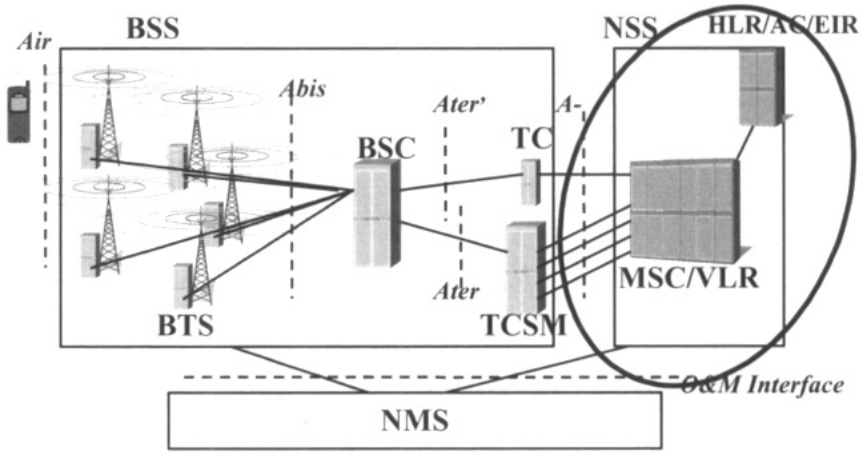
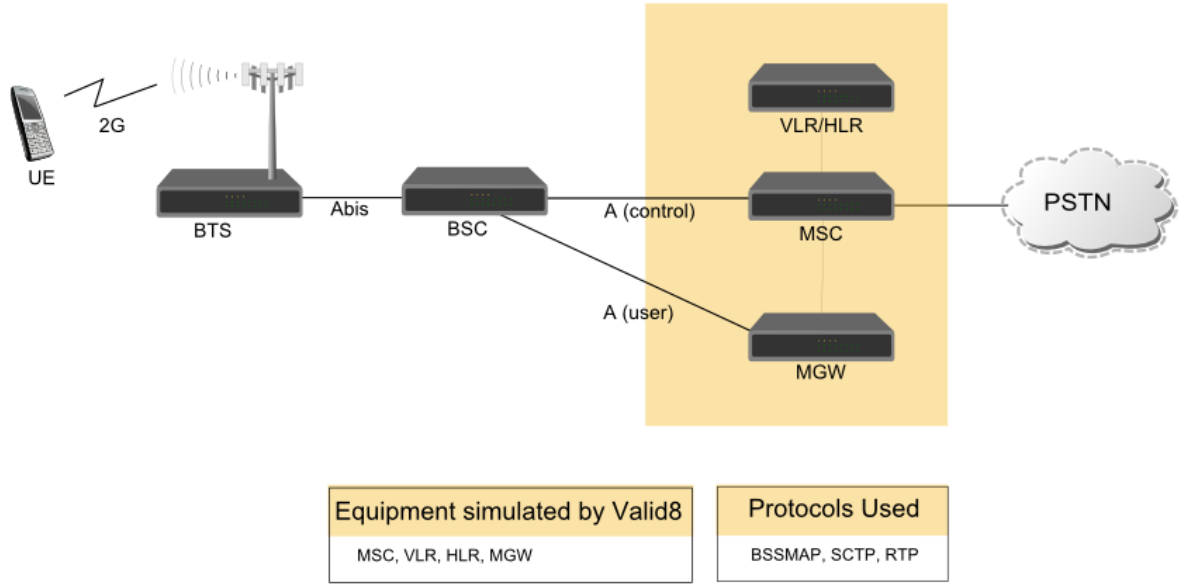
Core network Planning and Optimization of 2G Network

The Scope of Core Network Planning

- The core network in GSM is basically the circuit core.
- Core network planning in GSM consists of network elements such as MSC, VLR, HLR, AuC and EIR.





Elements of the Core Network

MSC/VLR

- Switching of subscriber calls, traffic management, paging, and the collection of charging-related information.
- Also acts as an interface between the network and the networks of other operators and PSTN networks.
- VLR participates in call processing and mobility management functions of the network such as the use of temporary mobile identification, IMSI attach/detach, location registration of the mobile subscriber.
- VLR is also involved in security functions IMEI (International Mobile Equipment Identification) checking.

HLR/EIR/AC

- HLR keeps all permanent information regarding subscribers and their equipment.
- EIR contains three lists: white, grey and black. The white list contains IMEI for all the authentic mobiles; the grey list has data for faulty mobiles; and the black list contains information about stolen/missing mobiles.
- AuC prevents an unauthenticated card from accessing the network.

CORE NETWORK PLANNING PROCESS

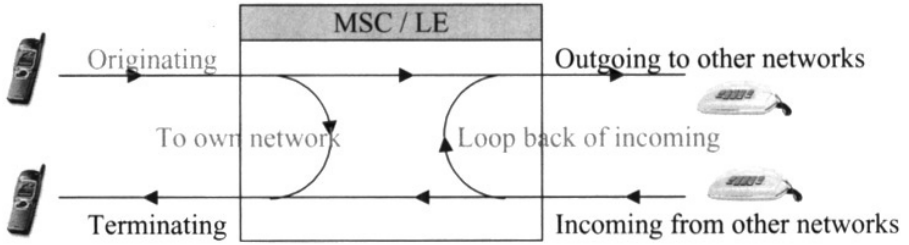
- It consists of two parts: switch network planning and signaling network planning

Network analysis

- Traffic distribution
- Apart from voice, this generally includes value-added services such as SMS, MMS, Internet, etc.

Network Dimensioning

- Number of switches required to handle subscribers and traffic (both present and forecast)
- The most efficient location of the switches in the network
- How the switches will be connected to each other (i.e. transmission plan for the switches)
- The most efficient way to route the traffic.



Basics of a Traffic Calculation

Consider a simple core network with one switch.

•Subscribers originating (SO): This is the traffic originated by subscribers of the network.

•Generally, this input comes from the network (or network operator). Typical values can

•be 65% for the switch and/or 50% for the LE.

•Subscribers terminating (ST): This is the traffic that is being terminated in the same mobile network. This value can be calculated as ST = 100% - SO.

•Own network (terminating) traffic: This is the traffic that is originated in the network and terminated there also. It is usually a product of subscribers in the network and SO.

•Loop back of incoming traffic: This is the traffic originating from the external networks and routed back to them.

•Outgoing and incoming traffic: Traffic going outside the mobile network to an external network is outgoing traffic, while traffic coming from external networks is incoming traffic.

These can be calculated as follows:

•Incoming = (ST- own network traffic)/(I - loop back of incoming traffic)

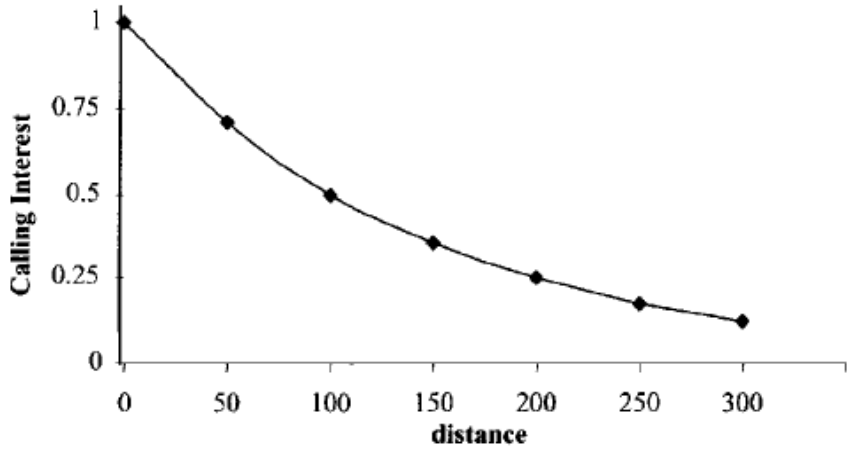
•Outgoing = SO - own network traffic + loop back of incoming traffic.

Calling and moving interest

Calling interest indicates the distance to which calls are made

- Moving interest is another parameter that defines the subscriber behavior of moving within the network.
- When the number of subscribers has been determined, the number of switches can be calculated. Thus:

Number of switches = number of subscribers/VLR (or HLR) capacity

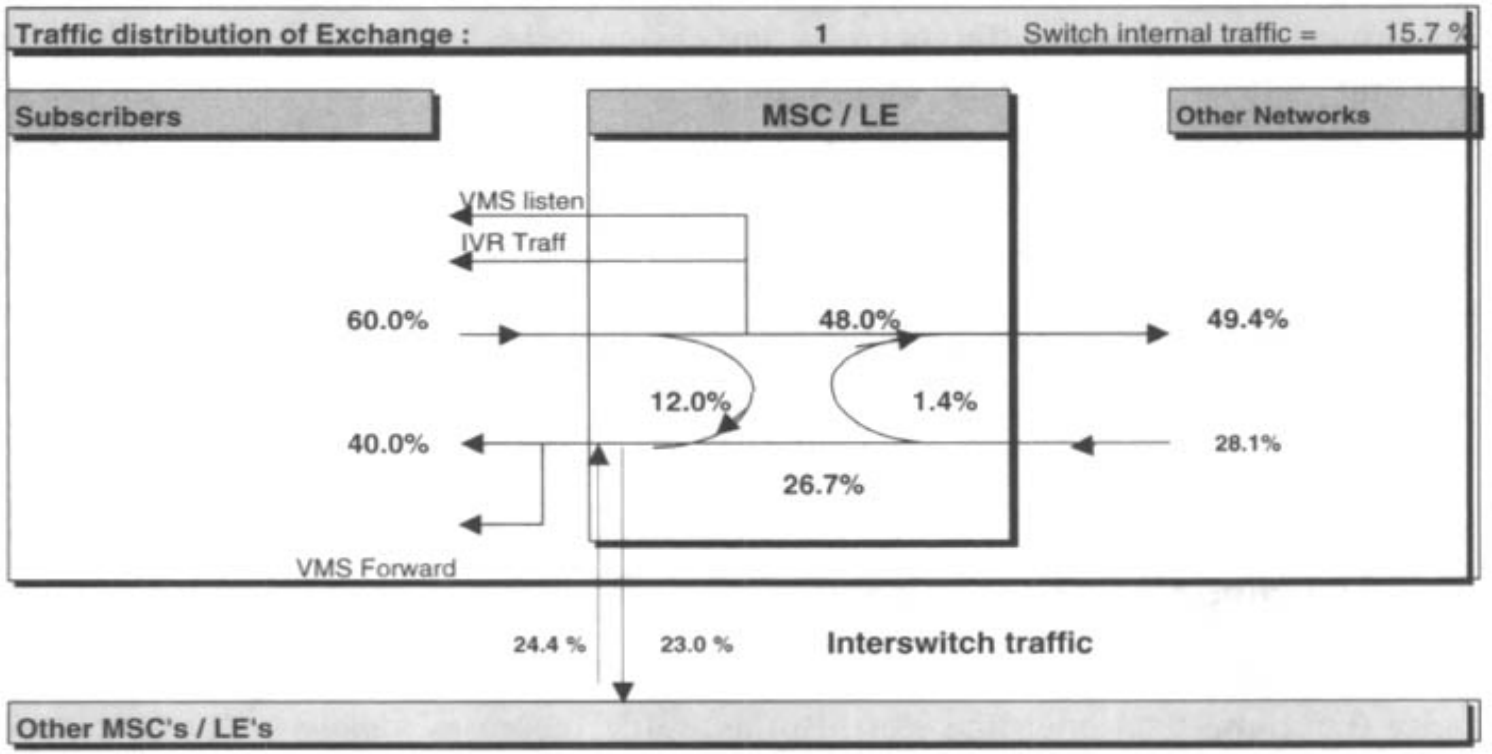


Traffic Dimensioning

There are four MSCs and an external network.
The number of subscribers handled by each MSC is 50,000.
With the traffic generated by each subscriber being 27 mErl (milli-Erlangs), the total traffic generated by each MSC is 1350 Erl.
The percentage of calls originating within their own switch is 60%, of which 40% terminate in the same network.
Calling interest and moving interest are 215 km and 50 km respectively.

Input	MSC1	MSC2	MSC3	MSC4
X	**0**	**0**	**200**	**100**
Y	**0**	**0**	**0**	**100**
subscribers	**50000**	**50000**	**50000**	**50000**
tr/subs (mErl)	**27**	**27**	**27**	**27**
total traffic	1350	1350	1350	1350
subs originating	**60%**	**60%**	**60%**	**70%**
subs terminating	40%	40%	40%	30%
to own network	**20%**	**20%**	**20%**	**20%**
to own NW of total	12%	12%	12%	14%
to own NW of total	162	162	162	189
loopback	**5%**	**5%**	**5%**	**5%**
initial outg ISW	110	110	93	136
initial outg ISW%	8%	8%	7%	10%

call int	215
move int	50



Traffic Theory...

- **Traffic Intensity, $E = \lambda t_h$ Erlangs** (Danish Mathematician)
  - λ = call arrival rate (calls/hour)
  - t_h = mean holding time (hours/call)

$\Rightarrow$ 1 Erlang = 1 channel occupied continuously

Example: Assume 100 subscribers with the following traffic profile:

20 make 1 call/hour for 6 min.	20x1x(6/60) = **2 E**
20 make 3 calls/hour for ½ min.	20x3x(½/60) = ½ E
60 make 1 call/hour for 1 min	60x1x(1/60) = **1 E**
100	**3.5 E**

$\Rightarrow$ 100 subscribers use 3.5 E... = 35 mE per subscriber

- Consider a single analog cell tower with 56 traffic channels, when all channels are busy calls are blocked. Calls arrive according to a Poisson process at a rate of 1 call per active user an hour. During the busy hour 3/4 the users are active. The call holding time is exponentially distributed with a mean of 120 seconds.
- (a) What is the maximum load the cell can support while providing 2% call blocking?

  From the Erlang B table with c= 56 channels and 2% call blocking the maximum load = 45.9 Erlangs
- (b) What is the maximum number of users supported by the cell during the busy hour?

  Load per active user = 1 call x 120 sec/call x 1/3600 sec = 33.3 mErlangs

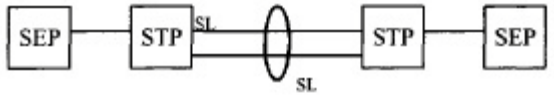
  Number active users = 45.9/(0.0333) = 1377

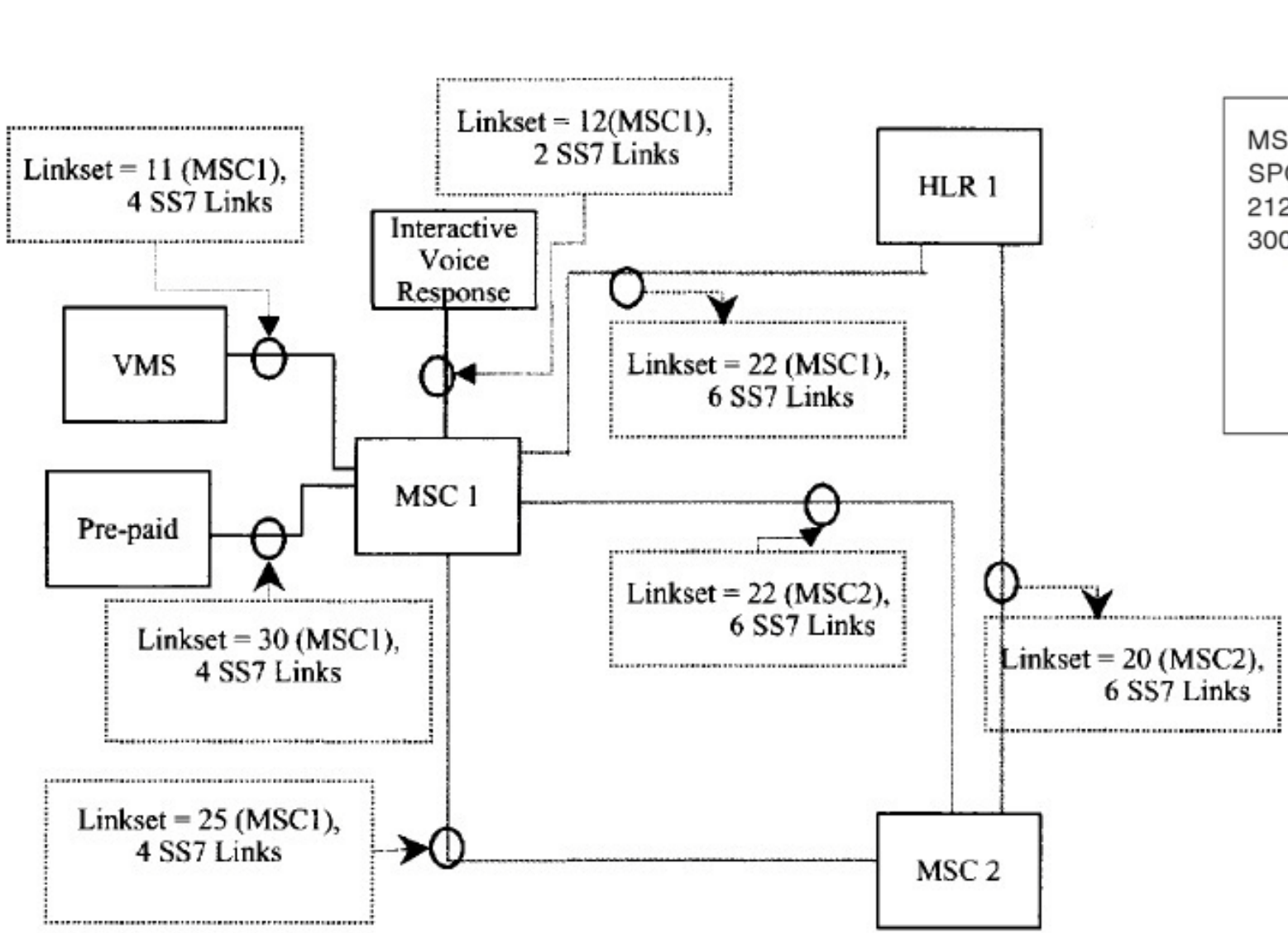
  Total number users = 4/3 number active users = 1836
- Determine the utilization of the cell tower ρ

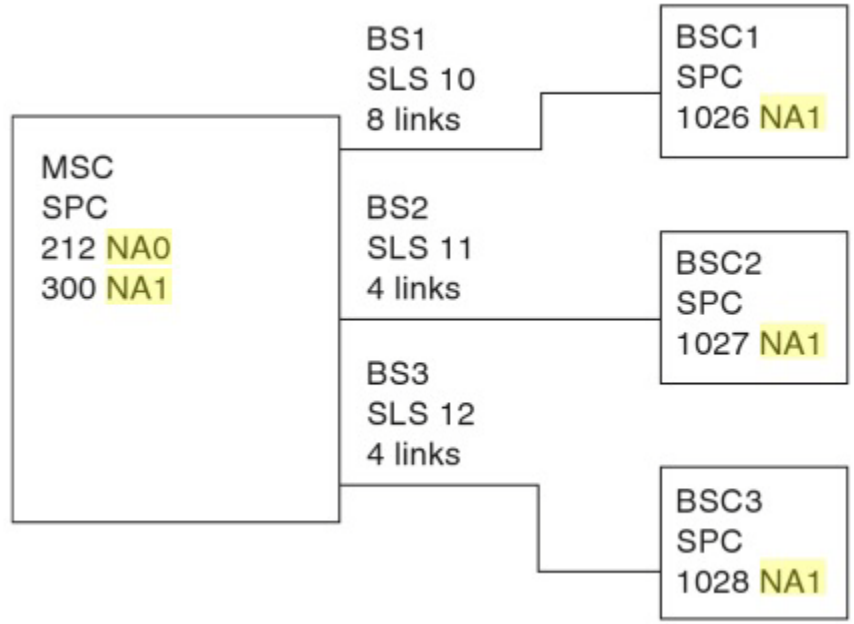
  $\rho = \alpha/c = 45.9/56 = 81.96\%$

Signaling

- Transferred on 64 kbps time slots in PCM.
- Any point that is capable of sending or receiving the signaling is known as a signaling point (SP).
- Signaling traffic passes through a signaling transfer point (STP) and reaches its intended destination, known as the signaling end point (SEP).
- Thus the SP and the SEP are the same. SPs are connected to each other via PCM links.
- A SP can also act as a signaling control point (SCP). Through this point, access to advanced services can be made, such as free phone numbers.
- Signaling networks can be of different types. Signaling network indicators give the information on the type of signaling network used. In GSM networks, as SS7 is used for signaling, four different types of networks are possible: NAO, NA1, INO and IN1. The first two are for national networks and the last two for international networks.
- A SP can support one or more network addresses. It can also support all four networks, but in that case it would have four different SPCs, one for each network.







Example of a signalling plan

THE INTELLIGENT NETWORK (IN)

- Allows these services to be managed and controlled more effectively.
- Pre-paid SIM cards, originating-call screening, reverse charging and free phone , VAS are examples of services provided by an IN network.
- One of the most important elements in an IN network is the IP (an intelligent peripheral).
- IP functions include IVR (interactive voice response), DTMF (Dual tone multi frequency) etc.

FAILURE ANALYSIS AND PROTECTION

Site failure

- A site rarely fails. If it does, this is usually due to conditions that are beyond human control - flooding, earthquake, fire, etc.
- Solution : choosing a site at a higher altitude where floods are common, avoiding buildings or locations that do not have proper fire detection and prevention equipment's, and adequate cooling arrangements to prevent over-heating of network elements.

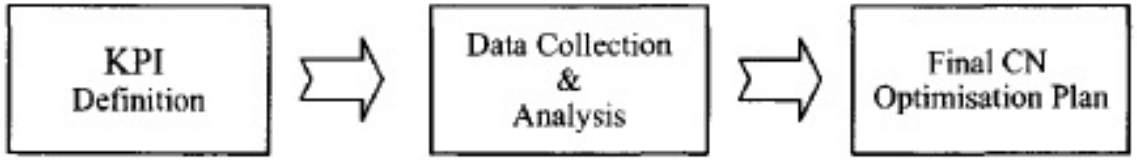
Equipment/node failure

- Arising from power or transmission problems may lead to temporary failure of the equipment or node.

DETAILED PLANNING

- Routing plans: Types of routing are decided in the analysis and dimensioning phase.
- Signaling plans: Signaling points, SEP, STP, etc., are defined.
- Numbering and charging: The numbering group used by each switch is finalized. Charging zones are defined, along with methods of collection and record transfers. The main categories of numbering plans are IMSI (International Mobile Subscriber Identity), MSISDN (Mobile Subscriber ISDN number), value-added services number (e.g. in a virtual private network), roaming numbers, handover numbers, test numbers, emergency numbers, etc.
- Synchronization plans: Synchronization is defined at switch level along with the priority settings.

CORE NETWORK OPTIMISATION



KPI may include parameters related to traffic and signaling performance, and measurements related to HLR, VLR and other network elements in the core network.

Data Collection and Analysis

Data Collection : Switching and signaling.

Data Analysis: Switching and Signaling

- Traffic handled by the switches/exchanges
- The exact amount of traffic under each traffic class
- Subscriber calling-related measurements (subscribers/calls/successful call attempts/ traffic intensity)
- Traffic loading in the switching exchanges and their availability (leading to congestion figures)
- Configuration of the signaling network

Core Network Optimization Plan

Switching Optimization Plan

- If a congestion problem is identified, extra PCM connections should be suggested at the location where it is experienced. If the congestion is severe and a new switch is required, then it should be proposed. A whole network topology should be produced, with information on the location of the new switch, traffic routed through it, etc.
- Inter-switch connections, and traffic routing between the MSC and transit switches, should be modified in locations/regions where a transit switch is carrying excessive traffic. This would mean devising new routing plans.
- When networks are rolled out, mismatch in naming conventions may happen. One of the objects of the optimization process is to clear the 'naming mess'. Naming conventions should be applied in a manner that it uniform in the whole network.

Signaling Optimization Plan

- The number of signaling links should be optimized, with increases or decreases as required.
- The signaling links and sets should be distributed uniformly across the network. If this is not the case, new signaling links and link sets should be proposed.
- Usually load sharing is not equal. New signaling plans and network topology should be created to remedy this.
- Proposals should be made for redundancy in the signaling control units.