NOKIA

BSS11.5
GSM/EDGE

BTS EDGE Dimensioning

Nokia Proprietary and Confidential

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Summary of changes

This is the first version of the document.

1 Abbreviations

3GPP	3rd Generation Partnership Project
Abis	Interface between BTS and BSC
APN	Access point name
ARP	Allocation/retention priority
BER	Bit error rate
BSC	Base station controller
BSS	Base station subsystem
BSSGP	Base station system GPRS protocol
BTS	Base station
BVC	BSSGP virtual connection
CCCH	Common control channel
CDR	Call detail record
CM	Configuration management
CS	Coding scheme
CSW	Circuit switched
DFCA	Dynamic frequency and channel allocation
DL	Downlink
DR	Dual rate
EDAP	EGPRS dynamic Abis pool
EDGE	Enhanced data rates for GSM evolution
EQoS	Enhanced Quality of Service
ET	Exchange Terminal
FM	Fault monitoring
FTP	File transfer protocol

FR	Frame relay
Gb	Interface between BSC and SGSN
GB	Guaranteed bit rate
GGSN	Gateway GPRS support node
Gi	Interface from GGSN towards the other network (Internet)
Gn	Interface between SGSN and GGSN
GPRS	General packet radio service
GWSB	Group switching in BSC
HLR	Home location register
HR	Half rate
HTxx	Hilly terrain xx km/h propagation model
IDD	Intelligent downlink diversity
IFH	Intelligent frequency hopping
IUO	Intelligent underlay overlay
ISN	Intelligent service node
IP	Internet protocol
KPI	Key performance indicator
LLC	Link layer control
MCMU	Marker and cellular management unit
MCS	Multi coding scheme
MMS	Multimedia message
MS	Mobile station
MOS	Mean opinion score
Non-GB	Non-guaranteed bit rate
PAPU	Packet processing unit
PCU	Packet control unit
PDP	Packet data protocol
PFC	Packet flow context
PM	Performance monitoring
PoC	Push to talk over cellular
PS	Packet switched
PTT	Push to talk
QoS	Quality of Service

RAxx	Rural area xx km/h propagation model
RLC	Radio link control
RTT	Round trip time
SDCCH	Slow dedicated control channel
SDU	Serving data unit
SGSN	Serving GPRS support node
SQM	Service quality manager
SSS	Scheduling step size
STC	Streaming traffic class
STT	Start to talk
TBF	Temporary block flow
TCH	Traffic channel
THP	Traffic handling priority
TREC	Treatment class
TSL	Timeslot
TUxx	Typical urban xx km/h propagation model
UL	Uplink
VTD	Voice transfer delay
WAP	Wireless access protocol

2 Terms and definitions

BTS: BTS equipment, including all the BCFs on the same site.

Cell: Logical cell at the BTS site, usually transmitting from the antenna(s) of one sector.

GB: In this document, guaranteed bit rate refers to dedicated data capacity (dedicated timeslots) or guaranteed throughput. This is per cell, not per user.

Non-GB: In this document, non-guaranteed bit rate refers to non-dedicated (default) data capacity or non-guaranteed throughput. This is per cell, not per user.

3 About this document

This document is a part of EDGE dimensioning documentation set (Figure 1) that includes dimensioning guidelines for BTS, Abis, BSC, Gb, and SGSN network elements and interfaces. All these documents are based on the same assumptions about the basic configuration needs (for example, traffic mix between circuit switched and packet traffic. Consequently, the documents are linked to the same traffic assumptions and network configurations. As a result, it is possible to perform a full BSS dimensioning of the basic configurations from BTS to SGSN by following these documents.

This document provides guidance for dimensioning Nokia base stations for EDGE into an existing GSM network. This document concentrates on calculating the needed HW equipment and modules. That is, the number of TRXs that satisfies the required capacity for both voice and data services on a BTS.

The output from this document is used for dimensioning the BSC, SGSN, and the transmission interfaces (Abis and Gb) between the network elements.

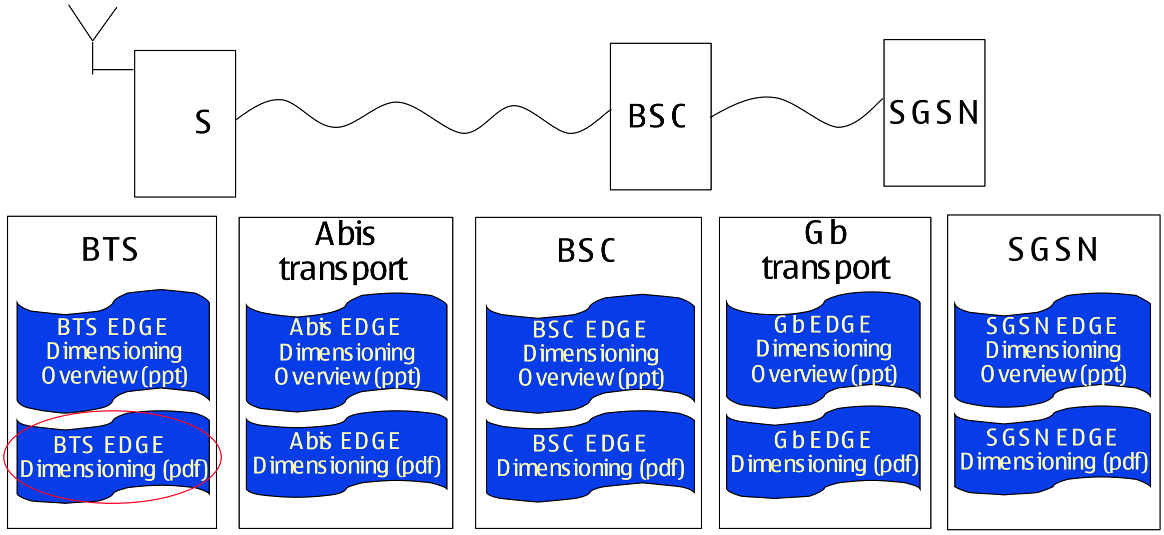


Figure 1. BTS, Abis, BSC, Gb, and SGSN dimensioning documentation set[1]

The EDGE dimensioning documentation set focuses only on the dimensioning phase. It does not cover the network planning or network optimisation phases. Nokia provides services and training for the dimensioning, planning, and optimisation phases. For details, contact your local Nokia representative.

Nokia provides the EDGE dimensioning instructions with detailed numeric values in the examples. The examples only illustrate the dimensioning process and the related calculations. The parameter values used in the examples are not Nokia recommendations. Nokia customers should analyse their own network status and the desired dimensioning outcome carefully before starting the dimensioning work.

[1] Contact your local Nokia representative to obtain the overview slide sets

4 Used dimensioning method

4.1 Process of dimensioning BTS

The accuracy of dimensioning of BTS depends on the accuracy of the input values. The capacity of the air interface has a significant role in defining the capacity of the rest of the network elements in the BSS and GPRS core network (the BSC, SGSN, and transmission interfaces between the different elements).

Changes in the BTS configurations have direct impact on the BSC and SGSN configuration. The BSC can handle a limited number of BTSs, TRXs, and timeslots. The PCUs have maximum data traffic limitations and restrictions for the number of PAPU units in the SGSN.

Figure 2 presents the process of dimensioning data traffic on top of voice traffic (the available capacity strategy). Figure 3 presents the process of dimensioning data traffic for the required capacity strategy.

Available capacity strategy

1. Calculate the available data TSLs

   1.1 Calculate/measure the current voice traffic per cell

   – If the measured traffic is not available, use the current configuration for voice traffic calculations (that is, based on the number of available traffic timeslots)

   1.2 Make a note of the signalling channels and free timeslots

   1.3 Calculate the available timeslots for data traffic:

   8 x the number of TRXs – signalling channels – free TSLs – voice erlangs

2. Calculate the achieved TSL throughput

   2.1 Consider the coverage and interference situation

   – Deployment strategy

   2.2 Estimate the GPRS/EGPRS division

2.3 Estimate the average throughput per TSL for GPRS and EDGE

- Calculate the average throughput on different cell layers

2.4 Calculate the average throughput per TSL

- Use the GPRS/EGPRS traffic division from step 2.2

3. Calculate the achieved average throughput

3.1 Multiply the number of data TSLs by the average throughput per TSL

- Calculate the average throughput on different cell layers

4. Check the result

4.1 If the data throughput is too low, consider introducing half rate or dual rate for voice to increase the number of TSLs for data

For more information on the available capability strategy, see Section 8.1.

Required capacity strategy

1. Calculate the required throughput

1.1 Calculate the payload per cell during busy hour

- The number of data users or data user penetration
- Data user profile(s)

1.2 Transfer payload to throughput (kbps)

1.3 Make of note of whether the throughput has to be guaranteed or not (GB or non-GB)

2. Estimate the average data throughput per timeslot, based on assumptions of the applied deployment strategy

2.1 Frequency band

2.2 Indoor/outdoor

2.3 GPRS/EGPRS division

2.4 Estimate the achieved throughput/TSL of the different layers

3. Calculate the needed TSLs/TRXs and the final throughput

3.1 Calculate the needed data TSLs

3.2 Make a note of the needed voice TSLs at the required blocking rate

- GB/non-GB

3.3 Calculate the needed signalling channels

- Combined/non-combined
- SDCCH configuration

3.4 Make a note of the free TSLs

3.5 Calculate the number of required TRXs

3.6 Calculate the achieved throughput with the required configuration

4. Check the result
   - OK
   - Over dimensioned
     - Introduce half rate/dual rate
     - Lower throughput requirements

       Lower throughput requirements:

       Check if there is enough bandwidth (C/I requirements can be met) for the amount of TRXs.
       - OK
       - If not OK, take the necessary actions

For more information on the required capability strategy, see Section 8.2.

Step 1: Calculate the available data TSLs

- 1.1 Calculate/measure the current voice traffic (based on measurements or configuration)
- 1.2 Make a note of the signalling channels and free timeslots
- 1. 3 Calculate the available timeslots for data traffic

The available TSL for data is: 8 x TRX – signalling channels – free TSLs – voice erlangs

Step 2: Calculate the achieved TSL throughput

- 2.1 Consider the coverage and interference situation (deployment strategy)
- 2.2 Estimate the GPRS/EGPRS division
- 2.3 Estimate the average throughput for GPRS and EDGE
- 2.4 Calculate the average throughput per TSL

Step 3: Calculate the achieved average throughput

- 3.1 Multiply the data TSLs by the average throughput per TSL (calculate the average throughput on different cell layers)

Step 4: Check the result

- 4.1 If the data throughput is too low, consider introducing half/dual rate for voice to increase the number of TSLs for data

Figure 2. BTS dimensioning process for the available capacity strategy

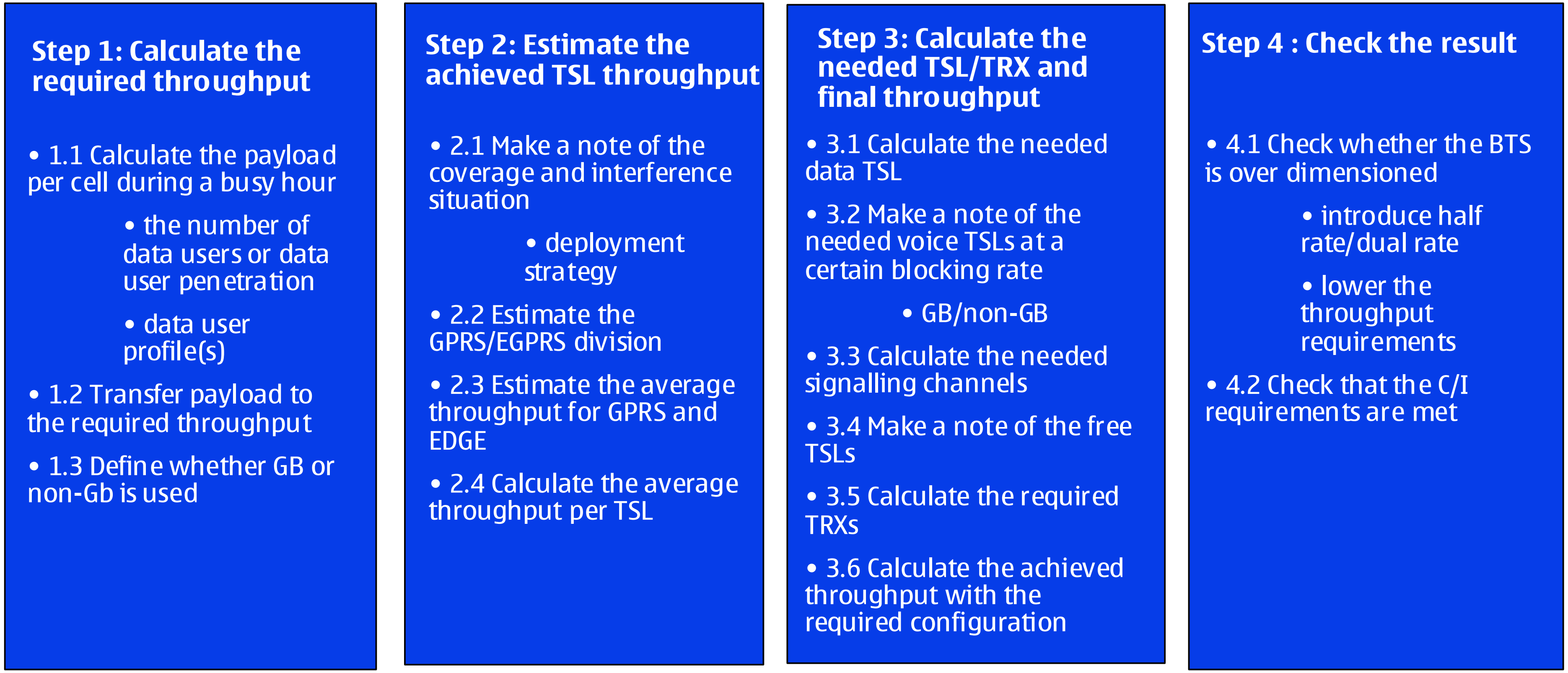


Figure 3. BTS dimensioning process for the required capacity strategy

5 Product overview

This document concentrates on the dimensioning of Nokia base station products that support EDGE. These products are Nokia UltraSite and Nokia MetroSite.

5.1 Nokia UltraSite

Nokia UltraSite EDGE BTS is a part of the Nokia UltraSite macrocellular solution. The solution delivers high-capacity and wide-coverage macrocellular BTS products, complete with transmission and auxiliary equipment. Nokia UltraSite EDGE BTS supports both omni-directional and sectored configurations for traditional voice and future data applications. The BTS can be used in GSM 800, 900, 1800, or 1900 systems, or as a GSM 800/1900 or GSM 900/1800 dual-band BTS. One UltraSite cabinet can contain between one and 12 (six transceivers with an integrated battery backup unit) transceivers (TRXs) in an omni-directional or sectored configuration.

5.2 Nokia MetroSite

The Nokia MetroSite EDGE Base Station is an all-climate BTS available for GSM 900, 1800, and 1900 and GSM/EDGE 800, 900, 1800, and 1900 systems, or as a dual band GSM 900/1800 or dual band GSM/EDGE 900/1800, 800/1800 or 800/1900 BTS. One MetroSite cabinet can contain between one and four transceivers in omni-directional or sectored configuration. Capacity can be increased by chaining up to three Nokia MetroSite EDGE base stations (including up to 12 TRXs) together as one base control function (BCF) object.

6 Generic assumptions

This chapter describes the theory behind calculating (or estimating) the throughput per timeslot. The TSL throughput calculation is important because the required number of timeslots for data is totally dependent on the throughput of a single timeslot.

Experiences from different networks show that the average throughput per timeslot for EDGE is about 30-36 kbps.

6.1 Coverage

In a packet switched network, the quality of service perceived by the user is typically measured by the data throughput and the effective delay of the transmitted data. Detailed network planning of the radio interface should ensure that the required coverage, capacity, and user throughput is available for the system launch.

The coverage planning aspects of GPRS implementation concern the provision of sufficient carrier-to-noise (C/N) ratios across the coverage area to allow for successful data transmission, on both uplink and downlink. Each coding scheme defined for GPRS is suited to a particular range of C/N (or Eb/No) for a given block error rate (BLER). Generally, the higher the level of error protection, the lower required C/N.

Due to the differing C/N requirements of the coding schemes, the relative coverage area of each is different. In addition to the existing GSM voice service, it is useful to compare the relative predicted coverage areas of the coding scheme.

In a mobile network, cells have to overlap to ensure mobility. This results in a better overall coverage than in a case of an isolated cell. In urban areas, cells tend to be much closer to each other. In this case, coverage is not usually the limiting factor but the interference caused by reused frequencies.

For example, in a dense urban environment where indoor coverage has to be good, handovers may take place at very high RX level values. In this case, it is possible that even the highest coding schemes can be used almost everywhere within that cell if the interference level is low.

Table 1 and Table 2 show the input signal level at reference performance for GMSK modulated signals (BTS) and 8-PSK modulated signals (MS) for GSM 900 and GSM 850. The tables give reference values for the minimum signal level for different coding schemes. That is, the received signal level (without interference) has to be at certain level to achieve the maximum throughput per TSL. For example, for a MS receiving with the coding scheme MCS-6 (8-PSK modulated signal), the signal level has to be at least -91 dBm without any interference (in the typical urban 50 km/h propagation model without frequency hopping) to achieve the maximum throughput of 29.6 kbps per TSL. Below this signal level, a lower coding scheme has to be used.

Table 1. Input signal level (for a normal BTS) at reference performance (BLER < 10%) for GMSK modulated signals. The table is from 3GPP specifications [2]. [2]

Type of channel	Propagation conditions	static	TU50 (no FH)	TU50 (ideal FH)	RA250 (no FH)	HT100 (no FH)
PDTCH/CS-1	dBm	-104(x)	-104	-104(x)	-104(x)	-103
PDTCH/CS-2	dBm	-104(x)	-100	-101	-101	-99
PDTCH/CS-3	dBm	-104(x)	-98	-99	-98	-96
PDTCH/CS-4	dBm	-101	-90	-90	*	*

Table 2. Input signal level (for a MS) at reference performance for 8-PSK (BLER < 10%) modulated signals. The table is from 3GPP specifications [2]. [3]

Type of channel	Propagation conditions	static	TU50 (no FH)	TU50 (ideal FH)	RA250 (no FH)	HT100 (no FH)
PDTCH/MCS-5	dBm	-98	-93	-94	-93	-92
PDTCH/MCS-6	dBm	-96	-91	-91,5	-88	-89
PDTCH/MCS-7	dBm	-93	-84	-84	*	-83**
PDTCH/MCS-8	dBm	-90,5	-83**	-83**	*	*
PDTCH/MCS-9	dBm	-86	-78,5**	-78,5**	*	*

[2] PDTCH for MCS-x cannot meet the reference performance for some propagation conditions (*).

[3] PDTCH for MCS-x cannot meet the reference performance for some propagation conditions (*). Performance is specified at 30% BLER for the cases identified with **.

6.2 Interference

The minimum BTS and mobile station (MS) performance in interference-limited scenarios have been included in the 3GPP specifications. The minimum performance is specified as the minimum carrier-to-interference (C/I) required to achieve 10% BLER for different channel conditions (see Table 3).

In addition to the fact that the signal level has to be at a minimum level for certain throughput, it also has to exceed the minimum required C/I value for that particular coding scheme. Using the same example as above, a MS receiving with coding scheme MCS-6 (minimum signal level -91 dBm) can use the maximum throughput per TSL if the current interference level is 18 dB below the current signal level.

The values in the tables are minimum required values. The real throughput achieved is affected by the MS and BTS properties.

The current interference situation in a mobile network depends on the deployment strategy (see Chapter 7).

Table 3. Minimum C/I for BLER < 10% in interference-limited scenarios (900 MHz band). The table is from 3GPP specifications [2].

Type of channel	Propagation conditions TU3 (no FH)	TU3 (ideal FH)	TU50 (no FH)	TU50 (ideal FH)	RA250 (no FH)
PDTCH/CS-1	13	9	10	9	9
PDTCH/CS-2	15	13	14	13	13
PDTCH/CS-3	16	15	16	15	16
PDTCH/CS-4	19	23	23	23	Performance not met
PDTCH/MCS-1	13	9	9	9	9
PDTCH/MCS-2	15	13	13	13	13
PDTCH/MCS-3	16	15	16	16	16
PDTCH/MCS-4	21	23	27	27	Performance not met
PDTCH/MCS-5	18	14.5	15.5	14.5	16
PDTCH/MCS-6	20	17	18	17.5	21
PDTCH/MCS-7	23.5	23.5	24	24.5	26.5 (30% BLER)
PDTCH/MCS-8	28.5	29	30	30	Performance not met
PDTCH/MCS-9	30	32	33	35	Performance not met

7 Deployment strategy

An operator may have more than one layer (frequency or logical) in use in the network. The way data is deployed on different layers has an impact on the achieved throughput per timeslot.

This chapter discusses different deployment strategies in detail.

7.1 Single band network

An operator with a single frequency band and narrow bandwidth has a challenging task for frequency planning. In such a case, even the BCCH frequencies can be relatively interfered, at least in macro cells. To lower the interference level in the network, the operator may introduce half rate and start building micro and indoor cells.

If the operator has a fairly wide bandwidth in use, it is possible to divide the frequencies for BCCH and TCH usage to ensure better quality on the BCCH frequencies. Packet data can then be used on the BCCH TRXs to guarantee as large a data coverage as possible. In addition, half rate, micro and indoor cells may be used to lower the overall interference.

7.2 Dual band network

A dual band network allows the operator to use two different frequency bands for both voice and data services. In areas of high traffic density, the propagation loss of the higher frequency band ensures lower interference level in the network.

7.3 Macro/micro cells

The location of the BTS antennas dictates the propagation environment. Macro cells have antennas above the average height of the rooftops, whereas micro cells have antennas clearly below rooftops, increasing propagation loss significantly. In a dense traffic environment, micro cells lower the total interference level in the network, because the signals attenuate rapidly. This allows the operator to build a high-capacity network even if the bandwidth is fairly narrow.

In a macro cell environment, signals propagate further, causing interference. When building macro sites, it is important to use antenna tilting and avoid situations where antennas point towards water areas or cause interference to remote areas (in other areas where radio waves propagate easily). In addition, it is recommended to use antennas with a low vertical beam width.

A useful way to lower the interference from macro cells is to use natural or man-made obstacles to point antennas to. This attenuates the signal propagation towards a certain direction.

7.4 Indoor/outdoor

Operators are forced to build coverage to practically almost anywhere where customers require service. This naturally includes indoor locations, such as office buildings, shopping centres, airports, and underground parking garages. In these areas, interference is not usually as big a problem as in an outdoor environment. Walls, ceilings, and other materials in buildings or other indoor locations absorb signal energy. This decreases interference. However, it makes building indoor coverage more challenging, especially in large indoor areas.

In indoor areas, interference tends to be very low regardless of the signal level. This allows very high data rates for PSW if the signal level is adequate.

7.5 Estimating the throughput per TSL

Chapter 6 presented the minimum requirements for C/N (coverage) and C/I (interference) for different coding schemes. This section discusses how the operator's deployment strategy has an effect both to coverage and interference.

If the network has already been launched with data (GPRS) services, the operator can monitor the average throughput values on a cell level and estimate the average throughput per timeslot.

If the operator has not started with data services, measuring the average coverage and interference levels in the network helps to estimate the average data throughput values.

If the network has not been launched or if the measuring would take too much time and resources, it is possible to use radio network planning tools to predict the average coverage and interference levels and estimate the average throughput values for EGPRS services.

7.6 Hardware related limitations

7.6.1 BB2E/BB2F

In UltraSite EDGE BTS, the GSM/EDGE RF unit (TSxB) always requires an EDGE capable baseband unit (BB2E or BB2F) even if it operates in GSM mode only.

The EDGE capable baseband unit (BB2E or BB2F) is backward compatible and also supports the GSM RF unit, TSxA. Table 4 shows the compatibility for the different BB2x and TSxx combinations.

EGPRS support requires an EDGE capable baseband unit (BB2E or BB2F) and and EDGE capable RF unit (TSxB).

Table 4 GSM/EDGE HW compatibility

BB2A + TSxA	OK
BB2A + TSxB	NOK
BB2E + TSxA	OK
BB2E + TSxB	OK
BB2F + TSxA	OK
BB2F + TSxB	OK

7.6.2 Transceiver units

This section describes the different BTS configurations in detail and includes recommendations for EGPRS.

7.6.2.1 Low configurations (one or two TRX per cell)

The options are limited for one TRX per cell. EGPRS must be on the same TRX as the BCCH. It is recommended to set the dedicated/default EGPRS territory to start from the last TSL 7 to maintain the data continuity.

For two TRXs per cell, it is possible to decide whether EGPRS is set on the BCCH or TCH TRX. Setting the EGPRS territory on the BCCH TRX may ensure better C/I performance if the operator has a limited frequency band in use for the TCH TRXs.

It is recommended to introduce EGPRS in the BCCH layer first and then, when required (when there are no more TSLs available in the BCCH TRX), use the hopping layer. If the EDGE TRXs (TSxB) is used, the baseband unit must be BB2E or BB2F (see Section 7.6.1). If TsxA is used, any baseband unit can be selected.

7.6.2.2 High configurations (more than three TRXs per cell)

The same information applies as in the previous sections. If BB hopping is used in a cell (preferably at least three TRXs), there are a few alternatives for HW configuration.

7.6.2.3 GSM HW configuration: BB2A + TsxA

No limitations in baseband hopping: BB hopping can be used in the GSM mode.

7.6.2.4 GSM HW configuration with EDGE BB unit BB2E or BB2F + TsxA

No limitations in baseband hopping: BB hopping can be used in the GSM mode.

7.6.2.5 GSM/EDGE HW configuration: BB2E or BB2F + TSxB

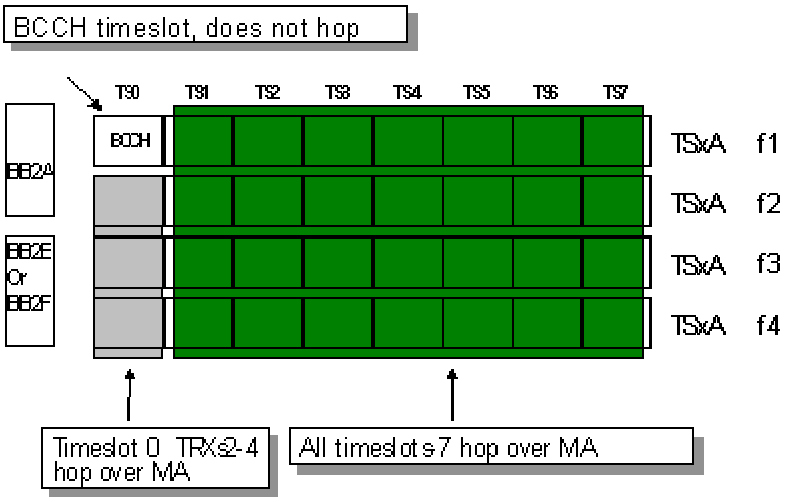
No limitations in baseband hopping. This configuration also supports BB hopping when EGPRS is activated.

7.6.2.6 Mixed GSM HW with GSM/ EDGE HW configurations

This section shows baseband hopping functionality in mixed configurations, where GSM and GSM/ EDGE hardware are in the same sector/ layer. Note that in mixed configurations, baseband hopping is supported in the GSM mode only.

7.6.2.7 BB2A and BB2E or BB2F with TSxA

Nokia UltraSite EDGE BTS SW CX3.3-1 allows baseband hopping in configurations where GSM RF units (TSxA) are controlled by any baseband unit. This is not possible with BTS SW releases prior to CX3.3-1.



The diagram above illustrates a baseband hopping configuration with four TSxAs controlled by one BB2A and one BB2E or BB2F.

7.6.2.8 BB2A and BB2E with TSxA and TSxB

Baseband hopping between TSxA and TSxB is not possible in this configuration without the multi-BCF feature. The TSxB and TSxA units need to be configured in their own hopping groups and have separate BTS objects for TSxA and TSxB units.

For more information on the multi-BCF feature, see Section 7.6.2.10.

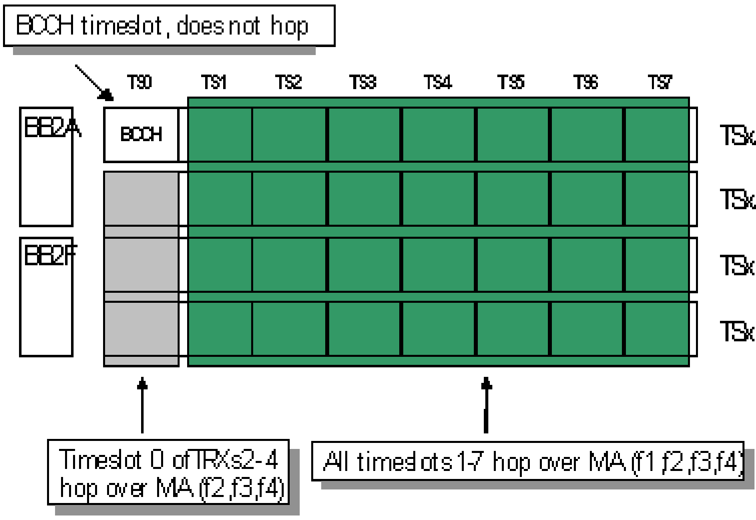
7.6.2.9 BB2A and BB2F with TSxA and TSxB

CX3.3-1 SW package and BB2F unit enable a mixed configuration BB hopping groups to be formed within UltraSite EDGE BTS.

Mixed configuration BB hopping has the following constraints:

- A mixed configuration hopping group is restricted to GMSK calls only.
- Each new TSxB that is configured for mixed configuration BB hopping requires a BB2F unit to control it. In this way, TSxB may be used to replace TSxA without loss of GMSK functionality.

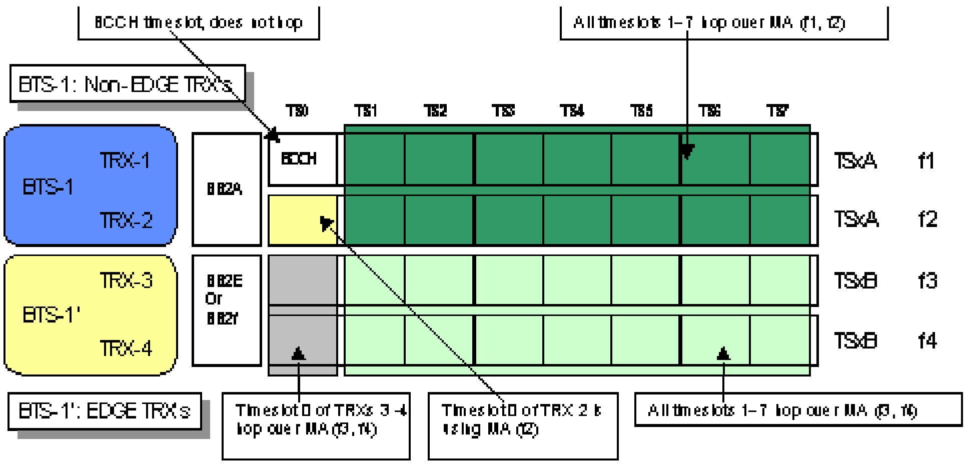
The following diagram illustrates a possible mixed configuration BB hopping group with two TSxAs and two TSxBs, controlled by one BB2A and one BB2F.



7.6.2.10 Mixed GSM HW with GSM/EDGE HW configuration

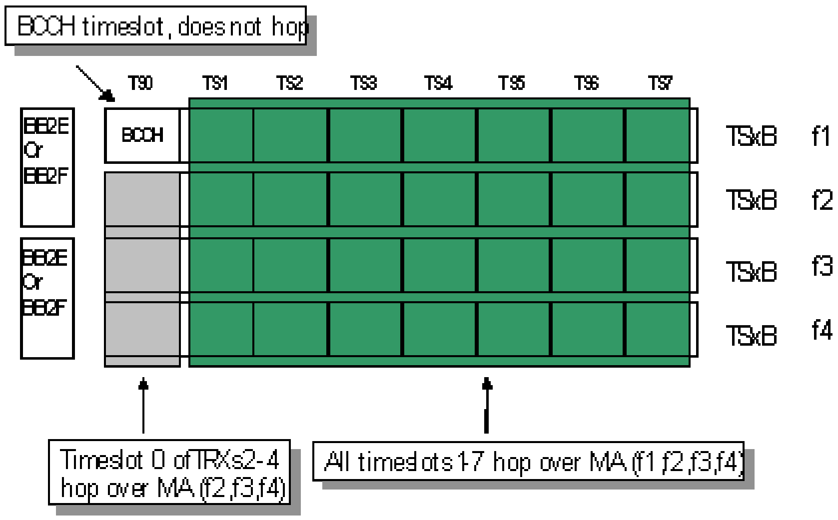
When EGPRS is enabled, the EDGE capable TRXs have to be configured to separate hopping groups from the GSM TRXs.

In mixed GSM HW with GSM/ EDGE HW configurations, the EDGE TRXs can be configured to separate hopping groups by using the multi-BCF feature introduced in BSS10.5. Below is an example configuration that uses the multi-BCF feature. For more information on the multi-BCF feature, refer to the BSS10/10.5 document *Features Under Development*.



7.6.2.11 GSM/EDGE HW configuration

There are no limitations in baseband hopping in the GSM/EDGE configuration when EGPRS is enabled.



7.7 BSS 11.5 software limitations

This section describes the interaction of the new BSS 11.5 features with EGPRS.

7.7.1 Frequency and Channel Allocation (DFCA)

EGPRS cannot be used on the TRXs where DFCA is activated. However, CSW data can be used as usual.

7.7.2 GPRS coding schemes CS-3 and CS-4 (GPRS rel2)

GPRS coding schemes CS-3 and CS-4 are supported in BSS11.5, and they are used in the examples in this document. CS-3 and CS-4 do not fit into one 16 kbit/s Abis/PCU channel. They require the use of the Dynamic Abis Allocation feature and EDGE TRX.

7.7.3 Extended Cell for UltraSite BTS

EGPRS cannot be used simultaneously with Extended Cell for UltraSite.

7.7.4 IDD for MetroSite

EDGE capable TRXs are required with IDD.

7.7.5 IDD with BB hopping

EDGE capable TRXs are required with IDD with BB hopping.

7.7.6 Baseband hopping

TS0 cannot be used for EGPRS because a different hopping group is used for that timeslot.

7.7.7 RF hopping

There are no limitations. The PreferBCCHforGPRS parameter can be used to move GPRS traffic onto a non-hopping carrier.

7.7.8 IUO/IFH

A GPRS MS does not have access to the IUO/IFH super layer.

7.7.9 AMH (TRHO)

Triggering can be configured to support the default GPRS territory.

7.7.10 HSCSD

HSCSD has priority over GPRS, but it can be controlled with HSCSD load parameters.

8 BTS capacity planning

The operator has to make a decision for minimum data throughput per cell if certain data services require guaranteed user bit rate. This affects the amount of dedicated EGPRS timeslots per cell and may cause more blocking for voice services. Within the data territory, the preference between different data services is modified with relevant parameters. This does not have a direct impact on the air interface capacity.

8.1 Available capacity

Using the existing BTS hardware, the operator can, with minimum effort, estimate the available air interface capacity for data services on top of voice. As the current voice traffic is known, it is fairly easy to calculate the average available capacity for data services.

It is possible to estimate the average available timeslots for data by taking into account the current voice traffic at a certain allowed voice blocking rate and calculating the needed free timeslots of the current configuration. By assuming certain throughput per timeslot and estimating the proportion of GPRS/EDGE users, a value for the maximum average throughput per cell can be calculated.

Voice blocking remains unchanged, as long as timeslots are not dedicated for data if voice traffic does not increase.

8.2 Required capacity

The operator may want to estimate the needed capacity based on assumptions on the number of data users in the network and on the average user traffic during busy hour. Different types of user profiles can be in use.

8.2.1 Traffic mix

8.2.1.1 Voice

For voice traffic, the operator has a few options on how the voice capacity is used in the air interface. The most significant impact on the number of needed timeslots is whether half rate is used. In addition, the maximum allowed voice blocking must be defined.

EGPRS cannot be used on half rate TRXs. However, it can be used on dual rate timeslots.

In this document, the voice traffic/user is assumed to be 25 mErl.

8.2.1.2 Data

Data volume per cell can be calculated (or estimated) as the total data volume per cell or it can be based on subscriber information. The simplest way is to estimate the total data volume going through a cell during a busy hour, based on the available average throughput for EGPRS enabled timeslots.

Calculating traffic using subscriber information is more complicated. First, the total number of subscribers (or the data user penetration value) must be known. Then, the user data amount per busy hour must be estimated as a total value or based on assumptions of data usage (for example, WWW, ftp, and e-mail).

Enhanced Quality of Service (EQoS) allows the operator to ensure a minimum guaranteed throughput for subscribers using streaming traffic class (STC). EQoS may cause blocking for CSW users if there is no more capacity available for CS. The PS service requires certain throughput, and PS capacity cannot be downgraded. However, blocking is only temporary and capacity is freed as soon as the STC users do not need it anymore. EQoS makes it possible to limit the number of users obtaining a service simultaneously at the cell. This is not possible with QoS. QoS makes it possible to distribute capacity between different user types and applications.

The concept of EQoS is complex and estimating data traffic behaviour of users is very difficult. In this document, the dimensioning is done based on average values. This is not directly affected by EQoS. Detailed planning and optimisation is required to take EQoS into account in the dimensioning phase. EQoS is not used in the example cases of this document.

Another significant factor in the dimensioning of the air interface is the coding scheme. This coding scheme has a significant role when the total throughput on cell basis is calculated. For GPRS, the slowest coding scheme CS-1 has a user bit rate of 8 kbps; the fastest CS-4 has a user bit rate of 20 kbps. For EGPRS, the respective values are 8.8 kbps for MCS-1 and 59.2 kbps for MCS-9.

8.2.1.3 Subscriber information (BH)

EGPRS best effort user information (example values):

- 30% of the total users

- One e-mail (5 kB)
- Three WWW pages (30 kB)
- One MMS (30 kB)
- A total of 65 kB per BH = 520 kbits

EGPRS streaming user information:

- 10 % of the total users (30% of the data users)
- One e-mail (5 kB)
- Two WWW pages (20 kB)
- Three minutes of streaming (~50 kbps => 9 Mb ~ 1 MB)
- A total of 9.2 Mbits

9 BTS dimensioning

9.1 Traffic mix

This section considers the dimensioning for a mixed traffic profile. As stated in Chapter 6, traffic planning includes a combination of voice and EGPRS (packet-mode) data. The first service requires a continuous connection for extended periods (tens of seconds, typically, for voice) while the latter can typically operate in a non-continuous mode with resources being allocated as and when available (capacity on demand).

9.1.1 Voice

The dimensioning examples in this document use three different environments. These are urban, residential, and rural.

In the urban area, the traffic density is fairly high (for example, 300 Erl/km2) and the network is interference limited. In the residential area, the traffic density can be, for example, around 10-30 Erl/km2 (this depends highly on population density). Outdoors, the network is still interference limited; indoors, the network is coverage limited. In the rural area, the traffic density is very low (for example, < 1 Erl/km2) and the network is coverage limited everywhere.

9.1.2 Data

The same area definition is used for data as for voice. For the urban area, the following requirements for data services per cell are assumed: 10% data user penetration and 90/10 division of best effort/STC users. For the residential area, the respective values are 5% and 95/5. For the rural area, the respective values are 2 % and 95/5.

The division between GPRS and EDGE traffic in the examples is 70/30.

The effect of occupancy or traffic mix is not taken into account in this document.

9.2 Signalling channels

9.2.1 Common BCCH

The usage of a common BCCH has an effect only on dual band sectors where the cell signalling channels of the other band are not needed, leaving more timeslots for voice and data. In this document, a common BCCH is not taken into account in the calculations.

9.2.2 GSM and EGPRS sharing CCCH

According to *GSM, GPRS and EDGE Performance* [1], one CCCH supports from one to two TRXs with the combined configuration and from two to seven TRXs with the non-combined configuration. The blocking probability is 0-2%. For voice, a non-combined configuration is normally needed for just two TRXs.

9.2.3 EGPRS on PCCCH (GPRS rel2)

According to *GSM, GPRS and EDGE Performance* [1], one PCCH allocated on one PDCH supports more than six TRXs dedicated to EGPRS. The blocking probability is 0-2%. If the PCCH is used, EGPRS does not have an impact on the AGCH and PCH. The PBCCH must be on the same TRX as the BCCH.

9.3 Dedicated, default, and additional GPRS territories

It is possible to define, per cell, dedicated timeslots exclusively for GPRS. Only GPRS can use these TSLs that can cause additional blocking for voice services. By using dedicated timeslots, the operator can ensure a minimum throughput for packet switched services. Circuit switched traffic has priority outside the dedicated territory. Within the default GPRS territory, timeslots are allocated for GPRS when the CSW load permits this. A dedicated territory is a subset of the default territory.

When the default GPRS capacity is allocated to GPRS, and the GPRS load increases, the PS RRM can request additional TSLs. Based on the circuit-switched load, the CSW RRM controls the allocation of additional TCHs. The territories consist of consecutive timeslots which is important for multislot operation. The maximum GPRS territory is defined by the MAX GPRS capacity parameter.

The territory definition is done with the parameter settings for each territory.

9.4 Available GPRS resource within the circuit-switched design

A system designed for circuit-switched traffic usually allows basic GPRS throughput. Since the system has been designed for a sufficient margin to permit a low blocking level, some of the extra instantaneous capacity can be used for packet data transmission. As long as the packet traffic can be temporarily interrupted to accommodate the peaks in circuit-switched traffic, there is no decrease in the circuit-switched services.

Table 5 shows the mean number of timeslots (TCHs) available for GPRS for different numbers of TRXs per cell and for circuit-switched blocking probabilities of 1% and 2%. The free timeslots between territories are taken into account.

Table 5. Mean number of timeslots available for GPRS

Number of TRXs (TCH)	GSM traffic (Erl) at 1% blocking	GSM traffic (Erl) at 2% blocking	Mean free TCHs for GPRS at 1% blocking	Mean free TCHs for GPRS at 2% blocking
1 (7)	2.5	2.9	3.5	3.1
2 (14)	7.3	8.2	5.2	4.3
3 (22)	13.6	14.9	6.9	5.6

9.5 Free timeslot (guard timeslot)

The guard TSLs are used to cope with voice-pre-emption. There are timeslots between the CSW and the PS territory. They are used temporary by voice while a downgrade in the PS territory is being performed to allocate a new voice call.

Preliminary values for the number of free timeslots in the CSW territory are given in Table 6. The mean number of free timeslots in the CSW territory is also given. The assumption is that there are, on average, an equal number of upgrades and downgrades.

Table 6 The number of free timeslots for different configurations

TRXs	Free TSLs (after a CSW downgrade)	Free TSLs (after a CSW upgrade)	Mean free TSLs in the CSW
1	1	1	1
2	1	2	1.5
3	1	2	1.5
4	2	3	2.5
5	2	4	3
6	2	4	3

10 BTS dimensioning examples

Note

The parameter values used in the examples are not Nokia recommendations. They are only used to illustrate the flow of the dimensioning calculations.

10.1 Case 1: Available capacity

10.1.1 Case 1.1: One TRX per cell

Step 1: Calculate the available timeslots for data traffic

1.1 Calculate/measure the current voice traffic

- 7 TCH => 7 TSLs for voice, leading to 2.94 Erl at 2% blocking

1.2 Make a note of the signalling channels and free timeslots

- Combined signalling channel structure (that is, one TSL for signalling)
- One mean free TSL in the CSW (can be changed with a BSS parameter)

1.3 Calculate the available timeslots for data traffic

- Timeslots available for EGPRS = 7 – 2.94 – 1 = 3.06

2.3 Estimate the average throughput for GPRS and EDGE and 3.1 Multiply data TSLs by the average throughput per TSL

Note

The values mentioned below values are only assumptions. Real calculations should be based on the operator's own network measurements (coverage and interference). The values presented in this document may be too pessimistic/optimistic and are only used as an example.

- With EDGE (33 kbps on average) gives 33 kbps * 3.06 = 101 kbps

- With GPRS (15 kbps on average) gives 15 kbps * 3.06 = 45.9 kbps
  - In a CS-2 only system, 10 kbps * 3.06 = 30.6 kbps

Similar calculations can be done for higher configurations. Table 7 shows the average maximum available throughput for cell configurations of 1-6 TRXs. In these calculations, the average throughput per timeslot is 33 kbps for EDGE; 15 kbps for GPRS (CS-3 and CS-4); and 10 kbps for CS-2.

Table 7. Average maximum available throughput for cells with 1-6 TRXs

#TRX	1	2	3	4	5	6
TCH TSL	7	14	22	30	37	45
Voice Erl	2,94	8,20	14,90	21,93	28,25	35,61
Free TSL	1	1,5	1,5	2,5	3	3
Mean TSL for PSW	3,06	4,3	5,6	5,56	5,74	6,39
EDGE throughput [kbps]	101,0	141,9	184,8	183,5	189,4	210,9
GPRS throughput [kbps]	45,9	64,5	84,0	83,4	86,1	95,9
GPRS CS-2 throughput [kbps]	30,6	43	56	55,6	57,4	63,9

10.2 Case 2: Required capacity

For more information on GB/non-GB, see Chapter 2.

10.2.1 Case 2.1: 300 Erl/km2, 10 % data user penetration

First, the voice traffic per cell has to be calculated, based on the following information (example values):

- 300 Erl/km2
- 10% data user penetration
- 90% best effort users and 10% STC users (of the data users)
- Best effort payload/user is 520 kbit/busy hour
- STC (streaming) payload/user is 9.2 Mbit/busy hour
- Micro cells
- Indoor and outdoor cells
- Micro cell coverage 0.046 km2
- In indoor cells, there are 1500 voice users/cell (extreme case) and 300 voice users/cell (normal case)
- Average EDGE throughput/TSL is 40 kbps in micro cells (outdoor) if a BCCH TRX is used (depends on the deployment strategy)

- Average EDGE throughput/TSL is 35 kbps in micro cells (outdoor) if a TCH TRX is used (depends on the deployment strategy)
- Average EDGE throughput/TSL is 45 kbps in indoor cells (depends on the deployment strategy)
- Average GPRS throughput/TSL is 16 kbps in micro cells (outdoor) if a BCCH TRX is used (depends on the deployment strategy)
- Average GPRS throughput/TSL is 12 kbps in micro cells (outdoor) if a TCH TRX is used (depends on the deployment strategy)
- Average GPRS throughput/TSL is 18 kbps in indoor cells (depends on the deployment strategy)

=> Voice traffic per cell:

- 13.8 Erl/cell in the outdoor micro cells (0.046 cell x km2 x 300 Erl/km2)
- 37.5 Erl/cell and 7.5Erl/cell in the indoor cells (1500 x 25 mErl and 300 x 25 mErl)

=>

- 13.8 Erl at 2% blocking requires 21 TSLs for voice
- 37.5 Erl at 2% blocking requires 48 TSLs for voice and 14 TSLs for 7.5 Erl cell

=>

- 13.8 Erl/cell equals 552 voice users at 25 mErl/user

Step 1: Calculate the required throughput

1.1: Calculate the payload per cell during a busy hour

- There are 55 data users in 13.8 Erl cells (10% data user penetration)
  - 49 best effort users (90% of the data users)
  - Six STC users (10% of the data users)
- There are 152 (30) data users in 38 (7.5) Erl indoor cells
  - 137 best effort users (27)
  - 15 STC users (3)

=>

- In 14 Erl cells, the required total payload is 49 x 520 kbit + 6 x 9.2 Mbit = 80.7 Mbit per busy hour
- In 37.5 Erl indoor cells, the required total payload is 137 x 520 kbit + 15 x 9.2 Mbit = 209.24 Mbit per busy hour
- In 7.5 Erl indoor cells, the required total payload is 27 x 520 kbit + 3 x 9.2 Mbit = 41.64 Mbit per busy hour

=>

1.2 Transfer payload to the required throughput

- The required total throughput is:
  a. 80.7 Mbit/3600 seconds = 22.42 kbps in a 13.8 Erl cell
  b. 209.24 Mbit/3600 seconds = 58.13 kbps in a 37.5 Erl indoor cell
  c. 41.64 Mbit/3600 seconds = 11.57 kbps in a 7.5 Erl indoor cell
- The minimum throughput for STC users is 50 kbps (assumed)
- The required throughput for best effort users is 7.08 kbps (49 x 520 kbit/3600 seconds)

=>

1.3 GB/non-GB)

Here, GB means dedicated timeslots for data, ensuring a minimum average guaranteed throughput for data services per cell (not per user). Non-GB means that the throughput per cell is not guaranteed (no dedicated timeslots for data services).

- The required throughput for a best effort service is 7.22 kbps (non-GB)
- The required minimum throughput for an STC service is 50 kbps (GB)
  - This is the minimum required guaranteed throughput for all cells
  - A certain amount of timeslots have to be dedicated

Step 2: Estimate the achieved throughput per TSL

In a micro cell environment, the BCCH frequencies tend to have a reasonable reuse ratio (for example, 12-15). However, the TCH frequencies may a have quite aggressive reuse ratio. This, of course, depends on the operator bandwidth. In these examples, it is assumed that the BCCH frequencies are not interference limited in micro cells, but TCH frequencies are.

In an indoor environment, the cells are only coverage limited. The following values are estimated example values. Different frequency layers are not considered in this example:

2.3 Estimate the average throughput for GPRS and EDGE

- Average EDGE throughput/TSL is 40 kbps in micro cells (outdoor) if a BCCH TRX is used
- Average EDGE throughput/TSL is 35 kbps in micro cells (outdoor) if a TCH TRX is used
- Average EDGE throughput/TSL is 45 kbps in indoor cells
- Average GPRS throughput/TSL is 16 kbps in micro cells (outdoor) if a BCCH TRX is used
- Average GPRS throughput/TSL is 12 kbps in micro cells (outdoor) if a TCH TRX is used
- Average GPRS throughput/TSL is 18 kbps in indoor cells

=>

2.2 Estimate the GPRS/EGPRS division

- 70/30 GPRS/EDGE usage

2.4 Calculate the average throughput per TSL

Note

The effect of multiplexing on throughput is not considered in this example. The operator should investigate the effect in the real network for more accurate calculations.

- 23.2 kbps/TSL for micro cells using a BCCH TRX (0.7 x 16 kbps + 0.3 x 40 kbps)
- 18.9 kbps for micro cells using a TCH TRX (0.7 x 12 kbps + 0.3 x 35 kbps)
- 26.1 kbps for indoor cells (0.7 x 18 kbps + 0.3 x 45 kbps)

Step 3: Calculate the needed TSL/TRX and the final throughput

- The needed timeslots for data services:
  - The requirement is 50 kbps (dedicated timeslots required)

=>

3.1 Calculate the needed data TSLs

- For a micro cell using a BCCH TRX: 50 kbps/23.2 kbps/TSL = 2.2 TSLs (dedicated)
- For a micro cell using a TCCH TRX: 50 kbps/18.9 kbps/TSL = 2.7 TSLs (dedicated)
- For indoor cells: 50 kbps/26.1 kbps/TSL = 2 TSLs (dedicated)

=>

Subcase A: Outdoor cells

The number of needed TRX with GB:

3.2 Make a note of the needed voice TSLs at a certain blocking rate, 3.3 Calculate the needed signalling channels, and 3.4 Calculate the free TSLs

- 21 TSLs needed for voice
- 1.5 free TSLs
- Two TSLs for signalling
- No timeslots left for data

=> Three TRXs is not enough

3.4 Calculate the required TRXs

- Four TRXs needed

3.5 Calculate the achieved throughput with the required configuration

- There are 7.5 TSLs available (32 – 21 – 1.5 – 2 = 7.5) for data, giving an average maximum rate of 174 kbps (for a BCCH TRX, 7.5 x 23.2 = 174)

The number of needed TRXs with non-GB:

- 13.8 TSLs for voice on average
- 1.5 free TSLs
- Two TSLs for signalling

=> Three TRXs needed

- 24 – 13.8 – 1.5 – 2 = 6.7 TSLs, on average, available for data giving:

  a 155 kbps (6.7 x 23.2 = 155 for a BCCH TRX) maximum for an outdoor cell on average

Subcase B: Indoor cells

3.2 Make a note of the needed voice TSLs at a certain blocking rate, 3.3 Calculate the needed signalling channels), and 3.4 Calculate the free TSLs

GB:

- 48 TSLs needed for voice (14 TSLs, normal case)
- 4 free TSLs (8 TRXs) / 1.5 free TSLs (3 TRXs)
- 3 TSLs for signalling (8 TRXs) / 2 (3 TRXs)

3.5 Calculate the achieved throughput with the required configuration

a. 64 – 48 – 4 – 3 = 9 TSLs, on average, available for data, giving 9 x 26.1 kbps = 196 kbps (extreme case), 8 TRXs needed

b. 24 – 14 – 1.5 – 3 = 5.5 TSLs, giving 5.5 x 26.1 kbps = 144 kbps (normal case), 3 TRXs needed

Non-GB:

- 37.5 TSLs for voice on average (7.5)
- Four free TSLs (1.5)
- TSL for signalling (2)

a. 56 – 37.5 – 4 – 4 = 10.5 TSLs, on average, available for data, giving a 243 kbps maximum on average (not guaranteed), seven TRXs is enough

b. 16 – 7.5 – 1.5 – 2 = 5 TSLs, giving 131 kbps on average (not guaranteed), two TRXs is enough

Step 4: Check the result

4.1 Over dimensioned

- The original requirement was 50 kbps guaranteed throughput per cell

a. In the outdoor cell case (four TRXs), if seven timeslots are dedicated (and 7.5 are available for data on average), GB is about 174 kbps. If a lower throughput is enough, then less timeslots can be dedicated (the rest is used for the default territory). With non-GB, the average maximum throughput is 151 kbps with three TRXs.

b. In the indoor cell cases (eight or three TRXs), if nine (or five in the three TRX case) timeslots are dedicated, GB is 196 kbps (about 144 kbps). If a lower throughput is enough, then less timeslots can be dedicated (the is rest used for the default territory). With non-GB, the average maximum throughput is 170/131 kbps with 7/2 TRXs.

c. Note that non-GB throughput values are the average maximum values. The real throughput depends on the voice traffic. Data throughput can be very low if voice traffic is high.

4.2 C/I requirements met

- Bandwidth is not known
  - C/I requirements are not known

10.2.2 Case 2.2: 3.5 Erl/km, 2, 5% data user penetration

For more information on GB/non-GB, see Chapter 2.

First, the voice traffic per cell must be calculated, based on the following information (example values):

- 3.5 Erl/km2
- 5% data user penetration
- 70% best effort users and30 % STC users (of the data users)
- Outdoor macro cells only
- Average EDGE throughput/TSL is 35 kbps in macro cells if a BCCH TRX is used (depends on the deployment strategy)
- Average EDGE throughput/TSL is 30 kbps in macro cells if a TCH TRX is used (depends on the deployment strategy)
- Average GPRS throughput/TSL is 14 kbps in macro cells if a BCCH TRX is used (depends on the deployment strategy)
- Cell indoor coverage is 0.97 km2 (with 85% indoor location probability, assuming that most of the users are indoors)

=>

- 3.4 Erl/cell for macro cells (3.5 Erl/km2 x 0.97 km2/cell)

=>

- 3.4 Erl at 2% blocking requires eight TSLs for voice

=>

- 3.4 Erl/cell equals 136 voice users at 25 mErl/user

Step 1: Calculate the required throughput

1.1 Calculate the payload per cell during a busy hour

- There are seven data users in a cell (0.05 x 136)
  - Five best effort users
  - Two STC users

=>

- The required total payload is 5 x 520 kbit + 2 x 9.2 Mbit = 21 Mbit per busy hour

=>

1.2 Transfer payload to the required throughput

- The required total throughput is:
  - 21 Mbit/3600 seconds = 5.84 kbps
- The minimum throughput for STC usage is 50 kbps (assumed)
- The required average throughput for best effort users is 0.722 kbps (5 x 520 kbit/3600 seconds)

=>

1.3 GB/non-GB

- The required average throughput for a best effort service is 0.722 kbps (non-GB)
- The required minimum throughput for an STC service is 50 kbps (GB)
  - This is the minimum required guaranteed throughput
  - A certain amount of timeslots have to be dedicated

Step 2: Estimate the achieved throughput per TSL

In a macro cell environment, the outdoor/indoor coverage is not as good as in a micro cell environment. The BCCH frequencies tend to have a reasonable reuse ratio (fro example, 12-15). However, the TCH frequencies may have quite an aggressive reuse ration. This, of course, depends on the frequency band and the operator bandwidth. In these examples, it is assumed that the BCCH frequencies are not interference limited, but TCH frequencies are.

=>

2.3 Estimate the average throughput for GPRS and EDGE

- Average EDGE throughput/TSL is 35 kbps in macro cells if a BCCH TRX is used

- Average EDGE throughput/TSL is 30 kbps in macro cells if a TCH TRX is used
- Average GPRS throughput/TSL is 14 kbps in macro cells if a BCCH TRX is used
- Average GPRS throughput/TSL is 12 kbps in macro cells if a TCH TRX is used

=>

2.2 Estimate the GPRS/EGPRS division

Note

The effect of multiplexing on throughput is not considered in this example. The operator should investigate the effect in the real network for more accurate calculations.

- 70/30 GPRS/EDGE usage

2.4 Calculate the average throughput per TSL

- 20.3 kbps for a BCCH TRX (0.7 x 14 + 0.3 x 35)
- 17.3 kbps for a TCH TRX (0.7 x 12 + 0.3 x 30)

Step 3: Calculate the needed TSL/TRX and the final throughput

- The needed timeslots for data services:
  - The requirement is 50 kbps (dedicated timeslots required)

=>

3.1 Calculate the needed data TSLs

- For cells using a BCCH TRX: 50 kbps/20.3 kbps/TSL = 2.47 TSL (dedicated)
- For cells using a TCH TRX: 50 kbps/17.4 kbps/TSL = 2.88 TSL (dedicated)

=>

GB:

The number of needed TRXs:

3.2 Make a note of the needed voice TSLs at a certain blocking rate), 3.3 Calculate the needed signalling channels, and 3.4 Calculate the free TSLs

- Eight TSLs deeded for voice
- 1.5 free TSLs
- Two TSLs for signalling

=> At least two TRXs needed

3.4 Calculate the required TRXs

16 – 8 – 1.5 – 2 = 4.5 TSLs left for data which is enough

=> Two TRXs needed

3.5 Calculate the achieved throughput with the required configuration

- There are 4.5 TSLs available for data, giving, on average, a maximum rate of 91 kbps (BCCH TRX)

Non-GB:

The number of needed TRX:

- 3.4 TSLs for voice on average
- One free TSL
- One TSL for signalling
- 8 – 3.4 – 1 – 1 = 2.6 TSLs, on average, available for data, giving an average maximum of 52 kbps (BCCH TRX, not guaranteed)
- One TRX is enough for the BCCH TRX

Step 4: Check the result

4.1 Over dimensioned

- The original requirement was 50 kbps guaranteed minimum bit rate
    a. With two TRXs, GB is about 91kbps if four timeslots are dedicated (and 4.5 are available for data on average). If a lower throughput is enough, then less timeslots can be dedicated (the rest is used for the default territory). With non-GB, the average maximum throughput is 52 kbps with one TRX.
    b. Note that the non-GB throughput value is an average maximum value. The real throughput depends on the voice traffic, and data throughput can be very low if voice traffic is high.

4.2 C/I requirements met

- Bandwidth is not known
    - C/I requirements are not known

11 Summary of BTS dimensioning outputs

This chapter presents the dimensioning output summary for the 300 Erl/km2 and 3.5 Erl/km2 cases.

11.1 Summary of the 300 Erl/km2 case

The selected input values (variables) for this case:

- Voice traffic density
- Cell type (deployment strategy)
  - Coverage and interference situation
- Data user penetration
- User profile/user profile distribution
- GPRS/EGPRS usage
- Average data throughput/TSL (depending on the cell type)
- Minimum required throughput
- Guaranteed/not guaranteed throughput

The needed number of TRXs is four with GB, and three with non-GB. However, in both cases the data achieved throughput is higher than required.

Using the values of the example it can be concluded that with four TRXs (7.5 TSLs for data) it is possible to increase the data user penetration up to 35% of the voice users (with the maximum throughput of 174 kbps/cell) if the voice traffic remains unchanged.

- With 35% penetration, there are 137 best effort and 58 STC users
- The required throughput is (137 x 520 kbit + 58 x 9.2 Mbit)/3600 seconds = 168 kbps

If the throughput does not need to be guaranteed (three TRXs), it is possible to increase the data user penetration up to 30% of the voice users (with the maximum throughput of 151 kbps/cell) if the voice traffic remains unchanged.

- With 35% penetration there are 137 best effort and 58 STC users
- The required throughput is (117 x 520 kbit + 50 x 9.2 Mbit)/3600 seconds = 145 kbps

With a high-density indoor cell (eight TRXs) the maximum user penetration is

- 15% with the maximum throughput of 196 kbps (GB), and
- up to 20% with the maximum average throughput of 261 kbps (non-GB/7 TRXs).

The respective values for a normal indoor cell are 55% and 50% (for 144 kbps/GB and 131 kbps/non-GB).

11.2 Summary of the 3.5 Erl/km2 case

In this case, the achieved throughput is also higher than the required. This makes it possible to allow the data user penetration to increase up to 75% for GB (two TRXs / 91 kbps) and up to 40% for non-GB (one TRX / 52 kbps) if the voice traffic remains unchanged.

12 Traffic monitoring principles

12.1 About traffic monitoring

Once the network has been dimensioned, the network planning, implementation, and optimisation phases follow. Network planning typically includes a detailed configuration and parameter plan, where features, such as EqoS, are planned in detail. Network monitoring is a part of a typical optimisation process. It can be used to verity whether the original dimensioning assumptions were correct. Traffic monitoring is used to trigger a network configuration change when the amount of traffic is higher or lower than assumed in the original dimensioning.

To perform monitoring, we can use the values of the counters implemented in the network element or some formulas involving several of these counters. In general, so-called PIs (performance indicators) and KPIs (key performance indicators) are defined.

A key performance indicator (KPI) is a value that presents some vital information about the network. The KPIs are mapped directly from PIs, a formula of several PIs, or directly from network counters.

The operator needs KPIs to monitor the performance of the network, to troubleshoot failures, and to ensure that the end user has the best possible perception of the service. To improve the performance of the network it is therefore important to check how the network is performing. This can be done by looking into different key performance indicators and setting the criteria for the network improvement or deciding when to increase capacity.

12.2 Measurements

In Nokia BSS, the BSC is responsible for traffic measurements. Each measurement type can activate a certain amount of counters, and each measurement has to be activated for all required BSCs. Typically, measurements provide data for all BTSs under the BSC. In addition to measurements, observations can be used for data collection. Observations are special measurements for a limited number of network objects. Observations typically provide a large amount of data. Measurements and observations are divided into the following groups according to their function:

- Call control measurements (CSW)
- GPRS measurements (PSW)
- Transmission measurements
- Observations

The following are EGPRS measurements:

- 72 Packet control unit measurement
- 73 RLC blocks per TRX measurement
- 74 Frame relay measurement
- 76 Dynamic Abis measurement
- 79 Coding scheme measurement
- 90 Quality of Service measurement
- 91 PBCCH availability measurement
- 95 GPRS cell reselection measurement
- 96 GPRS RX level and quality measurement
- 97 Enhanced Quality of Service measurement
- 98 Gb over IP measurement

Some of the above-mentioned measurements are related to optional features and are not useful if the feature has not been activated.

When BTS/BSC expansion needs are evaluated, monitoring both CSW and PSW traffic is required. There are several CSW related measurements, but most important for EGPRS are the following:

1. Traffic measurement
2. Resource availability measurement
3. Resource access measurement
4. Handover measurement

12.3 Key performance indicators (KPIs)

Nokia has divided the EGPRS BSS KPIs into the following categories: congestion, quality, network usage, and mobility.

For more information on the formulas and short descriptions for EDGE KPIs, refer to *EDGE Key Performance Indicators*. EDGE KPIs are also available in the NetAct Reporter tool.

A list of KPI groups and formula names for S11 are presented in Table 8.

Note

The list in Table 8 is subject to change, as Nokia constantly improves the definitions. This document is not always updated when there is a change in the KPIs. It is strongly recommended that you always refer to the separate *EDGE Key Performance Indicators* document within the BSS System Set documentation or to the Net Act Reporter tool.

The last letter after the formula ID number is for version control. When small improvements to the formula are made, the last letter is incremented but the formula number remains unchanged. KPI users should always use the most recent version of the formulas.

Table 8. KPI groups and formula names

KPI group	Description	Formula id	Measurements
Network Usage	Downlink GPRS RLC payload	trf_213a	a
	Uplink GPRS RLC payload	trf_212a	a
	Downlink EGPRS RLC payload	trf_215a	b
	Uplink EGPRS RLC payload	trf_214a	b
	Downlink GPRS Erlangs	trf_208a	a,b
	Uplink GPRS Erlangs	trf_205a	a,b
	Downlink EGPRS Erlangs	trf_162b	a,b
	Uplink EGPRS Erlangs	trf_161b	a,b
	Number of uplink simultaneous users	trf_231	a
	Number of downlink simultaneous users	trf_232	a
PDTCH congestion	DL multislot allocation blocking	tbf_16	a
	DL multislot soft blocking	blck_33	a
	Downlink TBFs pr timeslot	tbf_38c	a
PDTCH quality	Downlink GPRS RLC throughput	trf_235	a
	Uplink GPRS RLC throughput	trf_233	a
	Downlink EGPRS RLC throughput	trf_236	c
Mobility	Downlink TBF releases due to flush	tbf_36a	a
Abis congestion	DL inadequate EDAP channel time	dap_4	c
PCU congestion	Territory upgrade rejections due to lack of PCU capacity	blck_32	e
Gb congestion	Downlink Gb load	frl_8	d

a: Packet control unit measurement
b: Coding scheme measurement
c: Dynamic abis measurement
d: Frame relay measurement
e: Traffic measurement

Most of the KPIs are combined to be common for one BTS. Abis, PCU, and Gb congestions are related to Abis interface (Dynamic Abis), BSC, and Gb interface respectively. However, the BTS KPIs can be summed up (that is, over one BSC) to obtain the corresponding KPIs at the BSC level.

12.4 BTS traffic monitoring

BTS dimensioning focuses on defining the number of required timeslots and, consequently, the number of TRX units. The PDTCH congestion measurements DL multislot allocation blocking, DL multislot soft blocking, and DL TBF per timeslot are very useful in BTS traffic monitoring and detecting the potential need to optimise the configuration.

If the operator has not dedicated any capacity for EGPRS, then voice blocking is not affected by data traffic, because voice always have priority over data in such a case.

If dedicated data capacity is used, then voice blocking caused by data traffic may occur. When dedicated data capacity is used, increased voice blocking it is fairly easy to notice compared to a situation where dedicated data capacity is not used. If voice blocking increases (without increased voice traffic) after dedicated EGPRS territory is introduced, it is obvious that the dedicated data capacity causes the voice blocking. This should trigger a capacity expansion or a review of the number of dedicated data timeslots in the cells that suffer from blocking. Alternatively, if the voice capacity usage is very low, the data territory can be increased (if necessary) or the TRX count lowered.

If the dimensioned data capacity is too low, both the data usage and the territory upgrade rejection ratio can be very high. In this case, the dedicated data capacity should be increased. If the dimensioned data capacity is too high, the data usage and territory upgrade ratio are very low. In this case, the data capacity can be lowered (that is, the dedicated data capacity).

If the statistics show that according to the DL multislot allocation blocking KPI there is blocking but there are no upgrade requests yet, the reason may be that the territory is smaller than defined in the default settings (CSW use). The PCU will not make an upgrade request. This is because the CSW side returns the default channels back to the PS territory as soon as the CSW load allows this. This means that territory upgrade rejections may not happen even if there is a lack of resources.

References

1. Halonen, Romero, Melero: GSM, GPRS and EDGE Performance
2. 3GPP TS 05.05 V8.16.0 (2003-08)