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GPRS/EDGE Network Key Performance Indicators (KPIs)

This document presents the essential Key Performance indicators (KPIs) required for evaluation of Quality of Service (QoS) of EDGE – GPRS cellular networks in Pakistan.



Contents

- 1. Introduction4**
- 2. Technology.....4**
- 3. Methodology for Development of KPIs.....6**
- 4. Recommended KPIs.....6**
 - 4.1 Availability..... 6
 - 4.1.1 Network Availability..... 6
 - 4.1.2 Service Availability 6
 - 4.2 Latency 7
 - 4.3 Link Speed 7
 - 4.4 Throughput 7
 - 4.4.1 Download Speeds 7
 - 4.4.2 Upload Speeds..... 8
 - 4.5 Retainability 8
- Annex-A9**

Abbreviations

2G	Second Generation
ANSI	American National Standards Institute
BTS	Base Transmitting Station
CDMA	Code Division Multiple Access
DL	Down-Link
EDGE	Enhanced Data rate for GSM Evolution
EGPRS	Enhanced General Packet Radio Service
GSM	Global System for Mobile communication
GMSK	Gaussian Minimum Shift Keying
GPRS	General packet Radio Service
HSCSD	High Speed Circuit Switched Data
IP	Internet Protocol
<i>kbits/s/slot</i>	Kilo Bits per second per slot
Kb	Kilo bits
KB	Kilo Bytes
MCS	Modulation & Coding Scheme
PDP	Packet Data Protocol
PSK	Phase Shift Keying
QoS	Quality of Service
TDMA	Time division Multiple Access
UE – UT	User Equipment – User Terminal
UL	Up-Link
UMTS	Universal Mobile Telecommunication Service
USB	Universal Serial Bus

Definitions

Active UE	Any user equipment which is in process of downloading or uploading any content
PDP context	PDP (e.g., IP, X.25, Frame Relay) context is a data structure present on both the <i>Serving GPRS Support Node (SGSN)</i> and the <i>Gateway GPRS Support Node (GGSN)</i> which contains the subscriber's session information when the subscriber has an active session. When a mobile wants to use GPRS, it must first attach and then <i>activate a PDP context</i> .

1. Introduction

GPRS and EDGE are GSM wireless packet data transfer standards commonly referred as 2.5G and 2.75G respectively. Fig 1 below elaborates the positioning of EDGE and GPRS within the technology evolution growth path from 2G (GSM) to 3G (UMTS).

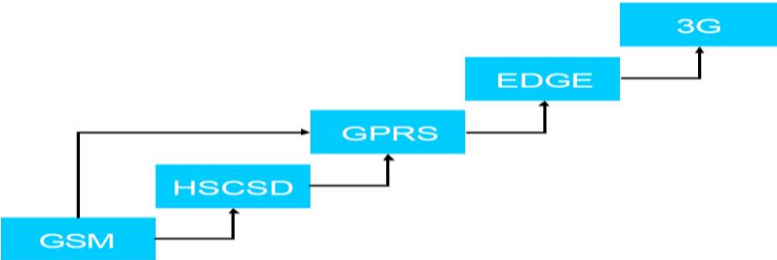


Fig: 1 Evolution from GSM to 3G

With the proliferation of Internet, packet switching technology was introduced to GSM, CDMA and TDMA (ANSI I36) mobile networks making it easier for non-voice applications.

EDGE is the next step up from GSM/GPRS communication leading towards 3G. It has higher data rates due to several technological improvements for example GPRS uses GMSK modulation for air interface whereas EDGE, in addition to GMSK, uses higher bit rate 8-PSK modulation. Moreover GPRS is a best-effort packet switched service where limited QoS is guaranteed during communication. In contrast EDGE introduces data transfer during mobility with a higher level of confidence.

2. Technology

In order to devise KPIs, it is prudent to have a background of the physical level frame structure of GSM. Fig 2 highlights how data is arranged into 8 time slots of one GSM frame, which are shared among multiple users to provide various voice and data services.

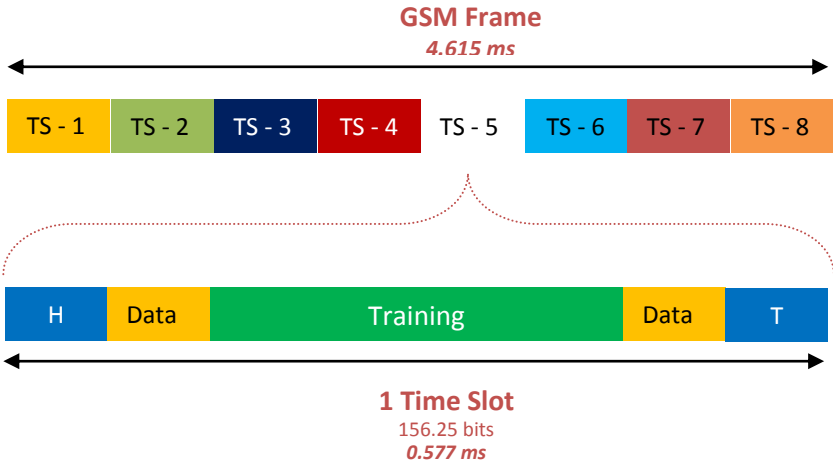


Fig: 2 GSM Frame of 8 Time slots

The difference between GPRS and EDGE arises on the basic usage of these slots. Fig: 3 shows that while standard GPRS transceivers support only the first two channel types, EDGE transceivers support all four. Physical channels are dynamically defined according to the need in the cell. For example, if a large number of speech users are currently active, the number of channels of the first and third types is increased, at the expense of fewer GPRS and EGPRS channels. Moreover EDGE can use all the 8 slots for data transfer whereas GPRS transceiver can normally operate with 4 slots however; in Pakistan's scenario currently 3 slots can be made available.

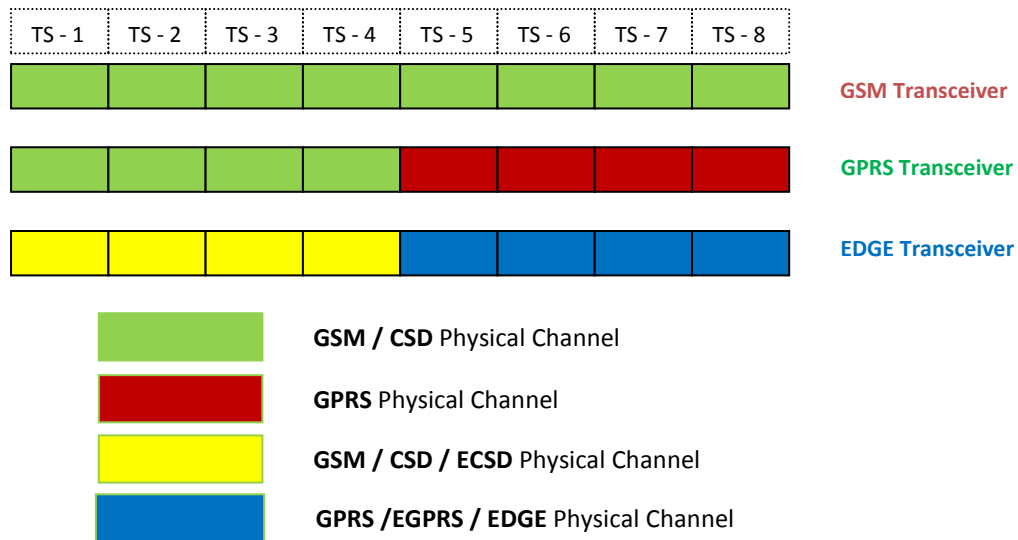


Fig: 3 Example of transceiver and channel plan in one cell

There exists a difference within the standards for the data rate per slot for GPRS and EDGE which is due to improved modulation and coding schemes for EDGE. This difference is shown in table: A below.

EDGE			GPRS	
<i>Coding and modulation scheme (MCS)</i>	<i>Speed (kbit/s/slot)</i>	Modulation	<i>Coding scheme</i>	<i>Speed (kbit/s)</i>
MCS-1	8.80	GMSK	CS-1	8.0
MCS-2	11.2	GMSK	CS-2	12.0
MCS-3	14.8	GMSK	CS-3	14.4
MCS-4	17.6	GMSK	CS-4	20.22
MCS-5	22.4	8-PSK	-	-
MCS-6	29.6	8-PSK	-	-

MCS-7	44.8	8-PSK	-	-
MCS-8	54.4	8-PSK	-	-
MCS-9	59.2	8-PSK	-	-

Table: A Speeds due to various coding schemes in GPRS/EDGE

3. Methodology for Development of KPIs

The KPIs have been developed keeping in view the following goals:

- a. Applicability
- b. End to End testing (non-intrusive for network under test)
- c. Ease of measurement
- d. Ease of understanding for a field testing person
- e. Similar treatment of rural and urban regions in terms of service offerings
- f. Push for future improvement in broadband networking

4. Recommended KPIs

GPRS/EDGE based networks can be monitored for QoS using the following parameters and subject to change by the Authority from time to time:

4.1 Availability

This KPI can be further classified into two parameters:

4.1.1 Network Availability

Provides verification on whether the operator provides GPRS/EDGE coverage in the testing area. Coverage maps may be obtained from the GPRS/ EDGE service providers before the actual on ground testing is done.

4.1.2 Service Availability

GPRS/EDGE services are activated after proper GPRS/EDGE ATTACH and PDP activation sequences before a user can actually connect to the destination on the internet. In our first phase of defining of KPIs, it is recommended that we do not categorize networks over the time duration taken in performing these protocols. However if a failure on attach or PDP activation occurs, then a user is unable to access the internet cloud. Therefore for the first phase it is recommended that only GPRS/EDGE ATTACH and PDP activation success be measured. Moreover the general user may not be more interested in how he connects to the internet as long as the connection time is within reasonable limits.

Categorization on the basis of this KPI is at Annex-A (*Table-1*).

4.2 Latency

Latency in a packet-switched network is measured either *one-way* (the time from the source sending a packet to the destination receiving it), or *round-trip* (the one-way latency from source to destination plus the one-way latency from the destination back to the source). For end to end testing, round trip is better suited.

Categorization on the basis of this KPI is at Annex-A (*Table-2*).

4.3 Link Speed

It is the speed at which UE is connected to its serving BTS. A good connection speed however does not guarantee a good connection to any web server. Infact it provides information about the capability of the host cellular GPRS/EDGE network at that time. For example a good Link speed may mean a good service provider network but on the other hand it may also mean that your network is relatively less loaded with real-time traffic (voice and data) and therefore it can allocate the available resources to the data request.

As shown in Fig: 3, GSM has eight time slots per frame. The time slot speed is dependent on channel conditions. The speeds, mentioned in Table-A, are dynamically chosen and eventually result in determining the overall download speed when a user may get. Based on these two parameters we can have an 8x9 matrix for EDGE and a 3x4 matrix for GPRS providing various speeds per time slot.

Ratings for GPRS/EDGE link speeds (see Annex-A (*Table-3*)) are based on the above mentioned criteria. For example a good edge network would allocate between '4 time slots at MCS-7 per second' upto '5 time slots at MCS-8' or any other combination ensuring the speeds per second remain within the anticipated limits.

4.4 Throughput

One of the most important and user specific KPI is the overall throughput you can get from your GPRS/EDGE service. These have been further subdivided into 'download' and 'upload' speeds as seen below. While recommending Throughput speeds differentiation has also been made between urban and rural area requirements. 5 time slots at MCS-8 rate are considered excellent for DL.

The average data speeds (both upload & download) of the test samples (minimum 5 samples proposed) should be at least 60 % of the of the peak link speeds for at-least 70% of the time during which measurements were made.

4.4.1 Download Speeds

Most of the time user uses the GPRS/EDGE service for surfing, downloading an email attachment etc. Consequently every service provider desires to stress on download speeds. For most users it has become a key parameter of interest for both the users and the service providers. Following assumptions were made while devising the KPIs:

4.4.1.1 Urban Environment

Ratings for GPRS/EDGE DL speeds (see Annex-A (*Table-4*)) for urban environment are based on the above laid criteria.

4.4.1.2 Rural Environment

Ratings for GPRS/EDGE DL speeds (see Annex-A (*Table-5*)) for rural environment are based on the criteria detailed above.

4.4.1.3 EDGE with Mobility

For EDGE download service during mobility (of over 70Km/h **or** as per the allowable/possible speed limits on the test field) rating should be done using (see Annex-A (*Table-6*)). These are half of the average of the corresponding fixed rural and urban download speeds.

4.4.2 Upload Speeds

Uploads using EDGE/GPRS are rather rare as compared to downloads, however there are instances of small documents and excel sheets uploaded by people for business applications or peer-to-peer uploads. Following assumptions were made while devising the KPIs:

4.4.2.1 Urban Environment

Ratings for GPRS/EDGE UL speeds (see Annex-A (*Table-7*)) for urban environments are based on criteria detailed above.

4.4.2.2 Rural Environment

Ratings for GPRS/EDGE UL speeds (see Annex-A (*Table-8*)) for urban environments are based on criteria detailed above.

4.4.2.3 EDGE with Mobility

For EDGE upload service during mobility (of over 70Km/h **or** as per the allowable/possible speed limits on the test field) rating should be done using (see Annex-A (*Table-9*)). These are half of the average of the corresponding fixed rural and urban uploaded speeds.

4.5 Retainability

Once a connection is established, user should be assured that his request is served during the whole session. Link may get disconnected on the access channel side due to propagation conditions or a case may be that link between UT & Node B exists but user is no longer able to access the desired IP address. The rating is done based on 'best of three' attempts criteria.

Performance of network can be verified according to the criteria laid down in Annex-A (*Table-10*).

Rating Tables

Tech.	Type	Pass	Fail
GPRS & Edge	Network	Network available	Network not available
	Service	Time < 7 sec	Time > 7sec

Table-1 KPI: Availability

Tech.	Good	Average	Poor	Unsatisfactory
GPRS	Delay <500ms	500ms - 800ms	800ms -1000m	Above 1sec
EDGE	Delay <100ms	100ms - 200ms	200ms – 500ms	Above 500 ms

Table-2 KPI: Latency

Tech.	Excellent	Good	Average	Poor	Unsatisfactory
GPRS	Over 43.2kbps	Between 43.2kbps - 36kbps	Between 36kbps - 24kbps	Between 24kbps - 12kbps	Below 12kbps
EDGE	Over 272kbps ¹	Between 272kbps ¹ - 179.2kbps	Between 179.2kbps - 88.8kbps	Between 88.8kbps - 44.8kbps	Below 44.8kbps

Table-3 KPI: Link Speed

Tech.	Unit	Excellent	Good	Average	Poor	Unsatisfactory
GPRS	Throughput	Over 6.48kbps	Between 6.48 kbps - 5.4kbps	Between 5.4kbps - 3.6kbps	Between 3.6kbps - 1.8kbps	Below 1.8kbps

	Time taken (approx)	Less than 77.2sec	Between 77.2sec – 92.6sec	Between 92.6sec – 139sec	Between 139sec – 278sec	Above 278sec
EDGE	Throughput	Over 40.8kbps ²	Between 40.8kbps ² – 26.88kbps	Between 26.88kbps – 13.32kbps	Between 13.32sec – 6.72sec	Below 6.72kbps
	Time taken (approx)	Less than 12.2sec	Between 12.2sec – 18.6sec	Between 18.6sec – 37.53sec	Between 37.53sec – 74.4sec	Above 74.4sec

Table-4 KPI: Throughput - DL Urban

Tech.	Unit	Excellent	Good	Average	Poor	Unsatisfactory
GPRS	Throughput	Over 13kbps	Between 13kbps – 10.8kbps	Between 10.8kbps – 7.2kbps	Between 7.2kbps – 3.6kbps	Below 3.6kbps
	Time taken (approx)	Less than 38.5sec	Between 38.5 sec – 46.3sec	Between 46.3sec – 70sec	Between 70sec – 139sec	Above 139 sec
EDGE	Throughput	Over 81.6kbps ³	Between 81.6.kbps ³ – 53.8kbps	Between 53.8kbps – 26.64kbps	Between 26.64kbps – 13.44kbps	Below 13.44kbps
	Time taken (approx)	Less than 6.13sec	Between 6.13sec – 9.3sec	Between 9.3sec – 18.8sec	Between 18.8sec – 37.2sec	Above 37.2sec

Table-5 KPI: Throughput – DL Rural

Tech.	Unit	Excellent	Good	Average	Poor	Unsatisfactory
EDGE	Throughput	Over 30.6kbps ⁴	Between 30.6kbps ⁴ – 20.17kbps	Between 20.17kbps – 10kbps	Between 10kbps – 5kbps	Below 5kbps

	Time taken (approx)	Less than 16.33sec	Between 16.33sec – 24.8sec	Between 24.8sec – 50sec	Between 50sec – 100sec	Above 100sec
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Table-6 KPI: Throughput – DL EDGE Mobility

Tech.	Unit	Excellent	Good	Average	Poor	Unsatisfactory
GPRS	Throughput	Over 4.8kbps	Between 4.8kbps – 4.32kbps	Between 4.32kbps – 3.6kbps	Between 3.6kbps – 2.4kbps	Below 2.4kbps
	Time taken (approx)	Less than 20.8.8sec	Between 20.8sec - 23.1 sec	Between 23.1sec – 27.7sec	Between 27.7sec – 41.7sec	Above 41.7sec
EDGE	Throughput	Over 18kbps	Between 18kbps - 9kbps	Between 9kbps – 6kbps	Between 6kbps – 3.5kbps	Below 3.5kbps
	Time taken (approx)	Less than 5.5sec	Between 5.5sec – 11.11sec	Between 11.11sec – 16.7sec	Between 16.7sec – 28.6sec	Above 28.6sec

Table-7 KPI: Throughput - UL Urban

Tech.	Unit	Excellent	Good	Average	Poor	Unsatisfactory
GPRS	Throughput	Over 9.6 kbps	Between 9.6kbps – 8.64kbps	Between 8.64kbps – 7.2kbps	Between 7.2kbps – 4.8kbps	Below 4.8kbps
	Time taken (approx)	Less than 10.41sec	Between 10.41sec - 11.6 sec	Between 11.6sec – 14 sec	Between 14sec – 21sec	Above 21sec
EDGE	Throughput	Over 26.9kbps	Between 26.9kbps - 13.4kbps	Between 13.44kbps – 10.56kbps	Between 10.56kbps – 5.3kbps	Below 5.3kbps

	Time taken (approx)	Less than 3.7sec	Between 3.7sec – 7.5sec	Between 7.5sec – 9.47sec	Between 9.47sec – 19sec	Above 19sec
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Table-8 KPI: Throughput - *UL Rural*

Tech.	Unit	Excellent	Good	Average	Poor	Unsatisfactory
EDGE	Throughput	Over 11.22kbps	Between 11.22kbps – 5.6kbps	Between 5.6kbps – 4.14kbps	Between 4.14kbps – 2.2kbps	Below 2.2kbps
	Time taken (approx)	Less than 8.91sec	Between 8.91sec – 18sec	Between 18sec – 24.15sec	Between 24.15sec – 45.5sec	Above 45.5sec

Table-9 KPI: Throughput – *UL EDGE Mobility*

Tech.	Excellent	Good	Poor	Unsatisfactory
GPRS & Edge	No disconnection	1 Disconnection out of three	2 disconnections out of three	More than 2 Disconnections

Table-10 KPI: Retainability