

INTRODUCTION TO TELEPHONE SWITCHING

ECE 525E– WIRELESS & MOBILE COMMUNICATION

Friday, February 10, 2023

DIRECT AND COMMON CONTROL SWITCHING SYSTEMS

- 1. Direct control switching systems:** The control subsystem is an integral part of the switching network itself, e.g. the Step-by-step switching system.
- 2. Common Control:** The control subsystem is outside the switching network, e.g cross-bar and all modern digital exchanges. Common Control Switching is also sometimes referred to as **indirect control or register control**.

MODEL OF A TELEPHONE SWITCH



1. The switching network is called a symmetric network when $M = N$.
2. The inlets/outlets may be connected to:
 - a) Local subscriber lines
 - b) Trunks to Other exchanges
 - c) Trunks from other exchanges

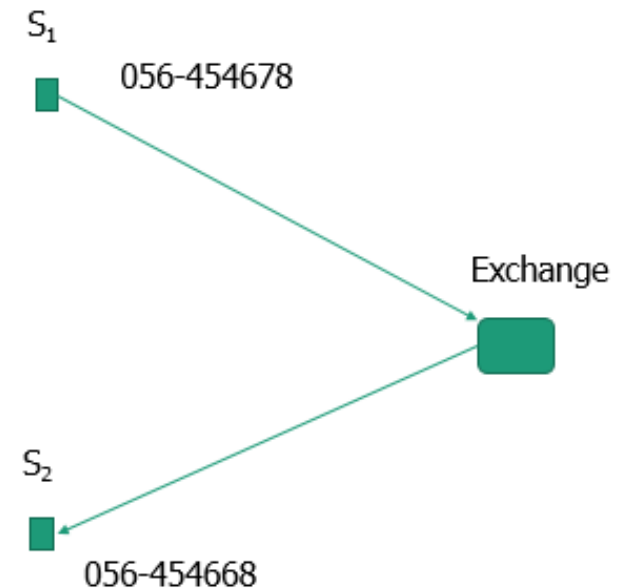
TYPES OF CALLS IN A FIXED EXCHANGE

Four types of connections can be established in a fixed telephone network, i.e

1. **Local call** connection between two subscribers in the same exchange.
2. **Outgoing call** connection between a subscriber and an outgoing trunk, or to a subscriber on another exchange.
3. **Incoming call** connection between an incoming trunk and a local subscriber;
4. **Transit call** connection between an incoming trunk and an outgoing trunk in a transit/tandem exchange.

LOCAL TELEPHONE CALL IN FIXED TELEPHONE SYSTEMS

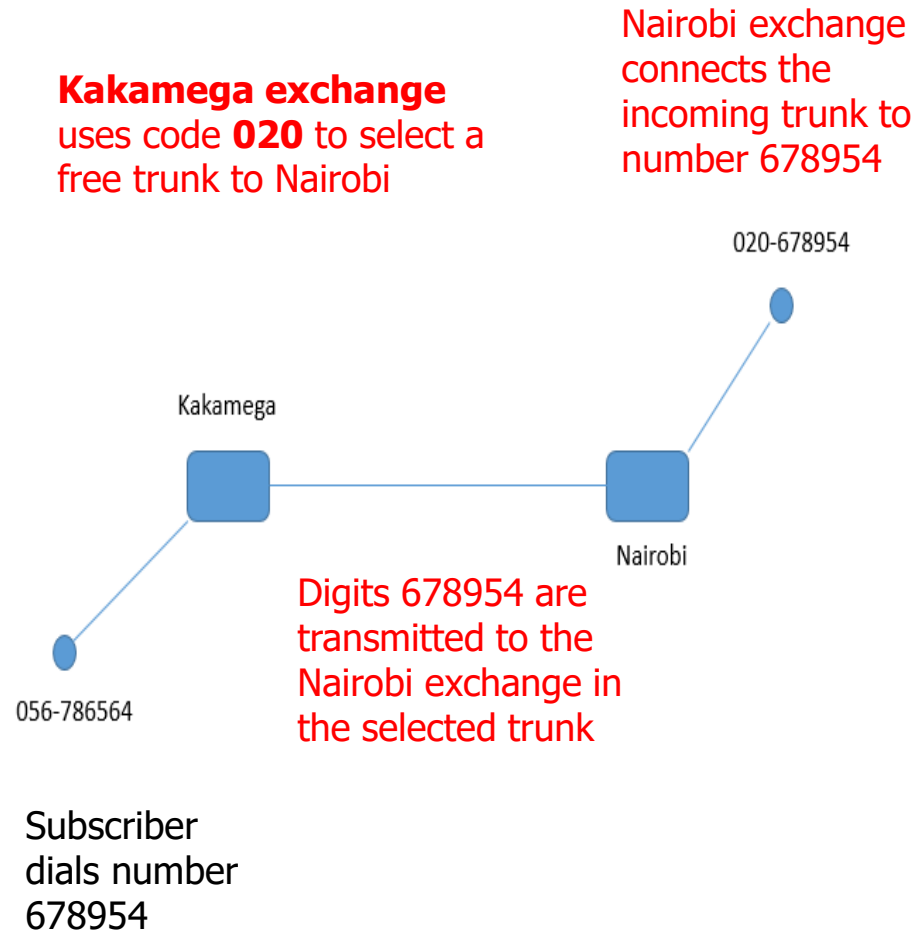
1. **A local call** is made when a local subscriber calls another local subscriber
2. The exchange uses the number minus the area code to establish the connection and from time to time, i.e 454668
3. **Local area traffic** varies from region to region. For instance:
 - a) most Central Business Area (CBA) subscribers will call each other during the day.
 - b) Most rural exchanges have relatively low local traffic since they mostly make calls to urban areas.
 - c) CBA local traffic is very low at night since most people stay in the residential areas.



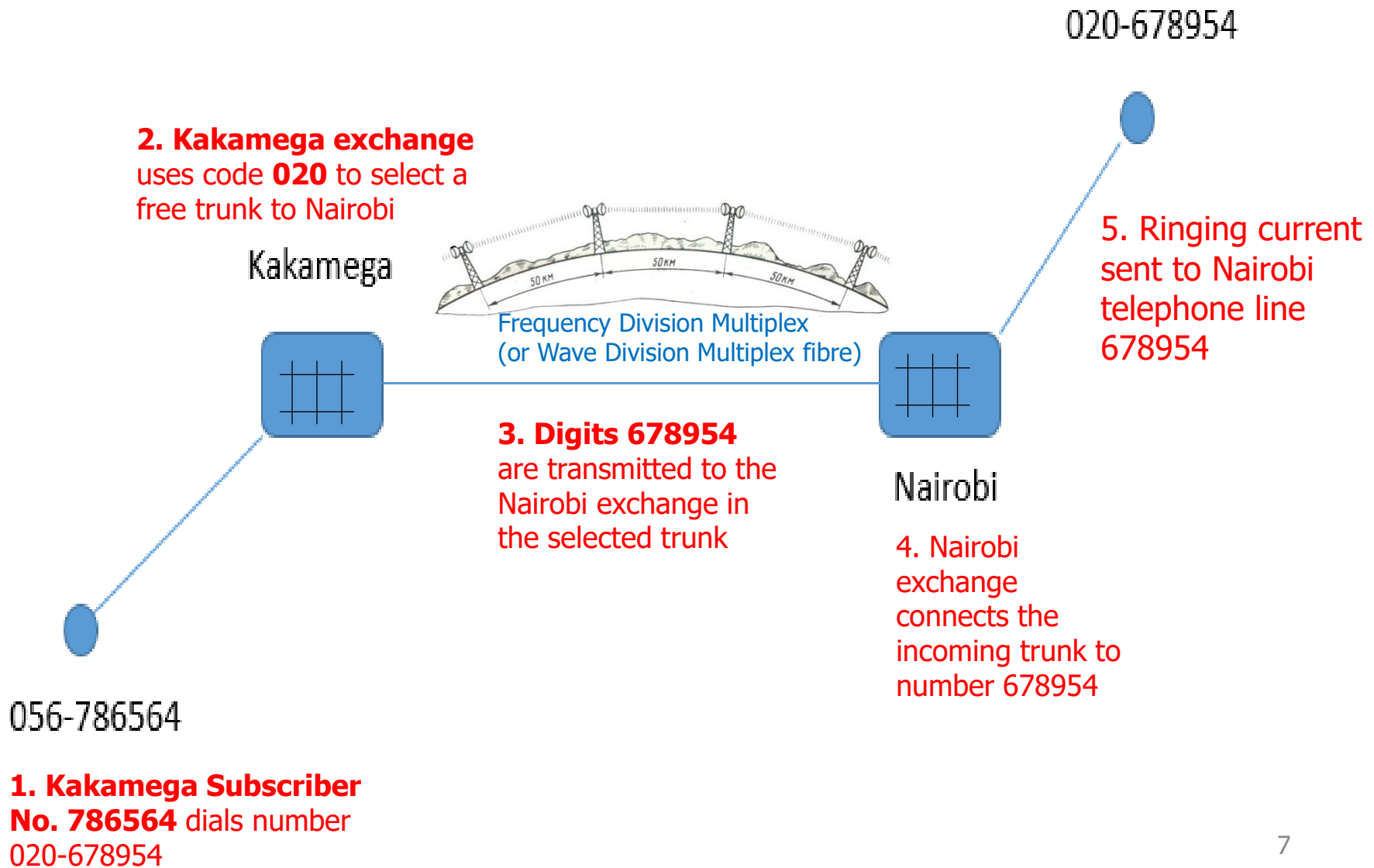
TRUNK CALL

1. **A trunk call connects** subscribers in the same country but on different telephone exchanges as follows:

- a) **The originating telephone exchange** uses the area code to select a trunk heading to the terminating exchange. It then connects the originating number to the trunk
- b) **The terminating exchange** uses the rest of the digits to establish a connection to the called telephone line.

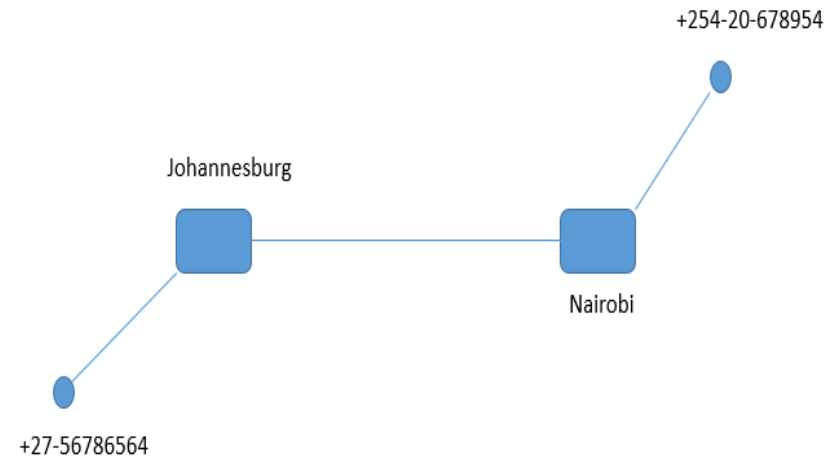


CALL SETUP PROCEDURE



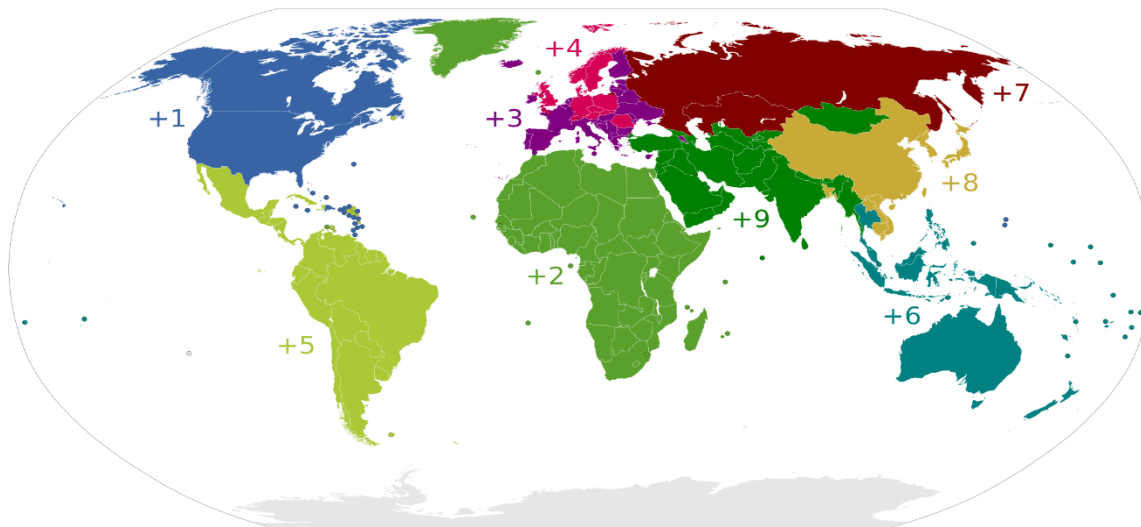
INTERNATIONAL CALL

1. An international call is made between two subscribers in different countries.
2. It is prefixed by the international code, which can be the international country code, e.g. **+254** for Kenya or **+27** for South Africa. In the fixed system, it can be prefixed by **000**.
3. It usually passes through an international gateway exchange.

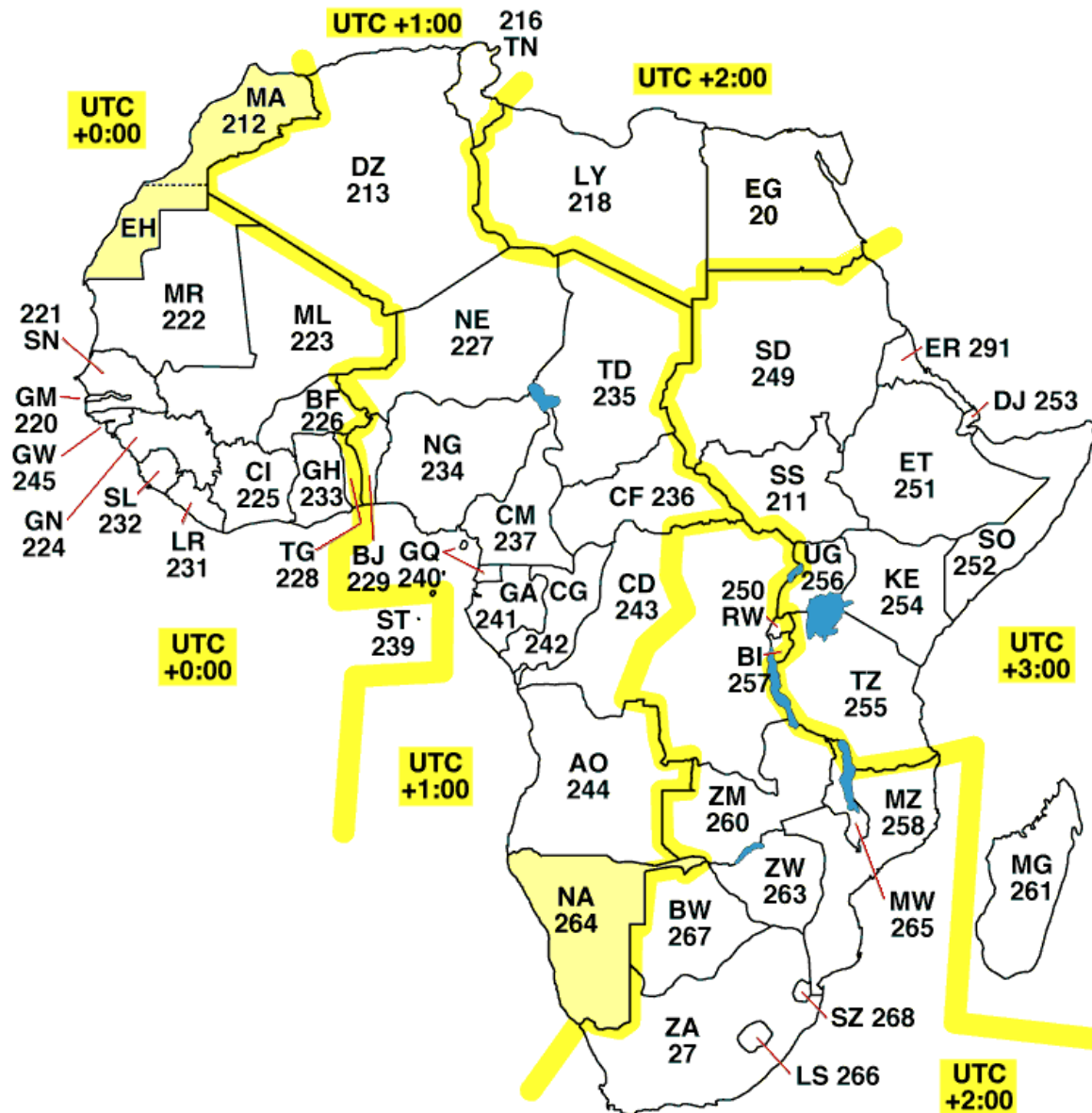


ASSIGNMENT OF INTERNATIONAL SUBSCRIBER DIALING CODES – WORLD ZONES

1. **World Zone** is the first digit of a country code.
2. It was conceived to correspond to a global region.
3. Over time, exceptions were made to this rule such as:
 - a) **Greenland (+299)** is not in Africa, but there was not enough room in Europe's two World Zones at the time Greenland's country code was assigned).
 - a) Special international services, e.g. **satellite telephone** have country code assignments under World Zones 8 and 9.



INTERNATIONAL DIAL-COUNTRY CODES FOR AFRICA

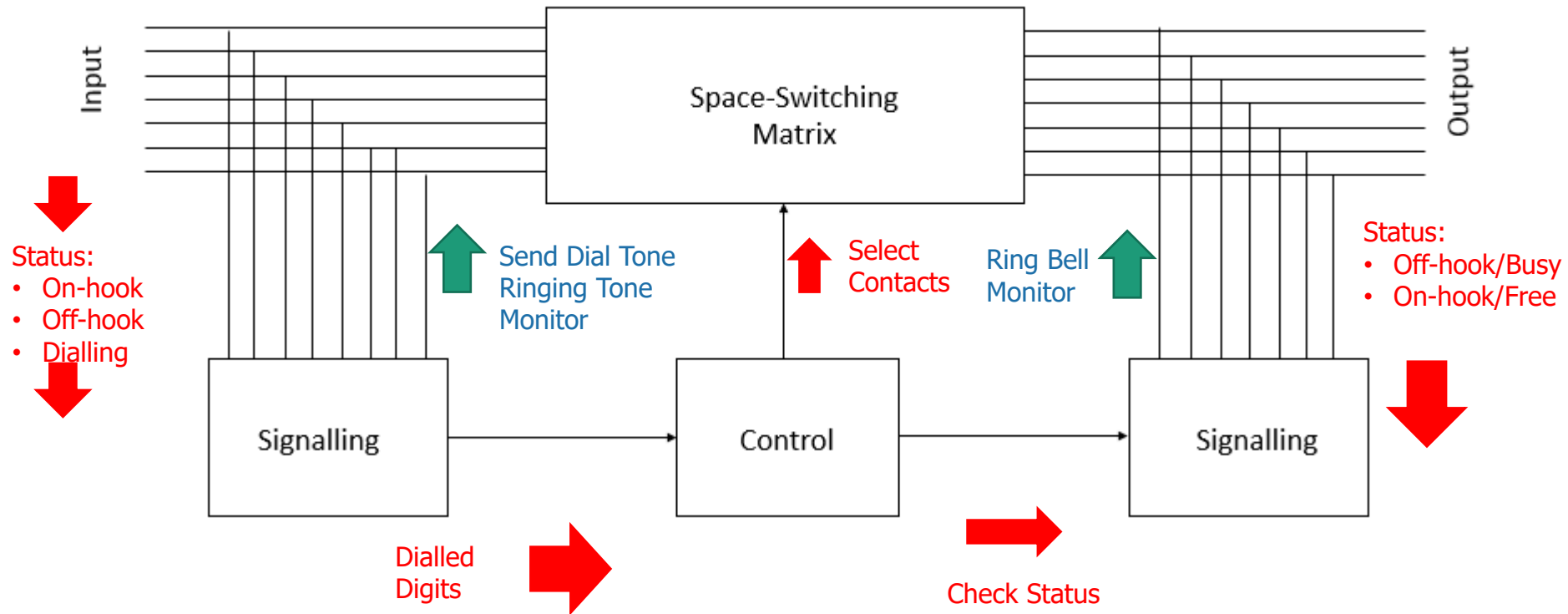


PRINCIPLES OF SPACE SWITCHING

Equipment associated with any switching system can be categorized as:

1. **Signalling** – Monitor activity of incoming/outgoing lines and forward status and control information to the control/switch.
2. **Control** – Monitor incoming signalling and set connections accordingly.
3. **Switching** – An array of selectable cross-points used to complete connections between input lines and output lines.

PRINCIPLES OF SPACE SWITCHING



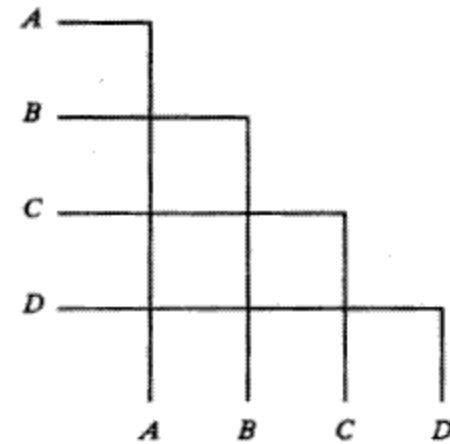
SINGLE-STAGE SWITCHES

Inlets

A	AA	AB	AC	AD	AE	AF
B	BA	BB	BC	BD	BE	BF
C	CA	CB	CC	CD	CE	CF
D	DA	DB	DC	DD	DE	DF
E	EA	EB	EC	ED	EE	EF
F	FA	FB	FC	FD	FE	FF
	A	B	C	D	E	F

Outlets

$$N_{SW} = N \times N$$



$$N_{SW} = N(N-1)/2$$

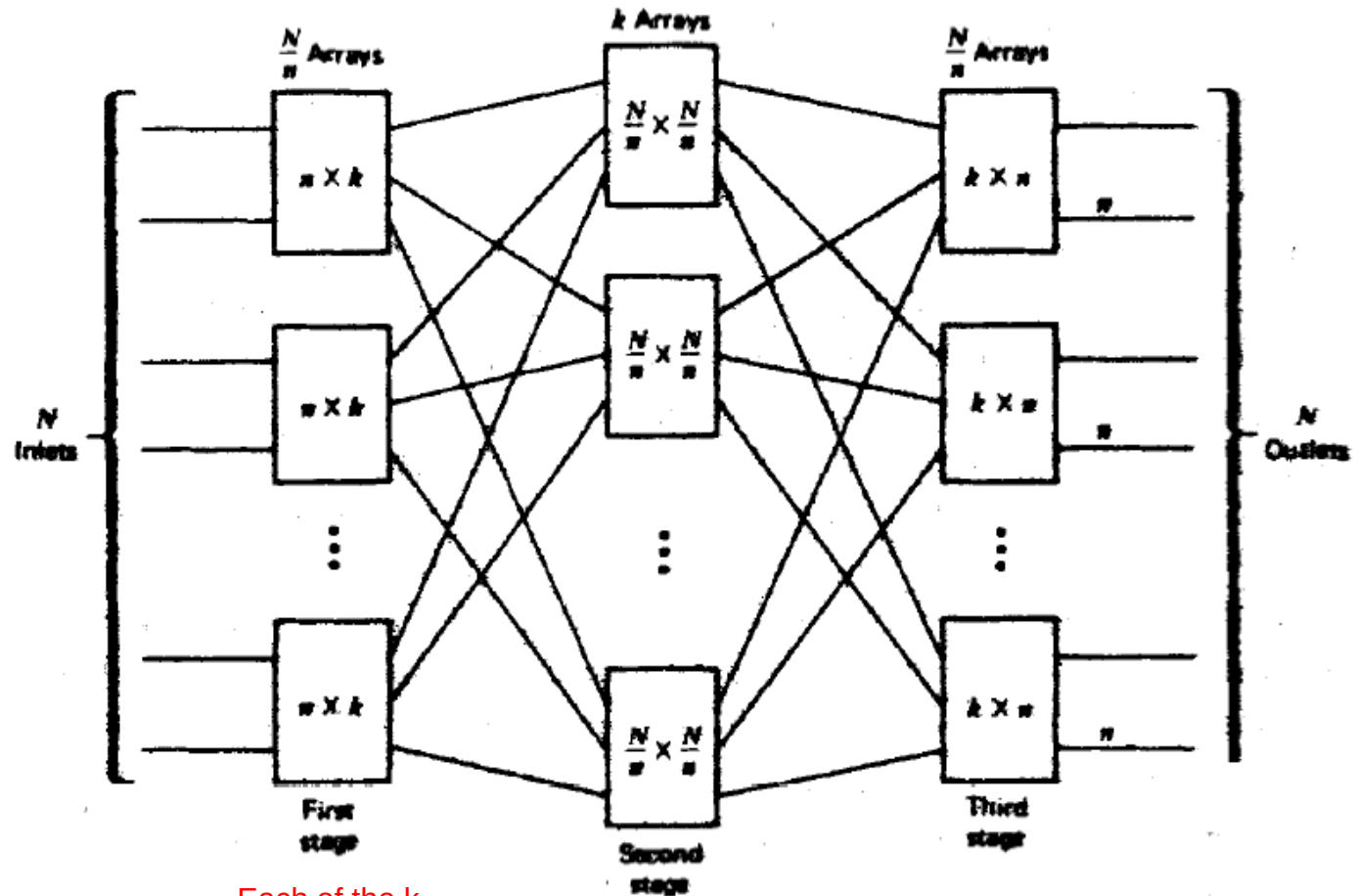
PROBLEMS OF SINGLE SWITCH SYSTEMS

1. Each Individual cross-point can only connect one particular input-output pair.
2. The number of cross-points required is prohibitive.
3. They offer a large number of capacitive loading on message paths.
4. A specific cross-point is required for a specific connection. If the cross-point fails, then the connection cannot be established.
5. Inefficient use of cross-points, e.g. only one cross-point in a row is used at a time.

SOLUTIONS TO THE SINGLE-STAGE SWITCH PROBLEMS

1. Ensure that a particular cross-point is usable for more than one potential connection.
2. Enable more than one path be available for any potential connection, to eliminate or reduce blocking and also provide protection against failure.

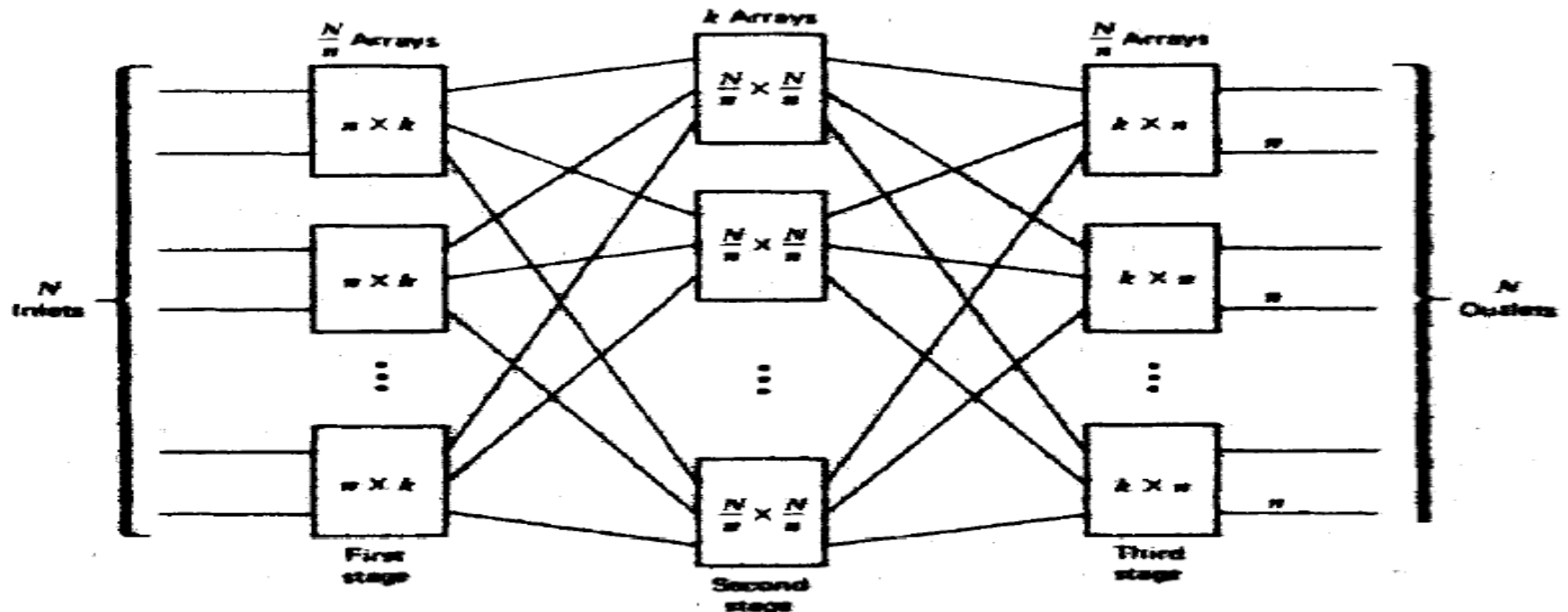
THREE STAGE SWITCHING MATRIX



Each of the k
outputs is connected
to one of the k
Arrays

Also called
Junctors

NUMBER OF CROSS-POINTS N_X FOR 3-STAGE



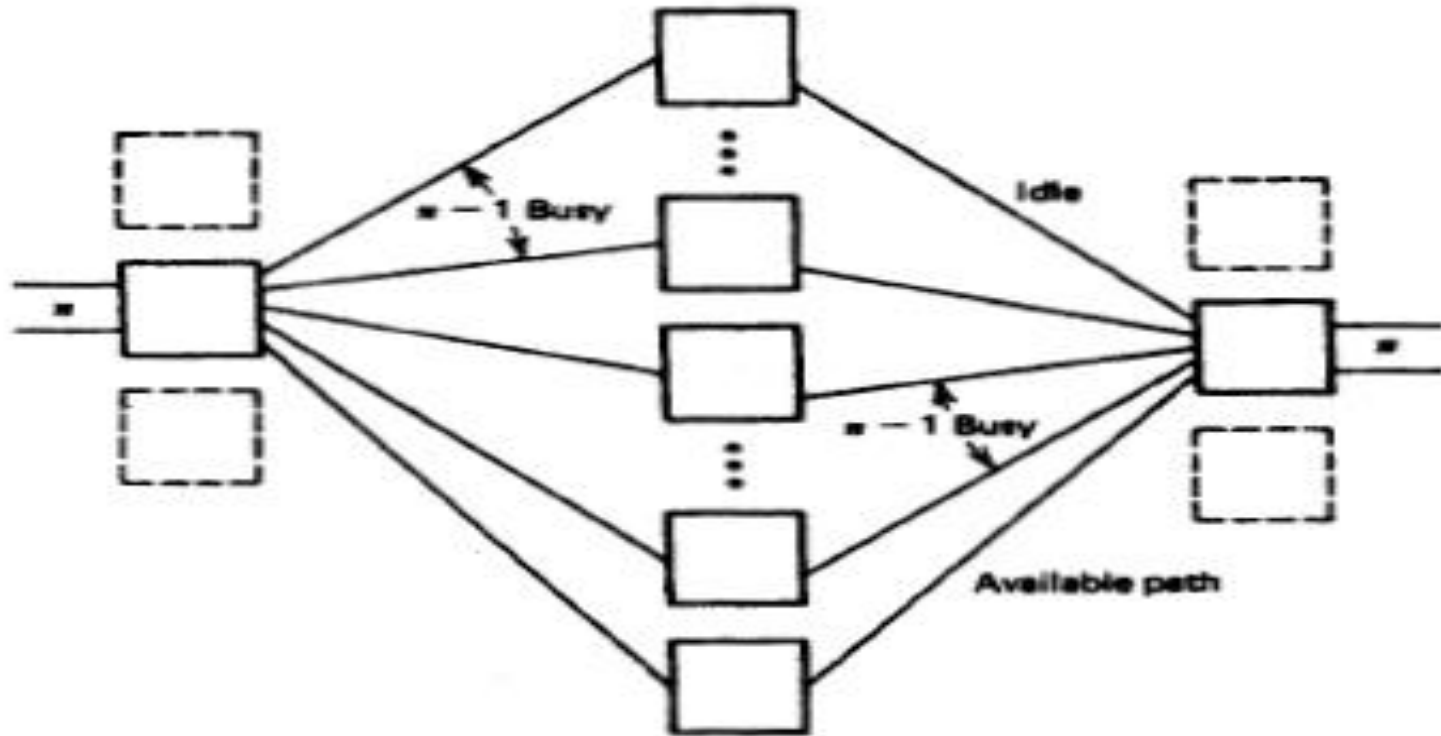
$$N_X = 2Nk + k \left(\frac{N}{n} \right)^2$$

where N = number of inlets-outlets

n = size of each inlet-outlet group

k = number of center-stage arrays

NON-BLOCKING 3-STAGE SWITCHES



Charles Clos of Bell laboratories demonstrated that:

If each individual Array is non-blocking, then the number of centre stages k is given by

$$k = 2n - 1$$

N_X FOR NON-BLOCKING OPERATION OF THREE STAGE

$$N_X = 2Nk + k \left(\frac{N}{n} \right)^2$$

where N = number of inlets-outlets

n = size of each inlet-outlet group

k = number of center-stage arrays

$$N_X = 2N(2n - 1)$$

(n)

Inserting James Clos value for k , i.e $k = 2n-1$ yields:

COMPARISON OF SINGLE STAGE AND THREE STAGE N_x

TABLE 5.1 Crosspoint Requirements of Nonblocking Switches

Number of Lines	Number of Crosspoints for Three-Stage Switch	Number of Crosspoints for Single-Stage Switch
128	7,680	16,256
512	63,488	261,632
2,048	516,096	4.2 million
8,192	4.2 million	67 million
32,768	33 million	1 billion
131,072	268 million	17 billion

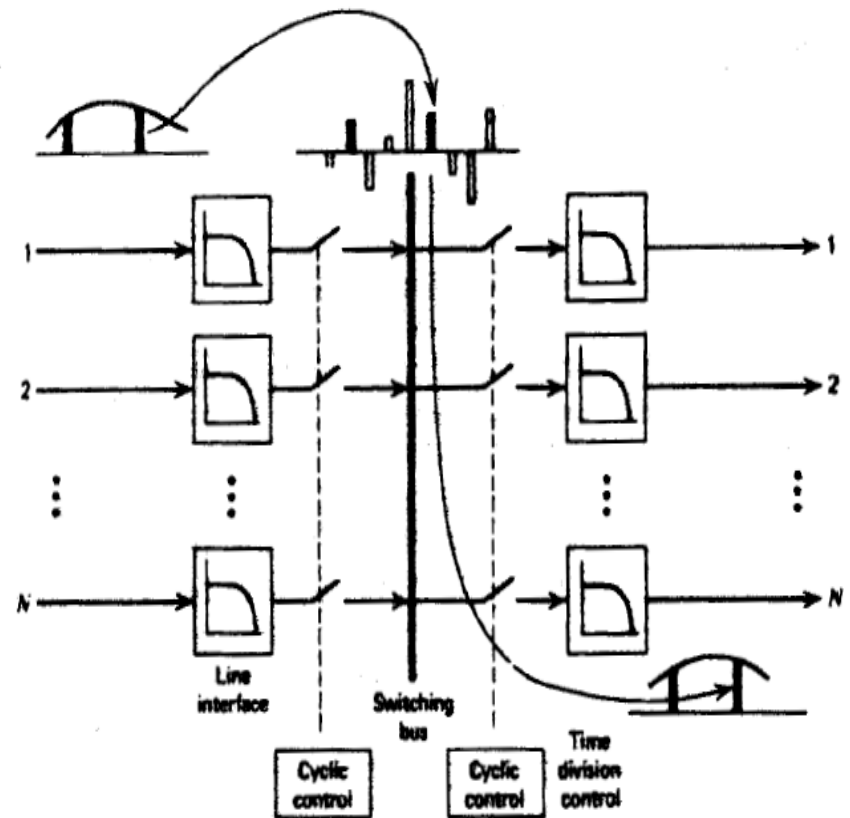
Alan Barrett

TIME DIVISION SWITCHING

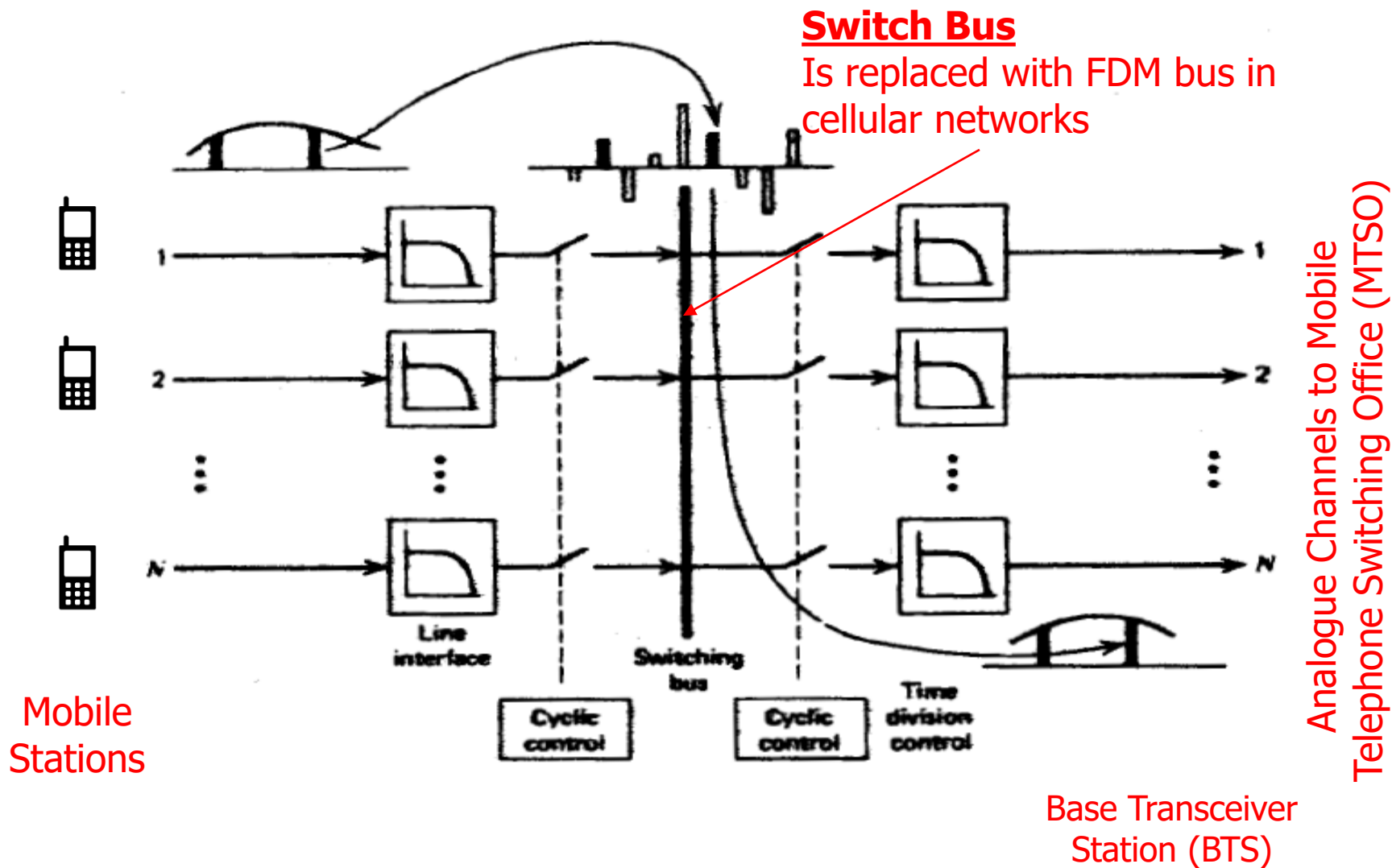
ECE 2526
MOBILE COMMUNICATION

TIME DIVISION SWITCHING

- Analog Time Division
Multiplexing involves sharing of cross-points for shorter periods of time so that individual cross-points and associated interstage links are continuously reassigned.

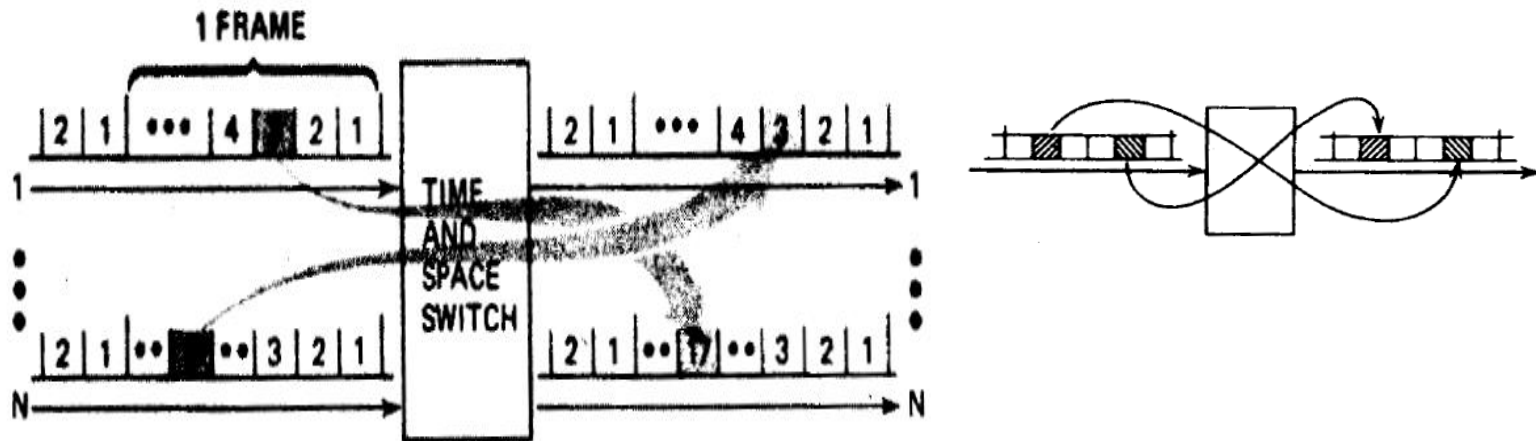


ANALOG TIME DIVISION SWITCHING



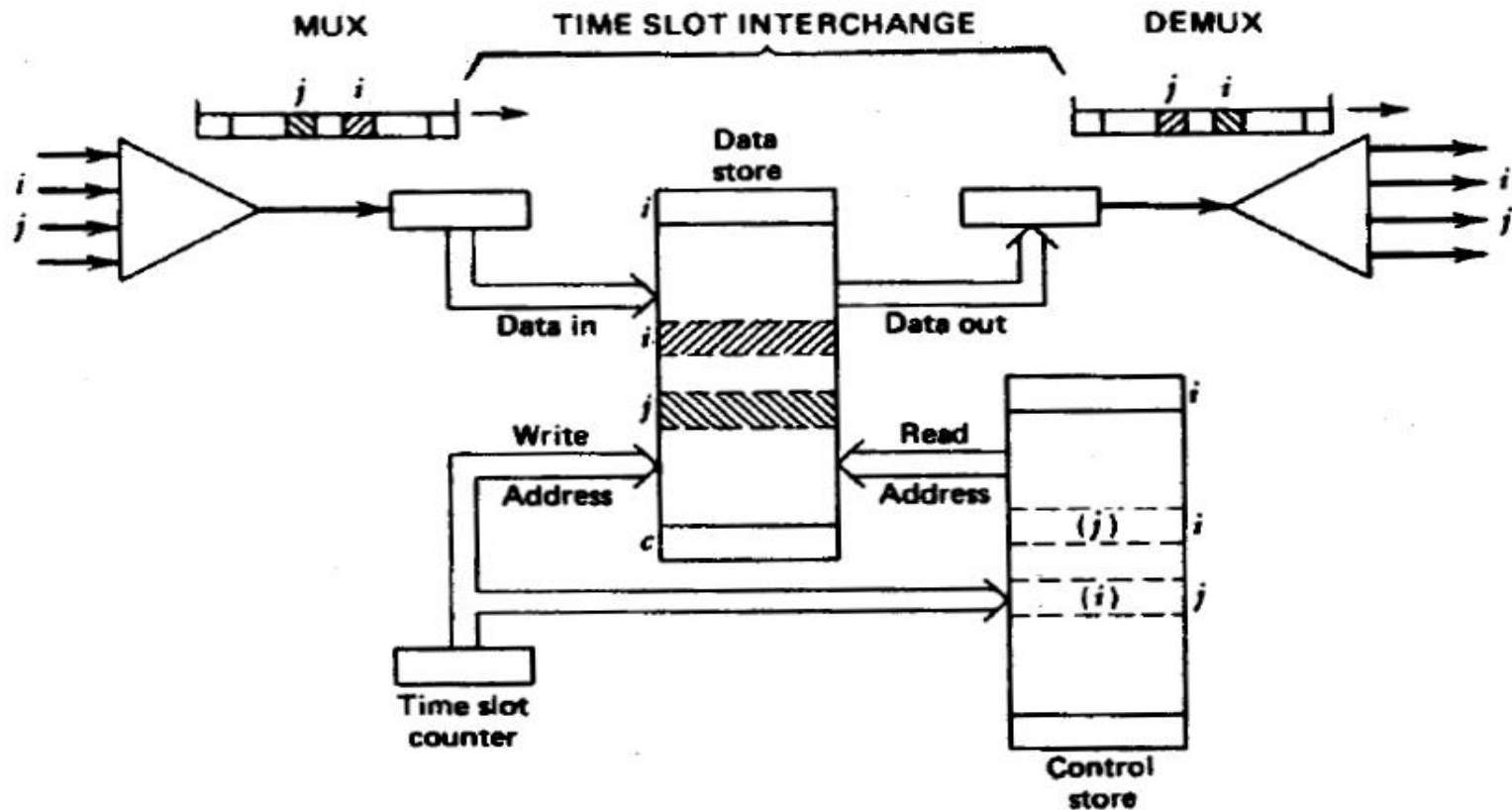
TIME & SPACE SWITCHING

Time space switching involves switching timeslots between different data streams.



1. Information arriving in time slot 3 of the first input link is transferred to time slot 17 of the last output link.
2. For duplex communication, the return connection is required and realized by transferring information from time slot 17 of the last input link to time slot 3 of the first output link.
3. Each connection requires two transfers of information, each involving translations in both time and space.

MUX/TSI/DEMUX MEMORY SWITCH



CALCULATING THE NUMBER OF CHANNELS IN A MEMORY SWITCH

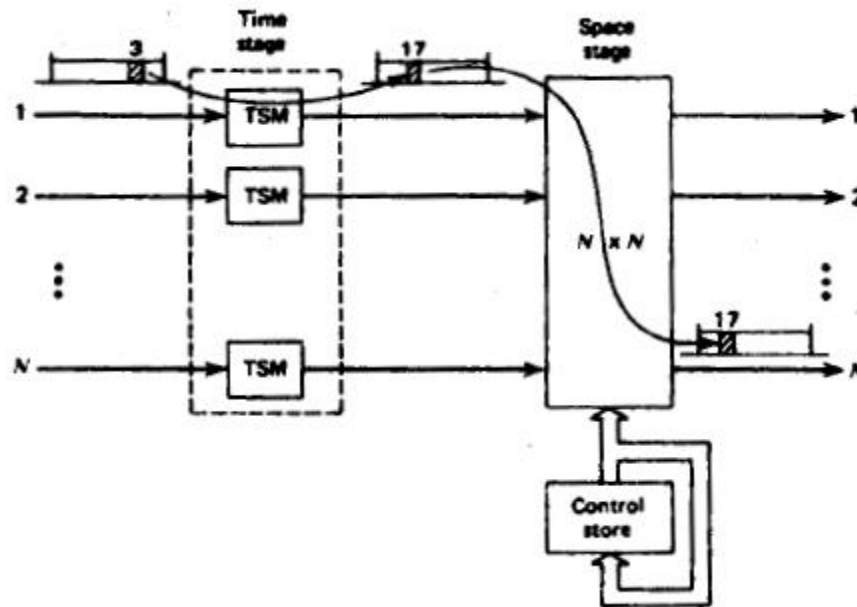
The Time frame for 8KHz sampled voice is 125 μ Sec.

Therefore, the number of channels c that can be supported by a simple memory switch is:

$$c = \frac{125}{2t_c}$$

Here t_c is the memory cycle time in microseconds

TIME-SPACE SWITCH



Information in time slot 3 of link 1 is delayed until time slot 17 on outgoing link N occurs.

WORKED EXAMPLE

- A Simple memory switch uses a 15.2nsec memory.
 - (a) How many 8KHz voice channels can it switch?
 - (b) If one word is assumed to be 8bits, what is the size of the RAM that is required?
 - (c) How many cross points would be required if the switch was realized by a space switch?

SOLUTION

1. The channels is c is given by:

$$c = \frac{T_{PCM Frame}}{2 \times T_{Memory}} = \frac{125}{2 \times 15.2 \times 10^{-3}} = \frac{125 \times 10^3}{30.4} = 4112$$

2. The RAM will have to store all the channels in order to be able to interchange channel 1 with channel 4112. Since each word is 8 bits (1 byte), the RAM should be able to store 4,112 bytes.

3. Number of cross points = $N(N-1)/2 = 4112 \times 4111 / 2 = 8,452,216$