

Contents

1	Introduction	1
1.1	Assumptions	1
1.2	Limitations	1
1.3	Concepts	1
2	Technical Background	3
2.1	Tracking Areas	3
2.2	Tracking Area Lists	3
2.3	Tracking Area Dimensioning	4
2.4	Tracking Area Planning	5
3	Paging	7
3.1	Paging Frames and Paging Occasions	7
3.2	Paging Procedure	8
3.3	Parameter maxNoOfPagingRecords	10
3.4	Parameter nB	10
4	Paging Capacity	13
4.1	MME Paging Capacity	13
4.2	RBS Paging Capacity	13
4.3	Example of Calculating RBS Paging Capacity	20
5	TA Dimensioning	23
5.1	Process Overview	23
5.2	Input Data	24
5.3	Equations	24
5.4	Example of TA Dimensioning	24
6	TA Planning	27
6.1	TA Lists with Multiple TAs	27
6.2	Early Strategies for TA Lists	28
7	Estimating Paging Traffic per Subscriber	31

1 Introduction

This document provides guidelines for dimensioning and planning Tracking Areas (TAs) in the LTE Radio Access Network (RAN):

- Dimensioning aims to find a suitable number of Radio Base Stations (RBSs) to include in a TA list
- Planning includes determining TA borders and configuring TA lists

Both core and radio aspects of TA dimensioning and planning are covered in the guidelines. The main target group for the document is radio network design engineers.

1.1 Assumptions

The LTE specification allows for different cells within one eNodeB to belong to different TAs. In the current implementation, all cells within one RBS must be allocated to the same TA. The restriction is considered in this document.

1.2 Limitations

- The document is valid for the current release
- The method applies only to the Frequency Division Duplex (FDD) mode of LTE. It is not valid for the Time Division Duplex (TDD) mode.

1.3 Concepts

The following concepts are used in this document:

Blocked page	A blocked page is a page that cannot be transmitted over the air interface at the first valid Paging Occasion (PO) due to lack of resources.
Page	The message sent by the Mobility Management Entity (MME) to the User Equipment (UE) during paging.
Paging	The procedure in which the MME notifies an idle UE about an incoming data connection. The procedure includes sending a paging message over the S1 Application Protocol (S1-AP) and the air interface.

Paging capacity	The average number of pages per second that a node can handle. Paging capacity incorporates various margins to manage conditions like traffic fluctuations.
Paging Frame (PF)	The radio frames where UE paging can take place.
Paging load	The fraction of resources required for paging.
Paging Occasion (PO)	The sub frames where UE paging can take place.
Paging record	Pages to different UEs can be multiplexed in the same Radio Resource Control (RRC) paging message. A paging record is the information associated with one of those pages.
Tracking Area (TA)	Cluster of RBSs having the same Tracking Area Code (TAC).
Tracking Area list	A list of TAs that indicates to the UE where its registration is valid.

2 Technical Background

This chapter provides a technical background to the TA function. For further information, refer to *Idle Mode Support* and the following 3GPP documentation available at www.3gpp.org:

- *3GPP TS 36.300, Overall description; Stage 2*
- *3GPP TS 36.304, User Equipment (UE) procedures in idle mode*

2.1 Tracking Areas

A Tracking Area corresponds to the Routing Area (RA) used in Wideband Code Division Multiple Access (WCDMA) and GSM/Edge Radio Access Network (GERAN). The TA consists of a cluster of RBSs having the same Tracking Area Code (TAC). The TA provides a way to track UE location in idle mode. TA information is used by the MME when paging idle UE to notify them of incoming data connections.

2.2 Tracking Area Lists

In LTE, the MME provides the UE with a list of tracking areas where the UE registration is valid. When the MME pages a UE, a paging message is sent to all RBSs in the TA list. The concept of TA lists is shown in the following figure:

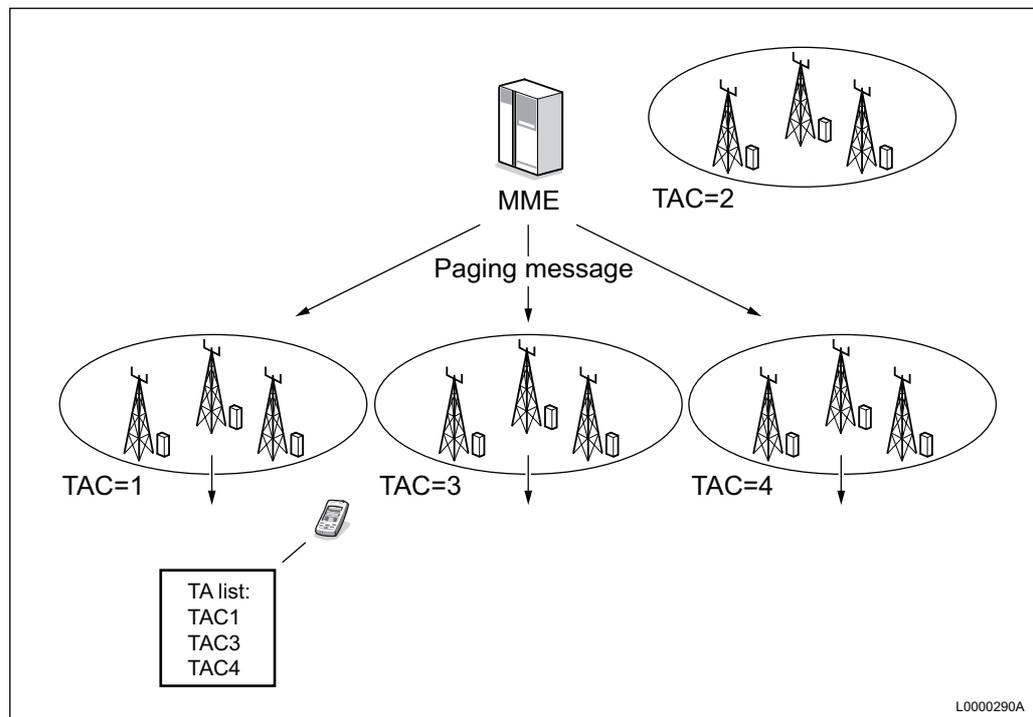


Figure 1 Concept of TA Lists

The MME sends the TA list to the UE during the TA update procedure. TA updates occur periodically, and when a UE enters a cell with a TAC not in the current TA list. The TA list makes it possible to avoid frequent TA updates due to ping-pong effects along TA borders. This is achieved by including the old TA in the new TA list received at TA update.

In MME releases prior to SGSN-MME R2010A RP02, the MME includes only the current TA in the TA list.

From SGSN-MME R2010A RP02, the operator can specify up to 15 TAs for each TA to include in the TA list. With the exception of the TAs specified by the operator, the MME automatically includes the old TA in the TA list to avoid ping-pong updates. For more information about TA list planning and handling, see Section 6 on page 27.

2.3 Tracking Area Dimensioning

TA dimensioning is the process of finding a suitable number of RBSs to include in a TA list.

A small number of RBSs in a TA list may require frequent TA updates. Frequent updates increases the MME load and UE battery consumption. In addition, frequent updates may reduce the paging success rate, because the UE cannot respond to paging during the TA update procedure.

By increasing the number of RBSs in the TA list, the TA update frequency is reduced. The drawback of adding more RBSs to the TA list is that the paging load increases. The upper limit of the number of RBSs in a TA list is determined by the paging capacities of the MME and RBS. For information about how to determine paging capacity, see Section 4 on page 13.

2.4 Tracking Area Planning

TA planning is the task of configuring TAs and TA lists so that areas with excessive TA update signalling are avoided. Information about TA planning is found in Section 6 on page 27.

3 Paging

Paging is used primarily to notify user equipment in idle state about incoming data connections. This chapter provides a summary of the paging function with emphasis on the parts relevant for TA dimensioning.

For further information, refer to:

- Document *Paging*
- The SGSN-MME document *EPS Mobility Management for LTE Access*
- *3GPP TS 36.304, User Equipment (UE) procedures in idle mode*

3.1 Paging Frames and Paging Occasions

UE paging is possible only in certain frames and subframes. The frames where paging is allowed are referred to as Paging Frames (PF) and the subframes are referred to as paging occasions, see Figure 2 on page 7.

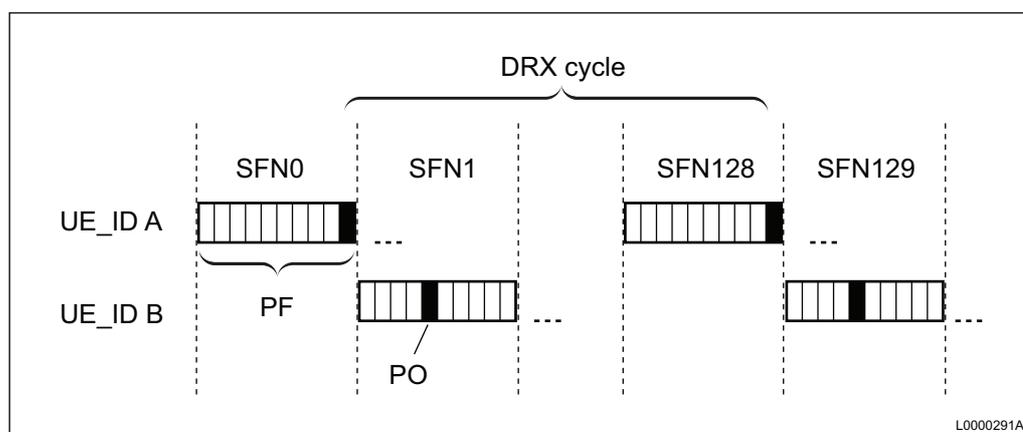


Figure 2 Paging Frames and Paging Occasions, DRX Cycle Equal to 1280 ms

The frequency of PFs and POs is determined by the parameter n_B , as described in Section 3.4 on page 10.

The `defaultPagingCycle` determines the Discontinuous Reception (DRX) cycle, that is, how frequently a UE monitors POs. A shorter DRX cycle decreases the time for paging but increases battery consumption.

The `UE_ID` is a number between 0 and 1023, calculated by the following expression:

$$UE_ID = n_{IMSI} \bmod 1024$$

Equation 1 Calculation of UE_ID

where n_{IMSI} is the last 10 digits of the International Mobile Subscriber Identity (IMSI).

The UE_ID is used to derive the System Frame Numbers (SFNs) in which a particular UE monitors paging.

For the equations in Section 4.2.3 on page 16 and Section 4.2.4 on page 18 to be valid, the IMSI number series used in the network must be selected so that UE are spread uniformly over the 1024 UE_IDs.

3.2 Paging Procedure

The MME is the core node responsible for UE paging. When the MME receives a downlink data notification message from the Serving Gateway (SGW), the MME sends an S1-AP paging message to all RBSs in the TA list. When the S1-AP paging message arrives at the RBS it is queued until the valid PO occurs. The message is then transmitted over the air interface using resources on the Physical Downlink Control Channel (PDCCH) and the Physical Downlink Shared Channel (PDSCH).

The Downlink Control Information (DCI) containing the scheduling assignment for the paging message is transmitted over PDCCH. The scheduling assignment is common for all UE monitoring a certain PO.

The following figure illustrates the paging procedure:

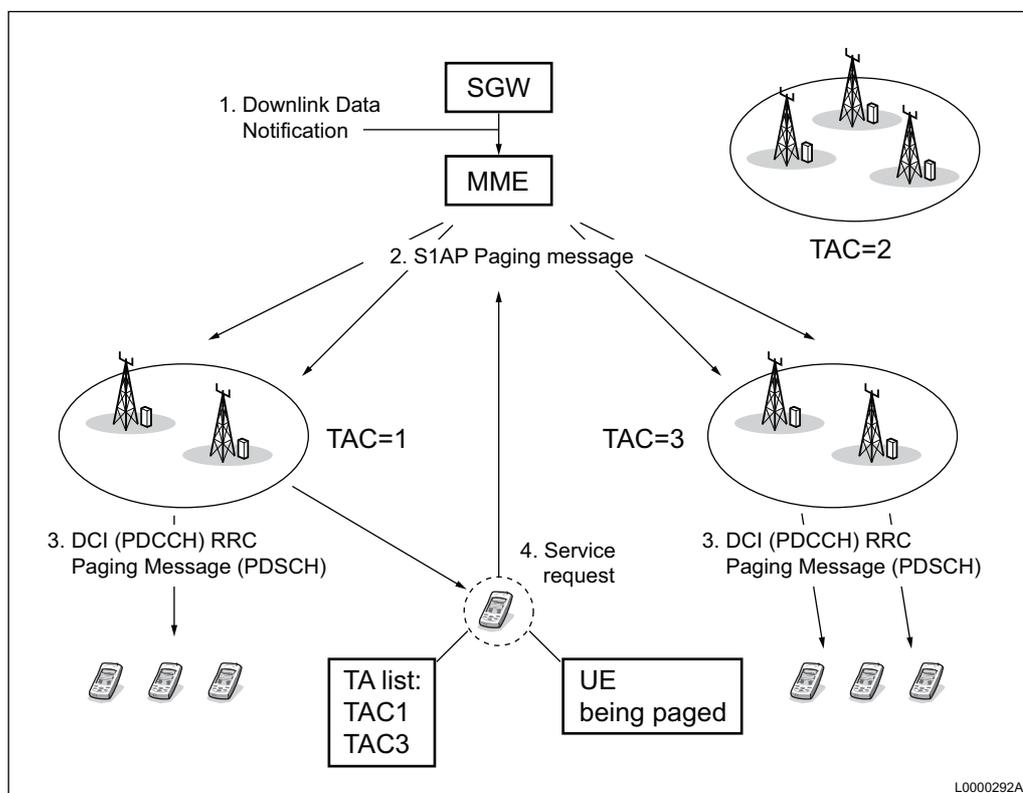


Figure 3 Paging Procedure

When UE monitoring the PO detects the scheduling assignment, the UE demodulates and decodes the RRC paging message sent on the PDSCH. The RRC paging message contains information about the exact identity of the UE being paged. UE that do not find their identities in the RRC paging message discard the data and sleep according to the DRX cycle. A UE recognizing its identity sends a service request to the MME. Several UE may be addressed in the same RRC paging message.

If the MME does not receive the service request within T_{3413} seconds, it resends the S1-AP paging message. In the initial attempt the message is sent to the RBSs within the same TA list. The maximum number of transmission attempts is specified by parameter N_{3413} .

When paging messages arrive in the RBS, the RRC layer tries to send the paging message in the first valid PO. If it is impossible to send the paging message in the first PO because of blocking, for example, attempts are made to send the paging message in subsequent POs according to the DRX cycle. The RRC layer tries to send the paging message during a period specified by the parameter `pagingDiscardTimer`, after which the paging message is discarded.

It is recommended that the `pagingDiscardTimer` timer be set equal to or smaller than T_{3413} . To guarantee at least one retransmission attempt by the

RRC layer, the `pagingDiscardTimer` must be set to a larger value than the `defaultPagingCycle`.

3.3 Parameter `maxNoOfPagingRecords`

A paging record refers to the paging information of one particular UE in the RRC paging message. The parameter `maxNoOfPagingRecords` controls the upper limit of the number of paging records that are conveyed during one PO.

Pages that cannot be sent during the first valid PO are referred to as blocked pages. Such pages are subject to transmission in subsequent POs, as described in Section 3.2 on page 8. To allow for a fast paging procedure minimizing the risk of delay, it is recommended that `maxNoOfPagingRecords` be set according to values shown in the following table:

Table 1 Recommended Settings of `maxNoOfPagingRecords`.

Bandwidth	5 MHz	10 MHz	15 MHz	20 MHz
Max Paging Records	7	16	16	16

In Table 1 on page 10, the value 7 corresponds to the maximum number of paging records that can fit in a 5 MHz subframe. The value 16 is the upper limit specified by 3GPP.

For 5 MHz bandwidth, setting `maxNoOfPagingRecords` to 7 could lead to a scenario in which a paging message consumes the entire bandwidth of a subframe. Since paging has higher priority than user data, this could prevent transmission of user data in the subframe.

By setting `maxNoOfPagingRecords` to a value lower than 7, it is possible to guarantee that paging messages do not consume all resources in a subframe. With appropriate dimensioning, the occasions where paging traffic consumes the entire resources of a subframe are rare and such precautions are generally not required.

The recommendation is to set `maxNoOfPagingRecords` equal to 7 for 5 MHz bandwidth.

`maxNoOfPagingRecords` should never be set to a value higher than 7 for 5 MHz bandwidth. With that setting, the RBS may try to create paging messages exceeding the available resources in the subframe, leading to failure of the entire paging message transmission.

3.4 Parameter `nB`

To a large extent, the RBS paging capacity is determined by the number of available POs per radio frame. This number is configured using the parameter

n_B . Valid values for n_B include: $1/32T$, $1/16T$, $1/8T$, $1/4T$, $1/2T$, T , $2T$, $4T$, where T is the defaultPagingCycle.

The following rules apply:

- If n_B is set equal to or larger than T , all radio frames may be used for paging and there are n_B/T POs per PF. An example is shown in Figure 4 on page 11.
- If n_B is set lower than T , only a fraction n_B/T of the radio frames may be used for paging and there is one PO per PF.

To summarize, the number of POs per radio frame (that is, the value relevant for paging capacity) is given by the following expression:

$$n_{PO,frame} = \frac{n_B}{T}$$

Equation 2 Number of POs per Radio Frame

where n_B is the value of the parameter n_B .

The following figure provides an example of the effect of n_B settings on the number of paging frames and paging occasions:

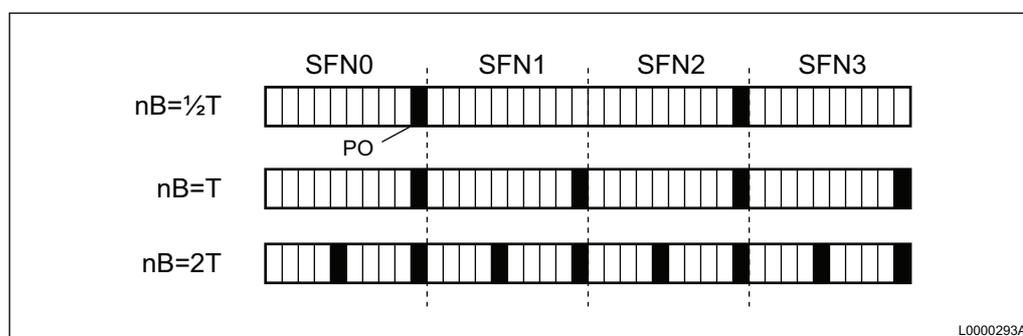


Figure 4 Effect of n_B Settings on Number of Paging Frames and Paging Occasions

The impact of n_B on paging capacity is described as follows:

- A lower value of n_B leads to fewer POs with more UEs paged on each occasion
- A higher value of n_B provides more POs with fewer UEs paged in each occasion.

In general, a lower setting is used when it is important to minimize PDCCH load. The drawback of a lower setting is that the paging messages become larger, increasing the risk that a page cannot be transmitted during the first valid PO as described in Section 3.3 on page 10.

For further details on selecting an appropriate setting of n_B , refer to Section 4.2 on page 13.

4 Paging Capacity

As described in Section 2.3 on page 4, the paging capacities of the MME and RBS have an impact on TA dimensioning. This chapter describes how to estimate the MME and RBS paging capacities.

4.1 MME Paging Capacity

MME paging capacity depends on the number of SCTP/S1 boards in the MME. For TA dimensioning, the recommendation is to not exceed 1500 outgoing pages/s per SCTP board. The MME paging capacity is expressed as:

$$C_{MME} = 1500n_{SCTP}$$

Equation 3 MME Paging Capacity

where

C_{MME} is the paging capacity of the MME for outgoing pages per second.

n_{SCTP} is the number of SCTP boards.

As an example, an MME configured with 5 SCTP boards has a paging capacity of $1500 \times 5 = 7500$ outgoing pages/s.

For further information about the MME, see the SGSN-MME document *SGSN-MME Technical Product Description Overview*.

4.2 RBS Paging Capacity

The RBS paging capacity depends partly on Central Processing Unit (CPU) constraints, and also on the amount of resources that the paging traffic is allowed to consume. The more resources used for paging, the higher the paging capacity.

The following criteria are used when calculating the RBS paging capacity:

CPU load The consumption of CPU resources due to paging traffic must be reasonably low for the CPU to handle other tasks. The capacity in relation to CPU constraints is referred to as C_{CPU} .

PDSCH load The consumption of PDSCH resources due to paging must be reasonably low. Paging traffic has higher

priority than user data and a high paging traffic may reduce downlink capacity and achievable bit rates. The capacity in relation to PDSCH load is referred to as $C_{PDSCHload}$.

Blocking

The fraction of paging records being blocked due to PDSCH limitations (see Section 3.3 on page 10) must be low. Blocking introduces delays in the paging procedure and in the set-up of the data connection. The capacity in relation to blocking is referred to as $C_{blocking}$.

PDCCH load

The consumption of PDCCH load due to paging must be reasonable low. Paging traffic has higher priority than user data, and high paging traffic may reduce the PDCCH ability to carry other signalling traffic such as downlink scheduling assignments and uplink scheduling grants. The capacity in relation to PDCCH load is referred to as $C_{PDCCHload}$.

The following sections describe how to calculate the paging capacity for each of the four criteria. The total RBS capacity is given as the minimum of the four capacity figures:

$$C_{RBS} = \min(C_{CPU}, C_{PDSCHload}, C_{blocking}, C_{PDCCHload})$$

Equation 4 RBS Paging Capacity

4.2.1 Paging Capacity and CPU Load

Incoming pages are handled by CPUs in the RBS. To ensure that paging traffic does not have an adverse effect on the ability of the CPU to handle other tasks, paging traffic must be reasonably low. For the purpose of TA dimensioning, the average paging intensity should not exceed 200 pages/s. The paging capacity related to CPU load is expressed as:

$$C_{CPU} = 200$$

Equation 5 Paging Capacity Related to RBS CPU Load

4.2.2 Paging Capacity and PDSCH Load

To calculate the paging capacity in relation to PDSCH load, the first step is to consider the average number of scheduling blocks, $n_{SB,page}$ required to convey a page over PDSCH. The exact number depends on the number of

paging records included in the RRC paging message. A useful approximation is provided by the following equation:

$$n_{SB,page} = 2.75 + 0.24(n_{PDCCHSymb} - 1)$$

Equation 6 Number of Scheduling Blocks Required to Convey One Page over PDSCH

where $n_{PDCCHSymb}$ is the number of symbols used for PDCCH. In the current release, $n_{PDCCHSymb}$ is equal to 2 for systems with a bandwidth of 5 MHz, and equal to 1 for systems with larger bandwidths.

Using the cost for conveying one paging message, the PDSCH paging load is expressed as a function of the paging intensity:

$$L_{PDSCH} = \frac{n_{SB,page} I_{page,s}}{100n_{SB,frame}} = \frac{[2.75 + 0.24(n_{PDCCHSymbols} - 1)] I_{page,s}}{100n_{SB,frame}}$$

Equation 7 PDSCH Load due to Paging

where:

$I_{page,s}$ is the paging intensity, that is, the average number of incoming pages to the RBS per second.

$n_{SB,frame}$ is the available number of scheduling blocks per frame, see Table 2 on page 15.

Table 2 Number of Scheduling Blocks per Frame

Bandwidth	5 MHz	10 MHz	15 MHz	20 MHz
$n_{SB,frame}$	250	500	750	1000

To calculate the paging capacity for PDSCH load, $C_{PDSCHload}$, the following expression is used:

$$C_{PDSCHload} = \frac{100n_{SB,frame} L_{PDSCH,max}}{2.75 + 0.24(n_{PDCCHSymb} - 1)}$$

Equation 8 Paging Capacity and PDSCH Load

where $L_{PDSCH,max}$ is the tolerable PDSCH load due to paging.

For convenience, the paging capacity as a function of the tolerable PDSCH load is plotted in the following figure:

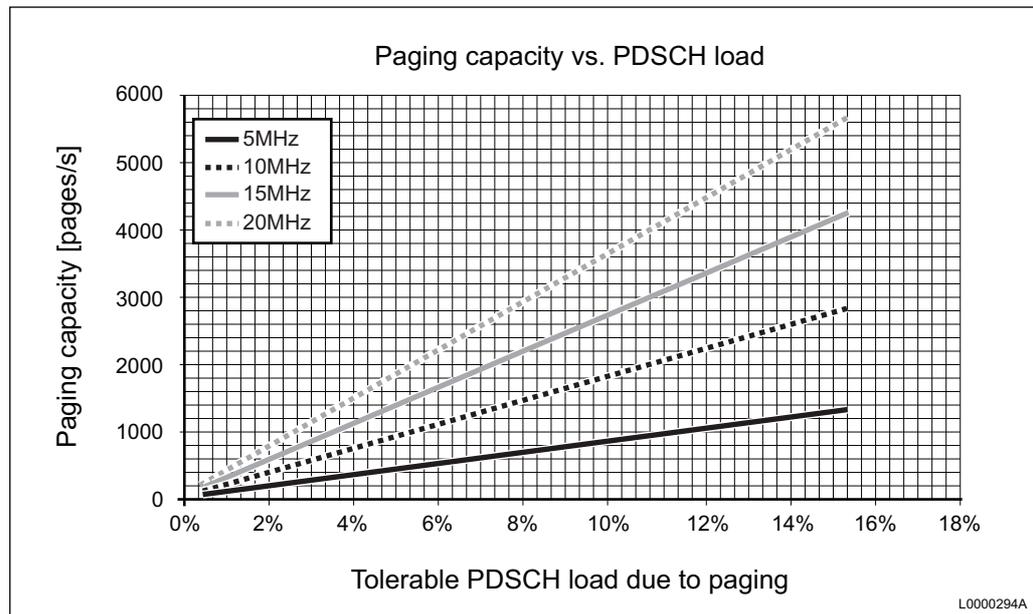


Figure 5 Paging Capacity in Relation to PDSCH Load

The value to use for $L_{PDSCH,max}$ is determined by the operator. As a general rule $L_{PDSCH,max}$ should not exceed 5%.

4.2.3 Paging Capacity and Blocking

As described in Section 3.3 on page 10, the number of paging records that can be transmitted during a subframe is limited by parameter `maxNoOfPagingRecords`. For low blocking levels, it is reasonable to assume that the incoming pages arrive according to a Poisson process. In that case, the capacity in relation to blocking is governed by the following expression:

$$P_{blocking,max} = 1 - \frac{R_{max} - e^{-C_{blocking,PO}} \times \sum_{R=0}^{R_{max}} (R_{max} - R) \frac{C_{blocking,PO}^R}{R!}}{C_{blocking,PO}}$$

Equation 9 Paging Capacity in Relation to Blocking

where:

$C_{blocking,PO}$ is the paging capacity in relation to blocking expressed as pages per PO.

$P_{blocking,max}$ is the tolerable probability for a page being blocked.

R_{max} is the value of `maxNoOfPagingRecords`.

Equation 9 on page 16 is valid only if the IMSIs used in the network are distributed uniformly over the 1024 UE_IDs (see Section 3.1 on page

7). For convenience, the equation is plotted in the following figure that shows paging capacity per PO versus blocking probability and value of maxNoOfPagingRecords:

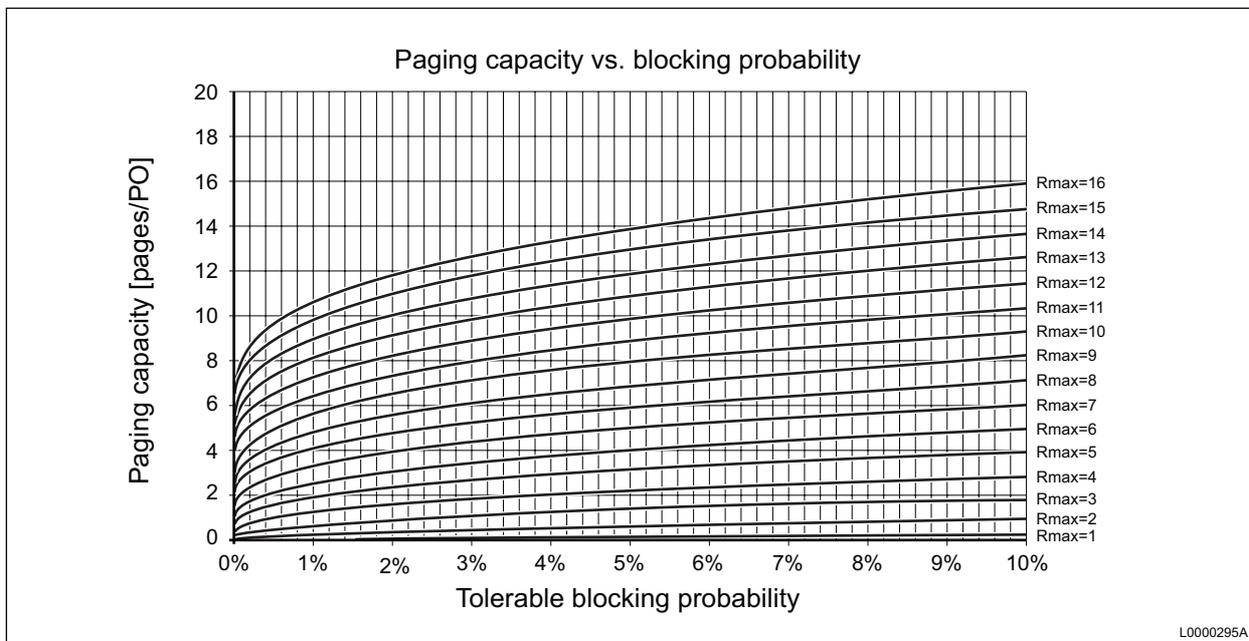


Figure 6 Paging Capacity per PO versus Blocking Probability

The dimensioning process requires the paging capacity in pages per PO, $C_{blocking,PO}$, to be converted to paging capacity in pages per second, $C_{blocking}$. The following expression gives paging capacity in relation to blocking, in pages per seconds:

$$C_{blocking} = C_{blocking,PO} \times 100n_{PO,frame} = C_{blocking,PO} \times 100 \frac{n_B}{T}$$

Equation 10 Paging Capacity in Relation to Blocking

where $n_{PO,frame}$ is the number of POs per radio frame, configured by the parameter n_B , as described in Section 3.4 on page 10.

To illustrate the procedure, assume that in a 5 MHz system, maxNoOfPagingRecords is set to 7, and that the tolerable blocking probability for paging records is 2%. According to Figure 6 on page 17, the maximum paging capacity per PO is about 4. If n_B is set to $\frac{1}{2}T$ (0.5 paging occasions per radio frame) the paging capacity becomes $C_{blocking} = 4 \times 0.5 \times 100 = 200$ pages/s.

By increasing n_B , the paging capacity in relation to blocking can be increased. However, an increase of n_B has an adverse effect on the paging capacity in relation to PDCCH load, see Section 4.2.4 on page 18.

The value to use for $P_{blocking,max}$ is determined by the operator. As a general rule $P_{blocking,max}$ should not exceed 2%.

4.2.4 Paging Capacity and PDCCH Load

As described in Section 3.2 on page 8, a common scheduling assignment for the paging message is sent on PDCCH. Assuming that the pages arrive according to a Poisson process, the probability of a scheduling assignment to send is given by:

$$P_{SA} = 1 - e^{-I_{page,PO}}$$

Equation 11 Probability for Scheduling Assignment

Since the scheduling assignment needs to reach all UEs in the cell (including those located in poor radio conditions), it is transmitted using 8 Control Channel Elements (CCEs). The average number of CCEs required for paging traffic per frame is expressed as:

$$n_{CCE,PO} = 8n_{PO,frame} (1 - e^{-I_{page,PO}})$$

Equation 12 Average Number of CCEs Required for Paging

The PDCCH load is calculated by comparing the number of CCEs used for transmitting the scheduling assignment per frame with the total number of CCEs per frame. The final equation for PDCCH capacity is written as:

$$C_{PDCCHload} = -100n_{PO,frame} \times \ln \left[1 - \frac{n_{CCE,frame} L_{PDCCH,max}}{8n_{PO,frame}} \right]$$

Equation 13 Paging Capacity in Relation to PDCCH Load

where

$C_{PDCCHload}$ is the paging capacity in relation to PDCCH load

$n_{CCE,frame}$ is the number of CCEs per frame, see Table 3 on page 18

$L_{PDCCH,max}$ is the tolerable PDCCH load due to paging

The following table lists the number of CCEs per frame. The settings for the current release are shown in bold:

Table 3 Number of CCEs per Frame

Bandwidth	5 MHz	10 MHz	15 MHz	20 MHz
$n_{PDCCHsymbols} = 1$	30	80	120	170

Bandwidth	5 MHz	10 MHz	15 MHz	20 MHz
$n_{PDCCHsymbols} = 2$	120	250	370	500
$n_{PDCCHsymbols} = 3$	200	410	620	840

Equation 13 on page 18 is valid only if the IMSIs used in the network are distributed uniformly over the 1024 UE_IDs, see Section 3.1 on page 7.

For convenience, the equation is plotted in the following figure that shows paging capacity versus tolerable PDCCH load for the current release:

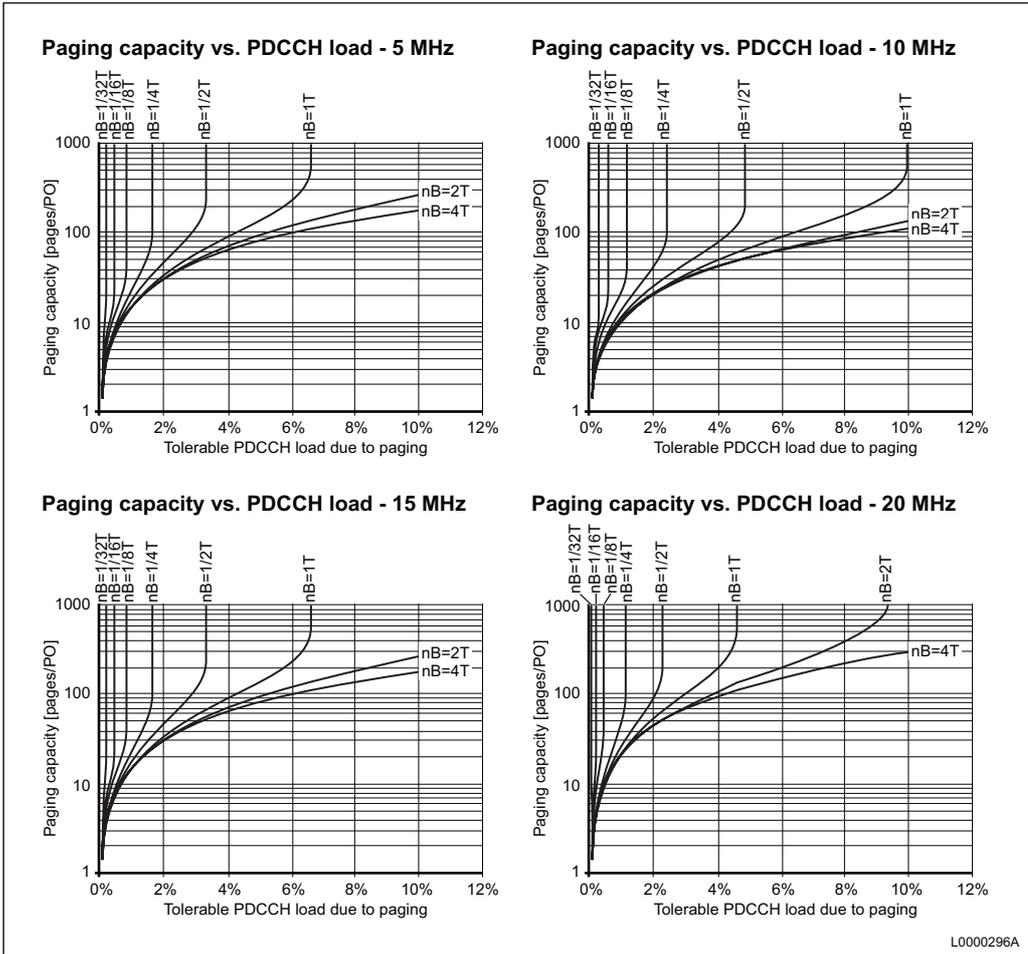


Figure 7 Paging Capacity versus Tolerable PDCCH Load

The value of n_B has a large effect on the paging capacity in relation to PDCCH load. The value of $L_{PDCCH,max}$ is determined by the operator. As a general rule $L_{PDCCH,max}$ should not exceed 5%.

4.3 Example of Calculating RBS Paging Capacity

This section provides an example of calculating RBS paging capacity.

4.3.1 Input

For a 5 MHz RBS with `maxNoOfPagingRecords = 7` the paging capacity should be calculated based on the following criteria:

- Paging capacity in relation to CPU load must not be exceeded
- PDSCH load due to paging traffic should not exceed 5%
- Blocking probability should not exceed 2%
- PDCCH load due to paging traffic should not exceed 5%

4.3.2 Solution

The following list shows the stages in finding a solution for paging capacity:

- 1 A suitable starting point is the paging capacity in relation to CPU load given by Equation 5 on page 14:

$$C_{CPU} = 200$$

- 2 The second step is to evaluate the paging capacity in relation to the PDSCH load criterion. By using Equation 9 on page 16 or Figure 5 on page 16, the paging capacity in relation to PDSCH load is:

$$C_{PDSCHload} = \frac{100n_{SB.frame}L_{PDSCH,max}}{2.75+0.24(n_{PDCCHsymbols}-1)} = \frac{100 \times 250 \times 0.05}{2.75+0.24(2-1)} \approx 420$$

- 3 The third step is to evaluate the paging capacity in relation to the blocking criterion. According to Figure 7 on page 19, with `maxNoOfPagingRecords` equal to 7 and a tolerable blocking probability equal to 2%, the paging capacity per PO is approximately equal to 4. The paging capacity in pages per seconds is calculated as:

$$C_{blocking} = C_{blocking,PO} \times 100 (n_B/T) = 4 \times 100 (n_B/T)$$

A setting of $n_B = T$ results in a paging capacity in relation to blocking of 400 pages/s. Reducing n_B to $1/2T$ results in a paging capacity in relation to blocking of 200 pages/s.

- 4 The fourth step is to evaluate the paging capacity in relation to the PDCCH load criterion. By using Equation 13 on page 18 or (easier) Figure 7 on page 19 the conclusion is that with $n_B = T$, the paging capacity in relation to PDCCH load is approximately 140 pages/s. With $n_B = 1/2T$, the paging capacity in relation to PDCCH capacity is infinite.

To maximize the paging capacity in relation to both steps 3 and 4, $nB = 1/2$ is selected.

- 5 The total RBS capacity is given by Equation 4 on page 14 to 200 pages/second:

$$C_{RBS} = \min(C_{CPU}, C_{PDSC\text{Hload}}, C_{blocking}, C_{PDCC\text{Hload}}) = \min(200, 420, 200, \infty) = 200$$

5 TA Dimensioning

The previous chapter described how to determine the paging capacity of the RBS and MME. The capacity values are used in the TA dimensioning process described in this chapter.

5.1 Process Overview

The process of TA dimensioning contains two main tasks:

- TA dimensioning for the MME
- TA dimensioning for the RBS

These steps can be done sequentially or in parallel. The output of the tasks is the total number of RBSs suitable to include in a TA list.

For information on the number of RBS to include per TA, and the number of TAs to include in a TA list, refer to Section 6 on page 27.

An overview of the process for TA dimensioning is shown in the following figure:

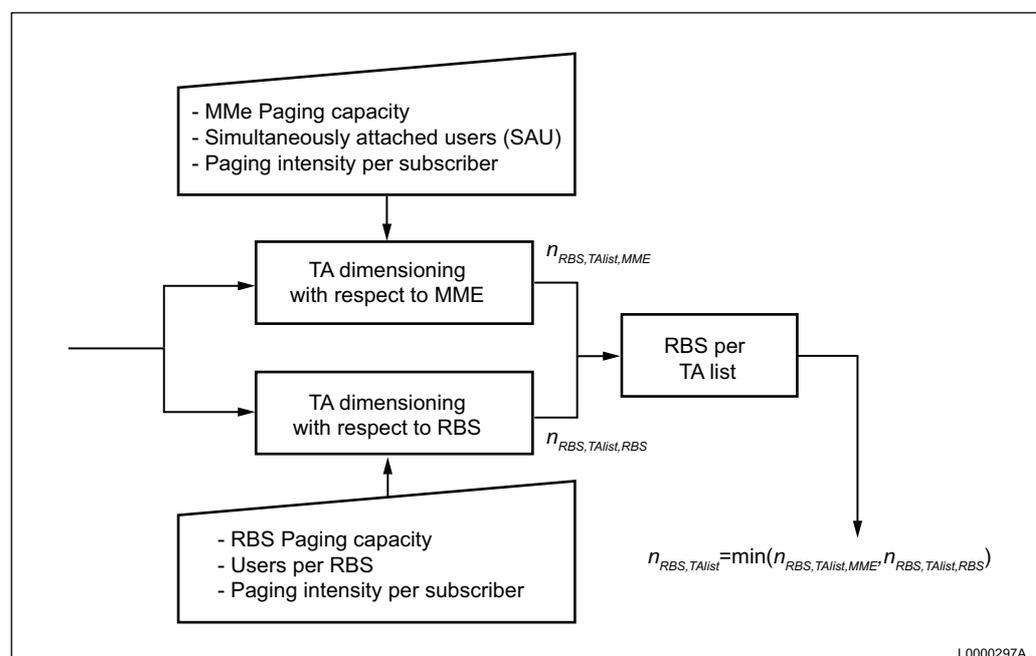


Figure 8 Overview of Process for TA Dimensioning

5.2 Input Data

The following input data is required in the TA dimensioning process:

- Paging capacity of the MME, C_{MME} , see Section 4.1 on page 13.
- Paging capacity of the RBS, C_{RBS} , see Section 4.2 on page 13.
- Paging intensity per subscriber (during busy hour), $I_{page,sub,s}$. This figure differs greatly between networks, see Section 7 on page 31.
- Number of Simultaneously Attached Users in an MME during busy hour, $n_{SAU,MME}$. This figure depends on subscriber base and the number of MMEs in the core network. It is not described further in this document.
- Average number of subscribers per RBS during busy hour, $n_{sub,RBS}$. This figure depends on the subscriber base and the number of RBSs. It is not described further in this document.

5.3 Equations

Having estimates of the input data described in Section 5.2 on page 24, the maximum number of RBSs in the TA list for MME paging capacity is calculated as:

$$n_{RBS,TAlist,MME} = \frac{C_{MME}}{n_{SAU,MME} \times I_{page,sub,s}}$$

Equation 14 Number of RBSs per TA List in Relation to MME Paging Capacity

In a similar way, the number of RBSs per TA list in relation to the RBS paging capacity is calculated as:

$$n_{RBS,TAlist,RBS} = \frac{C_{RBS}}{n_{sub,RBS} \times I_{page,sub,s}}$$

Equation 15 Number of RBSs per TA List in Relation to RBS Paging Capacity

The final result is given by the minimum of the two:

$$n_{RBS,TAlist} = \min(n_{RBS,TAlist,MME}, n_{RBS,TAlist,RBS})$$

Equation 16 Number of RBSs per TA List

5.4 Example of TA Dimensioning

This section provides an example of TA dimensioning.

5.4.1 Input

In this example, the number of RBSs in the TA list is calculated based on the MME being configured with 5 SCTP/S1 boards.

The following data is used in the example:

- In a city with 700,000 attached subscribers there are two MMEs.
- 50% of the subscribers have PC cards and 50% have handheld terminals.
- It is assumed that there are 0.39 paging requests for PC card users and 1.68 paging requests for handheld users per busy hour.
- There are approximately 5000 users per RBS and the RBS paging capacity has been determined to be approximately 200 pages/s, according to the example in Section 4.3 on page 20.

5.4.2 Solution

The following list shows the tasks in finding a solution for TA dimensioning:

- 1 The first step is to calculate the paging intensity per subscriber and second:

$$I_{page,sub,s} = \frac{0.39 \times 0.5 + 1.68 \times 0.5}{3600} = 0.0002875$$

- 2 The second step is to perform TA dimensioning in relation to the MME:

Assuming that the number of attached users in the two MMEs are equally split between the two MMEs, $n_{SAU,MME}$ becomes:

$$n_{SAU,MME} = 700000/2 = 350000$$

The MME paging capacity with 5 SCTP boards is:

$$C_{MME} = 1500n_{SCTP} = 1500 * 5 = 7500$$

Using Equation 14 on page 24 gives the number of RBS per TA list for MME paging capacity:

$$n_{RBS,TAlist,MME} = \frac{C_{MME}}{n_{SAU,MME} \times I_{page,sub,s}} = \frac{7500}{350000 \times 0.0002875} = 74$$

- 3 The third step is to perform TA dimensioning in relation to RBS paging capacity by using Equation 15 on page 24:

$$n_{RBS,TAlist,RBS} = \frac{C_{RBS}}{n_{sub,RBS} \times I_{page,sub,s}} = \frac{200}{5000 \times 0.0002875} = 140$$

- 4 The maximum number of RBSs to include per TA list is given by Equation 16 on page 24. In this example, the TA list size is limited by the MME capacity to 74 RBSs per TA list:

$$n_{RBS,TAlist} = \min(n_{RBS,TAlist,MME}, n_{RBS,TAlist,RBS}) = 74$$

6 TA Planning

When planning borders between TAs and TA lists, the following two general rules apply:

- TAs and TA lists should be planned so that areas with frequent TA update signalling are located in low traffic areas. This makes it easier for the RBS to cope with the additional signalling caused by the TA update procedure.
- TAs and TA lists should be planned so that the need for TA updates is minimized. This is accomplished by considering how users travel within the network. Busy roads, railways, and so on, should cross as few TA list borders as possible.

6.1 TA Lists with Multiple TAs

From release SGSN-MME R2010A RP02, up to 16 TAs per TA list will be supported. For every TA, the operator can specify a list of up to 15 TAs to include and the MME always adds the old TA to the list to reduce the risk of ping-pong updates.

In case TA lists with multiple TAs are employed, the average number of RBSs per TA should not exceed:

$$n_{RBS,TA} = n_{RBS,TAlist} / n_{TA,TAlist}$$

Equation 17 Number of RBSs per TA

where:

$n_{RBS,TAlist}$ is the number of RBSs to include per TA list, calculated in the dimensioning process.

$n_{TA,TAlist}$ is the number of TAs in the TA list. When TA lists with multiple TAs are used, the minimum value to use for $n_{TA,TAlist}$ is equal to 2. This is due to the fact that the MME always adds the current TA as well as the old TA to the list.

Besides reducing the risk for ping-pong updates, TA lists with multiple TAs can help resolve the issue of a few cells having to handle a high number of TA updates.

This is done by including many TAs in the TA list and defining the TA lists in a sliding window, as shown in the following figure:

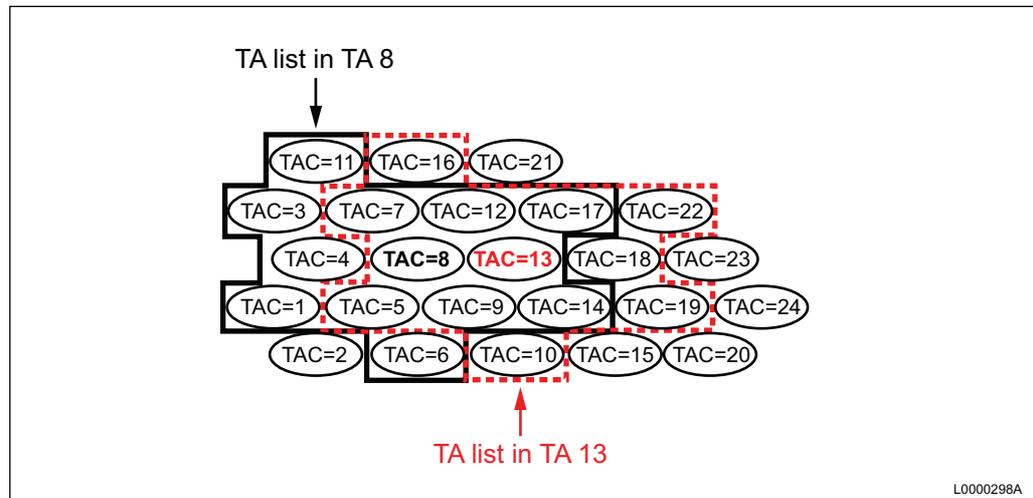


Figure 9 TA Lists Planned in Sliding Window

With this strategy, the TA update load is distributed over a large number of cells.

The operator can determine the number of TAs to include per TA list, taking into account the characteristics of the cell plan. The larger the number the more even is the distribution of TA update signalling. One drawback with a larger TA list is that it requires more planning and administration.

6.2 Early Strategies for TA Lists

This section describes strategies for planning TA lists.

6.2.1 Planning without Considering Future Migration to TA Lists with Multiple TAs

In MME releases prior to SGSN-MME R2010A RP02 only the current TA is sent in the TA list. With one TA in the TA list it is possible to allocate all $n_{RBS,TAlist}$ RBSs from the dimensioning exercise to the same TA, as shown in the following figure:

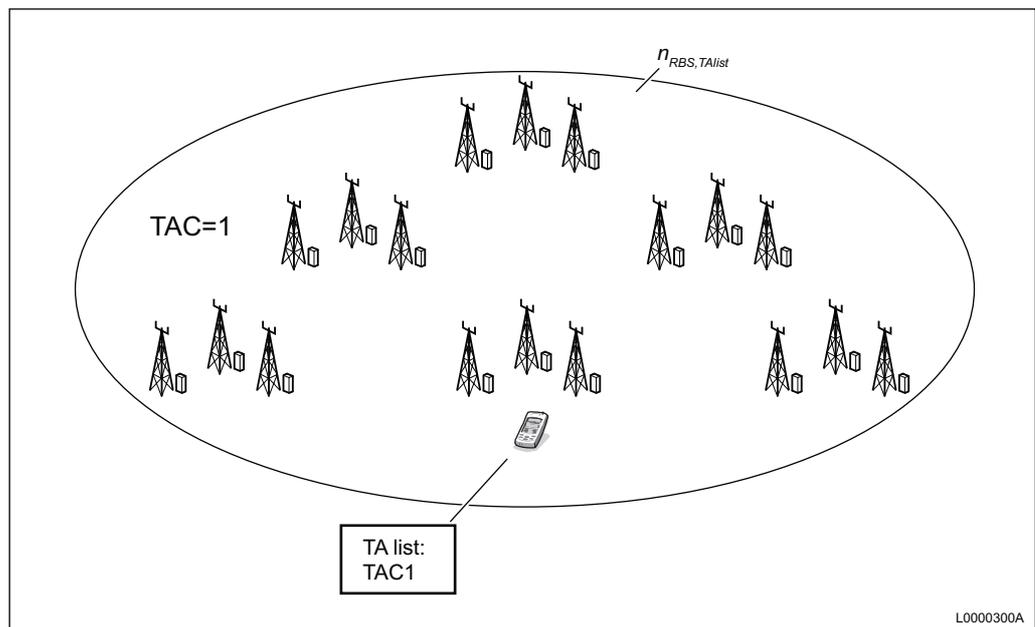


Figure 10 All RBSs Allocated to Same TA

With this strategy, the TAs are likely to be large, and large parts of existing RA boundaries can be re-used.

The drawback to this strategy is that TAs must be replanned once TA lists with multiple TAs are introduced to the network.

6.2.2

Planning without Considering Future Migration to TA Lists with Multiple TAs

To avoid replanning TAs when introducing TA lists with multiple TAs, the option exists to dimension the TA size according to Equation 17 on page 27. A drawback is that this strategy can lead to more frequent TA updates, increasing the MME load.

The additional update signalling is not a major problem if the number of subscribers is small. An example planning for multiple TAs per TA list is shown in the following figure:

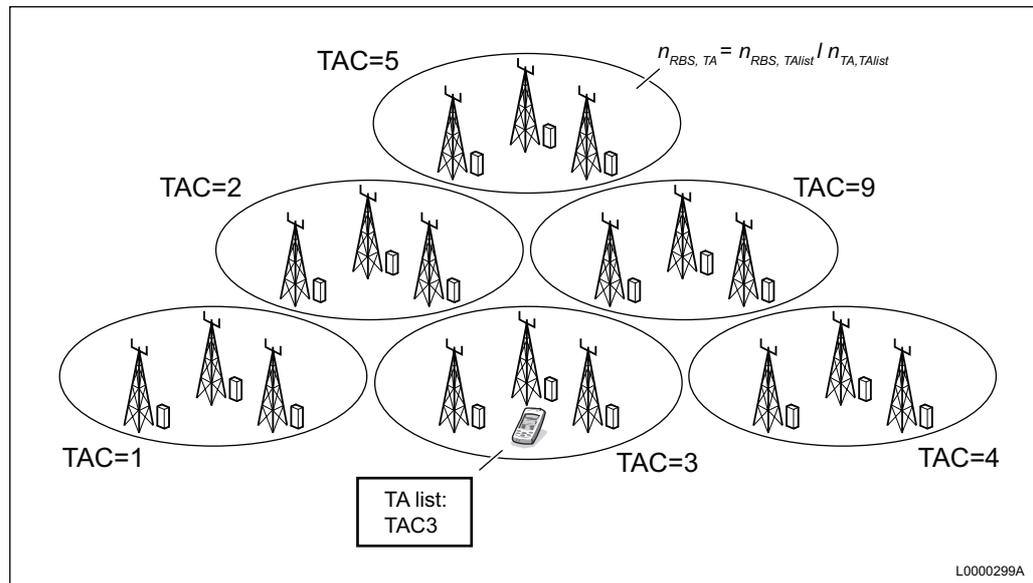


Figure 11 Example of TA Planning with One TA per TA List

7 Estimating Paging Traffic per Subscriber

The paging intensity per subscriber is a key parameter in the TA dimensioning process. Indications on what to expect are obtained by studying the paging intensity in 3G networks.

Experience from previous systems shows that the paging intensity differs greatly between networks, depending on service, tariffs, types of terminals, and so on.

Measurements have also shown that malicious software can generate large amounts of paging traffic. It is recommended that operators counteract these applications to reduce the paging load.

The paging intensity also depends on the setting of parameter `tInactivityTimer`, controlling the length of time that users must be inactive before being released to idle mode. The default setting of the timer is 61 seconds. A shorter value leads to a faster return to idle mode, and a higher paging intensity.