

Circuit Switching

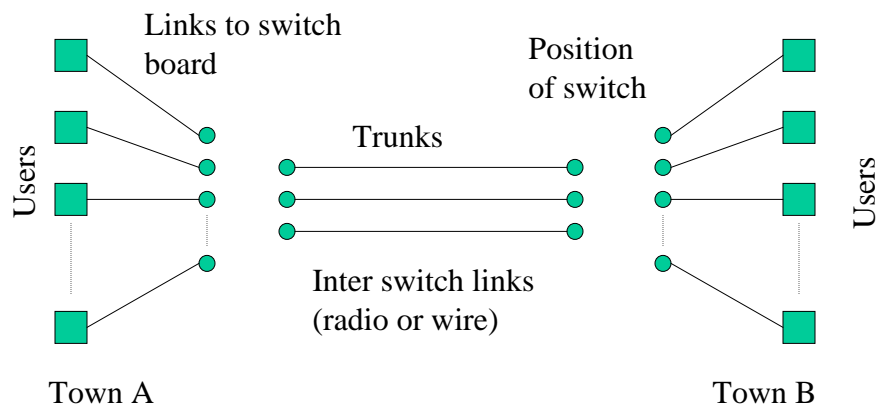
1. Point to point communications. Telephone, cellular phones.
2. Human operated switching centres
3. Automatic switching centres
4. PABXs
5. Calculation of congestion and number of switches required/ number of devices required.
6. Erlang tables

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I.1

Switching System

Consider below circuit switched network



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Human operated switch

1. Label users at town A as *A1, A2, A3, ...*
2. Label users at town B as *B1, B2, B3, ...*
3. Suppose A1 wants to call B2
4. A1 lifts handset and requests a connection to B2.
5. Operator at Switch A requests operator at Switch B for a connection.
6. Operator at B checks if B2 is free. If yes connection is established.
7. How many simultaneous calls can be supported?

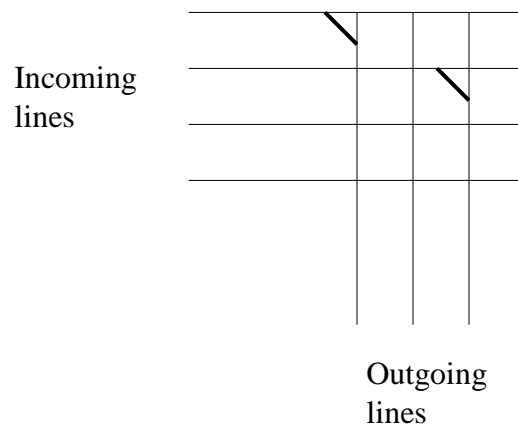
Automatic Switch

1. The human operator can be replaced by a switch.
2. Early switches were mechanical (Strowger systems)
3. The next type of switches were electro-mechanical (e.g. relays)
4. The next type of switches are semiconductor switches.
5. The switches require a controller. The early types had a mechanical or an electronic controller. The modern types are controlled with a microcontroller that can perform more functions.

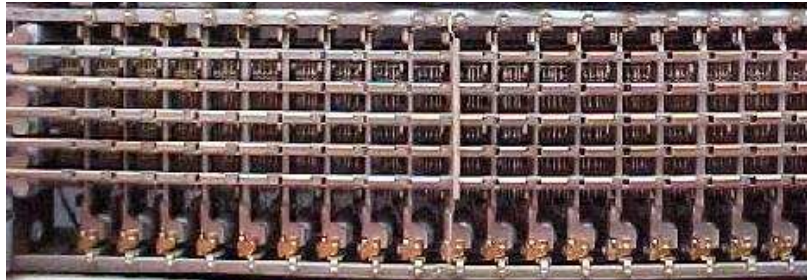
Trunk multiplexing

1. The maximum number of channels that can be supported by the trunk determines the capacity of the system.
2. The channels are multiplexed using Frequency division-multiplexing (FDM), Time division-multiplexing (TDM) or Code division-multiplexing (CDM). Space division-multiplexing is available in terms of physically different channels.

Crossbar Switch



Electro-mechanical Crossbar Switch



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Summary of Circuit Switching

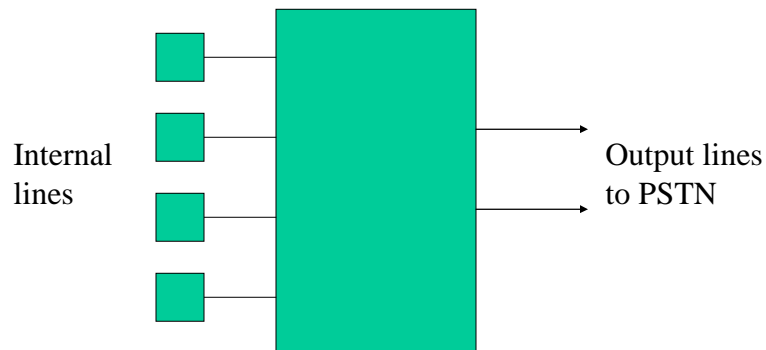
1. A circuit is first setup (e.g. Initiate call)
2. The circuit is dedicated to the calling parties for the duration of the call
3. The circuit cannot be shared with other independent callers during the calling time.
4. The circuit is released at the end of the call.

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PABXs

1. Operation of a simple PABX.
2. Inputs and Outputs in a PABX.



PABXs : Technical

1. A PABX is a private switch
2. Internal circuits can be switched to provide internal communications.
3. The number of external connections depend on the number of output lines.
4. A modern PABX consists of semiconductor switches and a microcontroller.
5. With a more powerful microprocessor traffic records can be stored and processed for billing purposes. This is usefull for hotels, companies, etc.

PABXs : Features and Benefits

1. Calls within the organisation can be transferred easily as all the phones link together; hence staff can talk to each other and pass on important messages quickly and easily.
2. The system allows other features such as call forwarding, call diversion etc.
3. Customers / clients can always contact your organisation.
4. The PABX system does not need an operator in order to access an outside line.
5. Staff can easily talk internally and externally.

PABXs : Types

Each PABX system has a maximum number of lines and a number of extensions on which they operate. For example a system has the capacity to have two direct lines and six extensions. It is possible with some PABX systems to expand their capacity at a later stage should your organisation require it. It is wise to consider this possibility before purchasing a system as some systems can not be expanded at a later stage.

1. 2 lines x 6 extensions
2. 3 lines x 8 extensions
3. 8 lines x 64 extensions
4. 32 lines x 1200 extensions

PABXs : Digital and Multimedia

1. Advanced PABXs support digital ISDN standards as well as normal, analogue lines.
2. Modular design to support expansion
3. Includes voicemail with compression cards
4. Supports Multimedia signals. Voice and data signals are merged. Possibility of visual telecommunications. File transfer and video transfer.
5. Multi-party talks and call holding features
6. Supports 10/100Mb LAN and VoIP

Installing a PABX

1. Carry out traffic calculations to determines number of PSTN lines. Allow for future expansion.
2. Prepare specifications for the equipment.
3. Prepare phone lines to be used (usually twisted pair).
4. Select supplier.
5. Order equipment.
6. Install PABX equipment.
7. Measure blocking probability

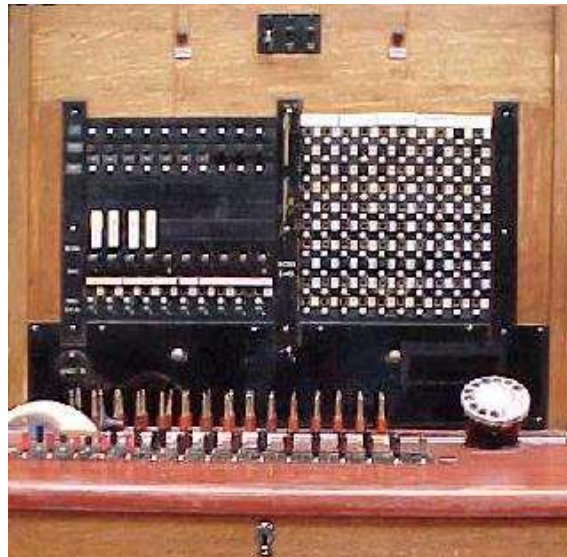
Step by Step PABX



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Manual Switchboard



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Digital PABXs



Large
organisations



Small
organisations



Home or
office PABX

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Traffic Modeling

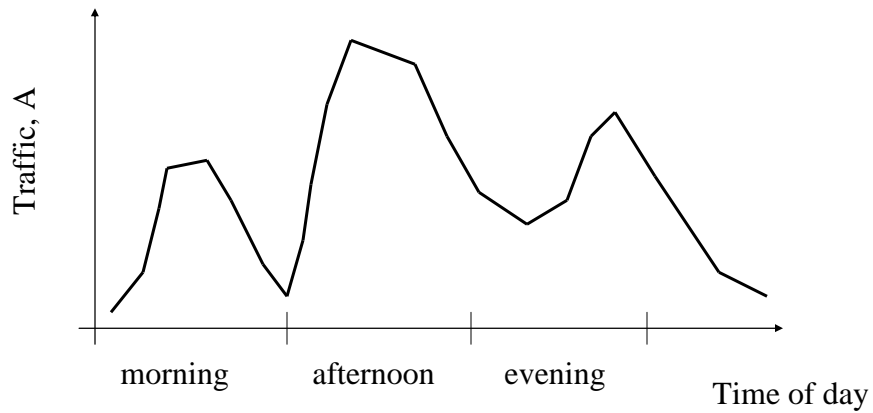
Switches cost a lot of money and therefore it is important not to over invest. Under investment can also result in loss of revenue. It is therefore important to have an idea of the right amount of switches required. This can be done by knowing the type, quantity and nature of the traffic. This can be obtained from the following methods.

1. Install equipment and take measurements during trial period. Increase the number of switches as required.
2. Use a mathematical model
3. Run a simulation
4. Study itemised bills

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Traffic characteristics



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Traffic Characteristics

1. Number of subscribers
2. Nature of subscribers
3. Time of day
4. Month of year
5. Holiday time
6. Tariff in operation
7. Busy hour
8. Lost-calls-cleared
9. Blocked calls queued

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Traffic Characteristics

1. The difference between the morning and the afternoon peaks could be reduced by lowering the tariff differential. This action will increase the efficiency of the system.
2. Busy hour traffic will give a very good indication of the capacity required in the trunk circuits
3. Lost calls cleared : When a subscriber tries to set-up a call and there is no free path available the call is cleared. There is no mechanism for waiting in a queue.

Erlang Models

Variables of interest

1. Mean call holding time
2. Call arrival rate
3. Blocking Probability

Tele-traffic theory can be used to model these or else one can take measurements over a long period of time.

Tele-traffic theory

$$A = \lambda s$$

A is the traffic in Erlangs

λ is the mean call arrival rate

s is the mean call holding time

λ and s are random variables

One ERLANG the traffic carried by one circuit for one hour.

Example 1

Question : A trunk has 5 lines. Mean call holding time is 3 minutes. Call arrival rate is 80 calls/hour. Find mean load per device.

Example 2

A trunk has 8 lines. 6 Erlangs of traffic is offered. Calculate the blocking probability.

Example 3

A trunk has n circuits. Normal load traffic is 3 Erlangs. Grade of service=0.03. Calculate smallest n . In emergency 20% increase in traffic occurs. Calculate new grade of service.

Example 4

A PABX is required for a trading company. Number of offices is 100. Mean holding time for external calls is 5 minutes. During working hours external call arrival rate is 50 per hour. Calculate number of external lines required.

Erlang – B tables

N/B	0.01	0.05	0.1	0.5	1.0	2	5	10
1	.0001	.0005	.0010	.0050	.0101	.0204	.0526	.1111
2	.0142	.0321	.0458	.1054	.1526	.2235	.3813	.5954
3	.0868	.1517	.1938	.3490	.4555	.6022	.8994	1.271
4	.2347	.3624	.4393	.7012	.8694	1.092	1.525	2.045
5	.4520	.6486	.7621	1.132	1.361	1.657	2.219	2.881
6	.7282	.9957	1.146	1.622	1.909	2.276	2.960	3.758
7	1.054	1.392	1.579	2.158	2.501	2.935	3.738	4.666
8	1.422	1.830	2.051	2.730	3.128	3.627	4.543	5.597
9	1.826	2.302	2.558	3.333	3.783	4.345	5.370	6.546
10	2.260	2.803	3.092	3.961	4.461	5.084	6.216	7.511
11	2.722	3.329	3.651	4.610	5.160	5.842	7.076	8.487
12	3.207	3.878	4.231	5.279	5.876	6.615	7.950	9.474
13	3.713	4.447	4.831	5.964	6.607	7.402	8.835	10.47
14	4.239	5.032	5.446	6.663	7.352	8.200	9.730	11.47
15	4.781	5.634	6.077	7.376	8.108	9.010	10.63	12.48
16	5.339	6.250	6.722	8.100	8.875	9.828	11.54	13.50
17	5.911	6.878	7.378	8.834	9.652	10.66	12.46	14.52
18	6.496	7.519	8.046	9.578	10.44	11.49	13.39	15.55
19	7.093	8.170	8.724	10.33	11.23	12.33	14.32	16.58
20	7.701	8.831	9.412	11.09	12.03	13.18	15.25	17.61

Assignment

Search for a 10/2 port or equivalent PABX.

Make a list of the services offered by the PABX and explain how each service can be offered.

Calculate the cost of running the PABX.

Calculate the scalability of the system.

Repeat the exercise for a larger PABX, say 100/8 port PABX which can be interfaced to a computer that yields billing information.