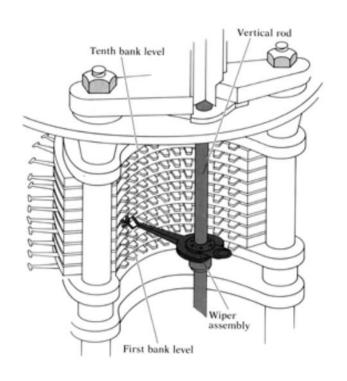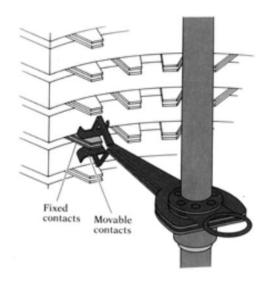
F. MICHAUX

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)

F. MICHAUX

2020

Pentaconta switch 1000A Model Crossbar

PENTACONTA GCID Montsouris Transit Switch Crossbar
 commissioned 1977 - Decommissioned 1993
Vendor : LMT
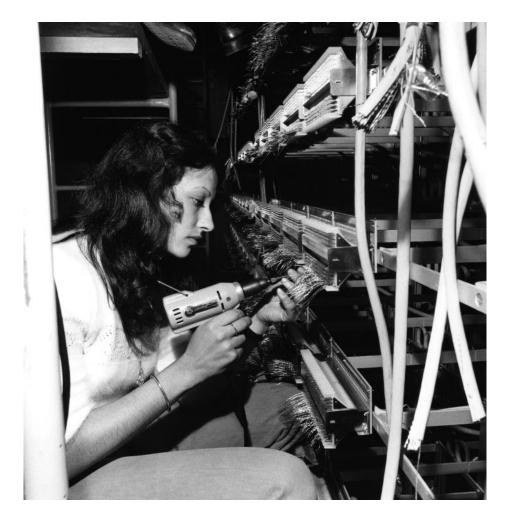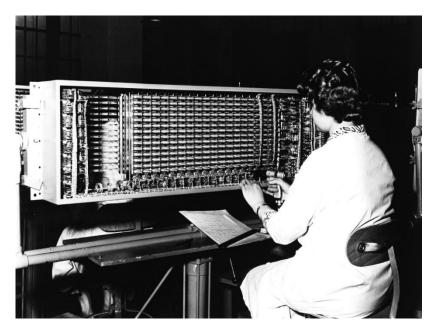
PENTACONTA crossbar wiring phase
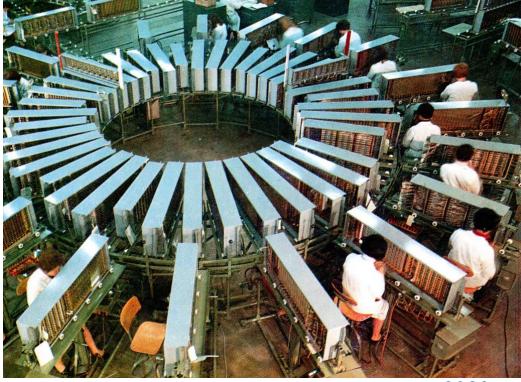
PENTACONTA wraping phase
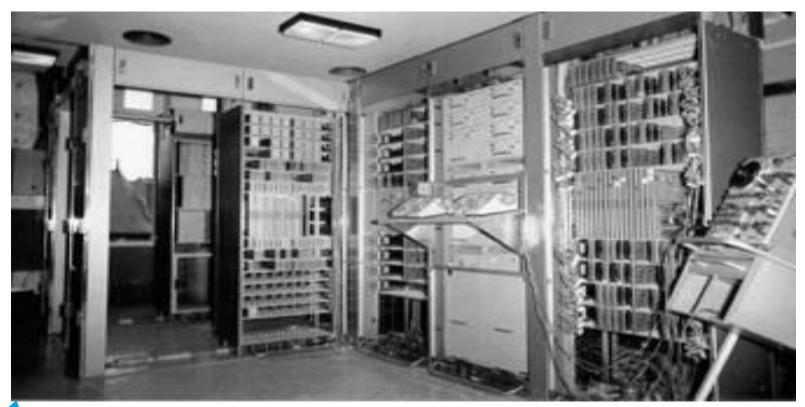
PENTACONTA Stand by Electric Generator

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)
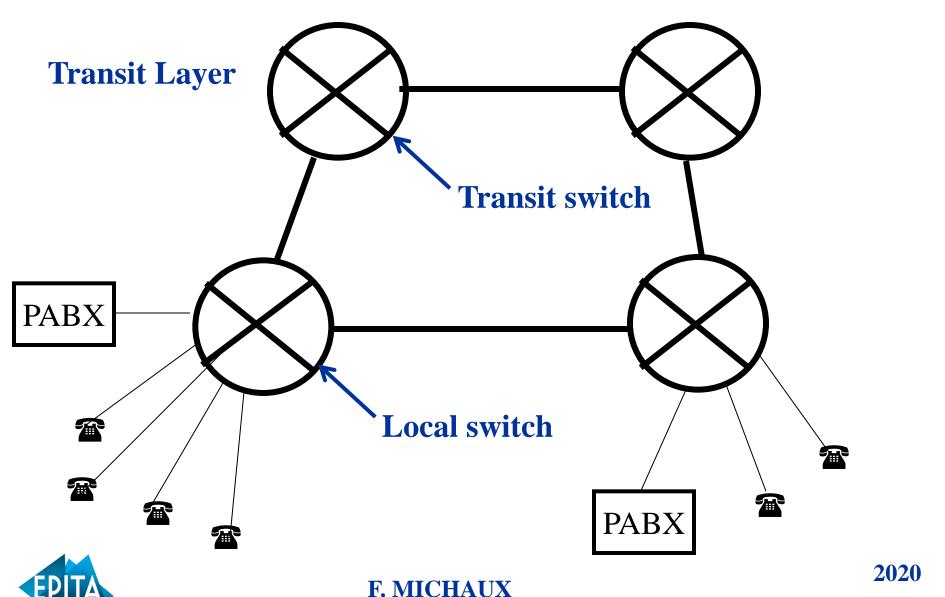
TYPE OF PUBLIC SWITCHES

There is 3 family of public switches
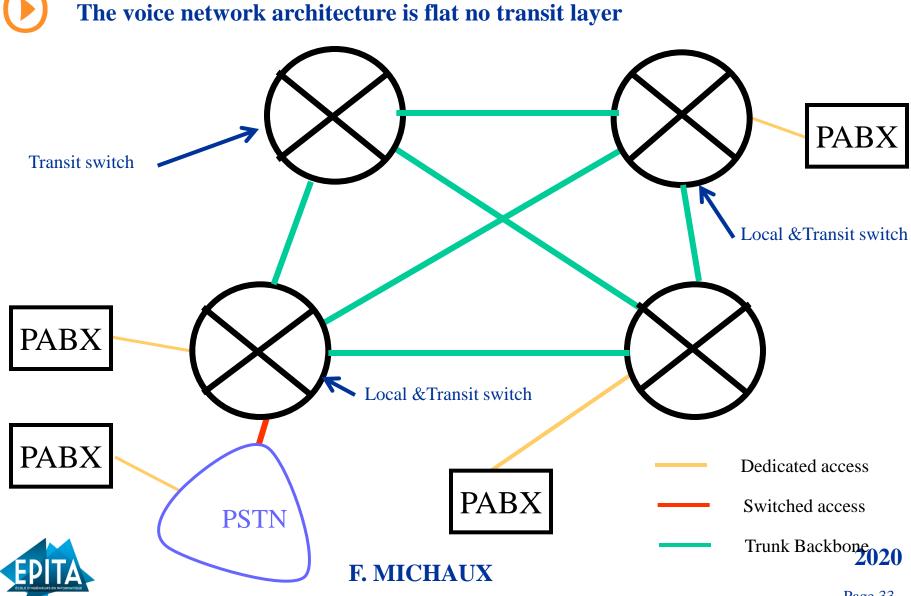
- ▶ LOCAL: used to connect customers and others switches

- ▶ 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.
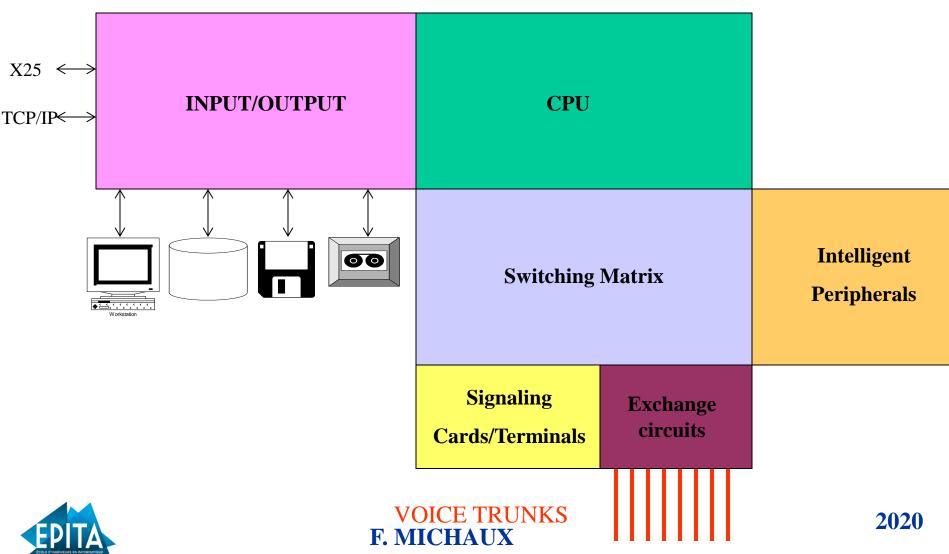
PUBLIC VOICE NETWORK ARCHITECTURE

Transit Layer

Transit switch

Local switch

PABX

PABX

VOICE NETWORK ARCHITECTURE

The voice network architecture is flat no transit layer

Transit switch

Local &Transit switch

PABX

PABX

Local &Transit switch

PABX

PABX

PSTN

Dedicated access

Switched access

Trunk Backbone

F. MICHAUX

2020

MAIN SWITCH COMPONENTS

X25

TCP/IP

INPUT/OUTPUT	CPU

Workstation

Switching Matrix

Intelligent Peripherals

Signaling Cards/Terminals

Exchange circuits

VOICE TRUNKS
F. MICHAUX

INPUT/OUPUT

MAIN SWITCH COMPONENTS

X25

TCP/IP

INPUT/OUTPUT

CPU

Workstation

Switching Matrix

Intelligent Peripherals

Signaling Cards/Terminals

Exchange circuits

VOICE TRUNKS

F. MICHAUX

2020

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

F. MICHAUX
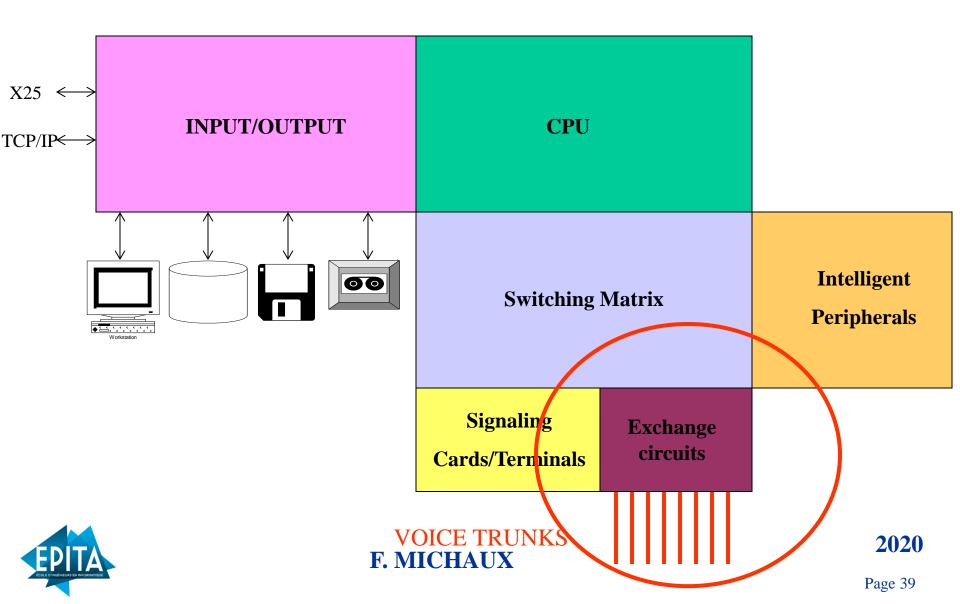
TDM TECHNOLOGIE

Transport, PCM...

MAIN SWITCH COMPONENTS

X25

TCP/IP

INPUT/OUTPUT

CPU

Workstation

Switching Matrix

Intelligent Peripherals

Signaling Cards/Terminals

Exchange circuits

VOICE TRUNKS
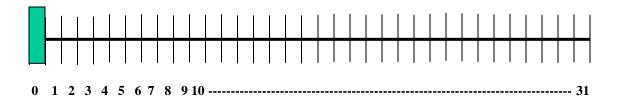
TDM TECHNOLOGIE

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

0   1   2   3   4   5   6 7   8   9 10 --- 31

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

F. MICHAUX

TDM TECHNOLOGIE

3.90625 µS

125 µS

0 1 2 3 4 5 6 7 8 9 10 --- 31

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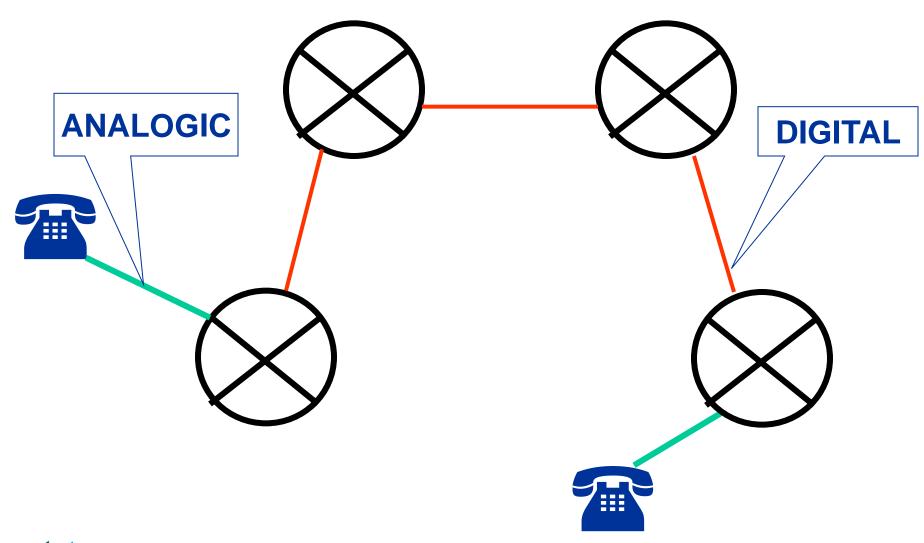
- Every 125 µS each time slot has a window of 125 µS / 32 = 3.90625 µS

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

$$2\ 048\ 000\ b/s \times 3.90625\ µS = \textbf{8 bits}$$

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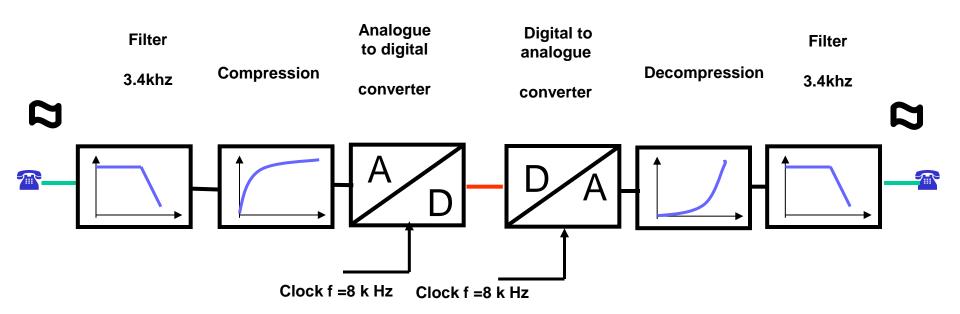
ANALOGIC & DIGITAL LINES

ANALOGIC

DIGITAL

DIGITALIZATION PRINCIPLE

Filter

3.4khz

Compression

Analogue to digital

converter

Digital to analogue

converter

Decompression

Filter

3.4khz

A / D

D / A

Clock f =8 k Hz

Clock f =8 k Hz

DIGITALIZATION PRINCIPLE

Signal Analogique → CAN → 01101011... Signal Numérique → Calculateur Numérique → 10101010... Signal Numérique → CNA → Signal Analogique

Schéma A. Perez-Mas

ANALOGIC VOICE SIGNAL

Voltage
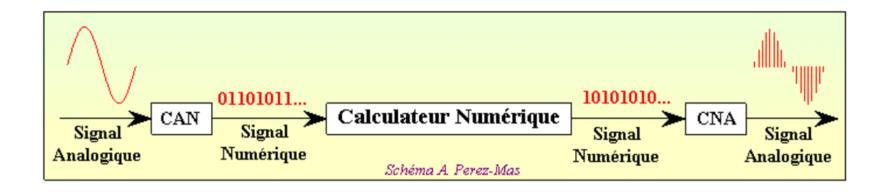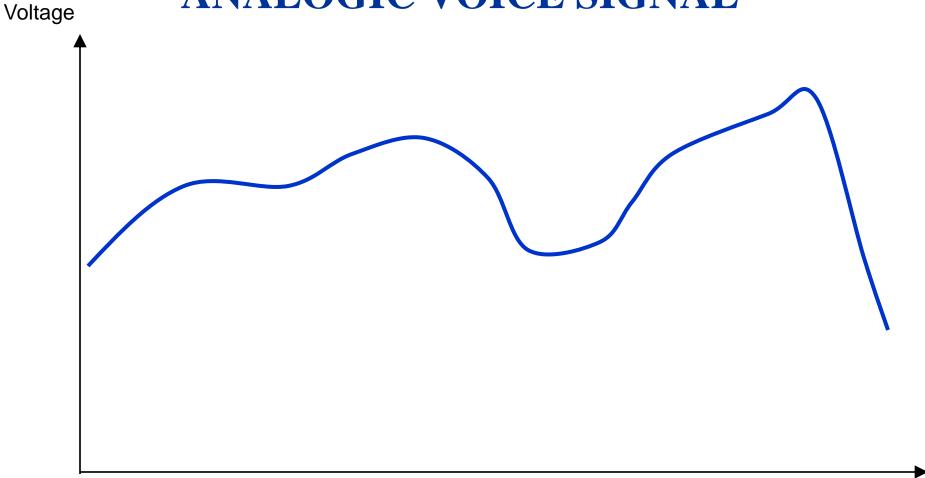
Time

Voice signal outside of an analogic phone

EPITA
ÉCOLE D'INGÉNIEURS EN INFORMATIQUE
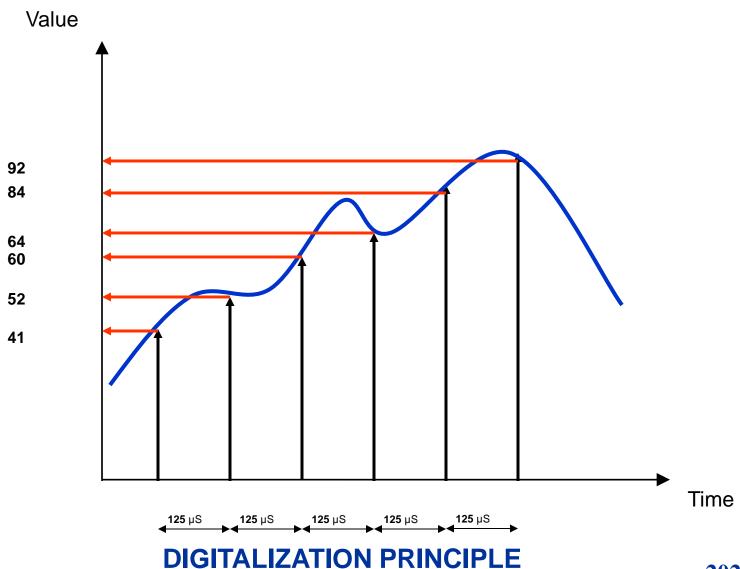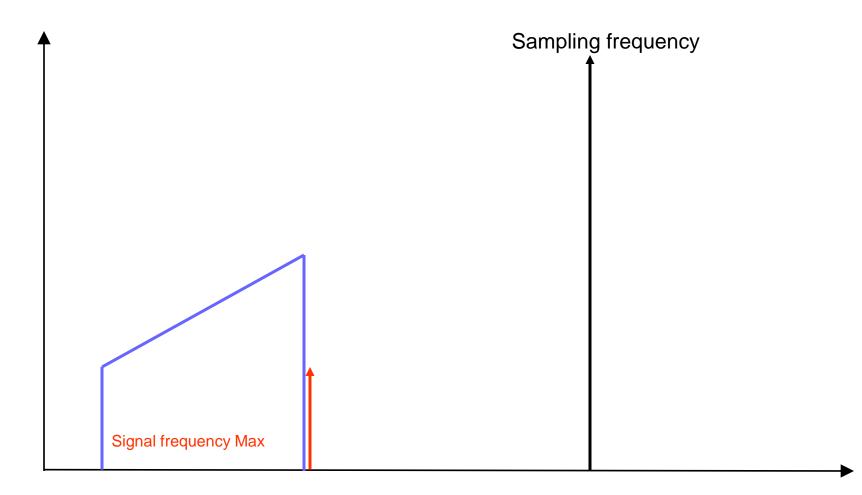
PULSE CODING MODULATION

DIGITALIZATION PRINCIPLE
F. MICHAUX

SIGNAL THEORY

Value

Sampling frequency

Signal frequency Max

FS = 8 khz

f
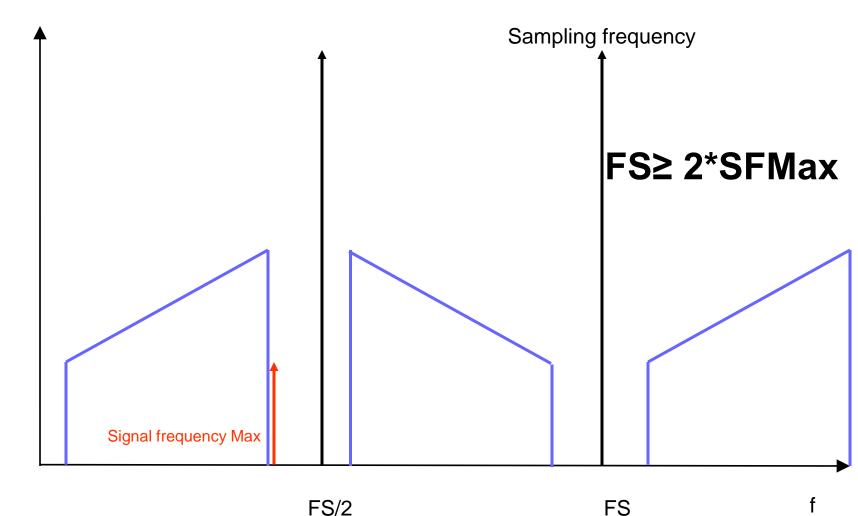
Voice spectrum

F. MICHAUX

2020

SIGNAL THEORY

Value

Sampling frequency

FS≥ 2*SFMax

Signal frequency Max

FS/2

FS

f

Spectrum about turn effect due to the sampling

F. MICHAUX

2020

Page 50

SIGNAL THEORY

Value

Sampling frequency

FS< 2*SFMax

In this case the spectrum is Changed

Signal frequency Max

FS/2

FS

f

Spectrum about turn effect due to the sampling

SIGNAL THEORY

Value

Sampling frequency

FS< 2*SFMax

**In this case the
spectrum is Changed**

Signal frequency Max

FS/2

FS

f

Spectrum about turn effect due to the sampling

F. MICHAUX

2020

SIGNAL THEORY

Value

The signal is not well filtered or the slampling frequency is not well adapted

92
84

64
60

52

41

Time

125 µS **125** µS **125** µS **125** µS **125** µS

DIGITALIZATION PRINCIPLE
F. MICHAUX

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 :
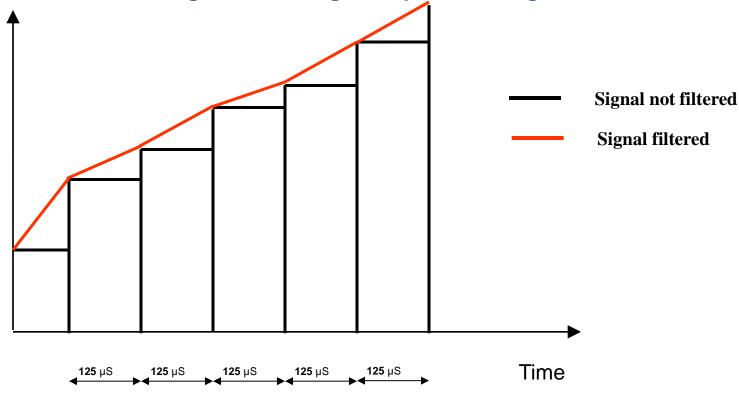
- ▶ The Sampling frequency is 8 KHz

- ▶ The voice spectrum is between 300-3400 hz

- ▶ Checking : 8000 ≥ 2 * 3400 = 6800

- ▶ This the reason why the voice signal is filtered

SIGNAL THEORIE
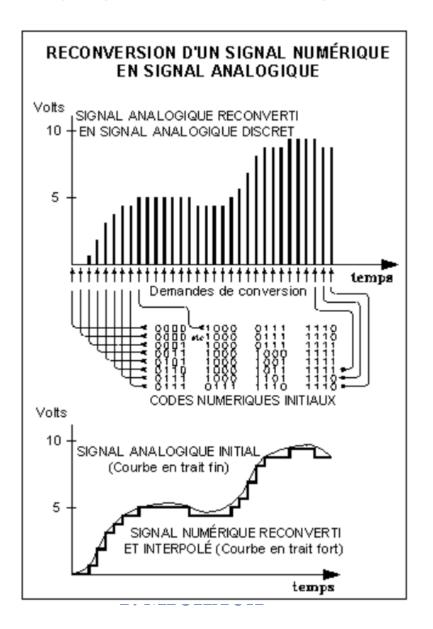
▶ The signal has to be filtered after the conversion digital to analog :

The conversion D to A generates high frequencies signal.

Signal not filtered

Signal filtered

125 μS   125 μS   125 μS   125 μS   125 μS

Time

SIGNAL THEORIE

RECONVERSION D'UN SIGNAL NUMÉRIQUE EN SIGNAL ANALOGIQUE

SIGNAL THEORIE
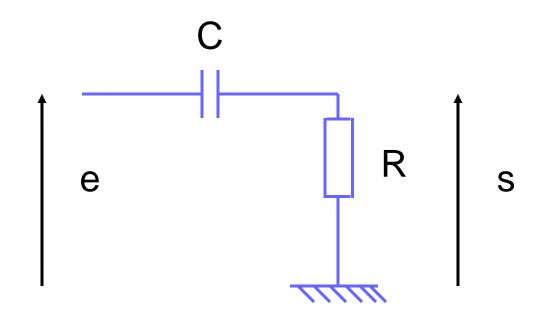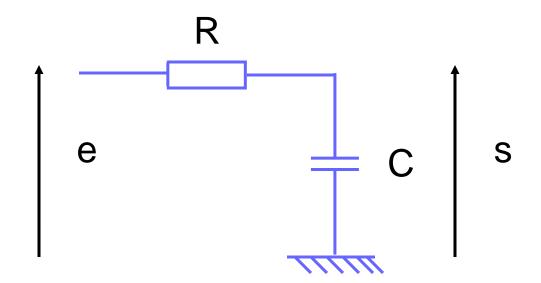
▶ Low frequencies suppressor

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**".

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

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 :
$$q = (Vmax - Vmin) / 2^n-1 = 10/255 = 39,215... \text{ mV}$$
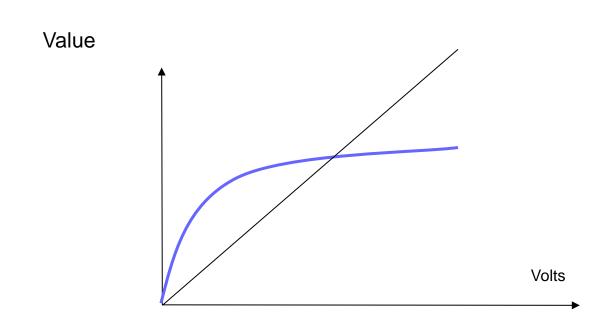
On peut encore évaluer l'incertitude relative de la mesure. q / (Vmax - Vmin)
C'est $1 / 2^{n-1}$

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.

Value

Volts

COMPRESSION 3/5

There is two kind of compression law :
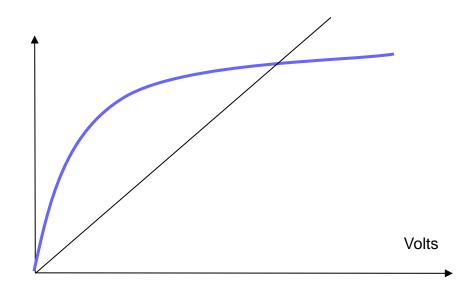
▶ The law μ used in North America and Japan.

▶ 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
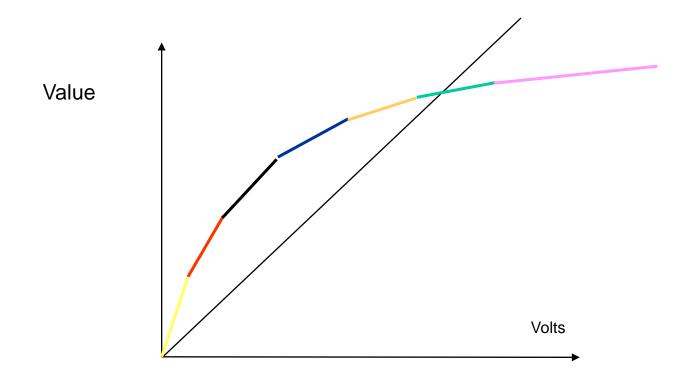
COMPRESSION 5/5
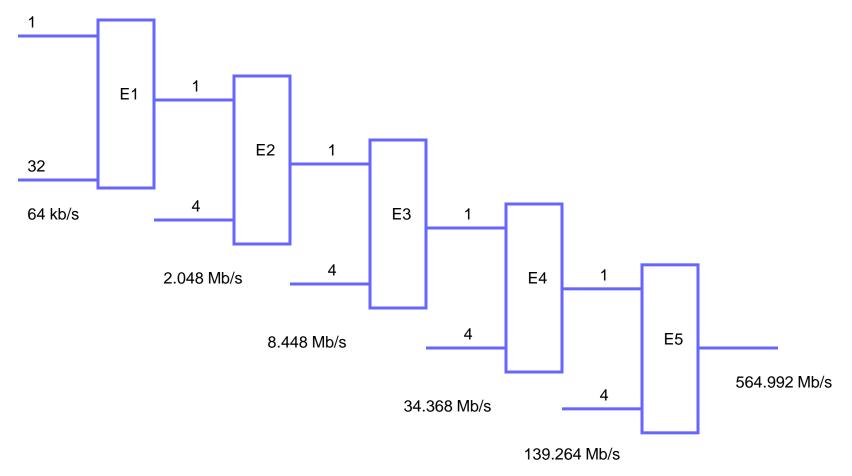
The law A is a sum of 7 linear segments

The law A

PLESIOCHRONE DATA HIERARCHY 1/2

1

E1

32

64 kb/s

1

E2

4

2.048 Mb/s

1

E3

4

8.448 Mb/s

1

E4

4

34.368 Mb/s

1

E5

4

139.264 Mb/s

564.992 Mb/s

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.
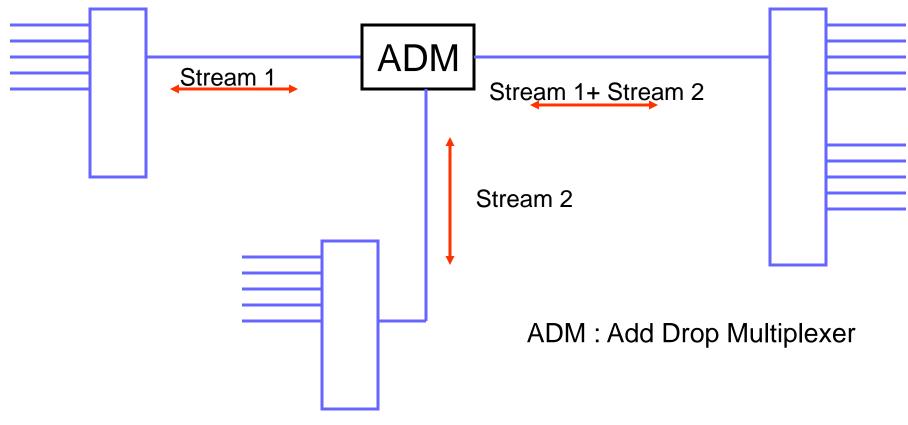
Conclusion:

▶ Interesting for a point to point traffic

SYNCHRONOUS DATA HIERARCHY 1/6
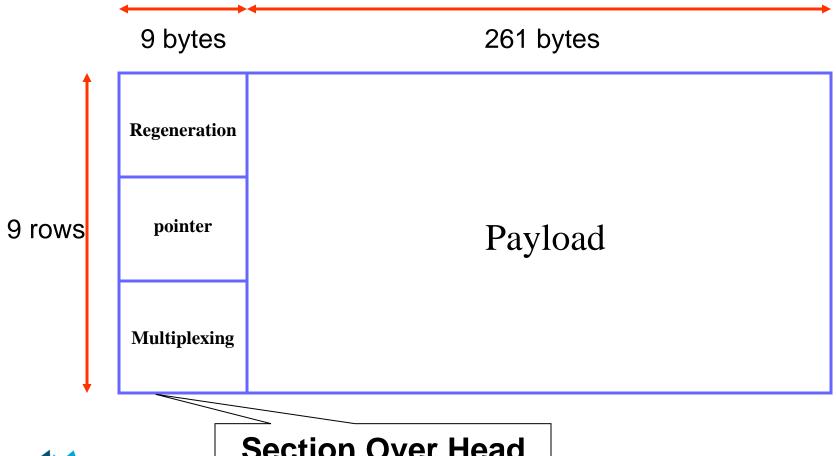
This technology is used in case of ring transport architecture

ADM

Stream 1

Stream 1+ Stream 2

Stream 2

ADM : Add Drop Multiplexer

SYNCHRONOUS DATA HIERARCHY 2/6

STM1 Container description

9 bytes   261 bytes

9 rows

Regeneration

pointer

Multiplexing

Payload

Section Over Head

2020

F. MICHAUX

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

F. MICHAUX

SYNCHRONOUS DATA HIERARCHY 5/6
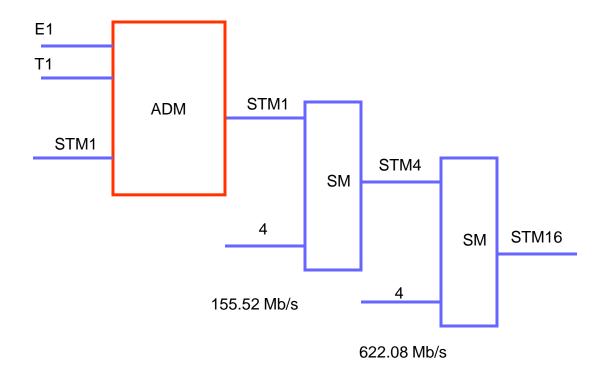
The benefit is :

▶ to multiplex a plesiochronous and synchronous traffic

▶ to multiplex E1 and T1

▶ to extract an E1 in a STM16

▶ Very flexible

SYNCHRONOUS DATA HIERARCHY

E1

T1

ADM

STM1

STM1

SM

STM4

4

SM

STM16

4

155.52 Mb/s

622.08 Mb/s
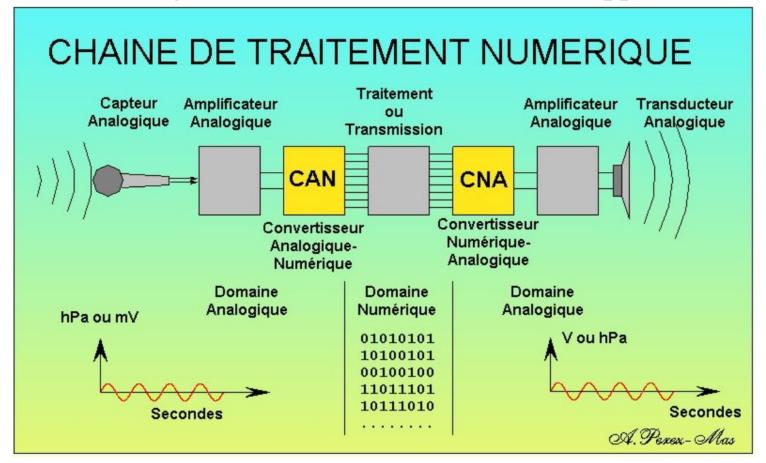
2488.32 Mb/s

ECHO EFFECT 1/4

In a long distance network a echo effect appears

F. MICHAUX

ECHO EFFECT 2/4
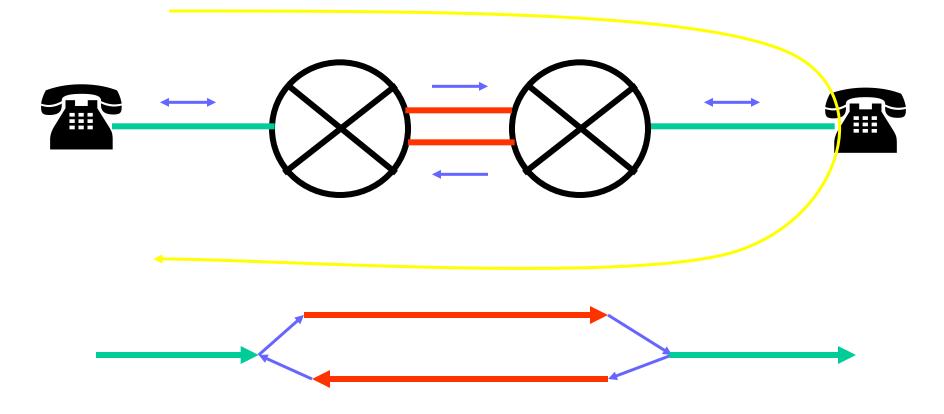
In a long distance network a echo effect appears
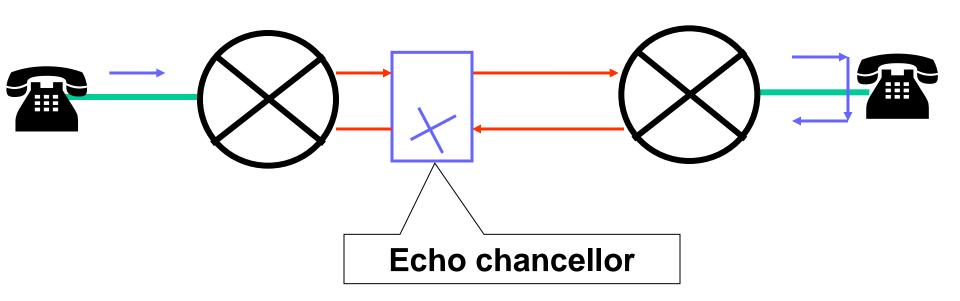
ECHO EFFECT 3/4

▶ **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

Echo chancellor
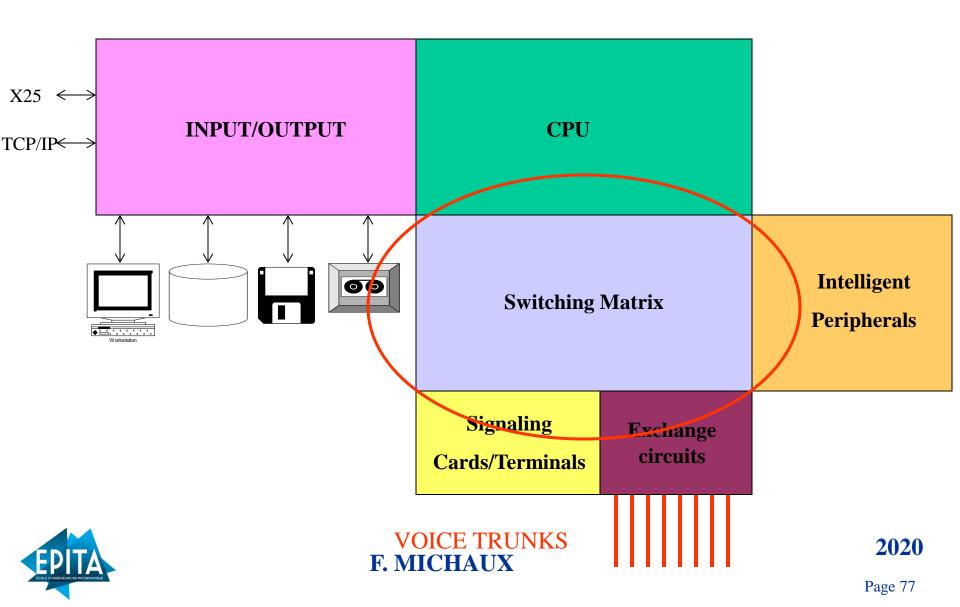
The echo chancellor memories the signal and cancels it at the return
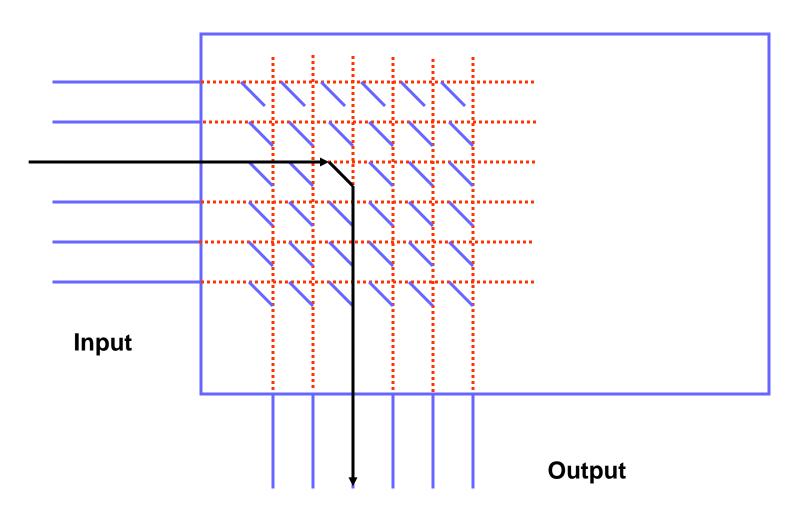
Switching Matrix

MAIN SWITCH COMPONENTS

X25

TCP/IP

INPUT/OUTPUT

CPU

Workstation

Switching Matrix

Intelligent Peripherals

Signaling Cards/Terminals

Exchange circuits

VOICE TRUNKS

F. MICHAUX

2020

SWITCHING MATRIX

Input

Output

Switching Matrix Principle
F. MICHAUX

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.

F. MICHAUX

SWITCHING MATRIX
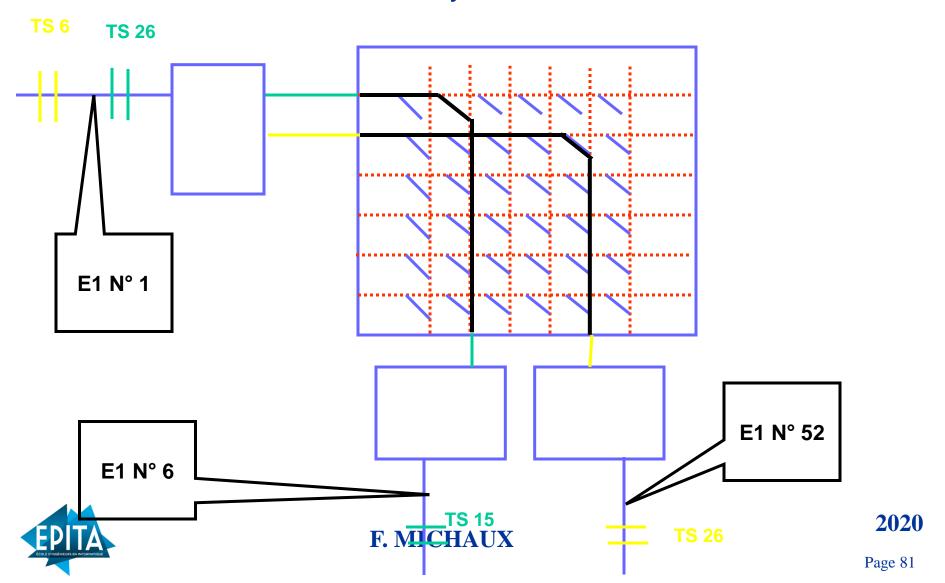
The size of a switching is calculated as the following:

- 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
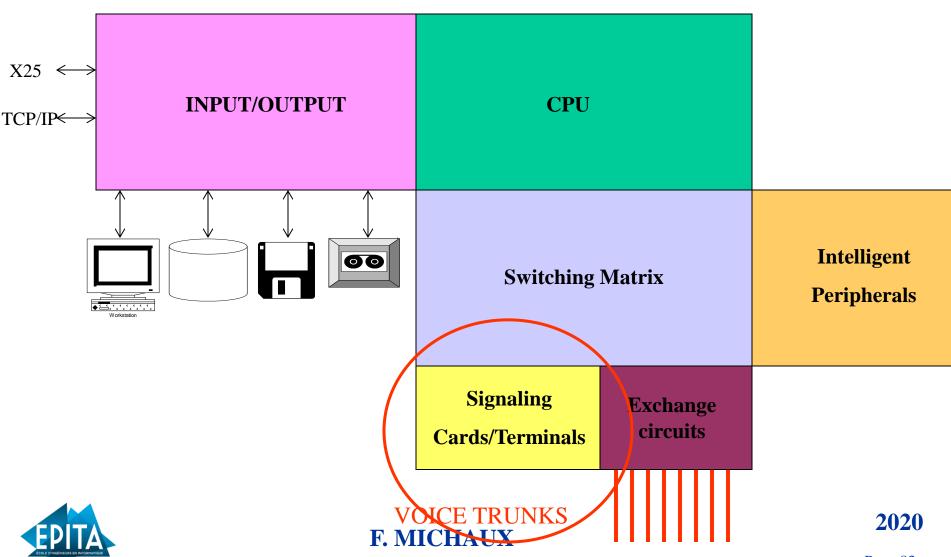
The E1 links have to be synchronised between them.

TS 6   TS 26

E1 N° 1

E1 N° 6

E1 N° 52

TS 15

TS 26

Signaling

MAIN SWITCH COMPONENTS

X25

TCP/IP

INPUT/OUTPUT	CPU

Workstation

Switching Matrix	Intelligent Peripherals

Signaling Cards/Terminals	Exchange circuits

VOICE TRUNKS

F. MICHAUX

2020

SIGNALING

The signaling allow to exchange information between nodes.

There is several kind of signaling
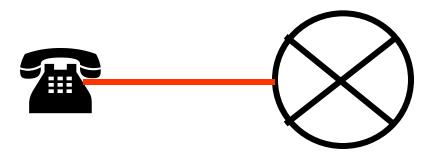
▶ Signaling circuit associated : eg : ISUP, ISDN, R2...

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

F. MICHAUX

CIRCUIT SIGNALING ASSOCIATED

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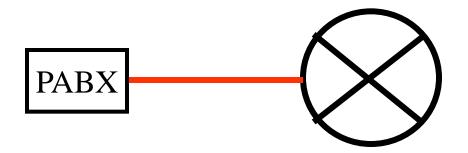
▶ USER signaling UNI (User to Network Interface) : (eg DTMF) between a analogic phone and a public switch

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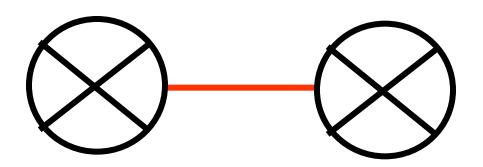
▶ User to User Interface: (eg QSIG, DPNSS,..) between two PABX.

CIRCUIT SIGNALING ASSOCIATED

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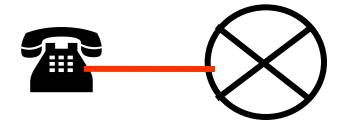
Network Signaling : NNI (Network to Network Interface) between public switch e.g. R2, TUP, ISUP..

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
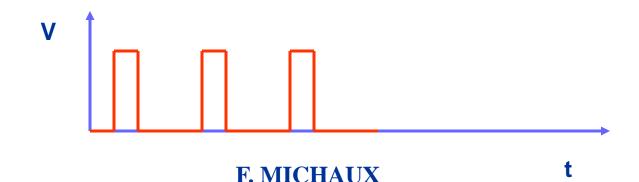
Dial 10 => 10 pulse on the line

Dial 9 => 9 pulse on the line

Dial 1 => 1 pulse on the line.

Example 3 is dialled

V

t

F. MICHAUX

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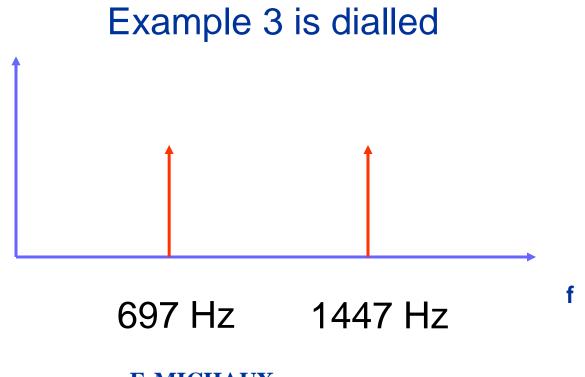
	1 209 Hz	1 336 Hz	1 447 Hz	1 633 Hz
697 Hz	1	2	3	A
770 Hz	4	5	6	B
852 Hz	7	8	9	C
941 Hz	*	0	#	D

F. MICHAUX

CIRCUIT SIGNALING ASSOCIATED
Signaling by Dual Tone MultiFrequency

The both frequencies are sent simultaneously

Example 3 is dialled

697 Hz   1447 Hz

f

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..)**
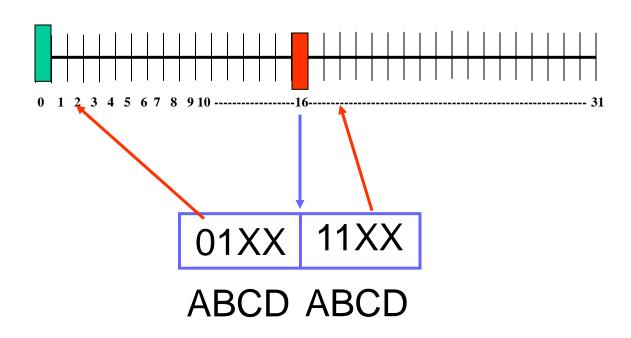
▶ **This solution is better but is still very poor**

CIRCUIT SIGNALING ASSOCIATED
CAS Signaling

CAS Means Channel Associated Signaling

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

0   1   2   3   4   5   6   7   8   9 10 ----------------16----------------------------------- 31

01XX	11XX

ABCD ABCD

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 …………….**

F. MICHAUX

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

Caller   Switch A   [MFC/R2 signaling]   Switch B   Called party

<------------ Idle [0x08] -------->

Pick up

--- Off-hook ---------->
<======== Dial tone ===
--- Digits ------------>
<========== Silence ===

--- Seize [0x01] ------------------>
<------------ Seize ack [0x0C] ---

--- Dialed digit 1 (I-x) --------->
<--------------- Get N+1 (A-1) ---
--- Dialed digit 2 (I-x) --------->

....

Dialing

<--------------- Get N+1 (A-1) ---
--- Last dialed digit (I-x) ---->
<------ Address complete (A-3) ---
--- User w/o priority (II-1) ---->
<---- User free, charge (B-6) ---

<================================= Ringback tone ===   --- Ring signal -------->
                                                        <-------- Off-hook ---

<--------------- Answer [0x05] ---   **Answer**

<================================= Speech =================================>
                                                        <------ On-hook ---

<------------ Clear Back [0x0C] ---
<=== Silence or tone ==   --- Clear forward [0x09] ---------->   **Hang up**
--- On-hook ---------->

<------------ Idle [0x08] -------->

F. MICHAUX

2020

Page 99

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**
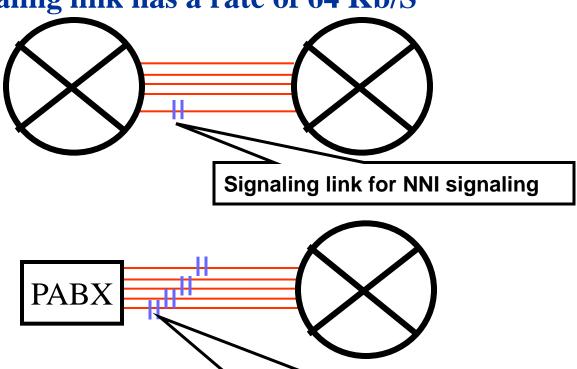
CIRCUIT SIGNALING ASSOCIATED

CCS Signaling

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

Signaling link for NNI signaling

PABX

Signaling link for UNI signaling

F. MICHAUX

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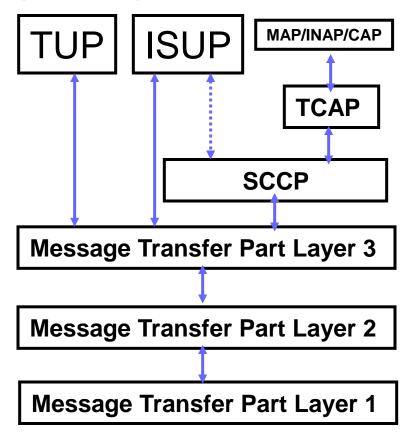
▶ The CCS Signaling is named signaling N°7, it's a message mode signaling.

▶ 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.

F. MICHAUX

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.

F. MICHAUX

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)

SIGNALING SS7
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.

SIGNALING SS7

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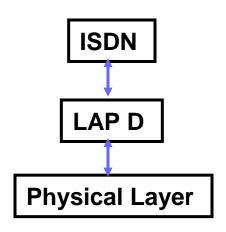
- Extended form of INAP is Customized Application for Mobile Networks Enhanced Logic (CAMEL). INAP is also application layer protocol to communicate with service control point (SCP).

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
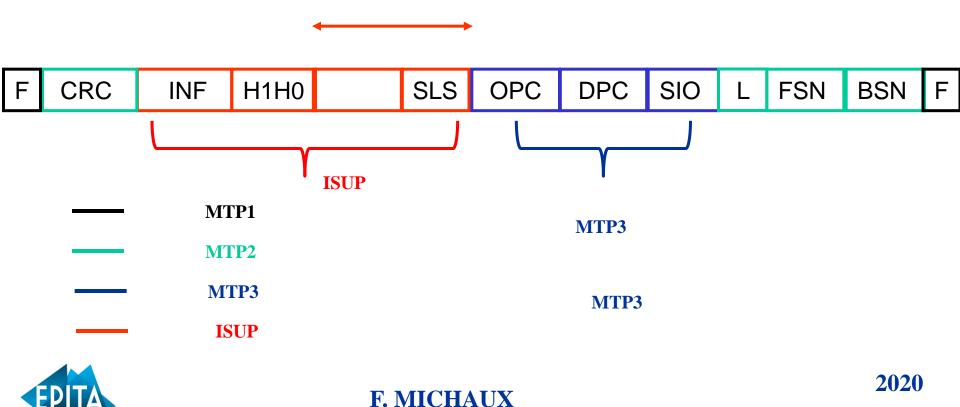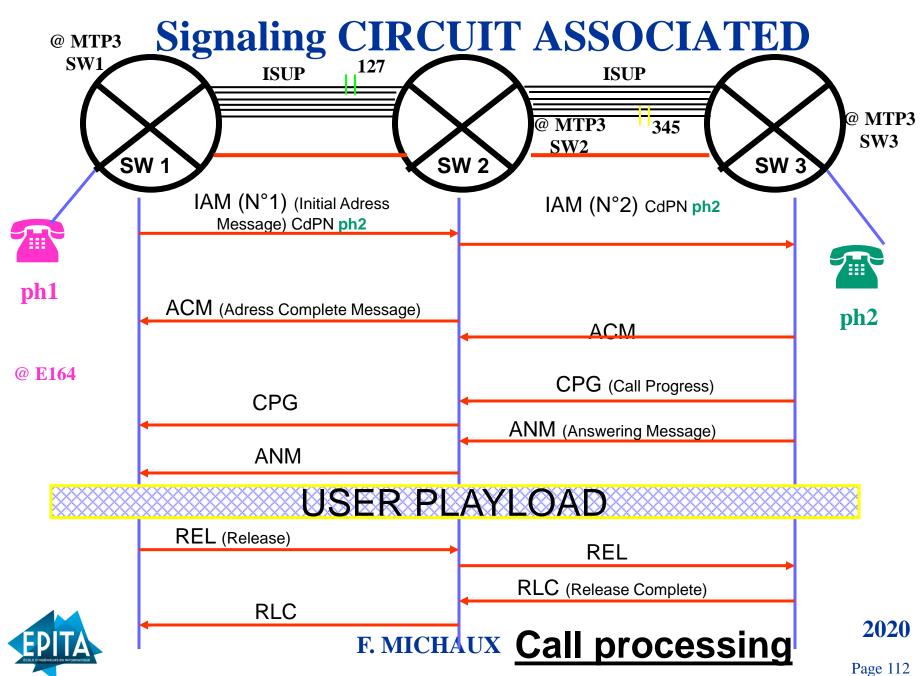
EXAMPLE OF ISUP MESSAGE

CIC 12 bits

| F | CRC | INF | H1H0 | | SLS | OPC | DPC | SIO | L | FSN | BSN | F |

ISUP

MTP1

MTP2

MTP3

ISUP

MTP3

MTP3

Signaling CIRCUIT ASSOCIATED

@ MTP3 SW1

ISUP 127

ISUP

@ MTP3 SW2 345

@ MTP3 SW3

SW 1 SW 2 SW 3

ph1

@ E164

ph2

IAM (N°1) (Initial Adress Message) CdPN **ph2**

IAM (N°2) CdPN **ph2**

ACM (Adress Complete Message)

ACM

CPG (Call Progress)

CPG

ANM (Answering Message)

ANM

USER PLAYLOAD

REL (Release)

REL

RLC (Release Complete)

RLC

2020

F. MICHAUX **Call processing**

SIGNALING SS7

ISUP MESSAGE IAM N°1

IAM H1HO 0001 0001

CIC : 12 bits Number of Circuit = 127

MTP3

MTP2

| F | CRC | INF | H1H0 | | SLS | OPC | DPC | SIO | L | FSN | BSN | F |

ISUP

@MTP3 SW1

@MTP3 SW2

0101 XX 10

ISUP : 0101

MTP3 : 0101

SCCP : 0011

INT: 00
NAT: 10

Calling party Number :
@ E164 ph 1

Called party Number :
@ E164 ph 2

EPITA
ÉCOLE D'INGÉNIEURS EN INFORMATIQUE

SIGNALING SS7

ISUP MESSAGE IAM N°2

IAM H1HO 0001 0001

CIC : 12 bits Number of Circuit = 345

MTP3

MTP2

| F | CRC | INF | H1H0 | | SLS | OPC | DPC | SIO | L | FSN | BSN | F |

ISUP

@MTP3 SW2

@MTP3 SW3

0101 XX 10

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
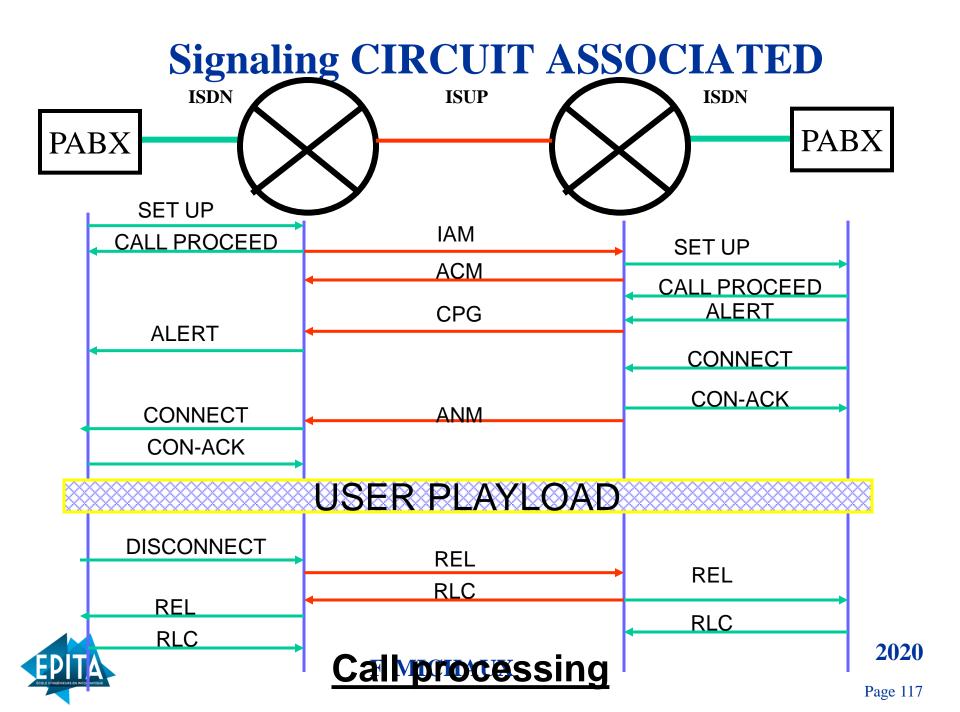
SIGNALING SS7 format ISUP Message
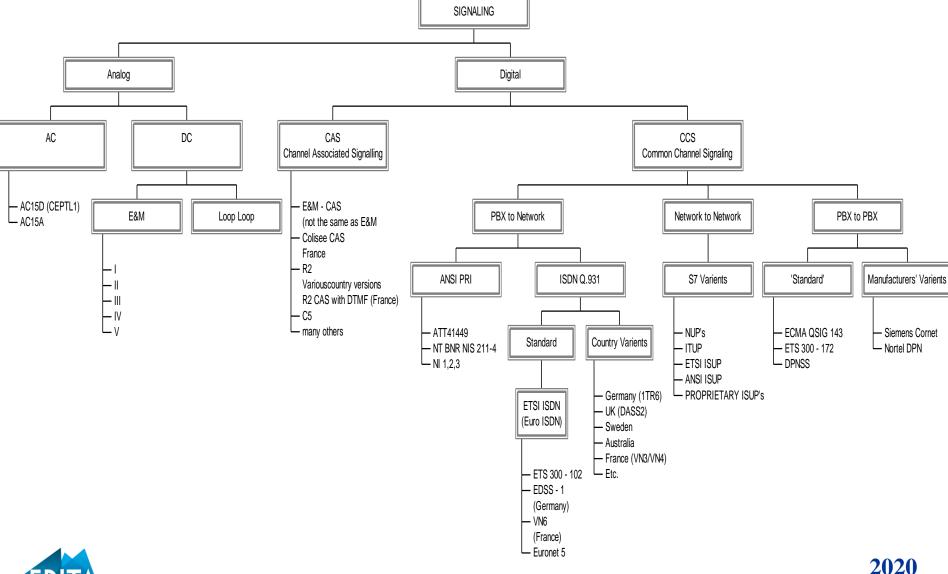
ISUP MSU

Signaling CIRCUIT ASSOCIATED

ISDN   ISUP   ISDN

PABX ───── ⊗ ─────── ⊗ ───── PABX

SET UP →
CALL PROCEED ←
                IAM →
                                        SET UP →
                ACM ←
                                        CALL PROCEED ←
                                        ALERT ←
                CPG ←
ALERT ←
                                        CONNECT ←
                                        CON-ACK →
CONNECT ←   ANM ←
CON-ACK →

USER PLAYLOAD

DISCONNECT →
                REL →
                                        REL →
                RLC ←
REL ←
                                        RLC ←
RLC →

Call processing
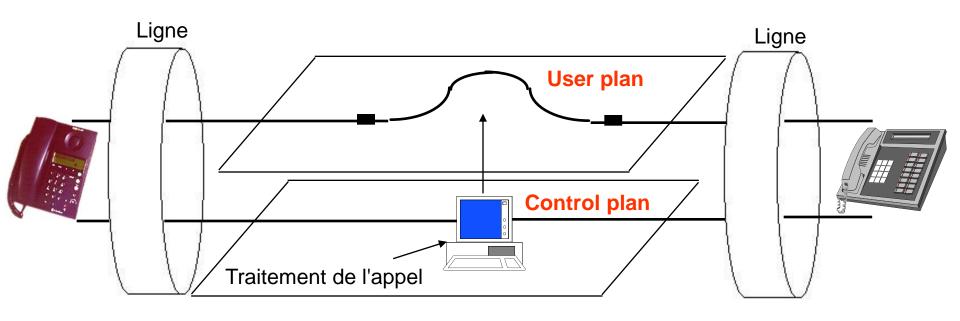
Signaling CIRCUIT ASSOCIATED

Control plan / User plan 1/13

Ligne

User plan

Control plan

Traitement de l'appel

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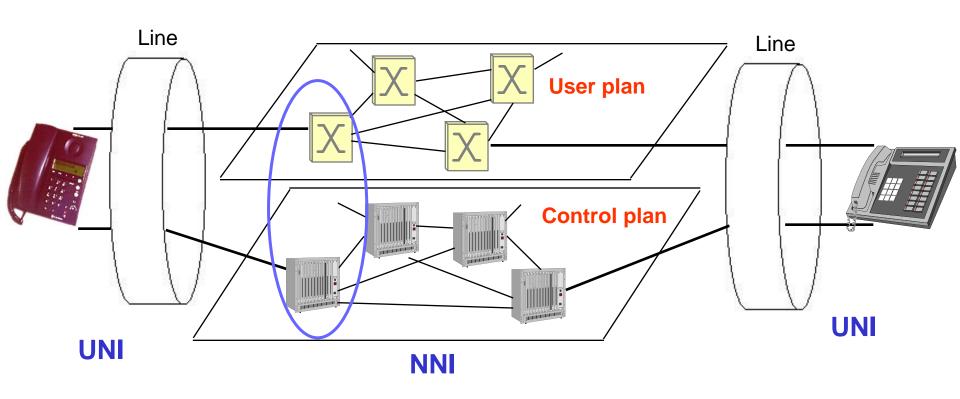
Control Plan : In charge to establish the connexion
User Plan : In charge to connect the voice ressources

⇨ **the both networks are parrallele**
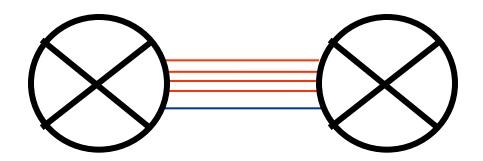
Control plan / User plan 2/13

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

Control plan / User plan 3/13
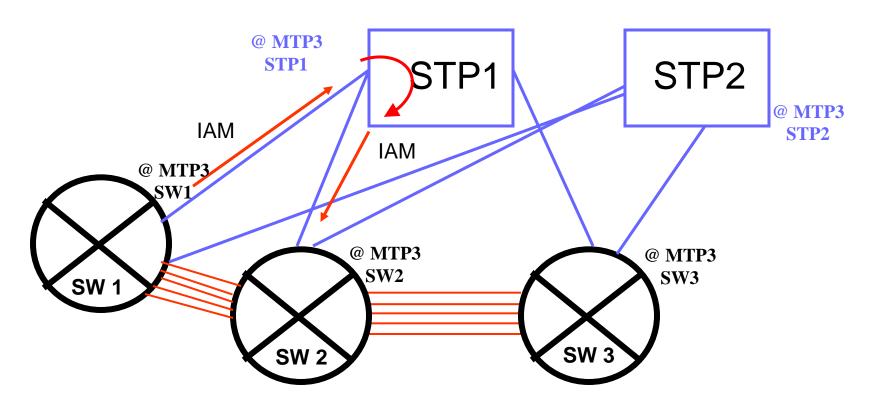
Associated mode
The Signaling link is dedicated to one voice trunk

Control plan / User plan 4/13
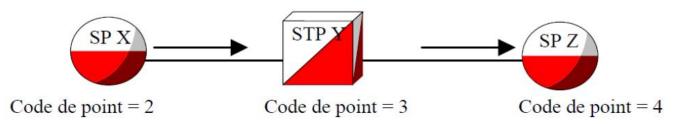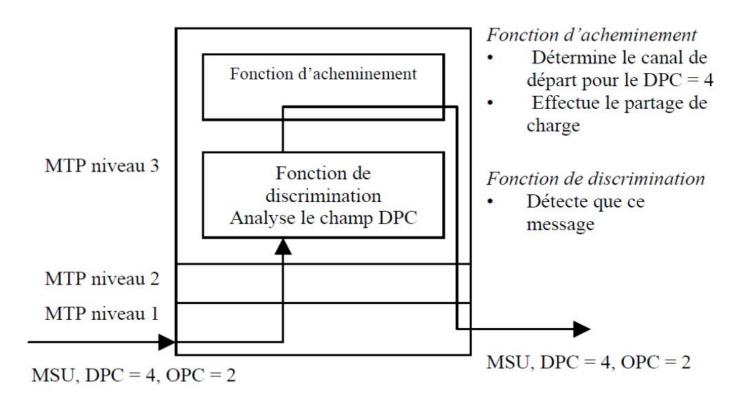
Quasi Associated mode
The Signaling link is not dedicated to one voice trunk

STP Function

SP X   STP Y   SP Z

Code de point = 2   Code de point = 3   Code de point = 4

Fonction d'acheminement

MTP niveau 3

Fonction de discrimination
Analyse le champ DPC

MTP niveau 2

MTP niveau 1

MSU, DPC = 4, OPC = 2

Fonction d'acheminement
- Détermine le canal de départ pour le DPC = 4
- Effectue le partage de charge

Fonction de discrimination
- Détecte que ce message

MSU, DPC = 4, OPC = 2

F. MICHAUX

Control plan / User plan 6/13

HLR1

SCP1

@ MTP3
SCP1

HLR : Home location register

SCP : Service Control Point

STP : Signaling transfert Point

@ MTP3
SCP1

@ MTP3
STP1

STP1

STP2

@ MTP3
STP2

@ MTP3
SW1

@ MTP3
SW2

@ MTP3
SW3

SW 1

SW 2

SW 3

Control plan / User plan 7/13

SCCP G

HLR1

SCP1

@ MTP3 SCP1

@ MTP3 SCCP1

SCCP G : SCCP Gateway

HLR : Home location register

SCP : Service Control Point

STP : Signaling transfert Point

@ MTP3 STP1

STP1

STP2

@ MTP3 STP2

@ MTP3 SW1

SW 1

@ MTP3 SW2

@ MTP3 SW3

SW 2

SW 3

Control plan / User plan 8/13
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)

GT - PC Z →PC NAT B	**GT - PC** Z →PC INT C	**GT - PC** Z → PC D	
SCCP	**SCCP**	**SCCP**	**SCCP**
MTP3	MTP3 / MTP3	MTP3 / MTP3	**MTP3**
MTP2	MTP2 / MTP2	MTP2 / MTP2	**MTP2**
MTP1	MTP1 / MTP1	MTP1 / MTP1	**MTP1**

PC NAT B   PC INT B   PC INT C   PC NAT C

PC A

GT MSC A

PC D

GT HLR D

Control plan / User plan
Global Tittle Adress 9/13

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 10/13

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
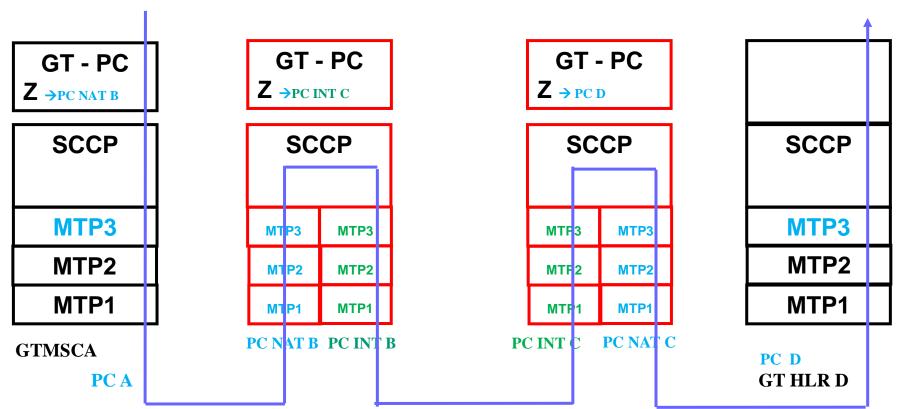
Bouygues : 33 6 60 +Subscriber IMSI

Control plan / User plan 11/13
SCCP G function

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

GT - PC	GT - PC	GT - PC	
Z →PC NAT B	Z →PC INT C	Z → PC D	
SCCP	SCCP	SCCP	SCCP
MTP3	MTP3 | MTP3	MTP3 | MTP3	MTP3
MTP2	MTP2 | MTP2	MTP2 | MTP2	MTP2
MTP1	MTP1 | MTP1	MTP1 | MTP1	MTP1

GTMSCA

PC A

PC NAT B   PC INT B

PC INT C   PC NAT C

PC D
GT HLR D

Control plan / User plan 12/13

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

F. MICHAUX

2020
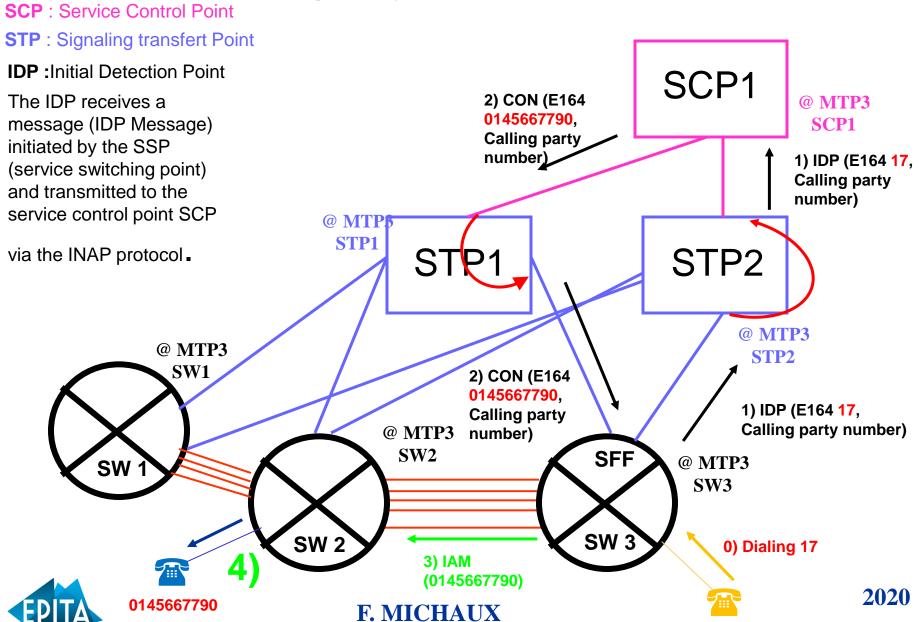
Control plan / User plan 13/13
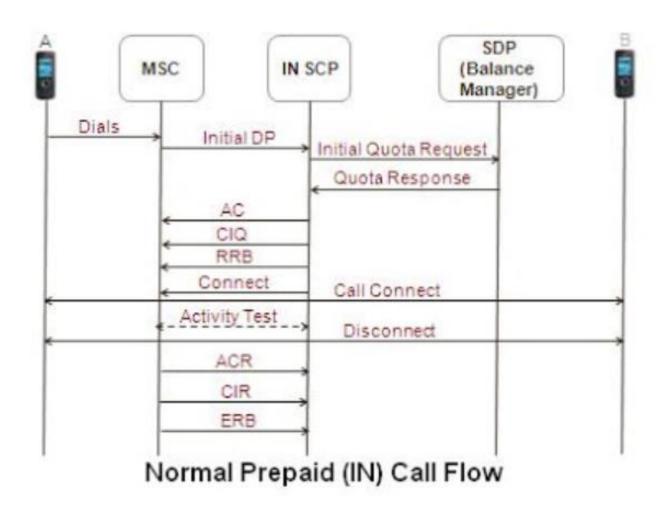
Signaling link dimensioning

- **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.

SCP1

@ MTP3 SCP1

2) CON (E164 **0145667790**, Calling party number)

1) IDP (E164 **17**, Calling party number)

@ MTP3 STP1

STP1

STP2

@ MTP3 STP2

@ MTP3 SW1

2) CON (E164 **0145667790**, Calling party number)

@ MTP3 SW2

1) IDP (E164 **17**, Calling party number)

SW 1

SW 2

SFF

@ MTP3 SW3

SW 3

4)

0145667790

3) IAM (0145667790)

0) Dialing 17

F. MICHAUX

2020

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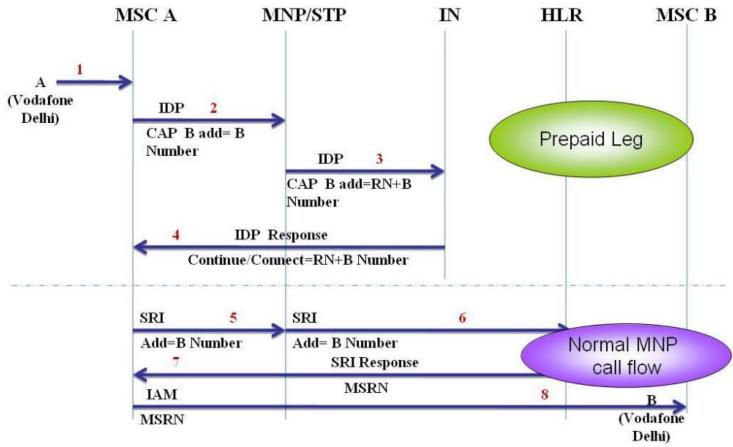
4. Connect :- After getting everything OK i.e. all request from IN side have been done then IN sends a Connect message to MSC for further call processing & connect the call.

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. <u>CIR (Call Information Report) :-</u> 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. <u>ERB (Evert Report BCSM) :-</u> 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.

Prepaid Service via IN solution

A Subscriber calls an B Subscriber (Ported In or Normal Subscriber), Both In Same PLMN (Local)
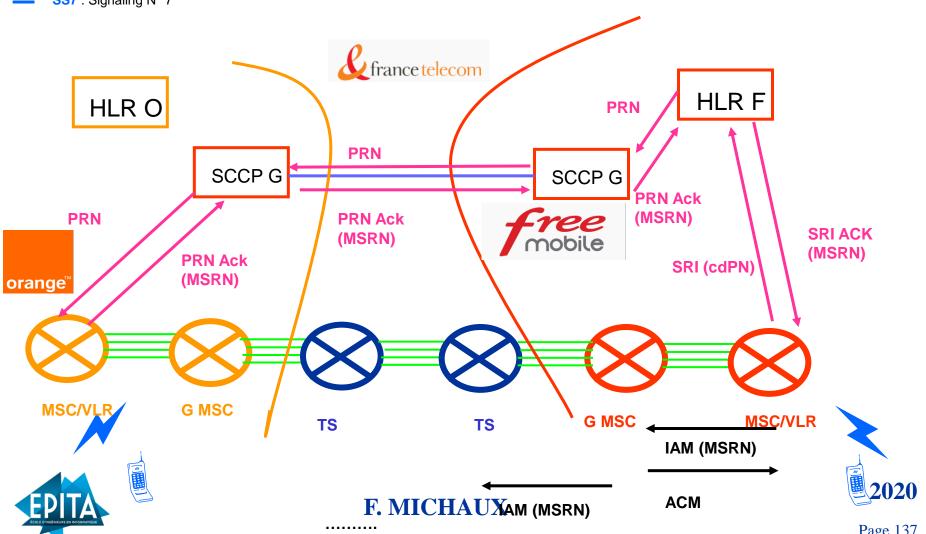
Free customer call in Roaming

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

HLR O

HLR F

SCCP G

SCCP G

france telecom

free mobile

orange

PRN

PRN Ack (MSRN)

PRN

PRN Ack (MSRN)

PRN

PRN Ack (MSRN)

SRI ACK (MSRN)

SRI (cdPN)

MSC/VLR

G MSC

TS

TS

G MSC

MSC/VLR

IAM (MSRN)

IAM (MSRN)

ACM

2020

F. MICHAUX

....

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

HLR O

SCCP G

STP

STP

orange™

MSC/VLR

G MSC

france telecom

TS

TS

free mobile

G MSC

SCCP G

STP

STP

HLR F

MSC/VLR

F. MICHAUX

2020

Page 138

Free customer call in Roaming
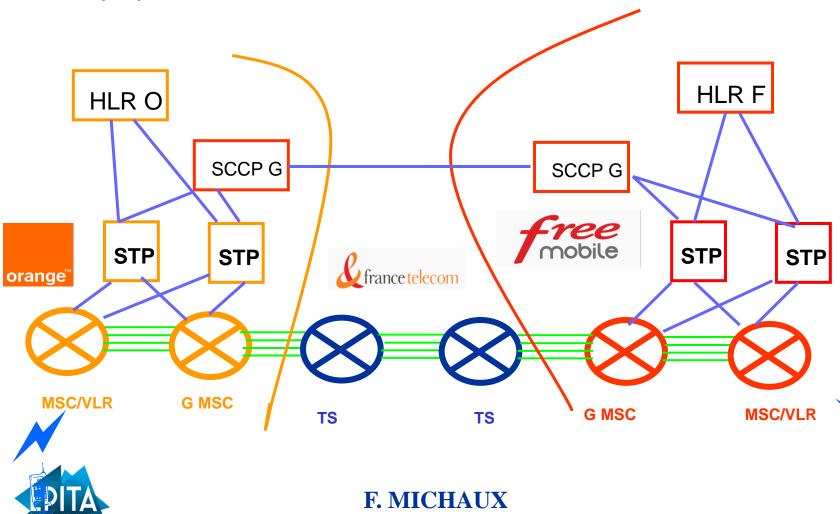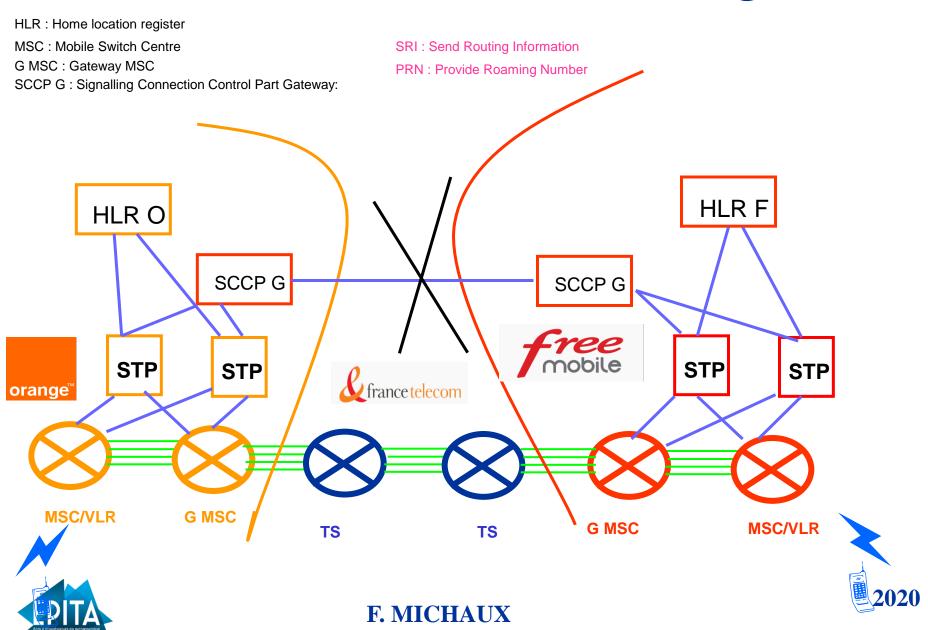
HLR : Home location register

MSC : Mobile Switch Centre

G MSC : Gateway MSC

SCCP G : Signalling Connection Control Part Gateway:

SRI : Send Routing Information

PRN : Provide Roaming Number

HLR O

SCCP G

STP

STP

orange™

MSC/VLR

G MSC

france telecom

TS

TS

free mobile

SCCP G

HLR F

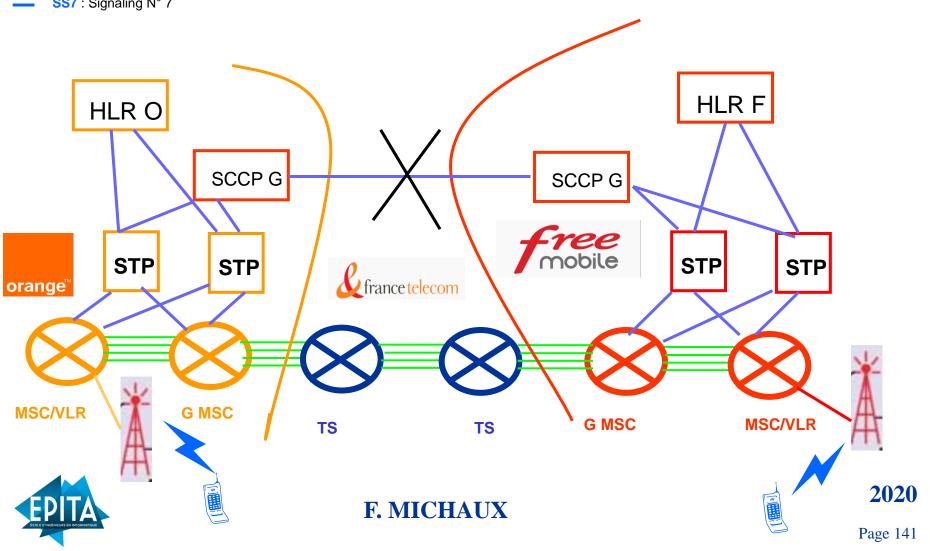**STP**

STP

G MSC

MSC/VLR

"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 O

SCCP G

STP

STP

orange™

MSC/VLR

G MSC

france telecom

TS

TS

free mobile

SCCP G

HLR F

STP

STP

G MSC

MSC/VLR

2020

F. MICHAUX

Page 141
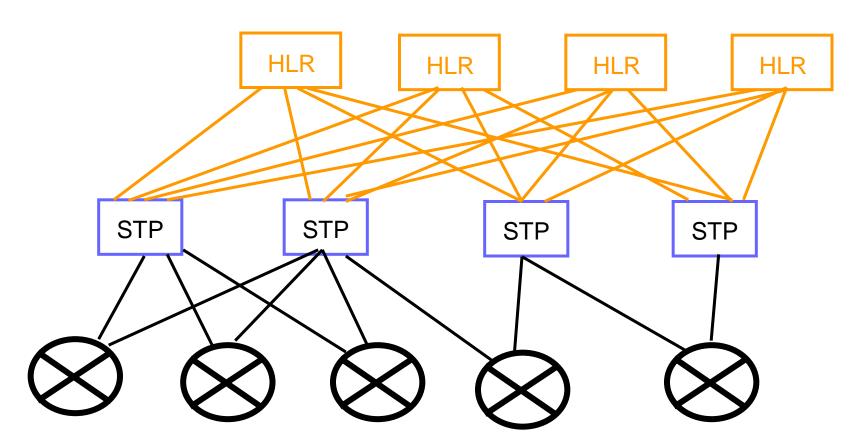
HLR classi connection to the STP 's

HLR : Home location register
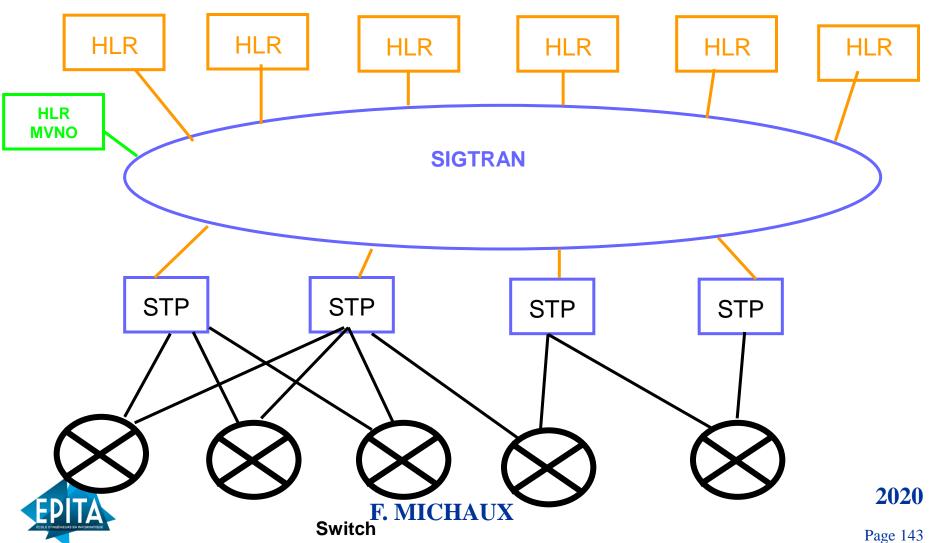
STP : Signalling Transfer Point

HLR connection to the STP 's via Sigtran

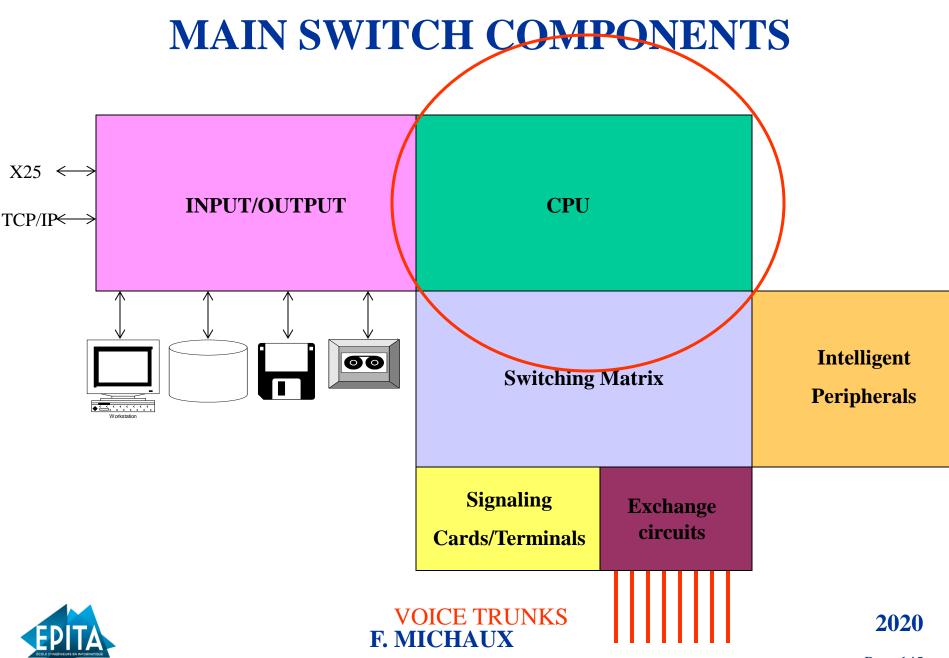HLR : Home location register

STP : Signalling Transfer Point

Sigtran : **Sig**naling **tran**sport (infrastrucure to carry SS7 singnaling on an IP network)

CPU

MAIN SWITCH COMPONENTS

X25

TCP/IP

INPUT/OUTPUT

CPU

Workstation

Switching Matrix

Intelligent

Peripherals

Signaling

Cards/Terminals

Exchange circuits

VOICE TRUNKS

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

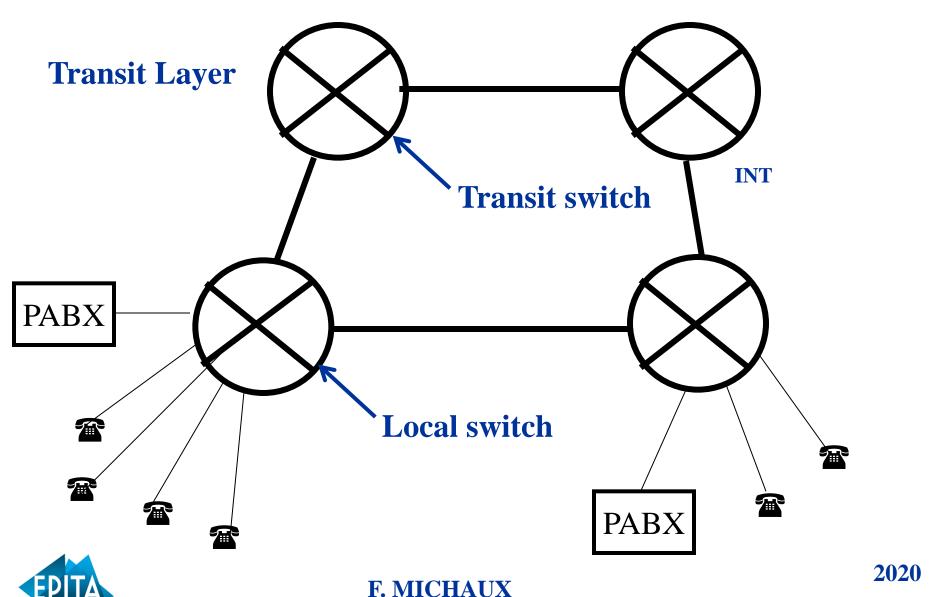- It's a real time software each call lauches a task.

CPU

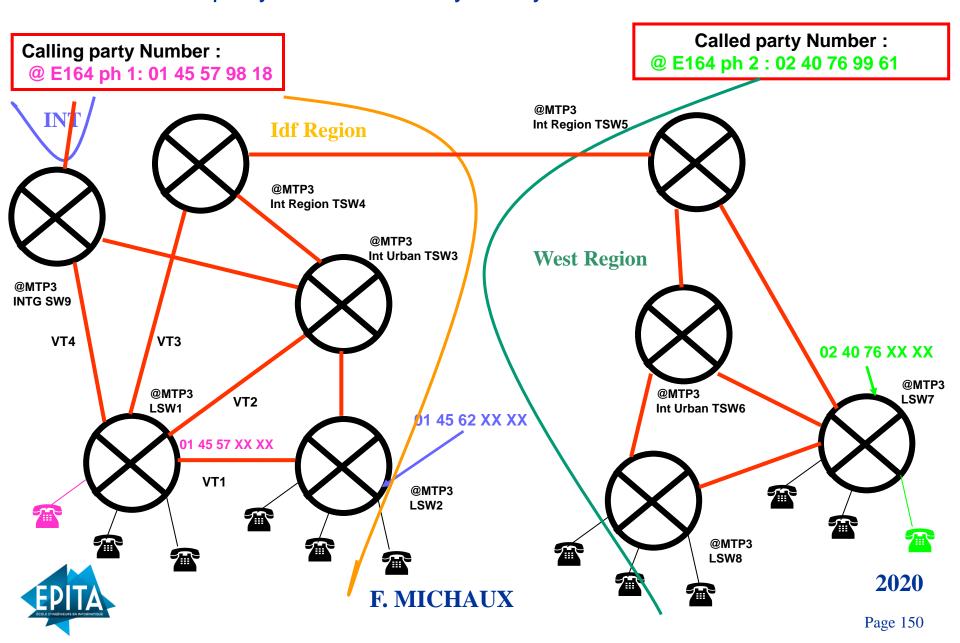The CPU is dimensioned by the traffic handles by the switch at the peak hour

▶ 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 ….

F. MICHAUX

2020

PUBLIC VOICE NETWORK ARCHITECTURE

Transit Layer

INT

Transit switch

Local switch

PABX

PABX

EPITA
ÉCOLE D'INGÉNIEURS EN INFORMATIQUE
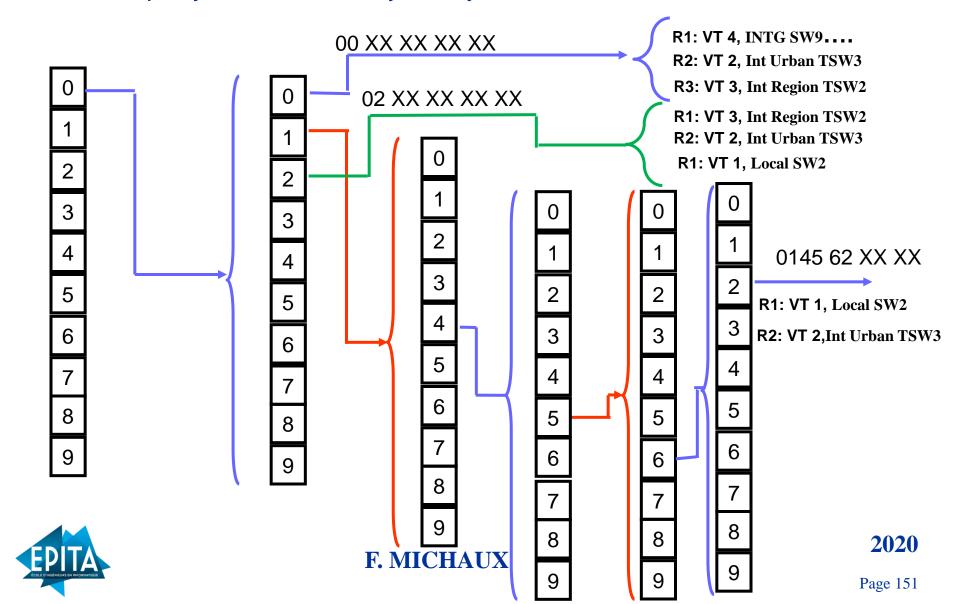
Translation principle
The called party number is analysed by the translation

Calling party Number :
@ E164 ph 1: 01 45 57 98 18

Called party Number :
@ E164 ph 2 : 02 40 76 99 61

INT

Idf Region

@MTP3
Int Region TSW5

@MTP3
Int Region TSW4

@MTP3
Int Urban TSW3

West Region

@MTP3
INTG SW9

VT4

VT3

02 40 76 XX XX

@MTP3
LSW1

VT2

@MTP3
LSW7

01 45 57 XX XX

01 45 62 XX XX

@MTP3
Int Urban TSW6

VT1

@MTP3
LSW2

@MTP3
LSW8

F. MICHAUX

2020

Translation principle LSW1

The called party number is analysed by the translation

00 XX XX XX XX

02 XX XX XX XX

0145 62 XX XX

R1: VT 4, INTG SW9....
R2: VT 2, Int Urban TSW3
R3: VT 3, Int Region TSW2

R1: VT 3, Int Region TSW2
R2: VT 2, Int Urban TSW3
R1: VT 1, Local SW2

R1: VT 1, Local SW2
R2: VT 2, Int Urban TSW3

F. MICHAUX

INTELIGENT PERIPHERALS

MAIN SWITCH COMPONENTS

X25

TCP/IP

INPUT/OUTPUT

CPU

Workstation

Switching Matrix

Intelligent Peripherals

Signaling Cards/Terminals
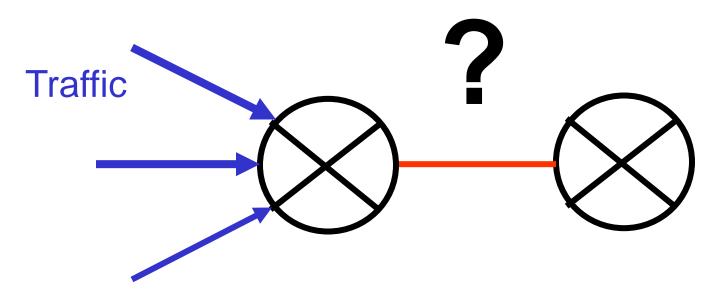
Exchange circuits

VOICE TRUNKS

F. MICHAUX

INTELLIGENT PERIPHERALS

The intelligent peripherals provide additional services for the basic calls :

▶ DTMF receivers

▶ Announcement machines

Traffic calculation

Traffic calculation

Traffic

?

▶ **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

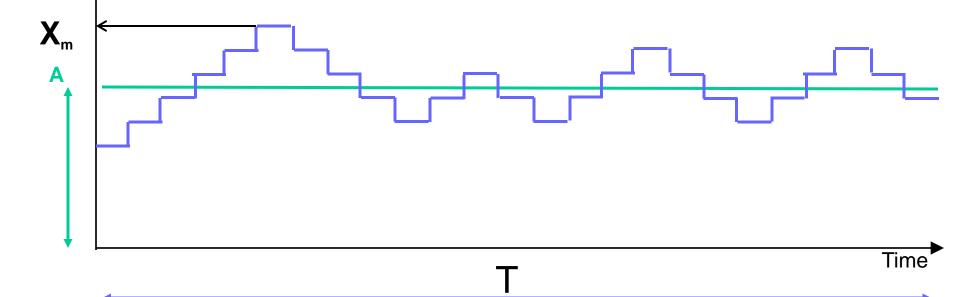**(*) Mister Agner Krarup Erlang (1878-1929) was Danish**

Erlang Law 1/13

Number of circuit

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

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

X_m

A

T

Time

EPITA
ÉCOLE D'INGÉNIEURS EN INFORMATIQUE

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
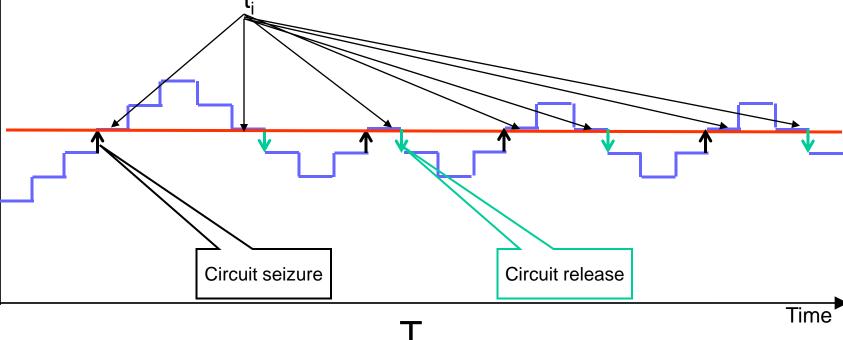
Result : 3/60* 20 000 = 1000 Erlangs

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 $P(X) = (\Sigma\ t_i)/T$

t_i

X

Circuit seizure
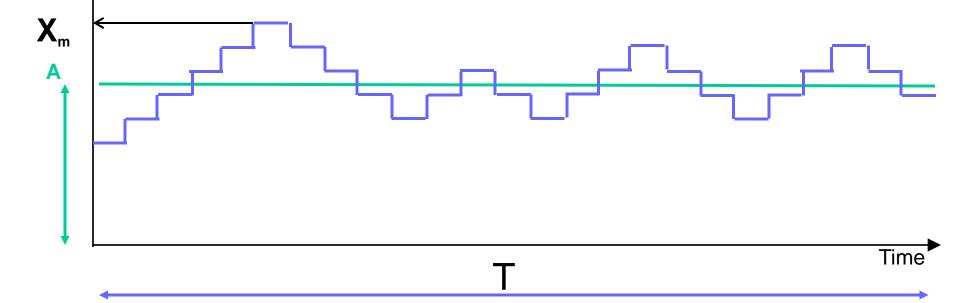
Circuit release

Time

T

Circuit occupation
F. MICHAUX

2020

Erlang Law 4/13

During a T the traffic A is average usage of the circuit during a T period
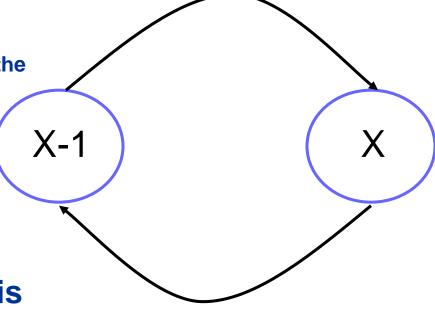
$$A = \sum_m (x_i t_i)/T$$

X_m

A

T

Time

Erlang Law 5/13

- λ_{X-1} is the rate of circuit seizure at the (X-1) state

- μ_X is the rate of circuit release at the (X) state

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

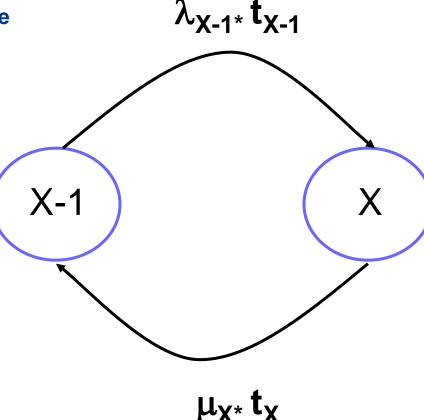$$\lambda_{X-1*}t_{x-1}$$

$$X-1 \qquad X$$

$$\mu_{X*}t_X$$

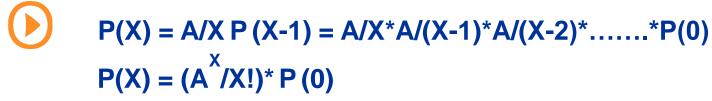**Transition between the states (X) and (X-1)**

Erlang Law 6/13

▶ λ_{X-1} does not depend of the circuit already seized but depends only of the traffic A

▶ μ_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
$A * \mathbf{P(X-1)}/\tau = \mathbf{(X)} * \mathbf{P(X)}/\tau$

$$\lambda_{X-1} * t_{X-1}$$

$$\mu_{X} * t_{X}$$

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

Erlang Law 7/13

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

$P(X) = (A^X/X!)* P(0)$
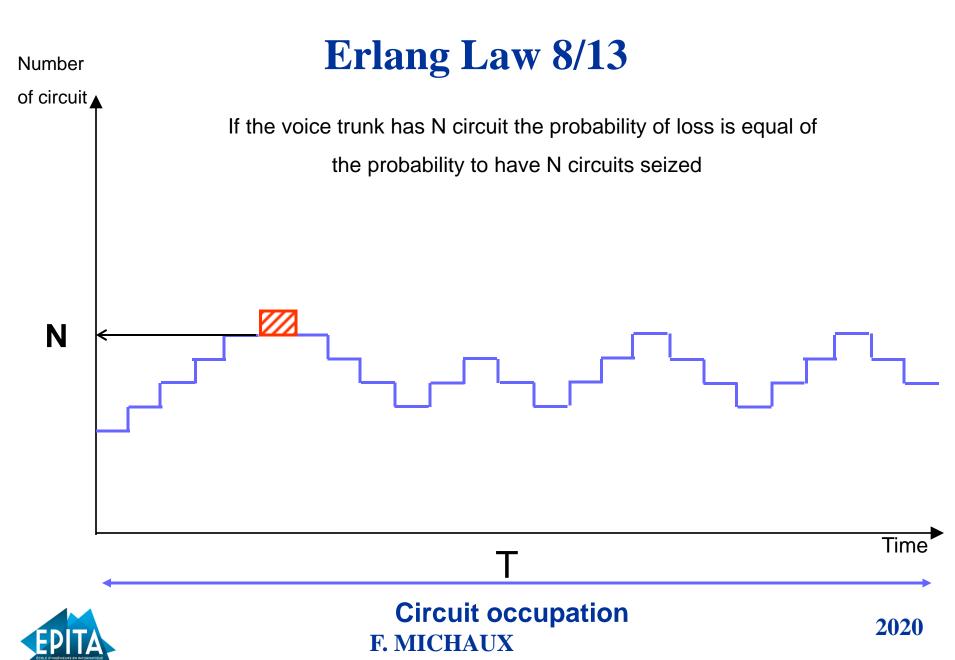
$\sum_{0}^{N} P(X) = 1$ N is the number of circuit of the trunk

▶ $P(0)* \sum_{0}^{N} (A^i/i!) = 1 \rightarrow P(0) = 1/\sum_{0}^{N} (A^i/i!)$

▶ $P(X) = (A^X/X!)/ \sum_{0}^{N} (A^i/i!)$ **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

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

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

N

Time

T

Circuit occupation
F. MICHAUX

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 :

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

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 $\qquad E_{(1,0)}(A) = 1$

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

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

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

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

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

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

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

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

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.

F. MICHAUX

2020

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).
- …………

2020

F. MICHAUX

QUESTIONS

?

QUESTIONS

▶ **Questions regarding the presentation ?**

▶ **Questions regarding the Telecommunication World ?**

How is the business ?
What is the future ?

Thank you for your attention