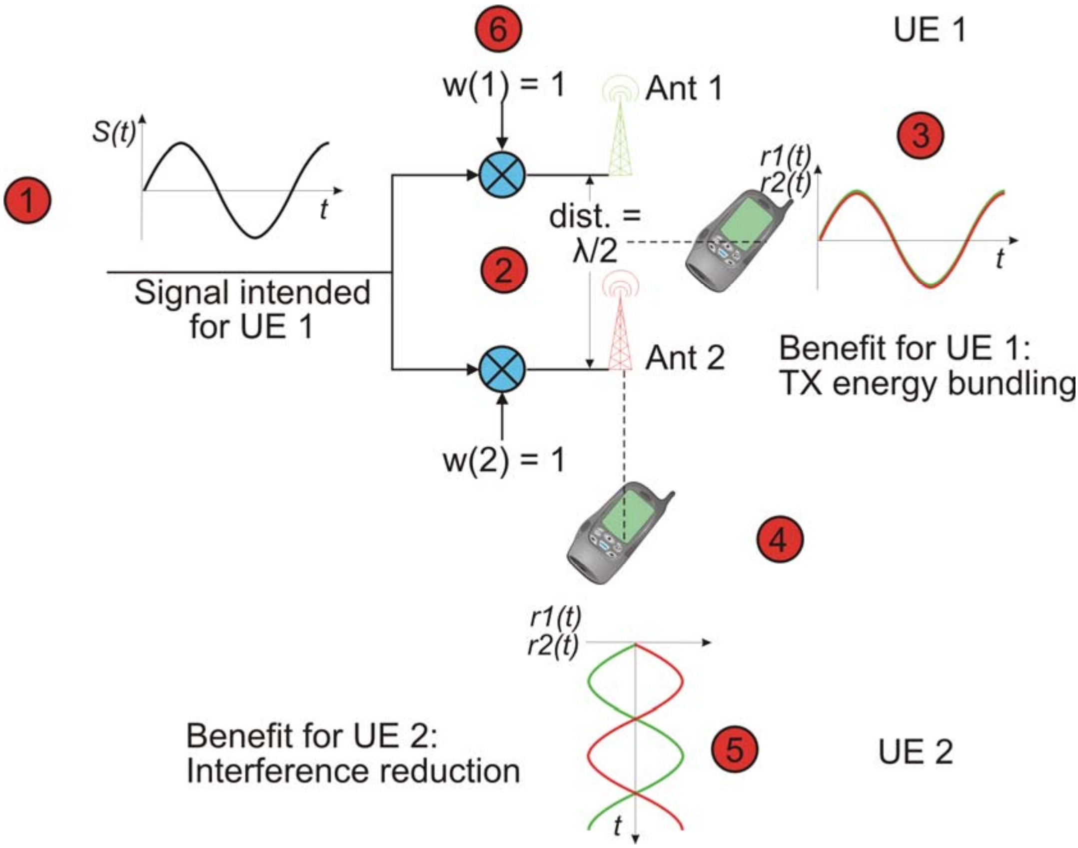
1.3.3.3.3 Adaptive Antenna Systems (AAS)



The objective of this section to show key features and key benefits of AAS.

Key point of this section is that AAS is both improving the signal quality and is reducing the interference in the system by means of weighing various TX antennas' signals with different antenna weights.

Image Description

- The top half of the picture is showing the generation of the signal for UE 1 in an AAS scenario with two antennas.
- The lower half of the picture is showing how the signal for UE 1 is perceived by UE 2.

1

1.3.3.3.3.1 Signal generation

In the upper part the physical setup the signal generation is shown. At first the user signal is created as if there were no AAS.

2 Then the signal is copied two times (once for each antenna) and is then multiplied with a user dependent weighing factor for each antenna. In the case of this picture the two weighing factors are both 1. In an AAS system the antennas are usually very close together: Typically half the wave length is chosen in order to perform beamforming.

1.3.3.3.3.2 Constructive superimposition at the intended receiver

3 In the picture the weighing coefficients are chosen in a way that the two antennas radio signals are superimposing constructively at the position of the UE. One benefit of the AAS is that the TX energy is bundled in the direction of the UE's the signal is intended for.
For realistic AAS more than 2 antennas are situated in a line (linear antenna array) or on a circle (circular antenna array).

Room for your Notes

- **Abbreviations of this Section:**

AAS	Adaptive Antenna Systems	**UE**	User Equipment
TX	Transmit		

4 **1.3.3.3.3.3 Destructive superimposition at the not intended receiver**

UE2 is located below the two antennas. Here the signal of antenna 1 has traveled exactly half a wavelength longer than the signal of antenna 2. This has the consequence that it always has a phase shift of 180 degrees compared with the signal of antenna 2.

5 This leads to a complete destruction of the two antennas signals. Here the benefit of AAS of interference reduction is shown very well.

What would happen once one of the two antennas is switched off?
How to achieve that that the AAS is radiating the signal towards UE2?

1.3.3.3.3.4 Generation of signals for multiple UE's

6 Each UE will have its own signal generated with its own weighing factors. After the weighing process for each UE the signals are added up before they reach the TX antennas. This feature is very important for AAS's application in modern mobile radio systems where multiple signals for multiple UE's are transmitted on the individual radio carrier.

Room for your Notes

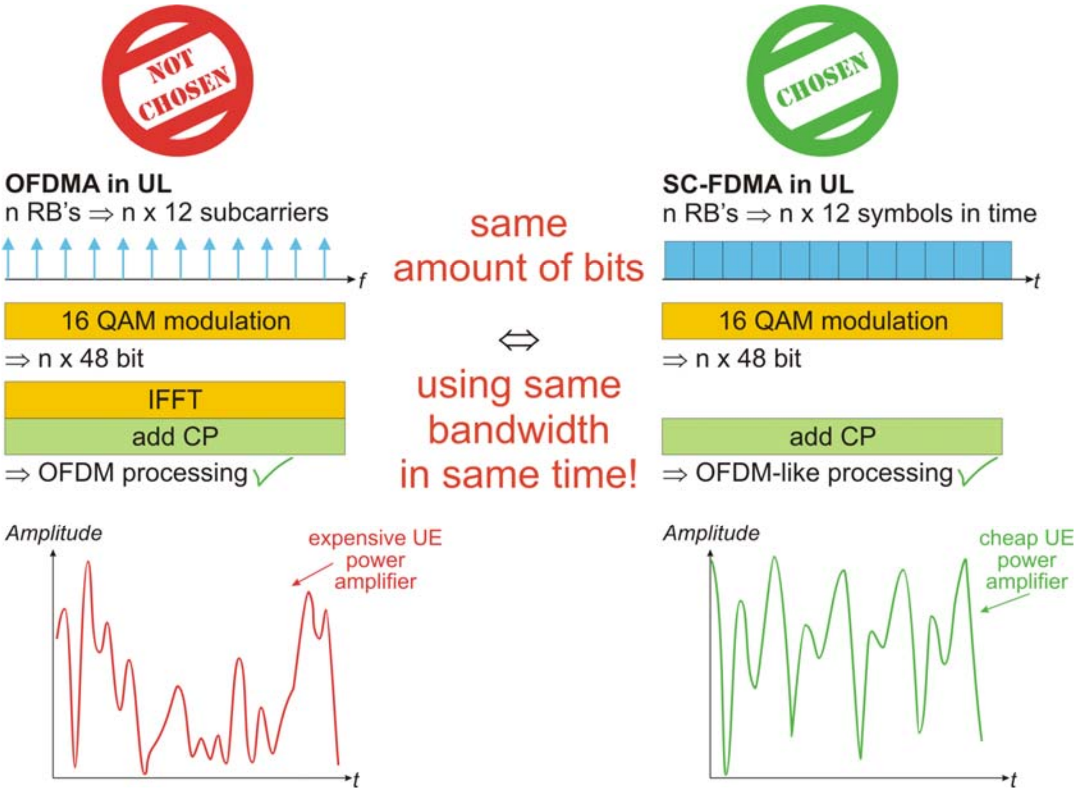
Room for your Notes

- **Abbreviations of this Section:**

AAS	Adaptive Antenna Systems	**UE**	User Equipment
TX	Transmit		

3

3.1.3 Choice of the UL Transmission Scheme



The objective of this section is to provide the reasoning behind the decision for SC-FDMA as the UL transmission technology.

Key point of this section is that SC-FDMA has been chosen because of the reduced AM requirements on the power amplifier of the UE compared to OFDM technology (cost reasons).

Image description

- The picture shows the distribution of 16-QAM modulation symbols on the OFDM carriers and the resulting time signal for OFDMA technology being used in the UL on the left hand side.
- The picture shows the distribution of 16-QAM modulation symbols on the SC-FDMA time symbols and the resulting time signal for SC-FDMA technology being used in the UL on the right hand side.

3

3.1.3.1 What would happen if OFDM would be used in the UL

Once OFDM would be used in the UL there would be the same RB structure as in the DL. Consequently multiple of 12 subcarriers would be used to map the UL bits of e.g. 16-QAM symbols on the subcarriers. Since all the subcarriers' signals superimpose on the time signal of the OFDM symbol, very severe AM would be the result. For high data rate UE's this AM would result in very expensive power amplifiers.

3.1.3.2 SC-FDMA is used for the UL

The advantage of a single carrier signal would be that the AM at the power amplifier is mainly determined by the modulation alphabet and not additionally by the number of subcarriers. Thus the AM and consequently also the power amplifiers price is much more favorable than for OFDM signals. In order to enjoy still the benefit of low processing power requirements of OFDM signals the SC- signal has been designed to fit into the corset of the would be UL OFDM signal by means of the following measures:

1. Choose the same amount of modulation symbols in the RB
2. Choose the same bandwidth occupied by the RB
3. Choose the same duration of SC-FDMA symbols (cluster of n x 12 modulation symbols)
4. Adding the same CP period as for an OFDM signal
5. Choosing the same sampling grid for the processed signals. (The modulation symbols are interpolated to sampling grid.)

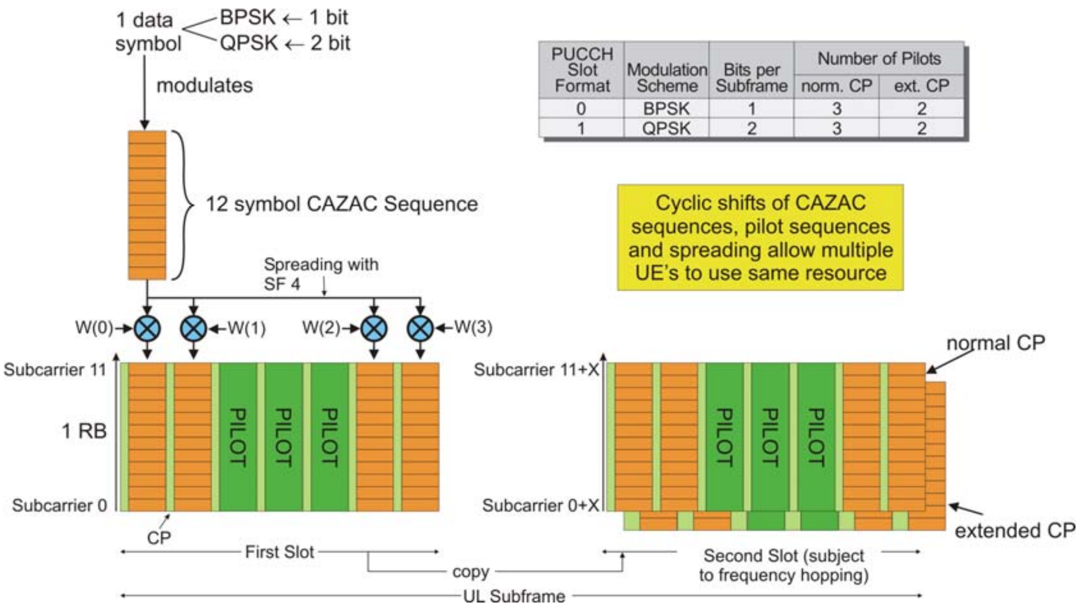
All these measures ensure that effectively the same subcarriers are used, that orthogonality is kept amongst the subcarriers and that a similar way to process the SC-FDMA symbols as for OFDM symbols is kept.

Room for your Notes

- **Abbreviations of this Section:**

16-QAM	16 symbols Quadrature Amplitude Modulation	**OFDMA**	Orthogonal Frequency Division Multiple Access
AM	Amplitude Modulation	**RB**	Resource Block
CP	Cyclic Prefix	**SC-FDMA**	Single Carrier Frequency Division Multiple Access
DL	Downlink	**UE**	User Equipment
OFDM	Orthogonal Frequency Division Multiplexing	**UL**	Uplink

3.3.2 PUCCH mapping for ACK/NACK only



PUCCH Slot Format	Modulation Scheme	Bits per Subframe	Number of Pilots	
			norm. CP	ext. CP
0	BPSK	1	3	2
1	QPSK	2	3	2

The objective of this section is to show how ACK's and NACK's are transmitted on the PUCCH with slot formats 0 and 1.

Key point of this section is that for these two slot formats both CDMA and cyclically shifted CAZAC sequences are used to multiplex different UE's to use the same UL resources for the PUCCH.

Image description

- The picture visualized the procedure of mapping the ACK's and NACK's on the subframe of the PUCCH.
- In the foreground the picture shown the normal CP configuration. Below the second slot the extended CP configuration is shown.

For the case that only ACK's and NACK's are in need to be transmitted, there the problem that a complete UL subframe is blocked once the PUCCH is transmitted with only one or two bits. This is why CAZAC sequences are modulated with the symbols to be transmitted on the PUCCH. This will provide a gain of 12. Another advantage is that once the CAZAC sequences are cyclically shifted different users with different shifts can be separated. In order to ease that more pilot SC-FDMA symbols are used than in the PUSCH. In order to differentiate in-between multiple UE's also the pilot sequences have to be cyclically shifted. The 3 pilots leave the remaining 4 data SC-FDMA symbols up to a CDMA process with SF 4. This spreading would also allow separating different users. In order to allow for a separation of the different users for the channel estimation process, different users have also different cyclic shifts for the Zadoff-Chu sequences for the pilot symbols.

Once the extended cyclic prefix is used for the UL there are 2 pilot symbols for a slot only. Compared to the normal cyclic prefix 1 symbol is missing (6 instead of 7 symbols).

!

The PUCCH slot formats are corresponding to 2 modulation schemes associated with the ACK/NACK transmission.
BPSK is used when only one TB has to be acknowledged. Only one bit is transmitted here.
BPSK is only suited to transmit one bit at a time. This is why in case the DL is transmitting two TB's at the same time (with MIMO) QPSK will be used.
[3GTS 36.211 (6.4)]

Room for your Notes

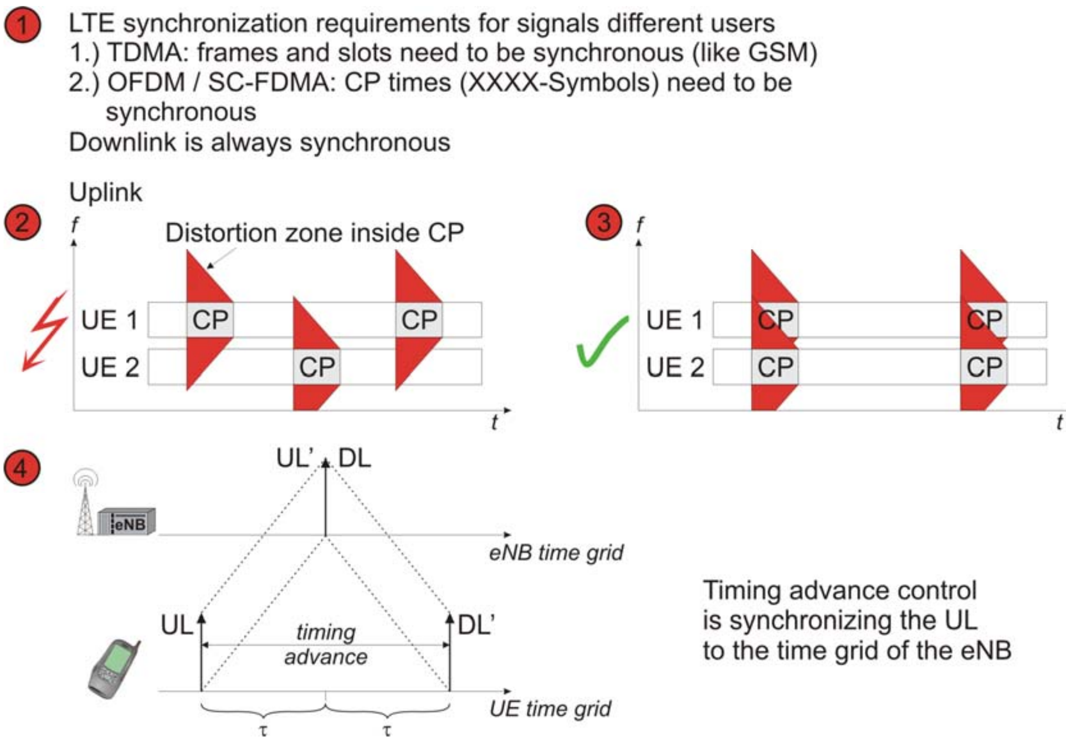
- **Abbreviations of this Section:**

3GTS	3rd Generation Technical Specification	**PUCCH**	Physical Uplink Control Channel
ACK	Acknowledgement	**PUSCH**	Physical Uplink Shared Channel
BPSK	Binary or Bipolar Phase Shift Keying	**QPSK**	Quadrature Phase Shift Keying
CAZAC	Constant Amplitude Zero Autocorrelation	**RB**	Resource Block
CDMA	Code Division Multiple Access	**SC-FDMA**	Single Carrier Frequency Division Multiple Access
CP	Cyclic Prefix	**SF**	Spreading Factor
DL	Downlink	**TB**	Transport Block
FDMA	Frequency Division Multiple Access	**UE**	User Equipment
MIMO	Multiple In / Multiple Out (antenna system)	**UL**	Uplink
NACK	Negative Acknowledgement	**eNB**	Enhanced Node B

3

3.5.1 Timing Advance Control

3.5.1.1 Principle



The objectives of this section are to show the principle operation of timing advance control in LTE and to state to what degree the time synchronization by means of timing advance control is in need to be maintained.

Key point of this section is that since LTE is a TDMA system like GSM TA like in GSM becomes necessary.

Image description

- This picture is stating the basic synchronization requirements for OFDM and is visualizing the behavior of the system in the synchronized and in the unsynchronized case.

In UTRA the downlink signals are synchronized to a 256 chip grid whereas the uplink signals are asynchronous amongst each other. This is a rather relaxed synchronization requirement.

1 However in LTE, due to the special nature of the applied OFDM and SC-FDMA technology even tougher synchronization requirements have to be followed.

Like in GSM there is the TDMA structure to be followed. This is requiring that the UL frames of all the UE's are synchronized to the eNB's timing grid.
As well the usage of OFDMA and SC-FDMA technology is implying that signals for multiple UE's are received or transmitted at the same time. In order to allow for a good separation of the signals for the different UE's this is requiring that the cyclic prefixes are coinciding. For the downlink this is quite simple to implement because the eNB is aligning the CP's of the signals for the different UE's automatically.
For the UL however this is more difficult to achieve. As shown in the picture once the UE's CP's are not arriving in a synchronous manner in the eNB the distortions caused by the changing symbol modulation in the CP interfere with the UE's signals on the neighboring carriers. This inference will make a successful detection impossible. 2
Only once the SC-FDMA symbols are synchronized such that their CP's are co-inciding the interference is falling into the CP. Since the CP is not processed for the detection process it is not harmful in the synchronized case. 3

Room for your Notes

- **Abbreviations of this Section:**

3GTR	3rd Generation Technical Report	**OFDMA**	Orthogonal Frequency Division Multiple Access
CIR	Channel Impulse Response	**SC-FDMA**	Single Carrier Frequency Division Multiple Access
CP	Cyclic Prefix	**TDMA**	Time Division Multiple Access
DL	Downlink	**UE**	User Equipment
GSM	Global System for Mobile Communication	**UL**	Uplink
LTE	Long Term Evolution (of UMTS)	**UTRA**	UMTS (Universal Mobile Telecommunication System) Terrestrial Radio Access
OFDM	Orthogonal Frequency Division Multiplexing	**eNB**	Enhanced Node B

3

4

Like in GSM this synchronization is achieved by means of timing advance control. The UE has to apply a timing advance which is shifting the gird of the UL timing against the downlink grid of the DL at the UE. Since both the downlink needs a propagation delay τ to arrive at the UE's position and the uplink needs a propagation delay τ as well to arrive at the eNB the uplink timing grid has to advance twice to propagation delay at the UE's position to arrive in the eNB's timing grid at the eNB's position.
The eNB is controlling the timing advance of the UE's by means of timing advance control commands. In general the average CIR profile is controlled since the control algorithm is too slow to follow the instantaneous changes of the mobile radio channels propagation delay. Since the CP can have a length of only about 5 µs the accuracy of the timing advance control has to be for sure better than 1 µs. It has to be highlighted here the timing advance inaccuracy is shortening the maximum length of the channel impulse response tolerated by the system.
It is open until now whether the timing advance control is an open or closed loop, and whether it is performed suing physical layer power control commands or using higher layer commands.

[3GTR 25.814 (9.1.2.6)]

Room for your Notes

Room for your Notes

- **Abbreviations of this Section:**

3GTR	3rd Generation Technical Report	**OFDMA**	Orthogonal Frequency Division Multiple Access
CIR	Channel Impulse Response	**SC-FDMA**	Single Carrier Frequency Division Multiple Access
CP	Cyclic Prefix	**TDMA**	Time Division Multiple Access
DL	Downlink	**UE**	User Equipment
GSM	Global System for Mobile Communication	**UL**	Uplink
LTE	Long Term Evolution (of UMTS)	**UTRA**	UMTS (Universal Mobile Telecommunication System) Terrestrial Radio Access
OFDM	Orthogonal Frequency Division Multiplexing	**eNB**	Enhanced Node B

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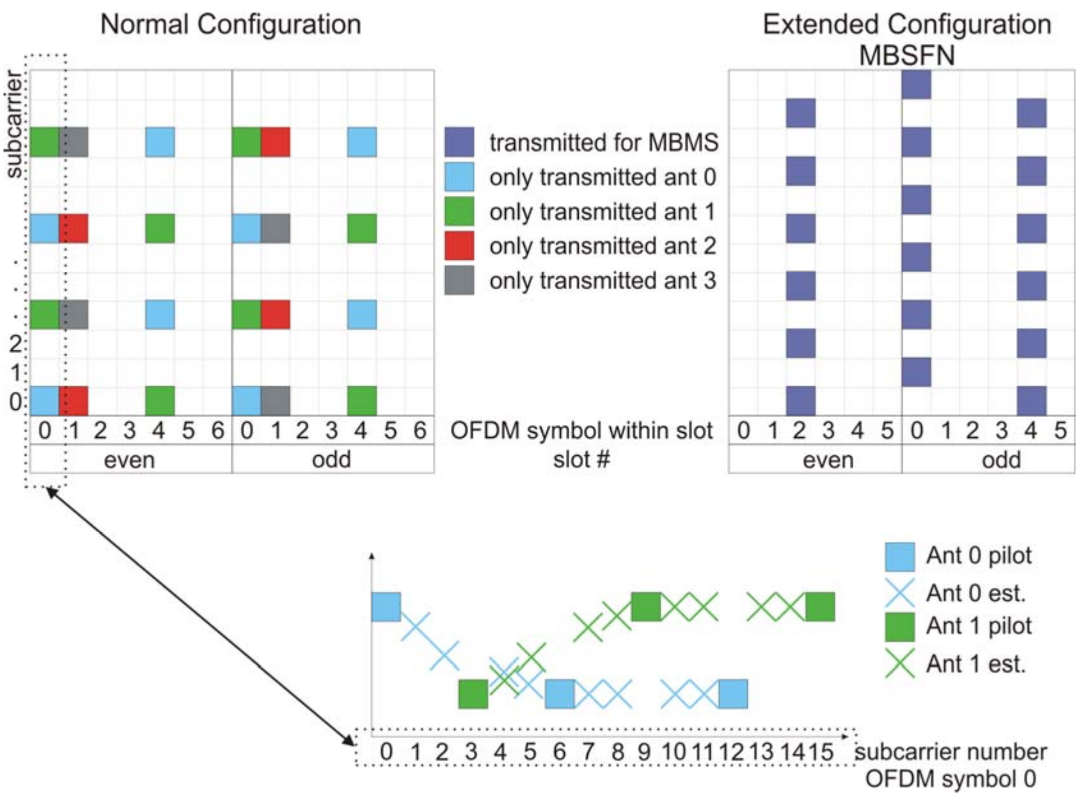
3.5.3.2 Channel Estimation Downlink



The objective of this section is to show how the reference symbols are distributed in time and subcarrier space and how it is ensured that the signals from different TX antennas can be separated in the downlink.

Key point of this section is that the special arrangement of the pilot symbols is enabling the receiver to estimate the channel impulse response belonging to the individual transmit antennas.

Image description

- The picture is focusing on the 15 kHz sub carrier spacing and is showing how the pilot subcarriers are distributed.

3.5.3.2.1 Normal configuration with 4 TX antennas

Here the pilot symbols have to enable the differentiation of 4 antennas. This is done by means of having exclusively reserved positions of pilot symbols for the individual antennas. If one antenna is transmitting on one subcarrier this subcarrier will not be used by the other antenna neither for pilot symbols nor for data symbols.

This has the advantage that no interference is coming from the other antennas for the channel estimation of the regarded antenna.
The disadvantage obviously is that the throughput to be transmitted for each antenna is suffering the more antennas are used.
For the 3rd and the 4th antenna the pilot symbols are less dense in the time domain, because 4 antennas would lead to an extremely high data rate and this is only less likely to successfully happening with a high UE mobility. So the UE speed to be supported can be lower from the channel estimation point of view also.

3.5.3.2.2 Normal configuration with less than 4 TX antennas
If the above allocation would be used for less than 4 antennas (2 and 1 antenna) there would be some positions which are never used. In order to gain throughput these positions will be used for data symbols again.

3.5.3.2.3 Extended configuration with 15 kHz subcarrier spacing
Here the difference is that there are only 6 OFDM symbols instead of the 7 symbols shown in the picture. The change here is that the symbols with the number 2 or 3 in the normal configuration is omitted.

3.5.3.2.4 Extended configuration with 15 kHz subcarrier spacing for MBSFN
This configuration is used for MBMS transmission combined with SFN only. Here the channel impulse responses can be very long. This is the reason why the pilots a more dense in the frequency domain. Since the MBMS services are expected to be associated with less mobility for the UE there are more OFDM symbols as for the other configurations.

3.5.3.2.5 Extended configuration with 7.5 kHz subcarrier spacing for MBSFN
This configuration is existing only in the DL – thus for broadcast operation.

As shown in the lower part of the picture, optionally the channel impulse response can be interpolated in-between the pilot symbols for equalizing the data symbols.

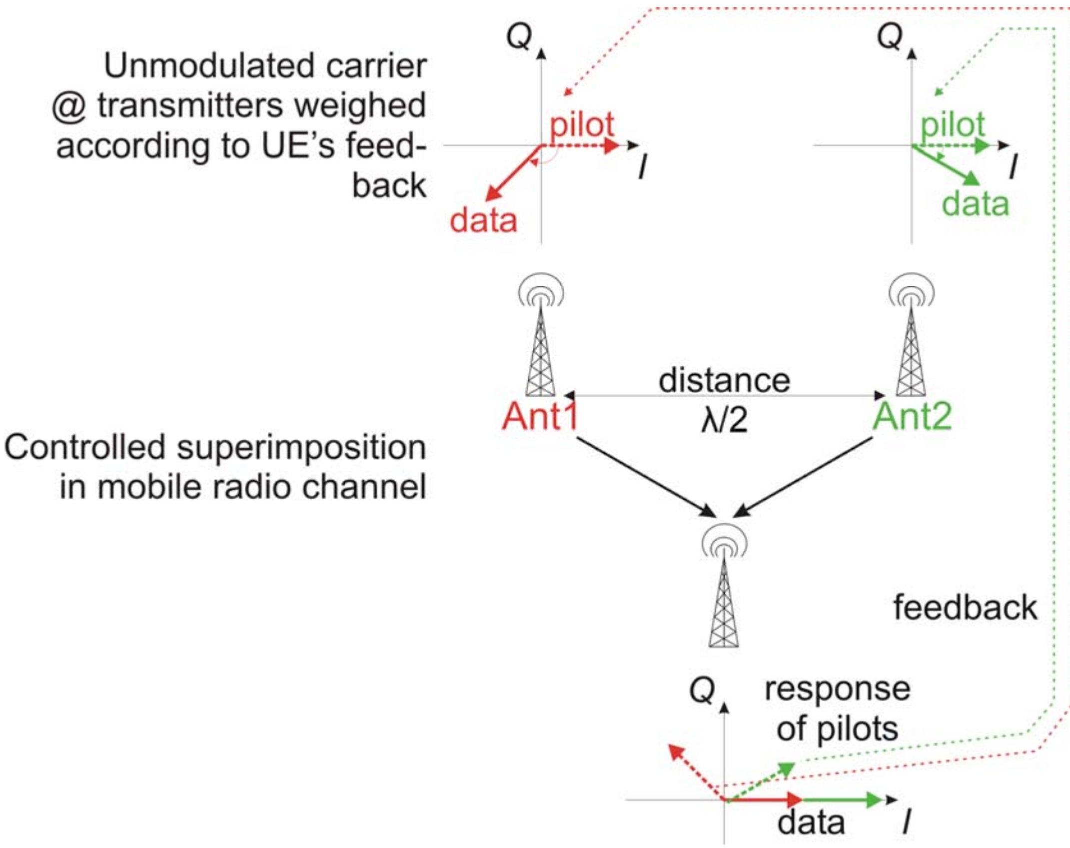
[3GTS 36.211 (5.6)]

- **Abbreviations of this Section:**

3GTS	3rd Generation Technical Specification	**SFN**	Single Frequency Network
DL	Downlink	**TX**	Transmit
MBMS	Multimedia Broadcast / Multicast Service	**UE**	User Equipment
MBSFN	MBMS over Single Frequency Networks	**kHz**	Kilo Hertz (10^3 Hertz)
OFDM	Orthogonal Frequency Division Multiplexing		

3

3.5.5.3 AAS



The objective of this section is to how the transmission diversity problem is solved by AAS.

Key point of this section is that the UE is measuring the responses of the mobile radio channel and is informing the eNB. Then the eNB can exploit this knowledge.

Image description

- The picture is showing the AAS case: two transmission antennas are received by one receive antenna. It is shown how the mobile radio channels are altering the pilot signals.

Here the eNB is transmitting pilot carriers. These pilots are analyzed by the UE. Then the UE determines how the data signal should have been rotated in the transmitter such that they are superimposing constructively at the antenna of the receiver. This knowledge is signaled in FDD systems to the eNB. Then the eNB can apply the beamforming weights to the data subcarriers whilst leaving the pilot subcarriers unchanged.

For TDD systems no signaling is necessary the eNB can just analyze the uplink signal and apply the reciprocity of the mobile radio channel in order to get the right beamforming coefficients.

Once the UE moved to fast (10 – 20 km/h) then the signaling is too slow to follow the changes of the mobile radio channel. Then AAS will not work with high performance in the DL any more. UL AAS will still be possible.

Since the transmit antennas are only half a wavelength apart from each other they are not independent form each other. Consequently only beamforming gain but no diversity gain can be exploited.

[3GTS 36.211 (5.3.4.1.3)]

Room for your Notes

- **Abbreviations of this Section:**

AAS	Adaptive Antenna Systems	**UE**	User Equipment
FDD	Frequency Division Duplex	**eNB**	Enhanced Node B
TDD	Time Division Duplex		

3

3.5.5.7 The Codebook

Transmission for 1 UE @ normal data rate $\begin{bmatrix} x \\ y \end{bmatrix}$ → weight for antenna 1 (x), → weight for antenna 2 (y)

#	1	2	3	4	5	6
Codebook entry	$\begin{bmatrix} 1 \\ 0 \end{bmatrix}$	$\begin{bmatrix} 0 \\ 1 \end{bmatrix}$	$\begin{bmatrix} 1 \\ 1 \end{bmatrix}$	$\begin{bmatrix} 1 \\ -1 \end{bmatrix}$	$\begin{bmatrix} 1 \\ j \end{bmatrix}$	$\begin{bmatrix} 1 \\ -j \end{bmatrix}$
Phasors						
Optimum for UE receives unaltered signal	only from ant 1	only from ant 2	with same phase from both antennas	opposite phase from both antennas	Ant 2 phase is 90° less than ant 1	Ant 2 phase is 90° more than ant 1

Transmission for 1 UE @ double data rate = Rank 2 beamforming
each stream gets own set of antenna weights
only the following combinations are allowed:
1 + 2; 3 + 4; 5 + 6
→ then MIMO performance is close to optimum

The objective of this section is to how the UE and eNB are communicating about the best set of beamforming weights for AAS and MIMO.

Key point of this section is that the UE is just providing the number of to be transmitted streams and the number of the set of beamforming weights according to a codebook.

3

Image description

- The picture is showing basic use of the codebook for LTE and the codebook entries for simple AAS in detail.

3.5.5.7.1 Optimum beamforming weights

The optimum set of beamforming weights for the case that the receiver has just 1 antenna is a set of weights which is maximizing the SIR at this receive antenna. Mathematically speaking this is the solution of a generalized Eigenvalue problem. Once for MIMO multiple data streams are transmitted each received antenna will have a set of optimum weights which is applicable to all the data streams. The task here is that the best combination of weight sets has to be found which is separating as much as possible the different data streams at the receive antennas already. This is leading to a generalized Eigenvalue problem taking the transmission of the other data stream as interference. The exact treatment of these problems would go far beyond the scope of this training. The reason why the mathematical terms are mentioned here is to illustrate two problems:

1. It will take a very big computational effort to determine the optimum sets of beamforming weights for each data stream
2. To signal these sets will consume a very big data rate.

Room for your Notes

- **Abbreviations of this Section:**

AAS	Adaptive Antenna Systems	**SIR**	Signal to Interference Ratio
LTE	Long Term Evolution (of UMTS)	**UE**	User Equipment
MIMO	Multiple In / Multiple Out (antenna system)	**eNB**	Enhanced Node B

3

3.5.5.7.2 Signaling of sub-optimum beamforming weights

For this reasons both eNB and UE have a codebook which will contain the codes to be used during the AAS and the MIMO operation. Then the UE only needs to signal the code number and the number of data streams it can take. This is reducing the signaling load.

Another advantage is that now the UE does not need to calculate (backward) the optimum sets of beamforming weights. It will just take the entries of the codebook to calculate (forward) the SIR's of the codebook entries and the different numbers of dada streams. This is requiring a lot less computational effort.

Then the UE will select the number of data streams and the number of the codebook entry and transmit it to the eNB. Of course the result will be not optimum but it is a good compromise in-between good performance, high data rate, and low signaling effort.

[3GTS 36.211 (5.3.4.1.3)]

Room for your Notes

Room for your Notes

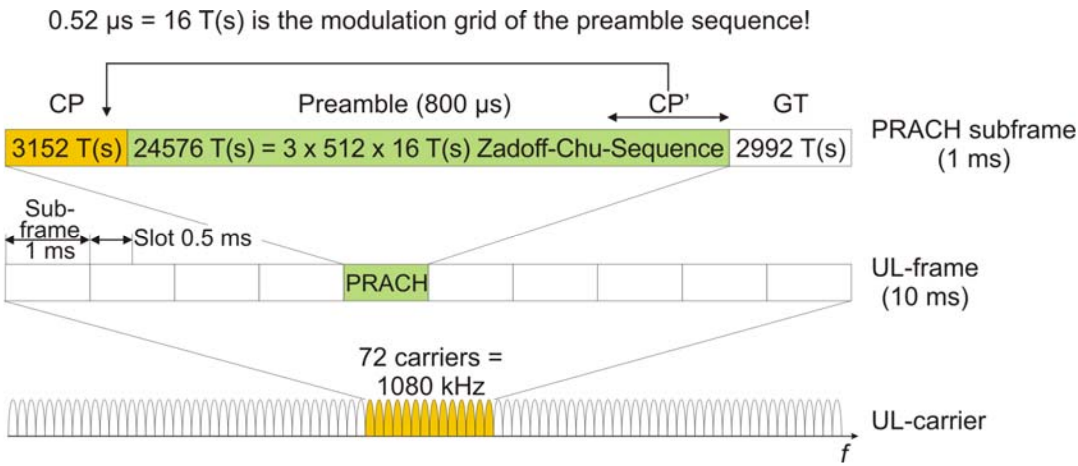
- **Abbreviations of this Section:**

3GTS	3rd Generation Technical Specification	**SIR**	Signal to Interference Ratio
AAS	Adaptive Antenna Systems	**UE**	User Equipment
MIMO	Multiple In / Multiple Out (antenna system)	**eNB**	Enhanced Node B

3

3.5.7 Random Access

3.5.7.1 PRACH Structure



The objective of this section is to introduce the structure of the PRACH

Key point of this section is the PRACH can be configured freely on frequency and subframe in the UL carrier and in the UL frame structure.

Image description

- This picture is showing how the PRACH is fitted on the UL carrier and on the UL frame. As well the PRACH structure inside the subframe is shown.

72 consecutive subcarriers (1080 kHz) are used for the PRACH. This means that the PRACH is fitting on the smallest discussed bandwidth for LTE.
The PRACH can be configured any of the 10 subframes on the given 72 subcarriers.

Inside the PRACH there is a long Zadoff-Chu sequence which is occupying 800 µs of the PRACH subframe. This RACH preamble is created in the frequency domain.
In the time domain then a cyclic shift may be applied and a CP is added.
The modulation grid of the PRACH is 16 T(s) being the same grid applied for the TA control algorithm.
The UE is transmitting the PRACH with 0 TA.
The guard time at the end of the PRACH is allowing for an interference free reception of the PRACH at the eNB up to a cell radius of 14.6 km. Once the distance in-between the UE and the eNB is exceeding that distance interference in the following subframe has to be expected. However since the PRACH preamble is very long and the interference is the lower the bigger the cells become the inference is tolerable.

Apart from the preamble structure shown on the picture above there are two other modes for the preamble. In the extended mode the CP is not transmitted. In the repeated mode the preamble is transmitted without CP.

!

[3GTS 36.211 (6.7), 3GTS 36.213 (6), 3GTS 36.300 (10.1.5)]

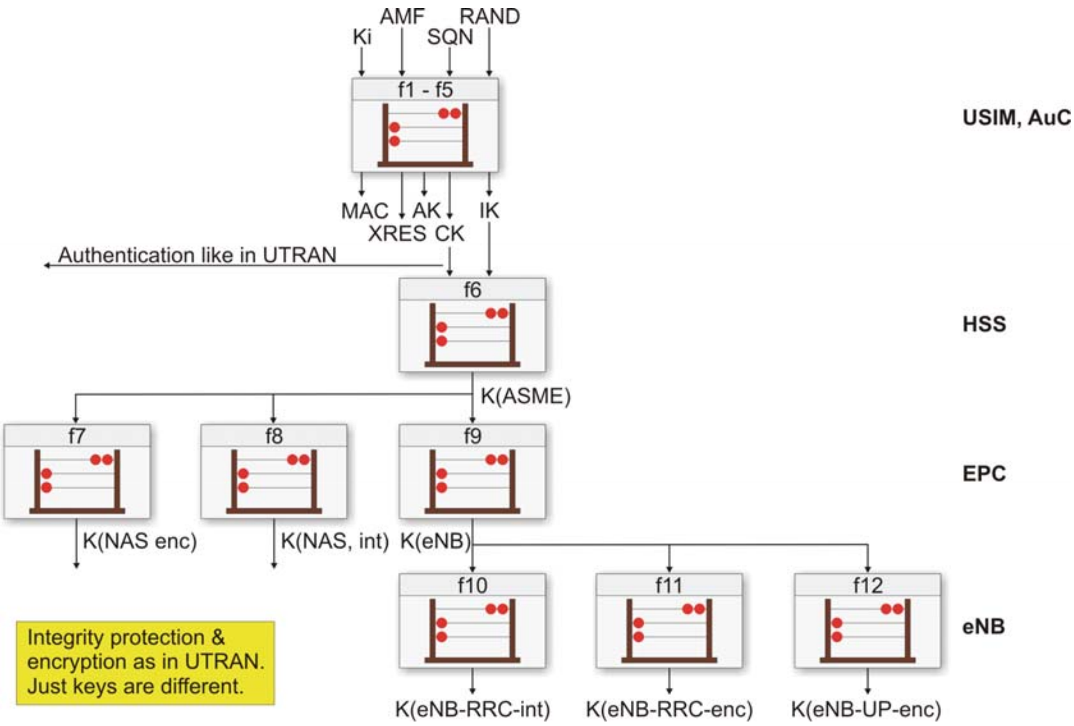
Room for your Notes

- **Abbreviations of this Section:**

3GTS	3rd Generation Technical Specification	**TA**	Terminal Adapter (ISDN)
CP	Cyclic Prefix	**UE**	User Equipment
LTE	Long Term Evolution (of UMTS)	**UL**	Uplink
PRACH	Physical Random Access Channel	**eNB**	Enhanced Node B
RACH	Random Access Channel		

4

4.11 Security in LTE



The objective of this section is to describe to different security procedures and their location in LTE.

Key point of this section is that the security algorithms are the same as for UTRAN. However the EPC transforms the keys such that different keys are applied for encryption and integrity protection and for the different individual network elements.

Image description

- The picture shows how the different security keys in LTE are derived from one another.

As it can be seen in the picture there is still an USIM used in LTE. This USIM is generating the keys in the same way as in UTRAN.
The authentication is following the same procedure as in UTRAN.
For the encryption and the integrity protection the HSS will create a new key – K_{ASME}.
This key will be used by the EPC to create 3 specific keys for the MME: once key for encryption of NAS messages and another key for integrity protection for the NAS messages. Each individual eNB will also get its own master key K_{eNB}. How the network entity specific keys are created exactly is FFS.
The eNB will then create 3 different keys from its master keys:

1. An encryption key for the RRC messages
2. An integrity protection key for the RRC messages
3. An encryption key for the user plane messages (integrity protection for the user plane is not necessary)

The UE is aware of all theses keys and will change the eNB specific keys upon handover or cell change.
The usage of the integrity protection and ciphering keys will most likely be the same as in UTRAN again.
[3GTR 25.813 (10), 3GTS 36.300 (14)]

Room for your Notes

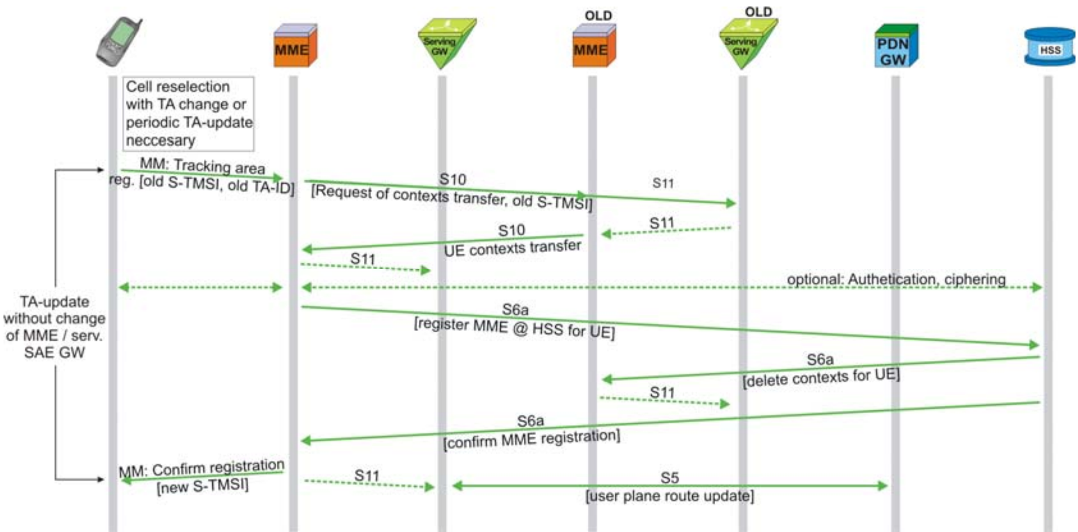
- **Abbreviations of this Section:**

3GTR	3rd Generation Technical Report	**MAC**	Medium Access Control
3GTS	3rd Generation Technical Specification	**MME**	Mobility Management Entity (3GTS 23.401) (Rel. 8 onwards)
AK	Anonymity Key (3GTS 33.102)	**NAS**	Non-Access-Stratum
AMF	Authentication management field (3GTS 33.102)	**RAND**	Random Number
AuC	Authentication Center	**RRC**	Radio Resource Control
CK	Ciphering Key (3GTS 33.102)	**SQN**	Sequence number (used in UMTS-security architecture / 3GTS 33.102)
EPC	Evolved Packet Core (3GTS 23.401) (Rel. 8 onwards)	**UE**	User Equipment
FFS	For Further Study	**USIM**	Universal Subscriber Identity Module
HSS	Home Subscriber Server (3GTS 23.002). HSS replaces the HLR with 3GPP Rel. 5	**UTRAN**	UMTS (Universal Mobile Telecommunication System) Terrestrial Radio Access Network
IK	Integrity Key (3GTS 33.102)	**XRES**	Expected Response (3GTS 33.102)
LTE	Long Term Evolution (of UMTS)	**eNB**	Enhanced Node B

4

Lessons Learned / Conclusions:

5.3 Tracking Area Update



The objective of this section is to show the information flow for a TA update of a UE.

Key point of this section is that for a TA update quite similar procedures are used as for the RA updates in UMTS and GPRS networks.

5.3.1 Inter MME tracking area update

The first step of the tracking area update is that a UE has selected a new cell found a new cell with a different TAI. Then it will initiate the TA update procedure and will send a tracking area registration message. This message will contain the old S-TMSI and the old TAI.
For the inter MME TA update procedure the MME which is connected to the eNB will find out that it has not administered the UE before and will contact the old MME which has previously administered that UE. This will be done by means of a request for transfer of the contexts which is accompanied by the old S-TMSI.
By means of the old S-TMSI the old MME will initiate the transfer of the UE's contexts to the new MME and the new Serving GW. Since old and new Serving GW are not logically interconnected the relaying of Serving GW's part of the UE context will involve S11 messaging on both sides.
Once the new MME has received the UE's contexts it might ask for UE authentication and for ciphering of the remaining procedure.
Then it will register as the MME responsible for the UE with the UE's HSS. The HSS will initiate the de-registration of the UE's contexts with the old MME and will then confirm the registration with the new MME.
Then the UE is informed that the TA registration is complete.
Finally the Serving GW will perform the user plane rout update with the PDN GW.
[3GTS 23.882 (7.7.2.3)]

5.3.2 Intra MME tracking area update

Once the TA update is necessary within the service area of the MME the TA update procedure become quite simple. Only the two MM messages indicated in the picture will be exchanged.
[3GTS 23.882 (7.7.2.2)]

Room for your Notes

- **Abbreviations of this Section:**

3GTS	3rd Generation Technical Specification	**RA**	Routing Area
GPRS	General Packet Radio Service	**SAE**	System Architecture Evolution
GW	Gateway	**TA**	Tracking Area
HSS	Home Subscriber Server (3GTS 23.002). HSS replaces the HLR with 3GPP Rel. 5	**S-TMSI**	SAE Temporary Mobile Subscriber Identity
ID	Identity	**UE**	User Equipment
MM	Mobility Management	**UMTS**	Universal Mobile Telecommunication System
MME	Mobility Management Entity (3GTS 23.401) (Rel. 8 onwards)	**eNB**	Enhanced Node B
PDN	Packet Data Network		