

Sharing Insights into CDMA Network Management & Optimization

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Main topics

1. Introduction
2. CDMA Deployment in Sri Lanka Telecom (SLT)
3. Planning and Engineering of CDMA Networks
4. CDMA Network Optimization
5. Efficiency of using NGN Switches in networks
6. Optimize the network for better GoS/QoS
– Case Study

1. Introduction

Introduction

- Sri Lanka is located in the Indian Ocean towards South of India.
- Sri Lanka is an island with 65,000 sqkm with population of 21 million people.
- Population Density of the country is 309 people per sq km
- Tea, rubber and coconut are main agricultural products.
- Foreign employment and free trade business are becoming major foreign exchange earnings in Sri Lanka.

Map of Sri Lanka

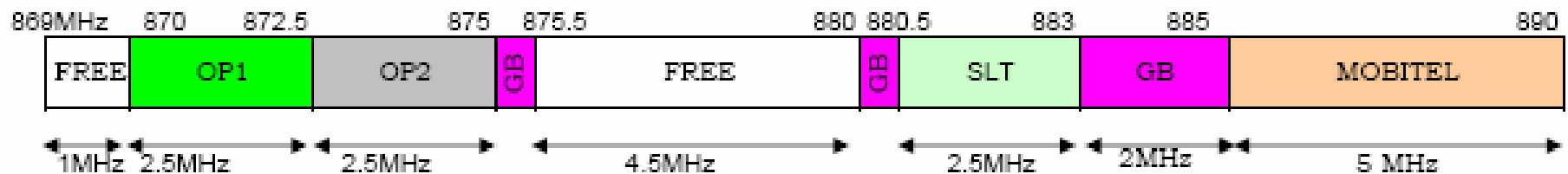


Current situation of Telecommunications in Sri Lanka

- Regulatory Authority:
 - The Telecommunications Regulatory Commission of Sri Lanka (TRC)
- Telecommunication Services were Privatized in 1996
- There are 7 major operators providing fixed and mobile telecommunication services in the country.
- 3 Fixed Operators (PSTN and CDMA)
 - Sri Lanka Telecom (incumbent operator with 35% shares to NTT Japan).
 - Suntel (51% Telia Sweden).
 - Lanka Bell (99% Milford Holdings Sri Lanka)
providing 2 million fixed telephones
- 4 Mobile Operators (All are GSM)
 - Dialog Telekom (87% owned by Telekom Malaysia)
 - Celltel (100% Millicom)
 - Mobitel (100% Sri Lanka Telecom)
 - Hutch (100% Hutchison)
providing well over 2 million mobile telephones.
- International telephone business is fully de-regularized and presently there are around 30 External Gateway Operators who have been licensed.

CDMA Rollout in the Country

- In year 2005 Government started issuing CDMA License
- As at today there are 5 CDMA operational networks
- Out of 5, three of them are operating in 800MHz Band
 - SLT, Lanka Bell and Suntel
- Remaining 2 are operating in 450MHz Band
 - Dialog Broadband, Tritel
- Presently there are around 1 million CDMA customers in the country



SLT Network

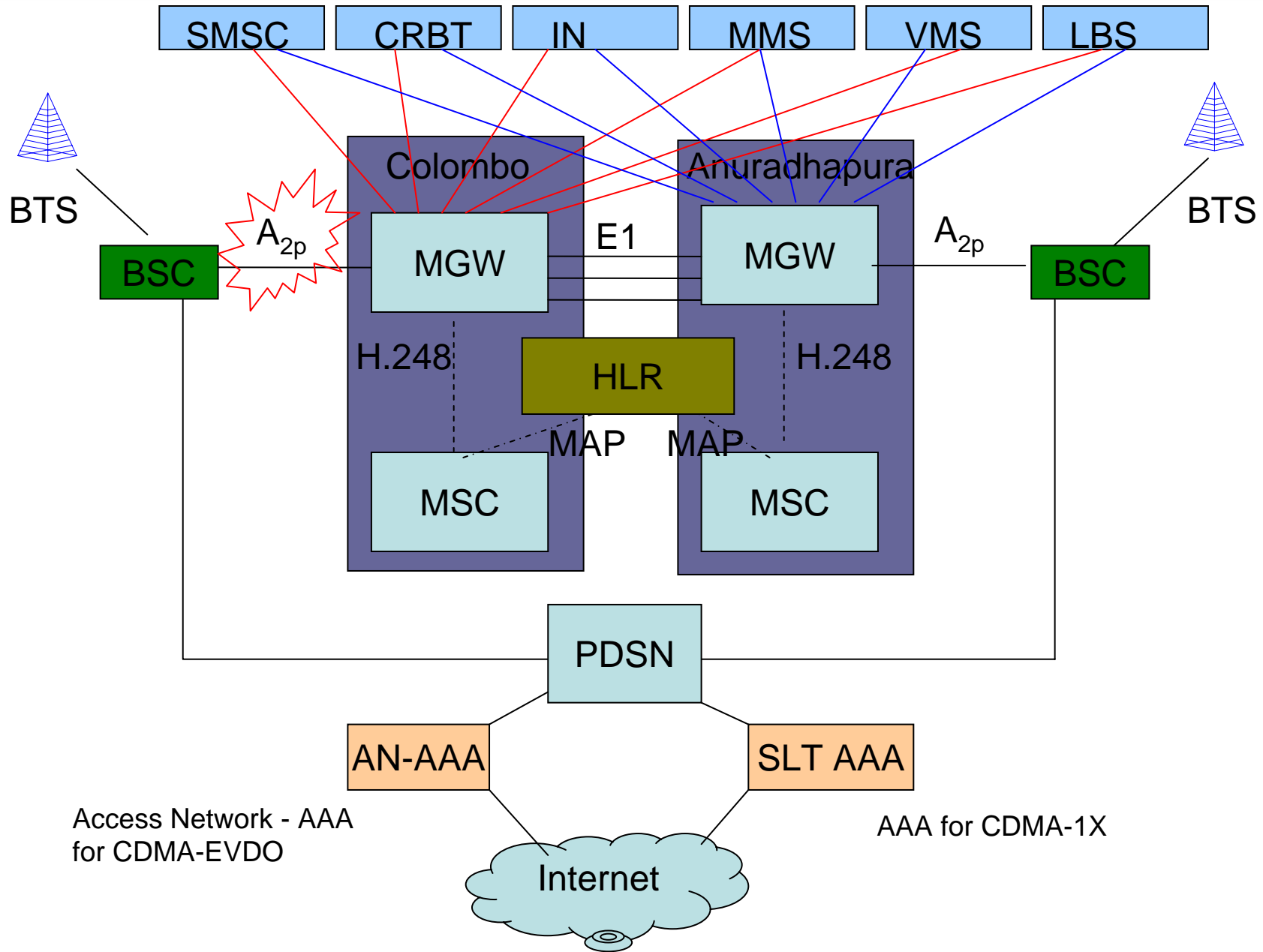
- SLT as an incumbent operator has been responsible for providing both voice and data services, domestic as well as international.
- In the domestic network access services has been provided by copper pairs and CDMA while in the transport network all the switches and transmissions are digital.
- SLT has introduced CDMA and ADSL service which has become very popular in Sri Lanka. Still the CDMA and ADSL services have been the major driver of SLT.
- Optical fiber rings already planned to provide Fiber Optic Super Highway interconnecting all the provinces of Sri Lanka. Already certain optical fiber rings have been commissioned while part of the other rings planed to be commissioned by the end of this year to provide optical fiber connectivity for the major cities of Sri Lanka.
- 228 numbers of towers have been deployed on Sri Lanka to provide radio communication to SLT network.

2. CDMA Deployment in Sri Lanka Telecom (SLT)

CDMA Deployment in SLT

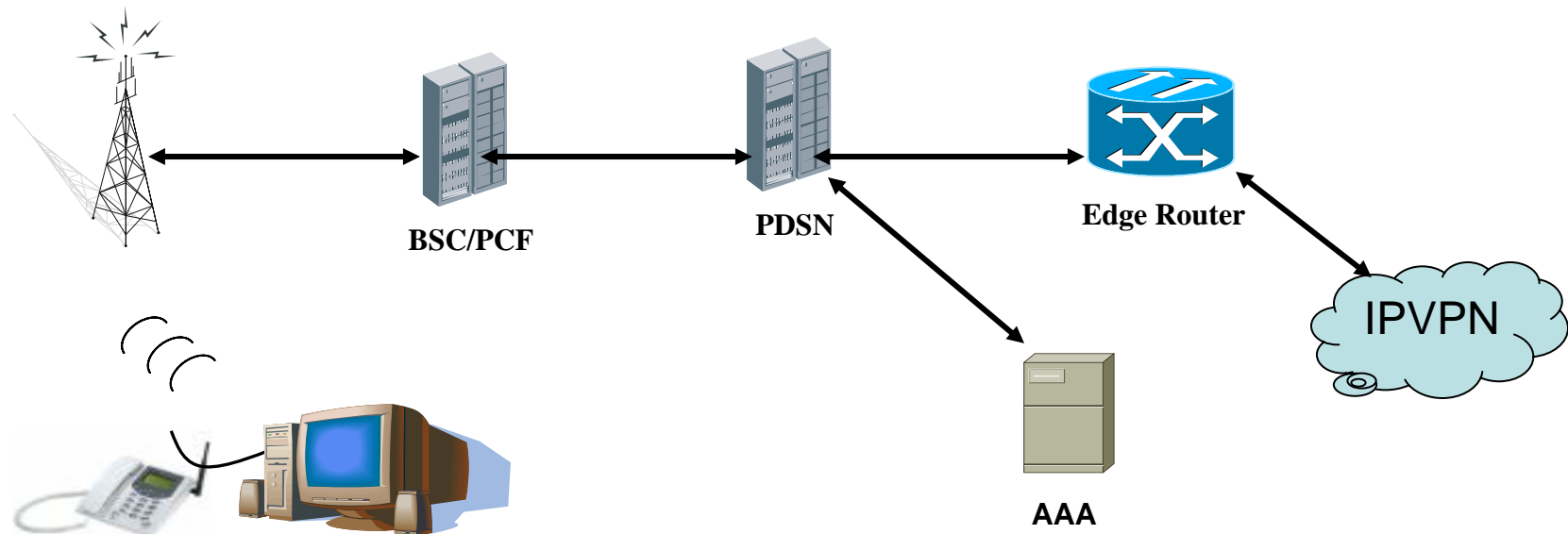
- Deployment in SLT commence from November 2005 and today more than 200 BTSs with more than 300k customers have been rolled out in the network.
- Two IP based Soft Switches from ZTE China are deployed in the network.
- These two Soft Switches will be interconnected with IP Technology.

CDMA Network Configuration

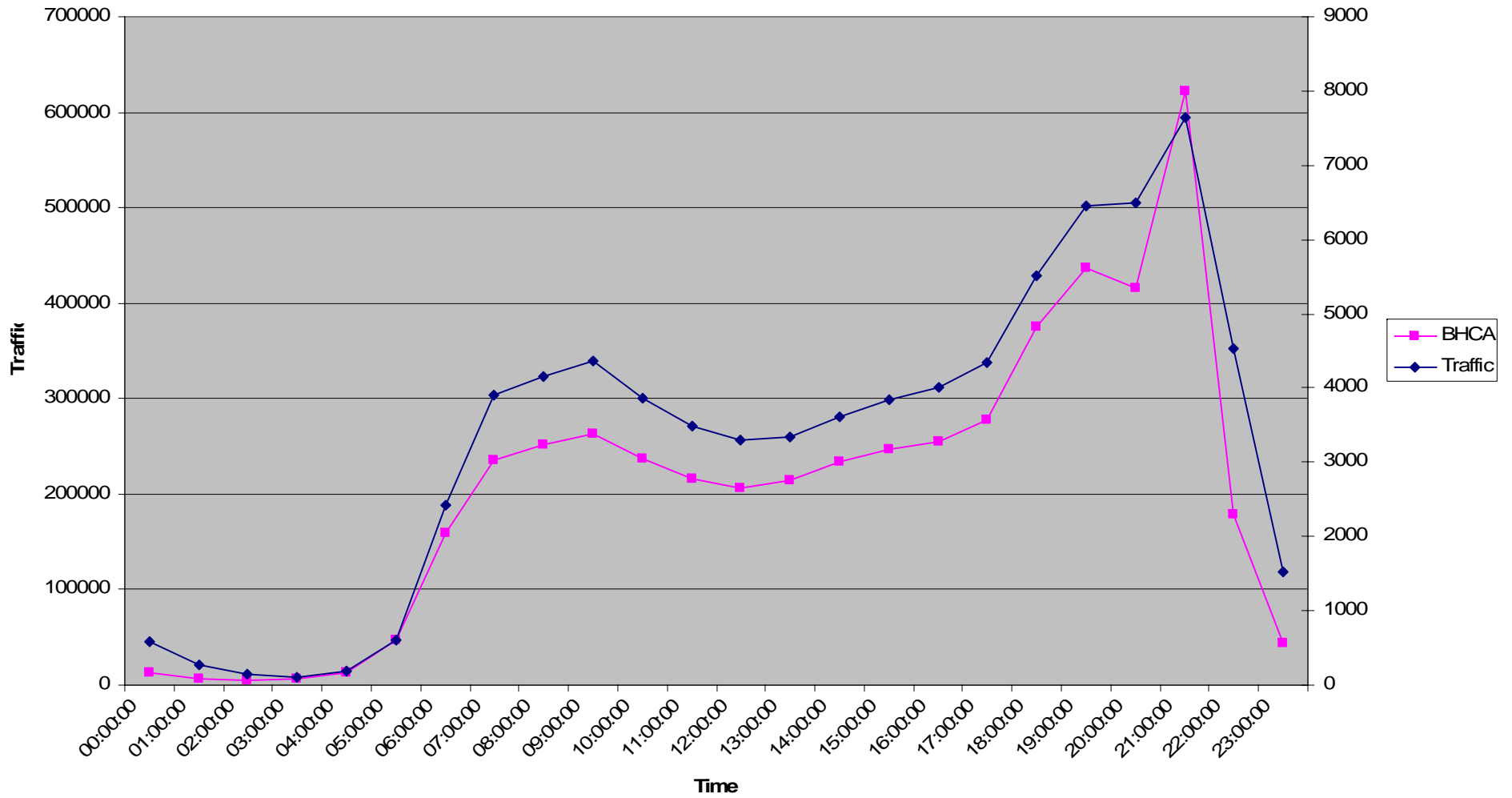


Special Features Adopted

- Through the PDSN (Packet Data Serving Node)
 - VPN Connectivity from CDMA Network (Remote schools and Banks)



Traffic Observed



BTS Deployed

- To cater different capacity and coverage requirement, SLT radio access network is composed of several different types of Base stations
 - S111: 1 Carrier x 3 Sectors Macro BTS
 - S222: 2 Carrier x 3 Sectors Macro BTS
 - M111: 1 Carrier x 3 Sectors Micro BTS
 - MO1: 1 Carrier x Omni Micro BTS
 - WMO1: 1 Carrier x Omni Wide Coverage Micro BTS

3. Planning and Engineering of CDMA Networks

Design and Planning of BTSs

- Identified the most critical areas according to the waiters list.
- Identified the existing telecommunications infrastructure in that area, Towers and connectivity
- Identified required Traffic Model and Link Budget
- Coverage was predicted for the short listed sites using Coverage Prediction Software and the site with the largest coverage was selected for commissioning the BTS

Major observations on Coverage Planning

- Initially low traffic volumes have been assumed though the actual traffic per subscriber is high. We used a comparatively low value, 0.025Erls per subscriber
- Cell coverage is influenced by factors such as antenna height, antenna type, down tilt angle and transmitted power
- Link Budget is used to estimate the path loss and the resulting cell radius for each morphology type

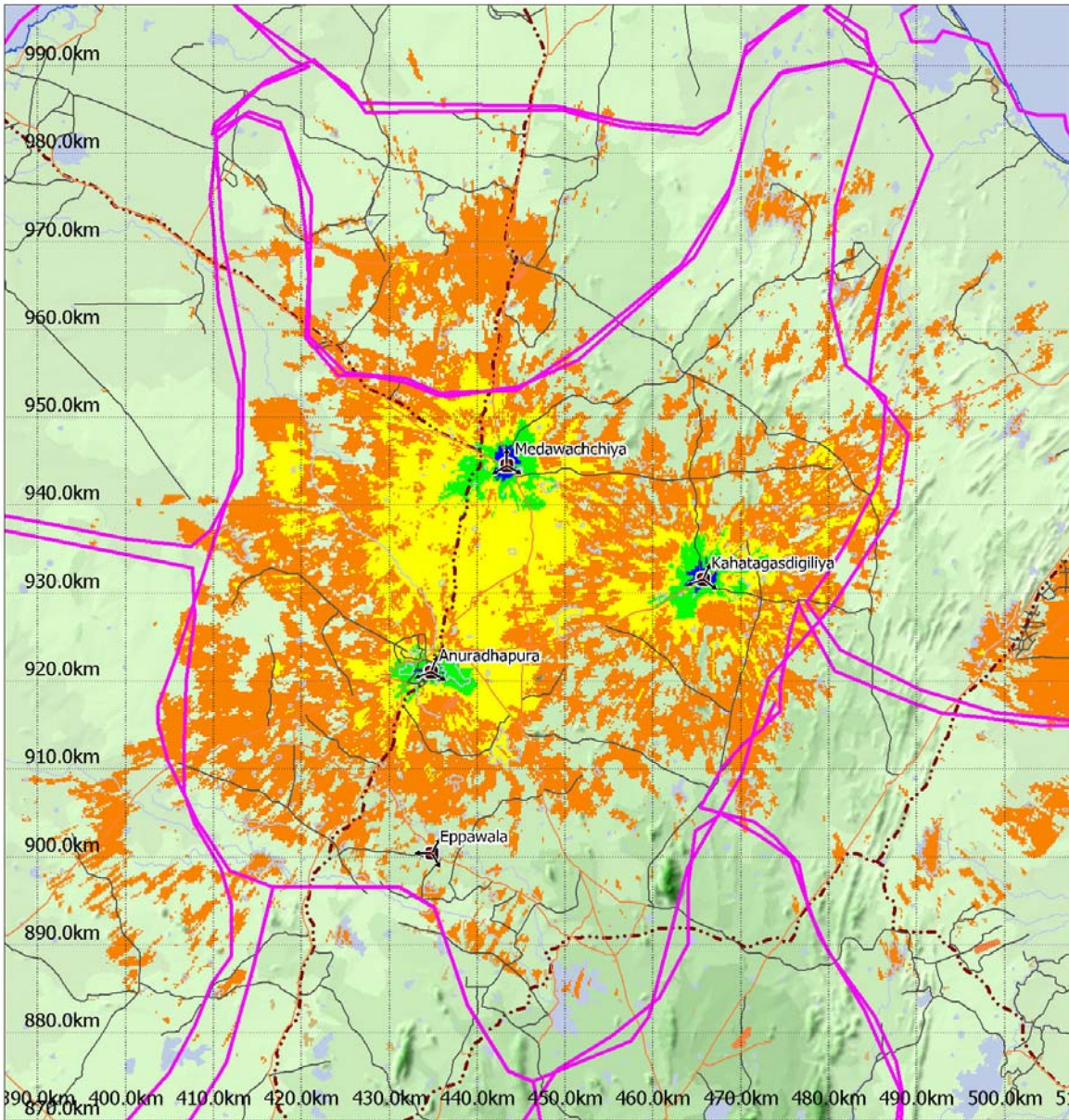
Major observations on Capacity Planning

- Capacity should be given some concern for the continuous construction at later stages
- Once the customers are been connected continuously observed
 - Power Overload statistics and
 - Traffic LoadOf each sector of all the BTSs
- Drive Tests are carried out when ever required and if found necessary introduce new BTS/s to share the traffic
- The above procedure is carried out as a routing work to maintain the good GoS in the network.

Coverage Prediction Software

- ZTE's ZXPOS CNS1 is used.
- Before simulating the coverage;
 - Created the network as required
 - Assigned antennas and propagation models
 - Set appropriate cell configurations
 - Set up carriers, bearers, services and terminal types
 - Created a traffic models for the terminal types
- 200m Digital Maps are used for coverage prediction

Coverage Map Example



ZXPOS CNS1
V5.0.2



Netscope
中兴通讯
ZTE CORPORATION

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SLT CDMA Project

Mon Nov 28 19:38:02 2005

Mean Received Power - Carrier CDMA Channel 1 from S

- 100.000 <= x < -90.000 dBm
- 90.000 <= x < -80.000 dBm
- 80.000 <= x < -70.000 dBm
- 70.000 <= x < -60.000 dBm
- 60.000 <= x < -50.000 dBm

- AIRPORT
- COASTLINE
- MAIN_ROAD
- RAILWAY
- SECONDARY_ROAD
- WATER
- Mapping Grid

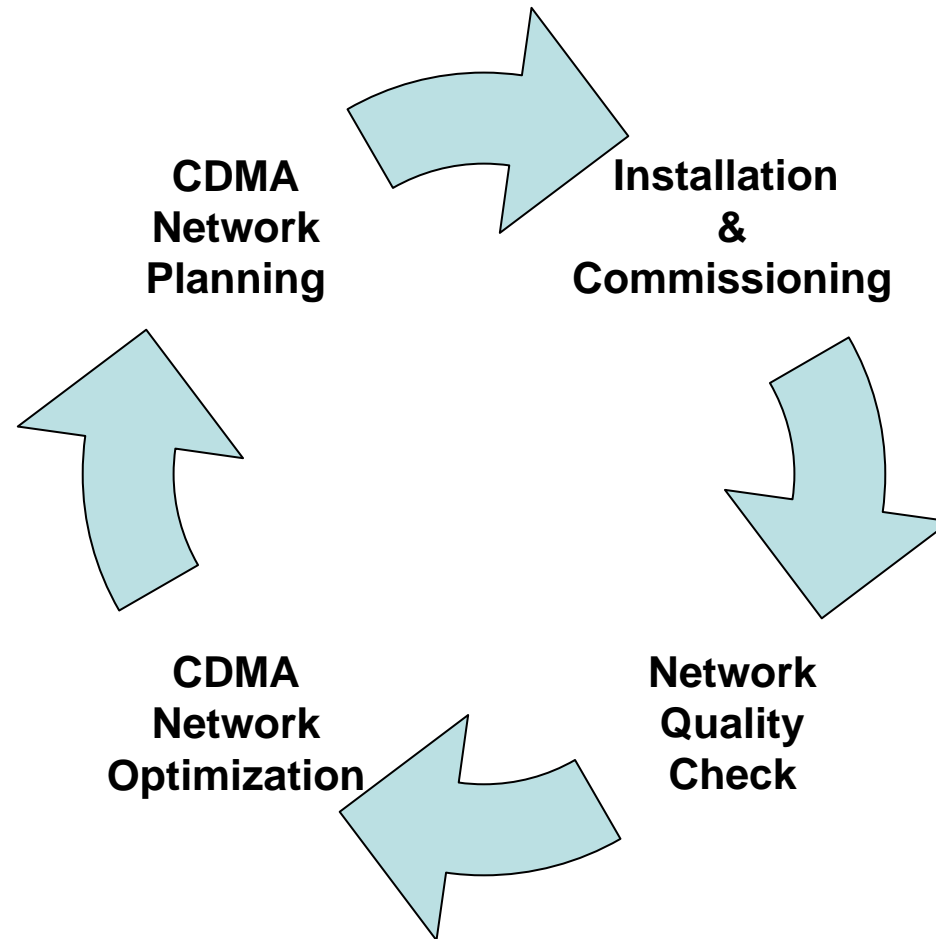
AD_p1 Filter

- CDMA BS
- 1st Name
- CDMA Sector

Top Right: 81.815295 9.019436
Bottom Left: 80.025153 7.956706
Scale Ratio 1:556556



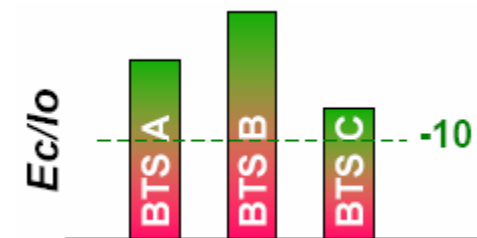
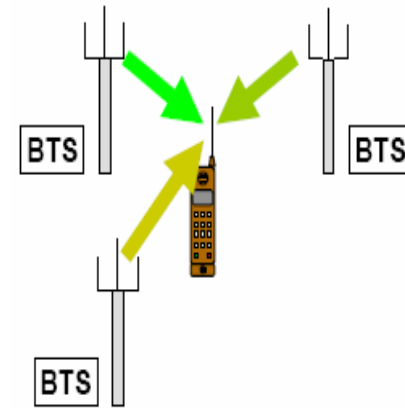
CDMA Network Planning & Optimization Cycle



4. CDMA Network Optimization

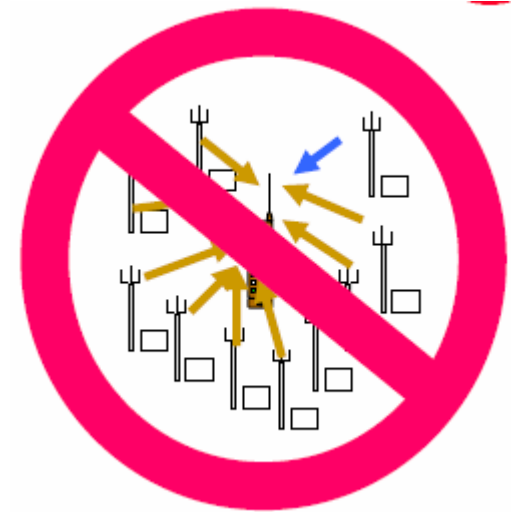
Good Performance

- One, two or three good signals in handoff
 - Composite $E_c/I_o > -10\text{db}$
- Enough Capacity, hence
No resource problems



Bad Performance

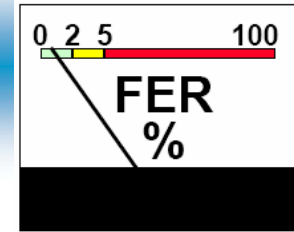
- Pilot Pollution
- Weak signals
- No enough resources
 - BTS forward/reverse power
 - Channel Elements (CE)
- Poor system statistics
 - High dropped calls
 - High access failures



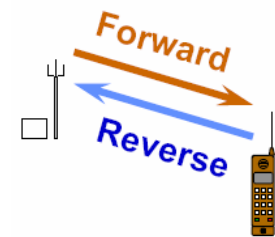
Performance Indicators

- CDMA Parameters and Measurements show the condition of the RF environment
- They are the main indicators used to guide CDMA optimization and troubleshooting
- Parameters and Measurements are collected at the subscriber end of the link
- Some parameters indicate uplink, some downlink and some both

Indicator 1: FER

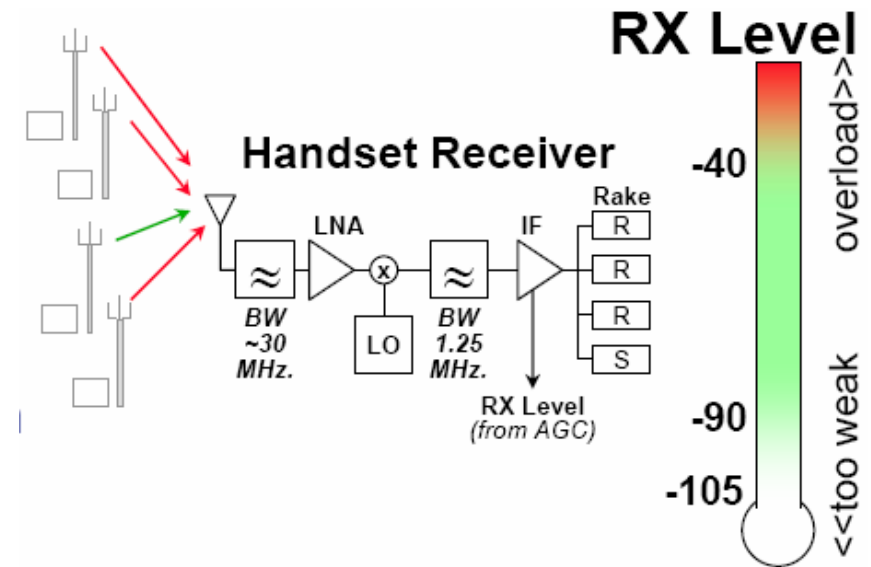


- Frame Error Rate (FER) is summary of call quality
- Forward Link FER is measured at Handset and Reverse Link FER is measured at BTS
- FER is the end-result of whole CDMA system
 - If FER is good, all other problems are not having much effect
 - If FER is bad, that is not the problem, that is the indication of the problem
 - Optimization Engineers to investigate other indicator to get a clue on what is wrong



Indicator 2: Handset Receive Power

- Usually expressed in dBm
- Measurement includes all RF signals in the carrier bandwidth, not just RF signals from the serving BTS
- Rx power is important but it's exact value isn't that critical



- Too little Rx power (-105 dBm or weaker) will leave noise, bad FER and other problems
- Too high Rx power (-35dBm or stronger) also leave inter-modulation and code distortion problems

Indicator 3: E_c/I_o

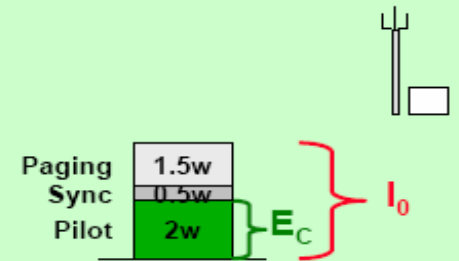
- E_c/I_o is the ratio of Pilot power to Total power
- This gives the signal strength of each sector
 - If the pilot of a certain sector is clean and strong, traffic channels of that sector are also clean and strong
 - If the pilot of a certain sector is weak, Traffic Channels of that sector are also weak

How E_c/I_0 Varies with Traffic Loading

- Transmit power of each sector is a sum of
 - Pilot, Sync and Paging channels power
 - Power of any traffic channels in use
- On a sector with no traffic, E_c/I_0 is about 50%, which is -3 db
- On a sector with maximum traffic, E_c/I_0 is about 20%, which is -7 db.

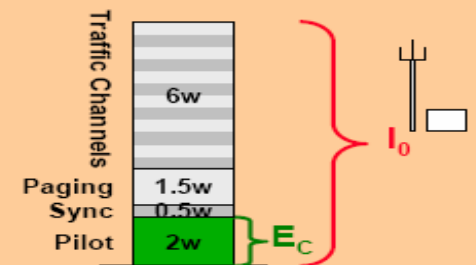
Light Traffic Loading

$$\begin{aligned} E_c/I_0 &= (2/4) \\ &= 50\% \\ &= -3 \text{ db.} \end{aligned}$$

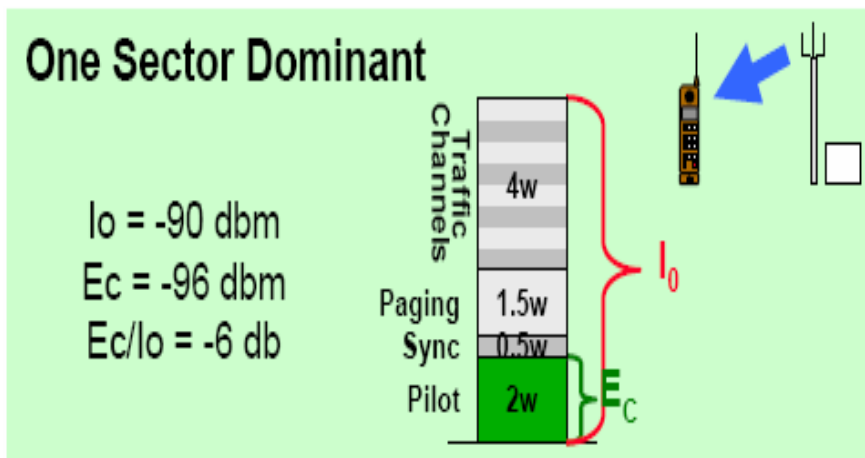


Heavily Loaded

$$\begin{aligned} E_c/I_0 &= (2/10) \\ &= 20\% \\ &= -7 \text{ db.} \end{aligned}$$

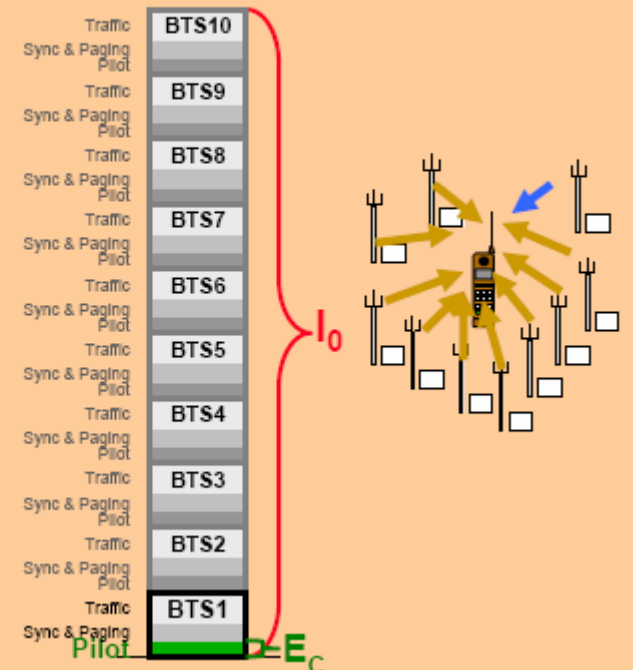


How E_c/I_o Varies with RF Environment



Many Sectors, Nobody Dominant

$I_o = 10$ signals
 each -90 dbm
 = -80 dbm
 E_c of any one
 sector = -96
 $E_c/I_o = -16$ db

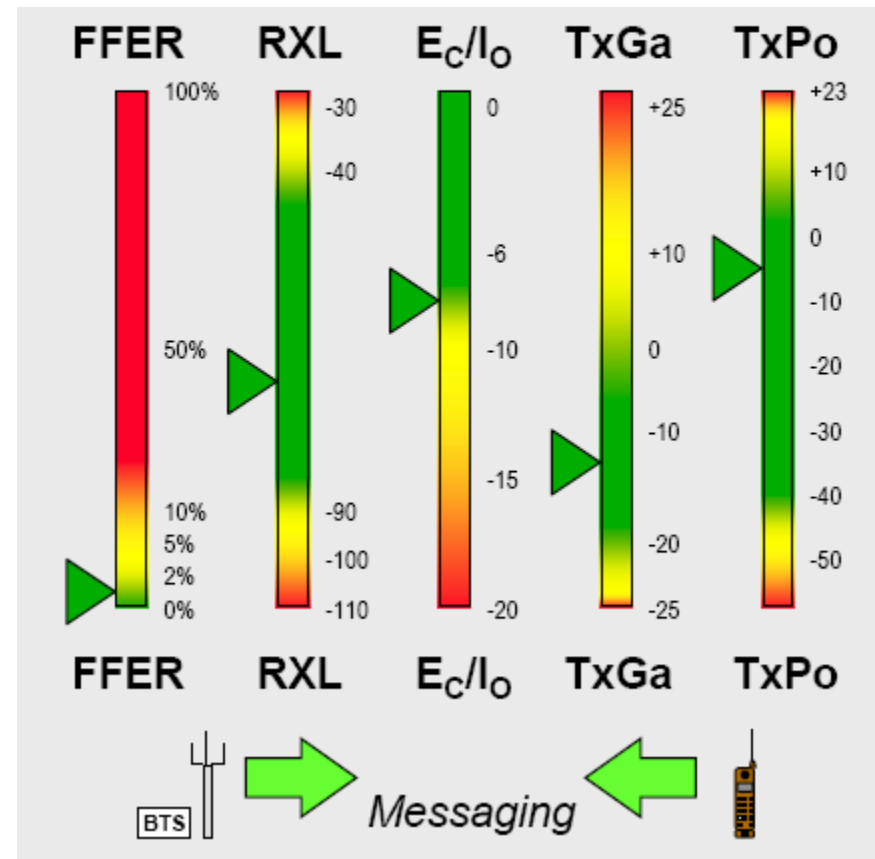


Indicator 4: Handset Transmit Power

- Actual Transmit Power of the Handset Transmitter
- Can't exceed Handset's maximum Tx power, typically +23 dBm
- However BTS ask Handset to do something impossible (lower than -60dBm or higher than +23dBm) something wrong
- Typical Values
 - -50dBm very close to BTS
 - 0dBm Middle of the Coverage Area
 - +23dBm Coverage hole

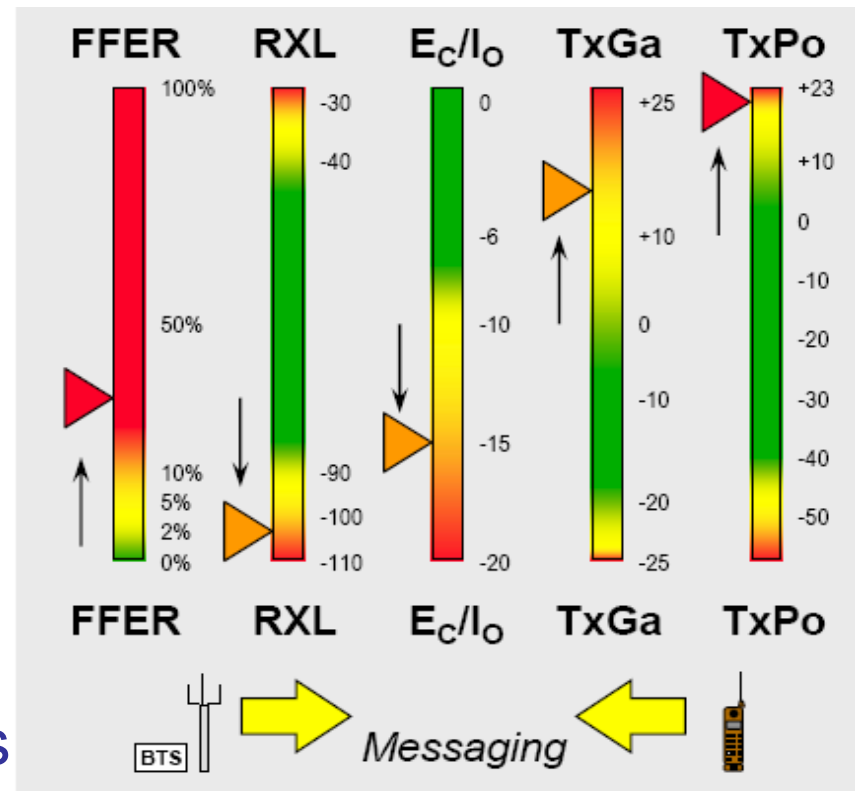
Identify a Good Call

- Low forward FER
- Receive power > -100 dBm
- Good E_c/I_o (> -10 dB)
- Normal Transmit Gain Adjust
- Transmit power $< +20$ dBm
- Good Messaging.



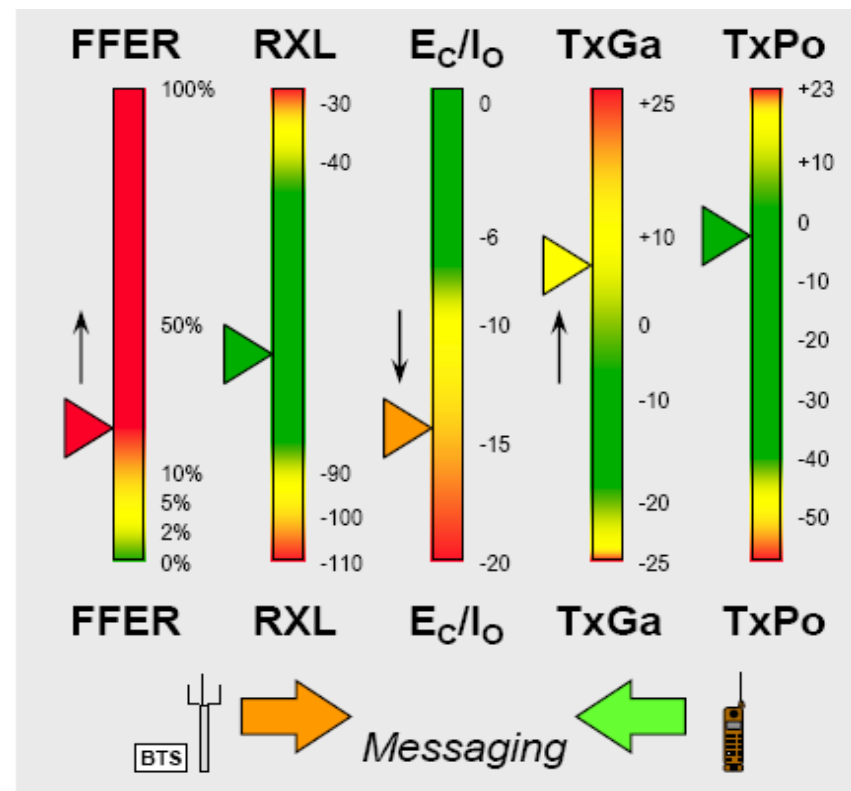
Identify a Dropped Call due to bad coverage

- High forward FER
- Low receive power (<-100 dBm)
- Low E_c/I_o (< -10 dB)
- Higher-than-normal Transmit Gain Adjust
- Higher-than-normal transmit power (> +20 dBm)
- Poor messaging on both links



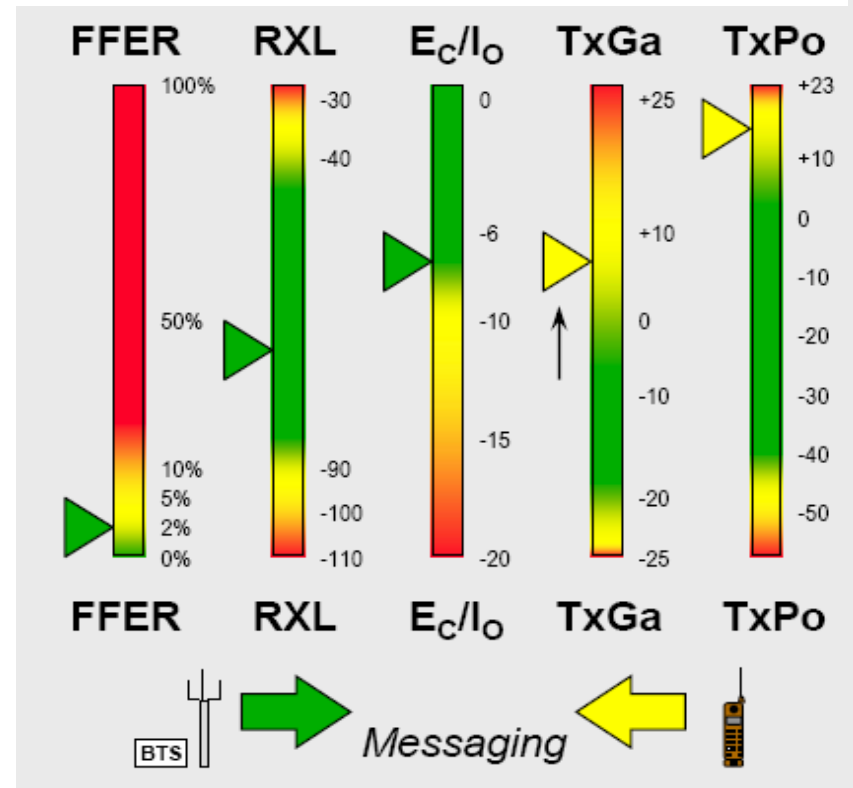
Identify Forward Link Interference

- High forward FER
- Good receive power (> -100 dBm)
- Low E_c/I_o (< -10 dB)
- Higher-than-normal Transmit Gain Adjust
- Normal transmit power ($< +20$ dBm)
- Poor forward link messaging



Identify Reverse Link Interference

- Good forward FER
- Good receive power (> -100 dBm)
- Good E_c/I_o (> -10 dB)
- Higher-than-normal Transmit Gain Adjust
- Higher-than-normal transmit power ($< +20$ dBm)
- Poor reverse link messaging



Complaints Reported

1. Signal available but cannot originate calls
2. Receiving signal strength vary time to time
3. Calls cut off frequently
4. Difficult to originate Calls during peak time (after 9:00 PM)
5. Initially enough signal available but latter reduced
6. Echo problem
7. No incoming calls, terminal need to restart frequently

Problem - 1

- **Problem:**
 - Signal available but cannot originate calls
- **Reason:**
 - BTS can't acquire messages in Access Channel since Cell Radius is set to default value.
 - Rx power is good but E_c/I_o is bad
- **Solutions:**
 - Increase Cell Radius, Search Window size and Pilot_Gain





Problem - 2

- **Problem:**
 - Receiving signal strength vary time to time
- **Reason:**
 - Traffic load variation
 - Pilot Pollution
- **Solution:**
 - Boost one or few signals which are intended to serve the location.
 - Eliminate unwanted signals
 - Install external antennas
 - Install new BTSs

Problem - 3

- **Problem:**
 - Call cutoff frequently
- **Reason:**
 - Hardware problem;
 - GCM card, CE faults, TRX etc.
 - Transmission problem
 - Neighbor list configuration is wrong or some cells are missing
 - Pilot confusion
 - BTS Power overload
- **Solution:**
 - Replace faulty hardware
 - Reconfigure Neighbor Lists correctly after doing Test
 - Adjust the output power of the BTSs
 - Install new BTSs





Problem - 4

- **Problem:**
 - Difficult to originate Calls during peak time (after 9:00 PM)
- **Reason:**
 - Insufficient Radio Resources;
 - Transmit Power of the BTS
 - CE Resources in the BTS
 - Congestion in the Trunk network
- **Solution:**
 - Open the 2nd carrier where ever possible
 - Introduce new BTSs
 - Add more CE recourses
 - Increase the capacity (E1s) of trunk network

Problem - 5

- **Problem:**
 - Initially enough signal available but latter reduced
- **Reason:**
 - Traffic in the cell is increasing rapidly, cell coverage will be reduced, specially during peak time
 - Changes in the terrain
 - RF hardware faults
- **Solution:**
 - Increase output power of the BTS (Control Channel power).
 - Install external antennas.
 - Introduce new BTSs.





Problem - 6

- **Problem:**
 - User hear the own voice during a call. This is known as Echo.
- **Reason:**
 - DTB card fault in MSS site
 - Terminal fault
- **Solution:**
 - Replace faulty cards
 - Replace faulty Terminals

Problem - 7

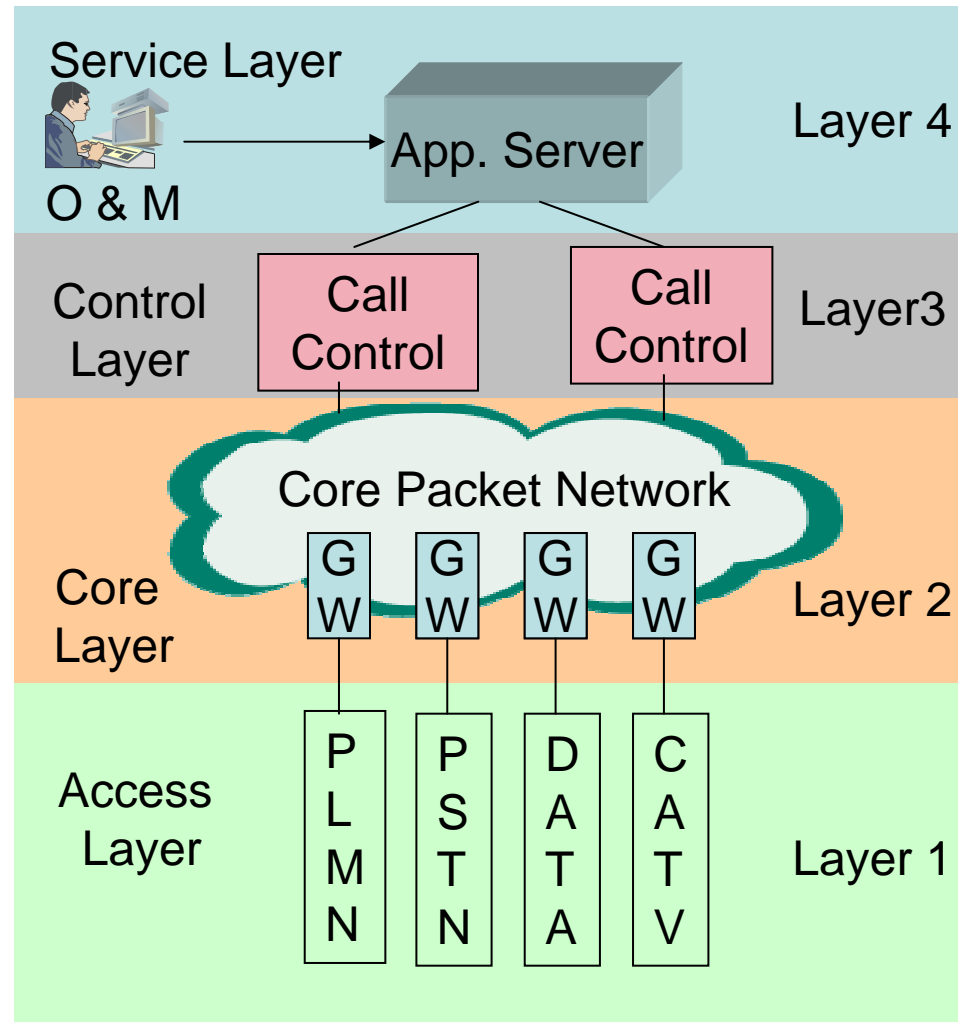
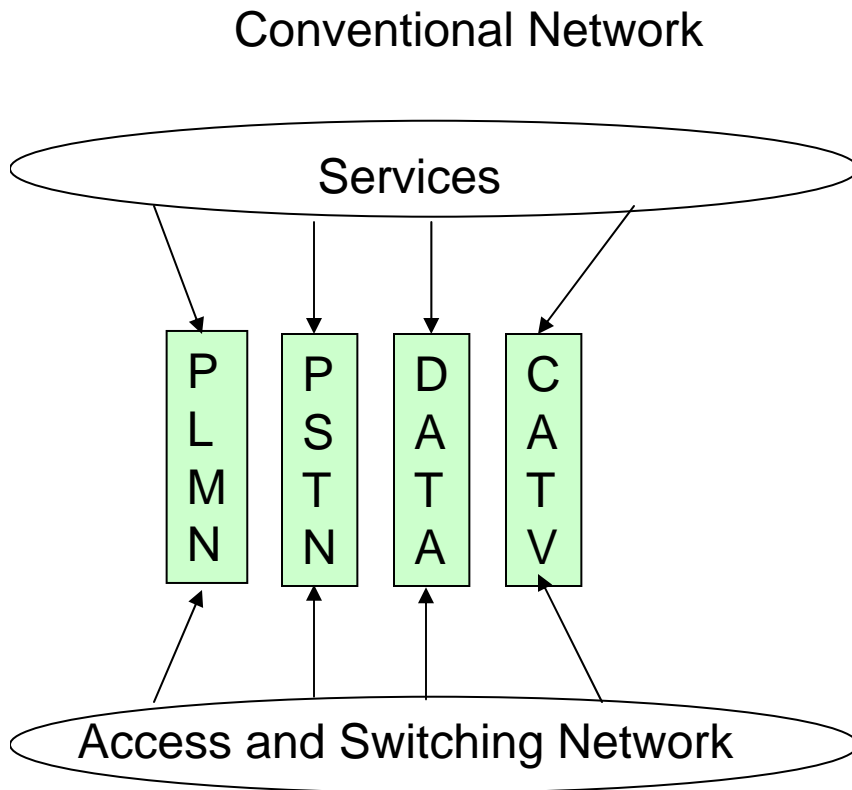
- **Problem:**
 - No incoming calls, terminal need to restart frequently
- **Reason:**
 - Terminals make frequent handoffs at LAC borders and/or BSC border, the MSS can not complete the registration in time.
 - Terminal faults.
- **Solution:**
 - Adjust BSC border and LAC borders as required
 - Adjust BTSs' output power as required
 - Change faulty Terminals



5. Efficiency of using NGN Switches in networks

Why NGN ?

Next Generation Network



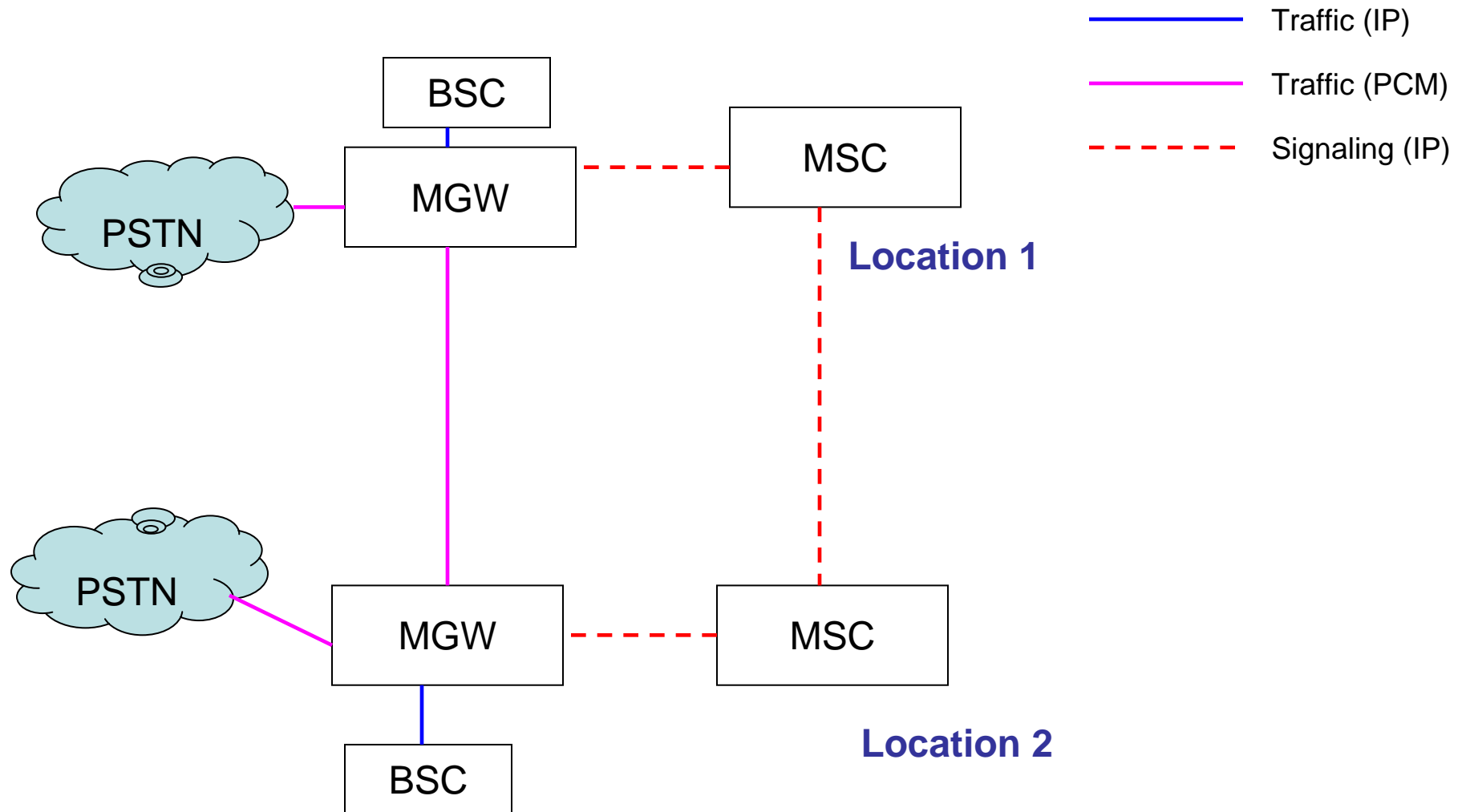
Characteristics of NGN

- NGN is a packet based network able to provide wire line, wireless and IP based customers with voice, data and multi media services.
- NGN is a flat network based on IP technology unlike PSTN which is a hierarchical network.

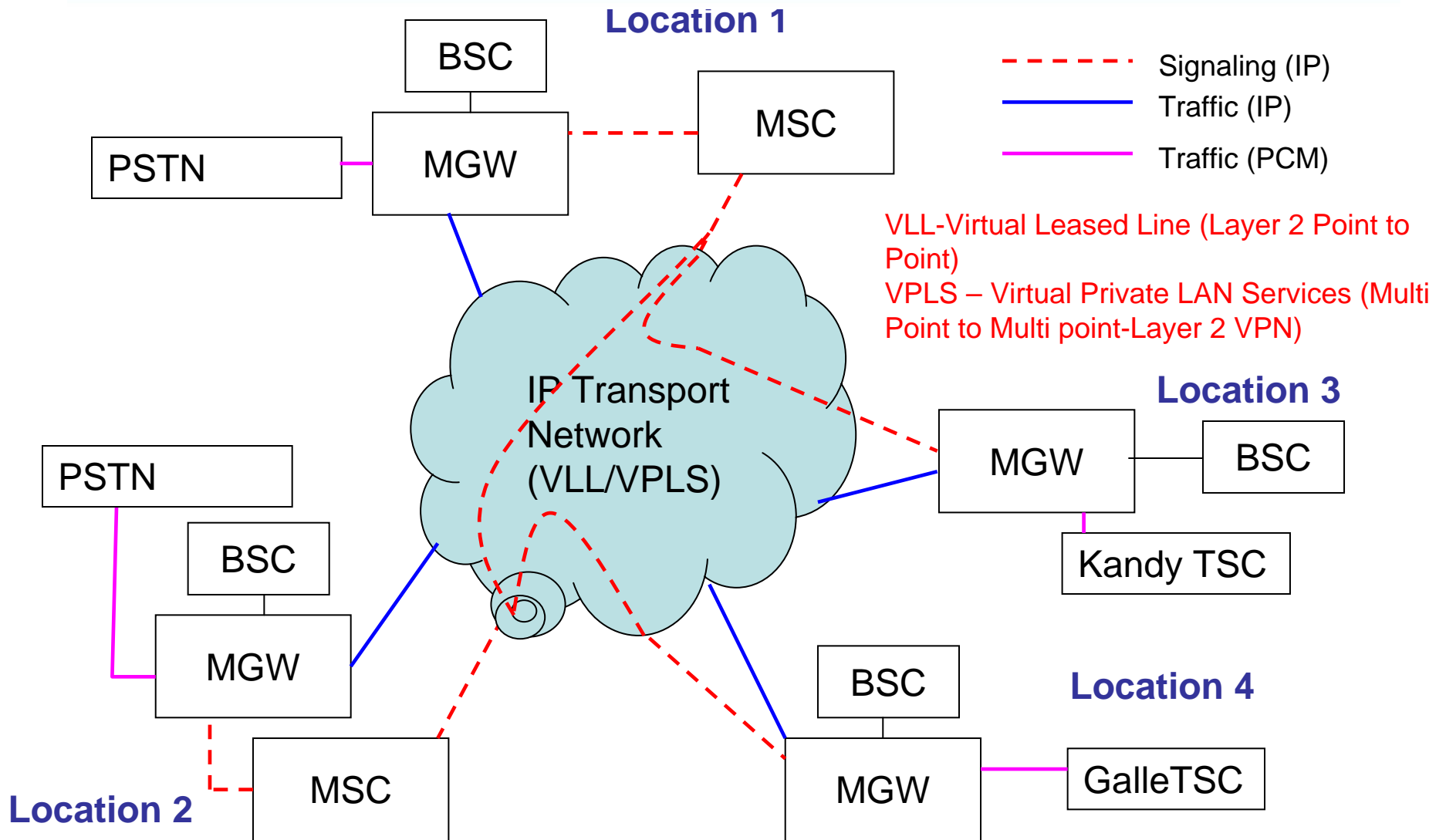
Advantages of NGN for carriers

- Save cost of implementation since it uses a common access and transmission network.
- New services can be introduced easily and fast.
- NGN uses open interfaces. This allows the carrier to choose the best suited network elements independent of the vendor.
- Software upgrade is easy and more efficient.
- A better Average Revenue Per User can be expected due to additional services provided.
- OPEX is low.

Present Scenario of CDMA Network



CDMA NGN Network



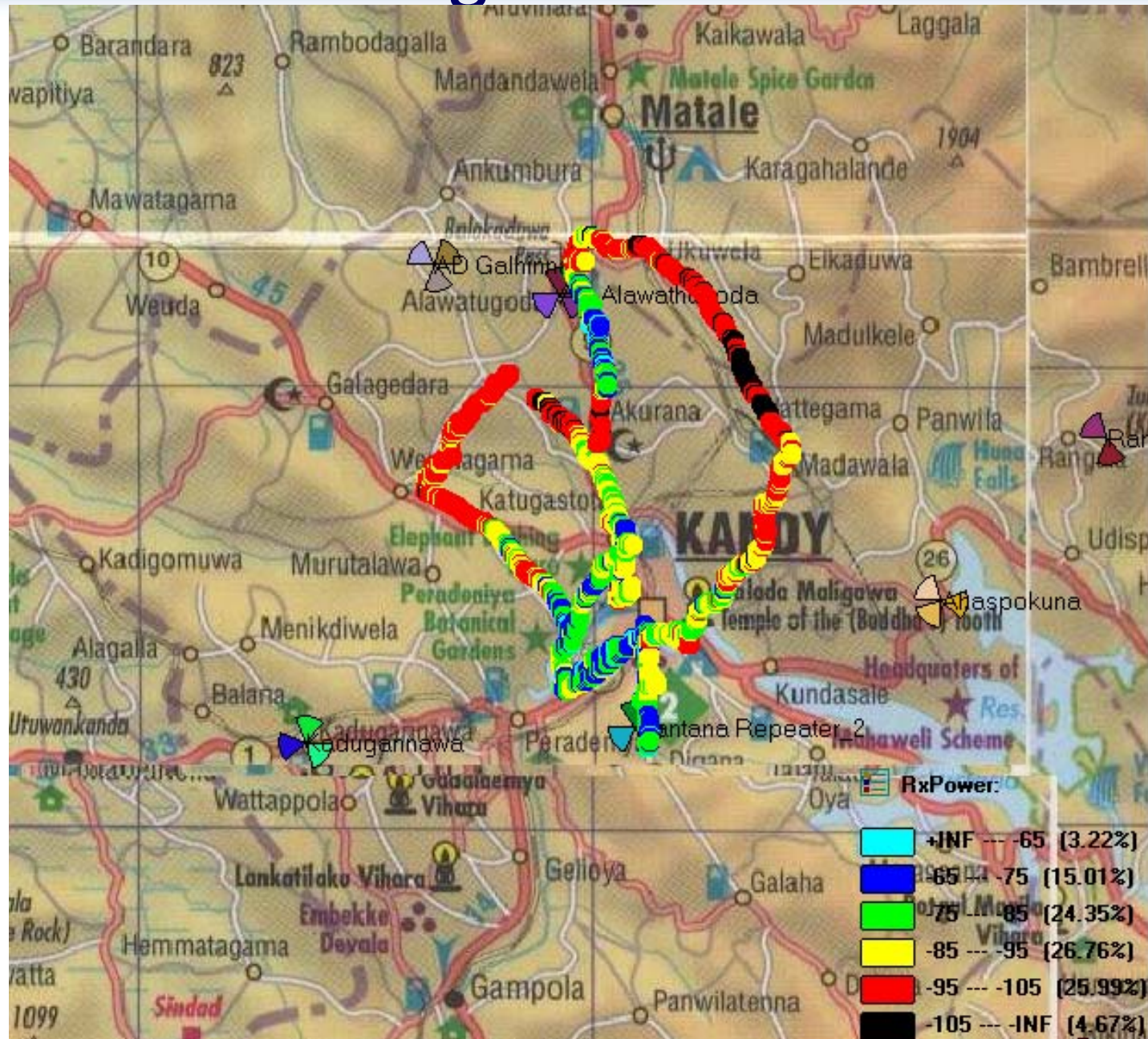
6. Case Study

Frequent Call Cutoff Problem at
Hantana

Problem

- Customers in Hanthana area complaint that,
 - it is very difficult to originate calls
 - and
 - they are experiencing frequent calls dropsespecially during the busy time (1500 hrs – 2130 hrs).

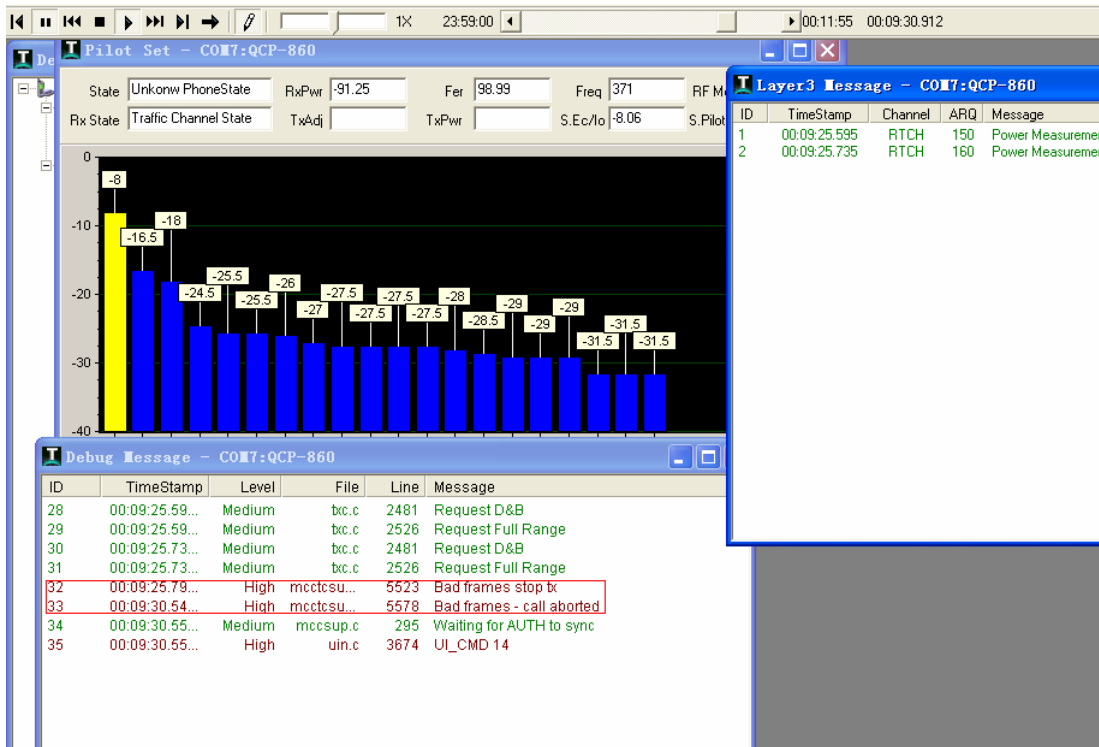
Coverage in the Area



Observations from of Drive Test

- Many areas with weak signals (95 – 105 dBm).
- In many of these weak signal areas, the primary PNs received were from BTS at Hantana.
- Coverage of the near by BTS, Alawathugoda, was small because of the mountains in the area.
- Found two types of dropped calls

Dropped Call Type 1

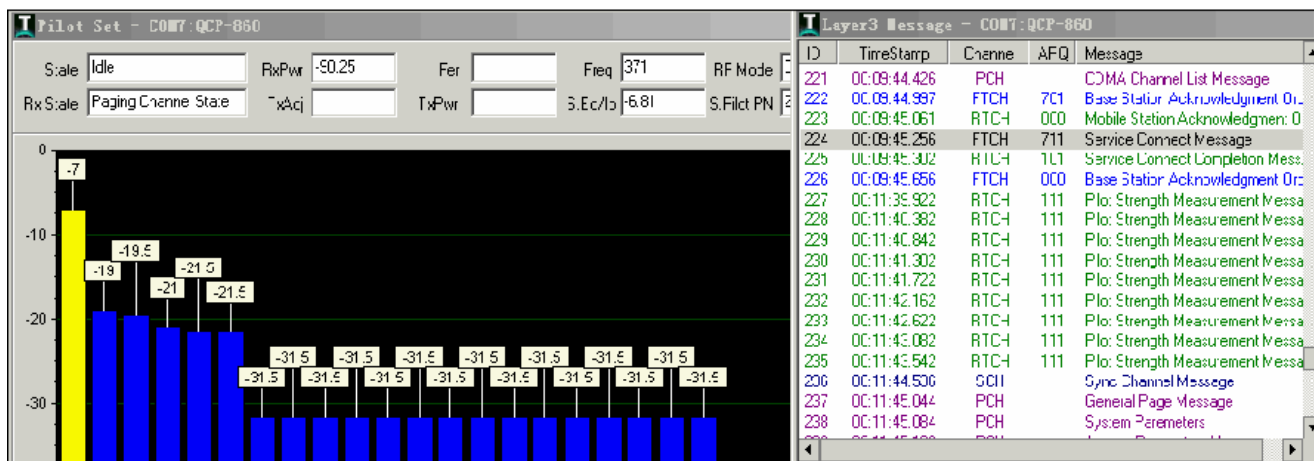


- Just Before the call drop, the FFER of the handset increased very high
- Then after receiving several bad frames, the handset closed its transmitter
- This lead to the dropped call.

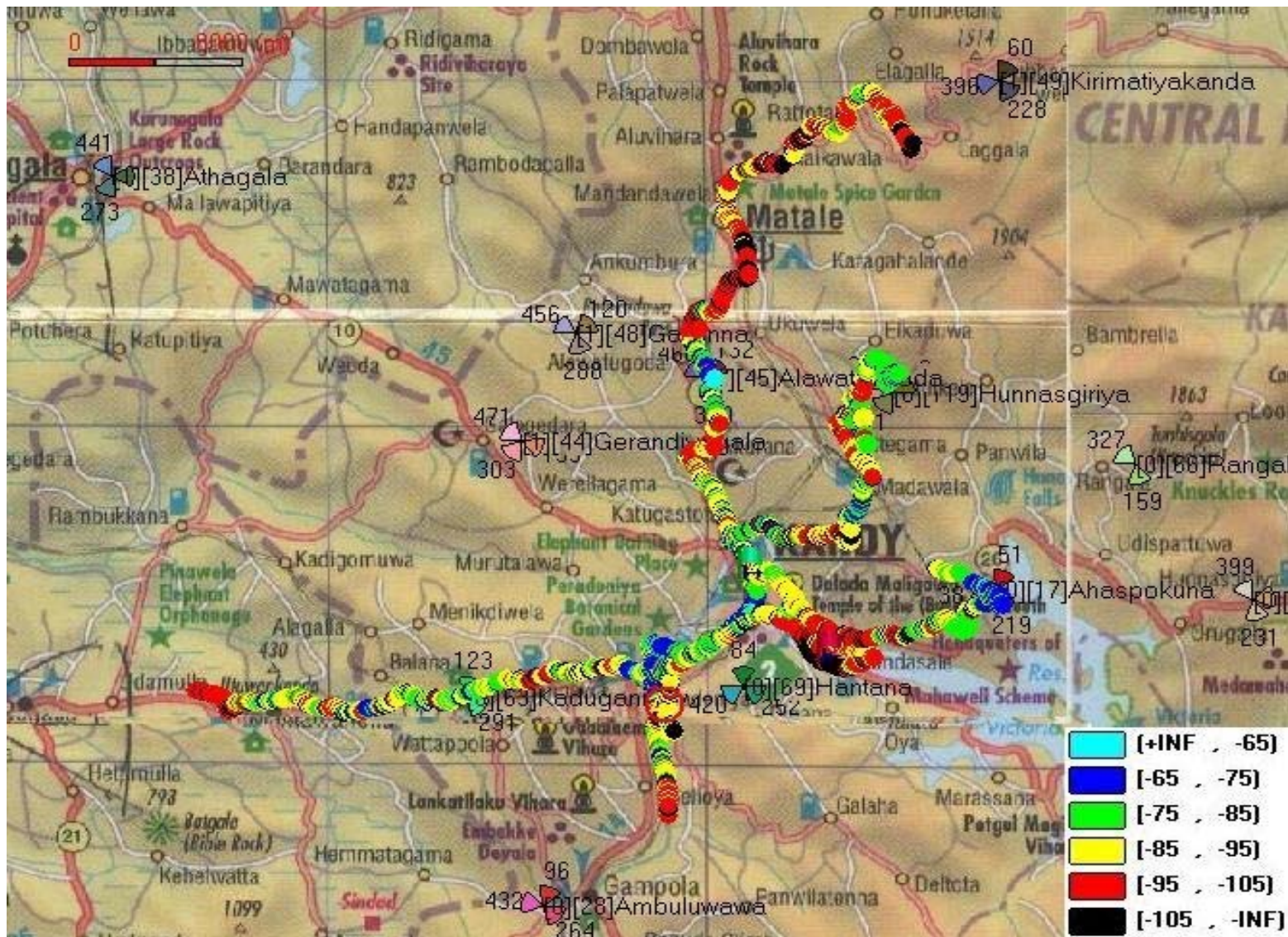
Observation: The Power Overload of Hantana BTS caused the poor forward link

Dropped Call Type 2

- Just before the call drop
 - FFER of the handset remained low
 - Handset sent several Pilot Strength Measurement Message (PSMM) to the BTS ,it didn't receive the response from BTS
- Handset releases the call after sending PSMM several times.
- Why can't handset receive the response message?
 - Case I: BTS can't receive the PSMM due to the poor reverse link.
 - Case II: BTS has sent the response message, but the handset can't receive it due to the bad forward link.
- Both of these two cases were caused by the power overload of Hantana.



Current Coverage in the Area



Solutions

- To relieve the overload, adjusted the down-tilt and the direction of the antennas to reduce coverage radius.
- The overload in sector 1 is reduced, but the overload in sector 3 remained same because the traffic is still there.
- Reduced the gain of the control channel to control the coverage radius.
- Installed new BTSs in the area to improve the signal strength and to absorb the traffic nearby.

Conclusion

- CDMA Technology has provided the network roll-out to satisfy the major fixed line demand and created zero waiters in Sri Lanka.
- CDMA is more susceptible to traffic in a given cell. When the traffic increases cell radius decreases. Hence more vigilant monitoring of traffic is needed.
- QoS of the CDMA customers has to be constantly monitored. This monitoring has to be done under the normal hours and high peak traffic hours. If under the normal hours QoS is poor immediate network optimization to be carried-out.
- Network optimization is becoming more complex with the number of BTSs are increasing with the increasing traffic.
- Sri Lanka Telecom has successfully address the Quality of service to maintain more than 90% of the customers to be happy in their CDMA network.

THANK YOU