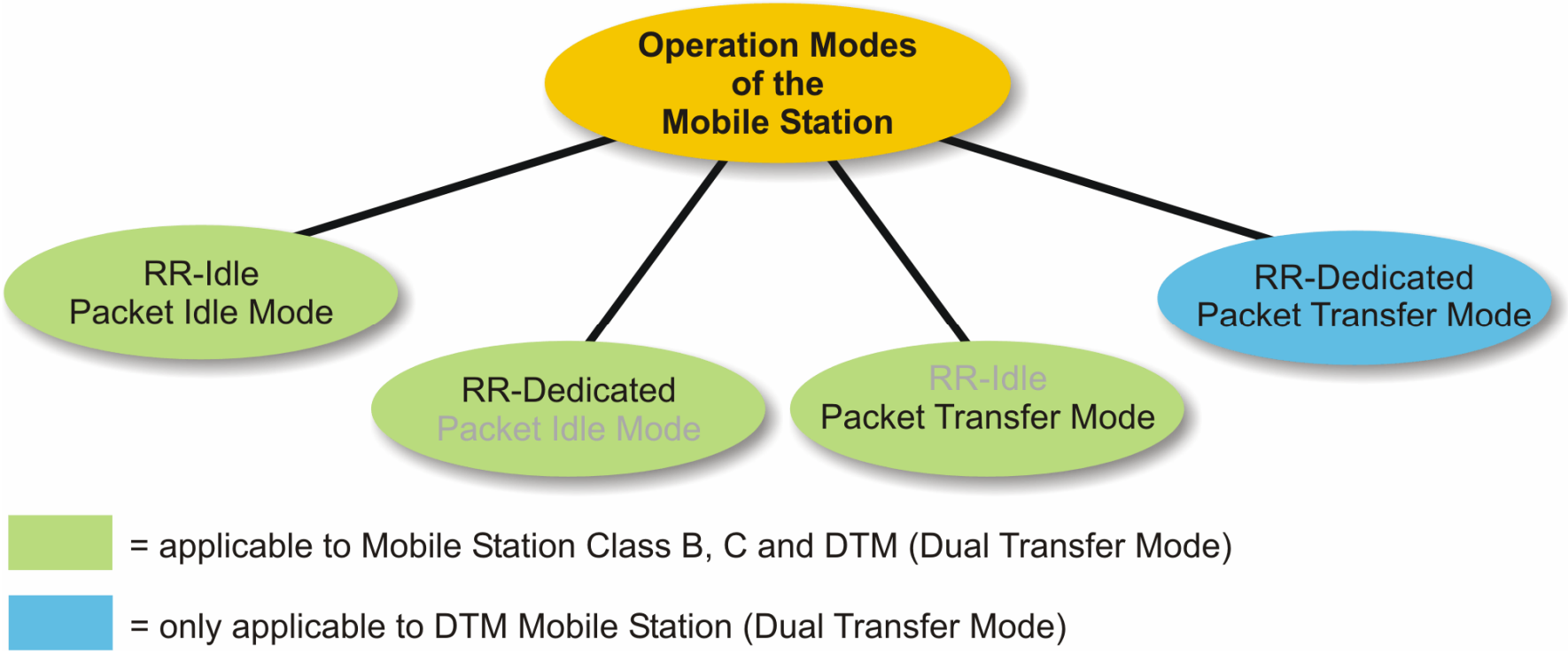
Operation Modes of the Mobile Station

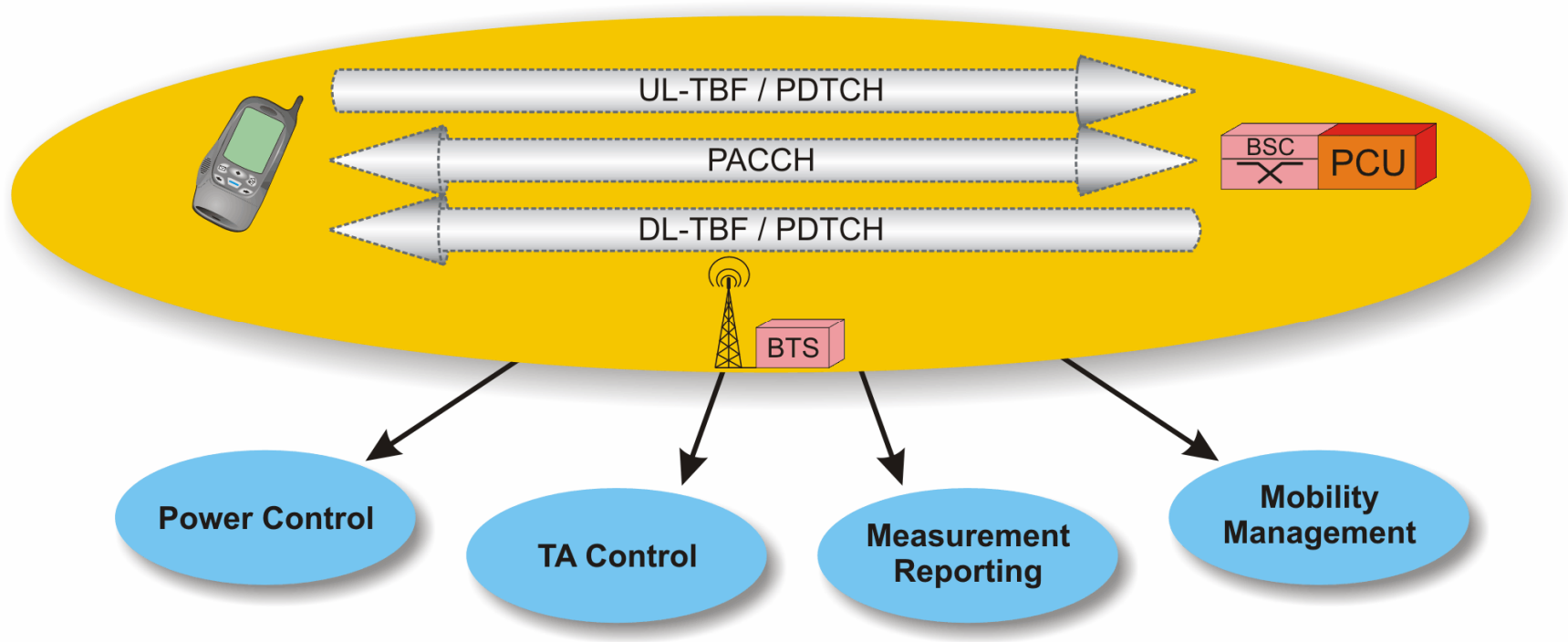


Operation Modes of the Mobile Station

Depending on the user requirements, the DTM-capable mobile station may be in one of the four indicated operation modes. Note that only the fourth operation mode, Dual Transfer Mode, is specific to a DTM-capable mobile station. The remaining three operation modes are also applicable to standard class B mobile stations.

- **RR-Idle / Packet Idle Mode**
  The mobile station does not have any dedicated radio resources nor a TBF allocated to it. The mobile station may or may not be attached to the circuit-switched and/or packet-switched core network domain.
- **RR-Dedicated / Packet Idle Mode**
  The mobile station has been allocated dedicated radio resources and is using the SDCCH+SACCH-configuration or the TCH+FACCH+SACCH-configuration. The TCH is either for data or for speech transfer and the related information is relayed by the BSC to and from the circuit-switched core network domain. The mobile station does not have allocated a TBF.
- **RR-Idle / Packet Transfer Mode**
  No SDCCH+SACCH or TCH+FACCH+SACCH are allocated to the mobile station. However, the mobile station has one or two TBF's allocated to it (One ⇔ uplink or downlink, Two ⇔ uplink and downlink). The included information is relayed by the PCU to and from the packet-switched core network domain.
- **RR-Dedicated / Packet Transfer Mode**
  In dual transfer mode, the mobile station has definitely been allocated an SDCCH+SACCH or a TCH+FACCH+SACCH. Depending on the DTM-operation mode, the mobile station has in addition been allocated zero, one or two TBF's, that is, the mobile station is in addition in packet transfer mode. The case "zero TBF" relates to the case when the mobile station or the PCU are allowed to transmit GPRS-signaling information over the DCCH (⇔ SDCCH or FACCH). This mode is called in this document "Shared Use Operation Mode".

Important Aspects of Packet Operation Mode



Important Aspects of Packet Operation Mode

⇒ As the figure illustrates, in packet operation mode there are so called TBF's (Temporary Block Flow) used to convey user data between mobile station and PCU.
⇒ TBF's are unidirectional and only exist for the very time that they are actually needed.
⇒ The only bidirectional packet channel is the PACCH (Packet Associated Control Channel) which is used to transfer RLC/MAC control information.

- **Like in dedicated operation mode, there are some important issues to be considered for the packet-switched operation mode**

Measurement Reporting
Measurement reporting occurs only event-triggered and not periodically.

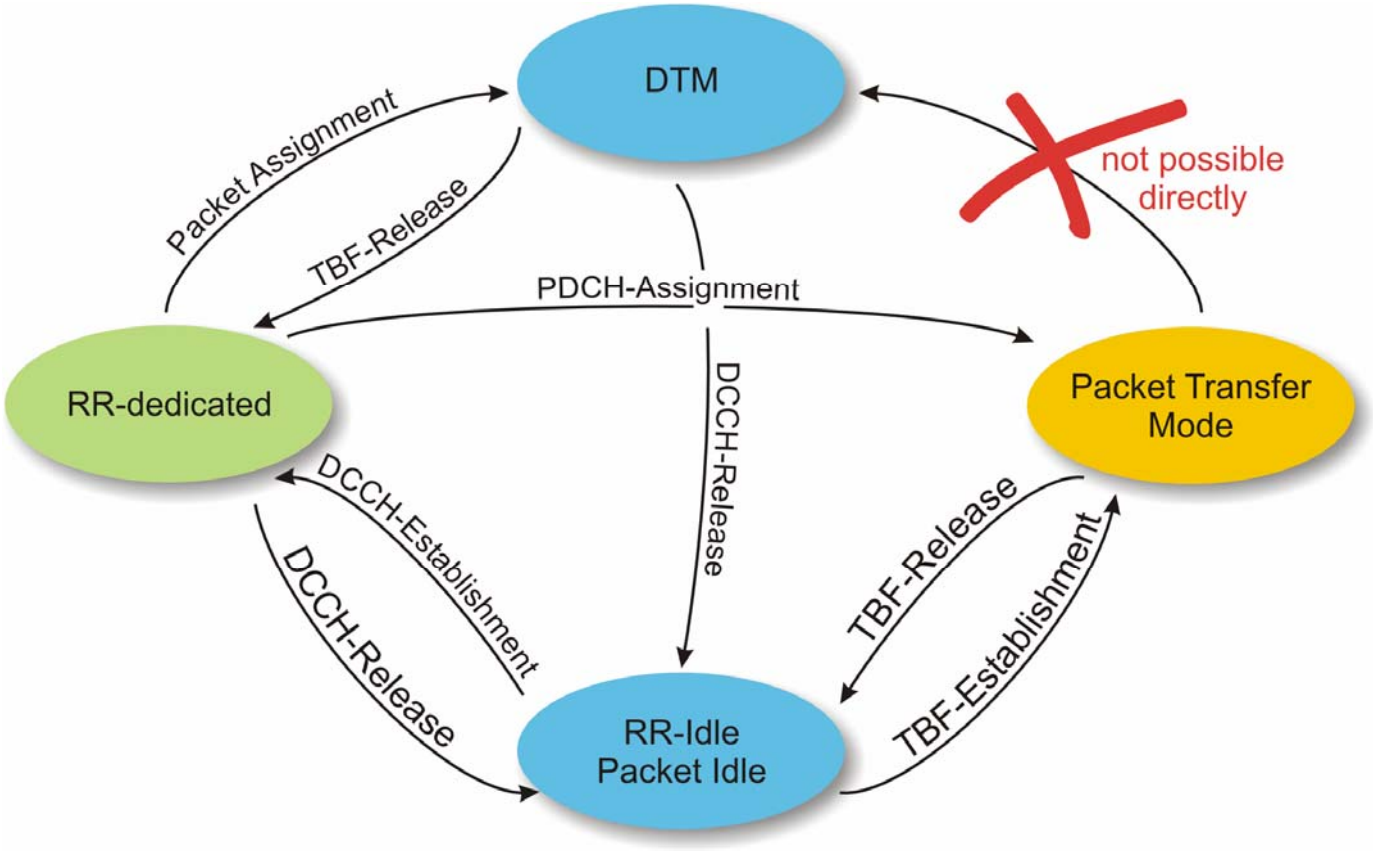
Power Control (Uplink and Downlink)
While power control information in dedicated mode is conveyed to the mobile station periodically, in packet-switched operation mode power control information is only conveyed to the mobile station when needed.

TA (Timing Advance) Control
We will talk about timing advance control in packet-switched operation mode on the following slides.

Mobility Management

Unlike in circuit-switched operation mode, the mobile station is required to perform routing area update scenarios and even cell update scenarios while in packet transfer mode.

State Transitions of the Mobile Station with DTM



State Transitions of the Mobile Station with DTM

Transitions between the four different states need to follow pre-defined paths:

RR-Idle/Packet-Idle ⇔ Packet Transfer Mode
A change between these two states occurs through the standard procedures for the establishment and release of uplink and/or downlink TBF's.

RR-Idle/Packet-Idle ⇔ RR-Dedicated Mode
A change between these two states occurs through the standard procedures for the establishment and release of a DCCH (e.g. TCH+FACCH+SACCH).

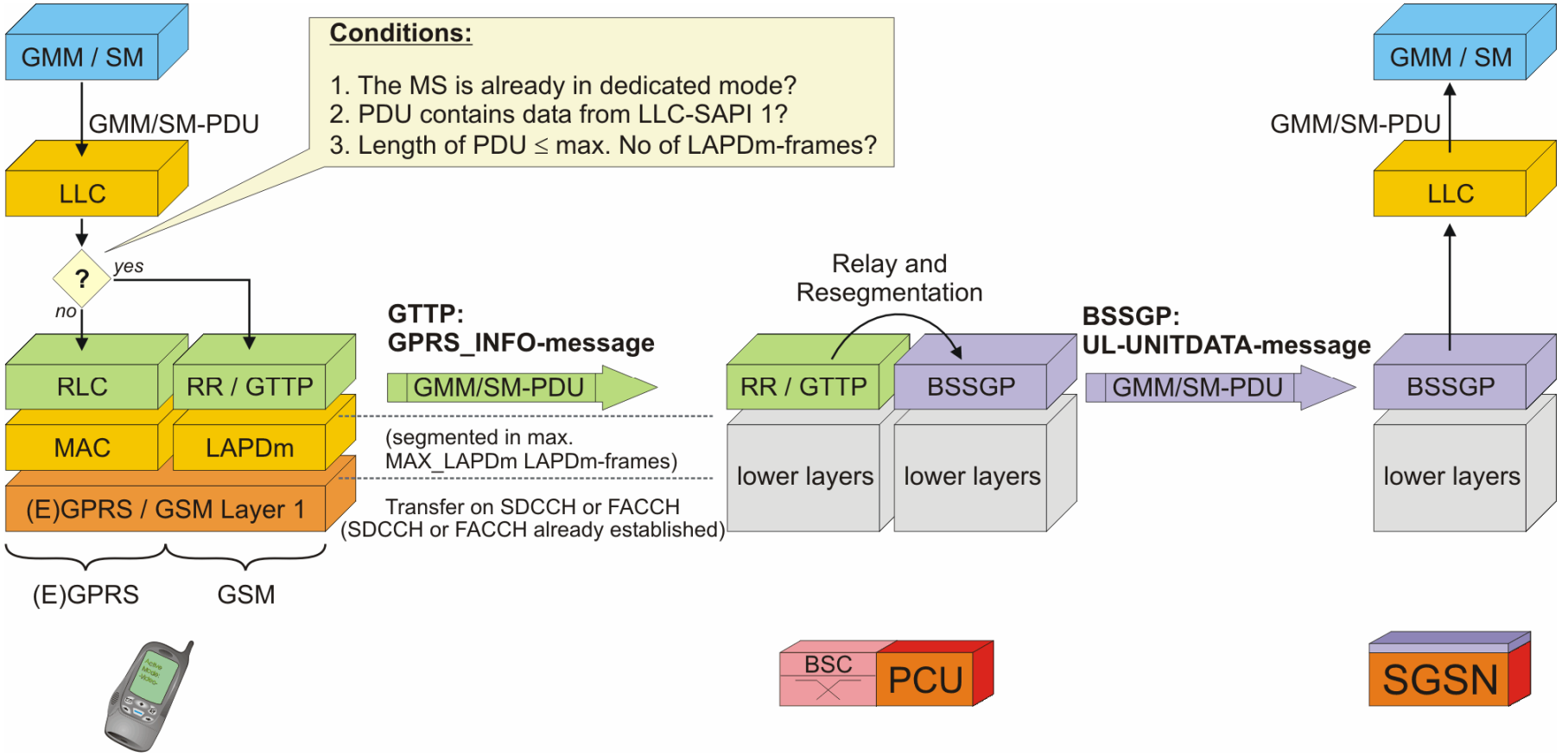
RR-Dedicated Mode ⇔ DTM
DTM-specific procedures are necessary to change from RR-dedicated mode to DTM. However, the standard TBF-release procedures will return the mobile station to RR-dedicated mode.

RR-Dedicated Mode ⇨ Packet Transfer Mode
The 3GPP-standard at least proposes the PDCH_ASS_CMD-message to locally release the DCCH and switch to either an uplink or downlink TBF.

Most importantly, there is no means to switch to DTM while the mobile station is in Packet Transfer Mode. To do so, the mobile station has to release the TBF, establish a DCCH (for instance to do a voice call) and then it may resume the packet data transfer by moving to DTM.

[3GTS 03.64 (6.2.5)]

Details of the Shared Use Operation Mode (Uplink Direction)



Details of the Shared Use Operation Mode (Uplink Direction)

In this operation mode, the transfer of GPRS-related signaling information (GMM or SM) occurs without TBF-establishment but via the circuit-switched DCCH (either SDCCH or FACCH).

Most importantly, this allows the mobile to perform cell update and routing area update scenarios without delay when a circuit-switched DCCH already exists.

Uplink Direction

⇒ The mobile station has to transmit a GMM- or SM-PDU towards the SGSN. This PDU is conveyed towards LLC which embeds it into an LLC: UI-frame (6 additional octets).

⇒ The DTM-capable mobile station needs to implement a decision point between LLC and the lower layers. Depending on the conditions, stated in the figure, the mobile station may transmit the LLC-PDU not via a TBF but via an already established DCCH.

That is, if the LLC-PDU:

⇒ And, most importantly, if the mobile station already has a DCCH established,

⇒ Contains signaling information (SAPI = 1)

⇒ Is no longer than 93 – 233 octets (depending on the setting of MAX_LAPDm).

The LLC-PDU shall be transmitted using that DCCH rather than establishing an uplink TBF.

⇒ A new protocol, the GPRS Transparent Transport Protocol (GTTP) and the GTTP: GPRS_INFO-message have specifically been introduced to allow for the tunneling of LLC-PDU's through the DCCH.

Note that on SDCCH, the unused SDCCH-frames will be used while on TCH+FACCH+SACCH, the respective numbers of bits have to be stolen from the TCH and for the use on the FACCH.

⇒ In the BTS, the incoming LAPDm-frames will be desegmented and the GTTP: GPRS_INFO-message is sent over the Abis-interface towards the BSC.

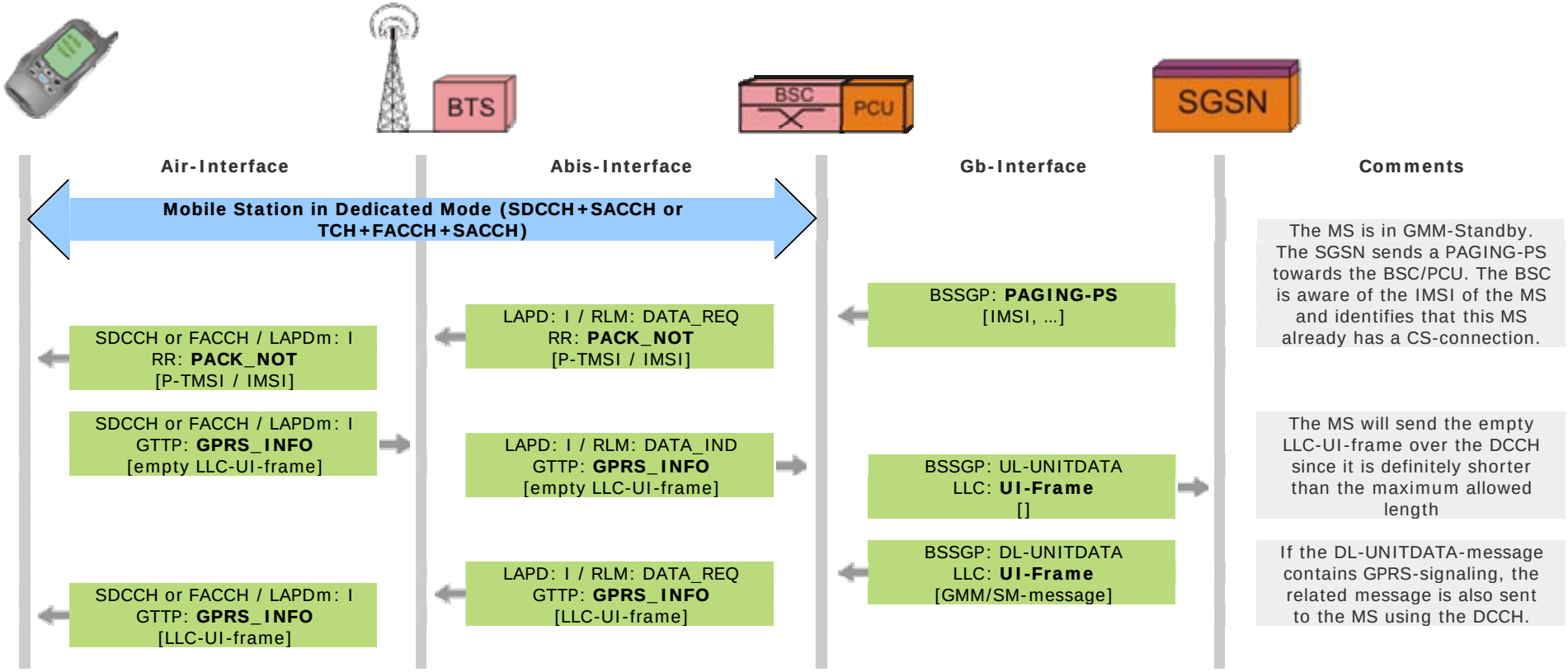
⇒ The BSC will simply relay the GPRS_INFO-message towards the PCU.

⇒ The PCU will build a BSSGP: UL-UNITDATA-message which carries the mobile station's TLLI in its header and which carries the LLC-PDU in its data portion.

⇒ Finally, the LLC-PDU reaches the SGSN and the content is delivered to GMM or SM.

[3GTS 43.055 (4.1.2)]

MS in GMM-Standby State



MS in GMM-Standby State

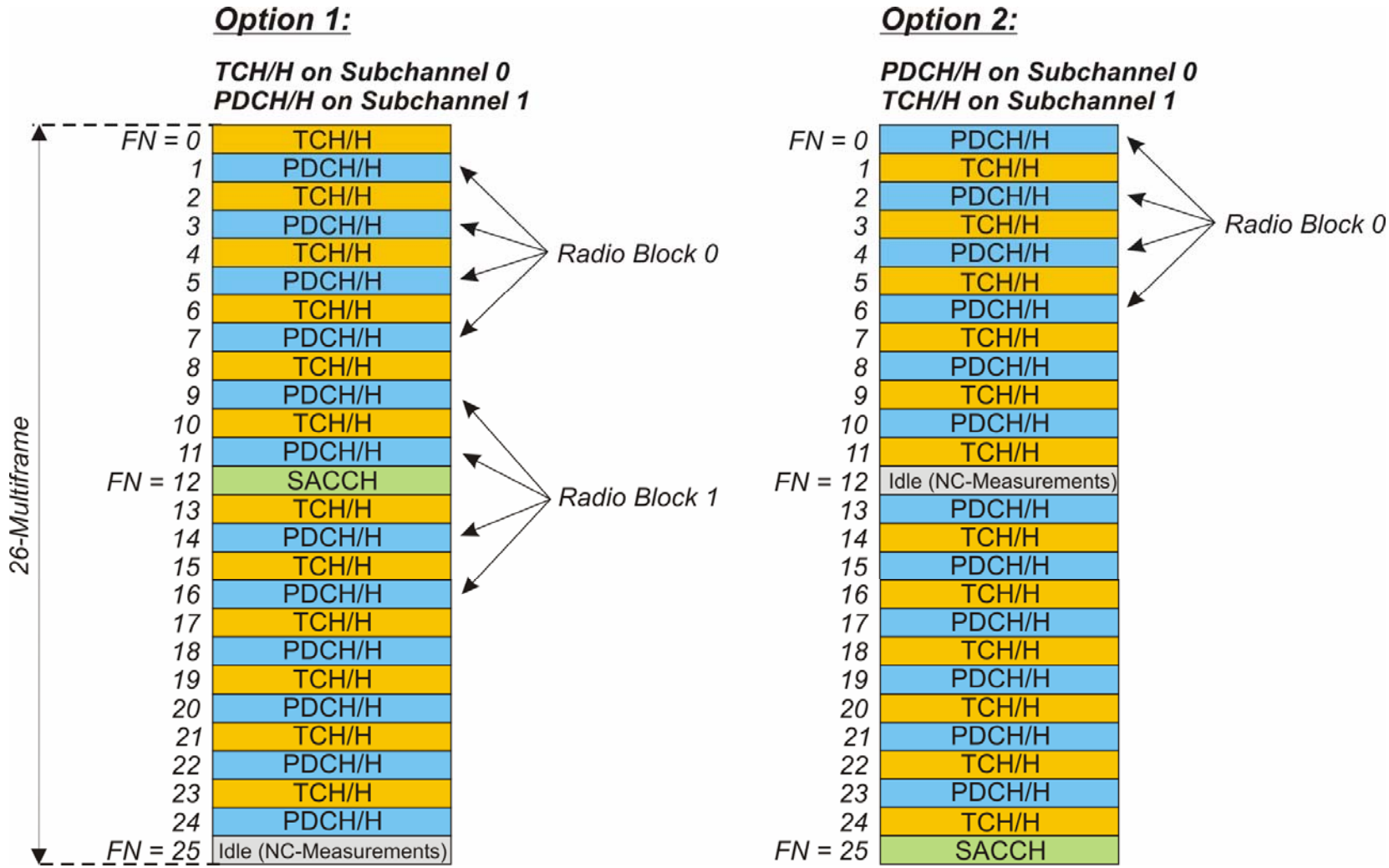
- ⇒ If the mobile station is in GMM-standby state, the SGSN will first send a BSSGP: PAGING-PD-message to the PCU.
- ⇒ The PCU needs to check with the BSC, whether the addressed mobile station is currently in dedicated mode. This check is done based on the IMSI of the mobile station and requires that the BSC is aware of the IMSI of the mobile station.

This requires the previous transmission of the IMSI of the mobile station to the BSC by the MSC. That is, a new BSSAP-message (⇔ COMM_ID) is required that will transmit the mobile station's IMSI to the BSC whenever a circuit-switched connection is established between the mobile station and the MSC.

- ⇒ If this condition is true, the BSC will send an RR: PACK_NOT-message through the BTS towards the mobile station.
- ⇒ The mobile station will send its empty LLC-UI-frame (⇔ packet paging response) also through the DCCH towards the BSC which will relay it towards the SGSN.
- ⇒ Consequentially, both entities the SGSN and the mobile station are in GMM-ready state and the SGSN can transmit the LLC-frame towards the mobile station using the procedure illustrated on the previous slide. Obviously, this is only true, if the LLC-frame contains signaling information (⇔ GMM- or SM-message).
- ⇒ If, however, the LLC-frame would not contain a GMM- or SM-message, the network would need to assign packet-switched resources by transmitting a PACK_ASS-message or a DTM_ASS_CMD-message to the mobile station.

[3GTS 43.055 (6.1.2.3.2)]

PDCH/H + TCH/H – Configuration



PDCH/H + TCH/H – Configuration

The figure illustrates the two options for the allocation of half rate channels in a single slot configuration. Accordingly, the figure shows two alternative 26-multiframes.

⇒ Either the PDCH/H or the TCH/H occupies the subchannel 0. In a half rate configuration, subchannel 0 always relates to all even numbered frame numbers of the lower half of the 26-multiframe while subchannel 1 combines all odd numbered frame numbers of the lower half of the same 26-multiframe. The figure illustrates that the opposite applies for the upper half (FN = 13 – 25) of the 26-multiframe.

⇒ Either FN = 12 or FN = 25 are used for the SACCH or for neighbor cell measurements.

⇒ By using half rate channels, the mobile station is occupying only a single timeslot but packet-switched and circuit-switched services are used simultaneously.

⇒ The PDCH/H-channels achieve exactly half of the throughput rates of the "normal" full rate PDCH's. That is, depending on the coding scheme (CS-1, CS-2, CS-3, CS-4 or MCS-1 – MCS-9) the PDCH/H achieves RLC-SDU-throughput rates of 4 kbit/s, 6 kbit/s, 7.2 kbit/s or 10 kbit/s.

Note:

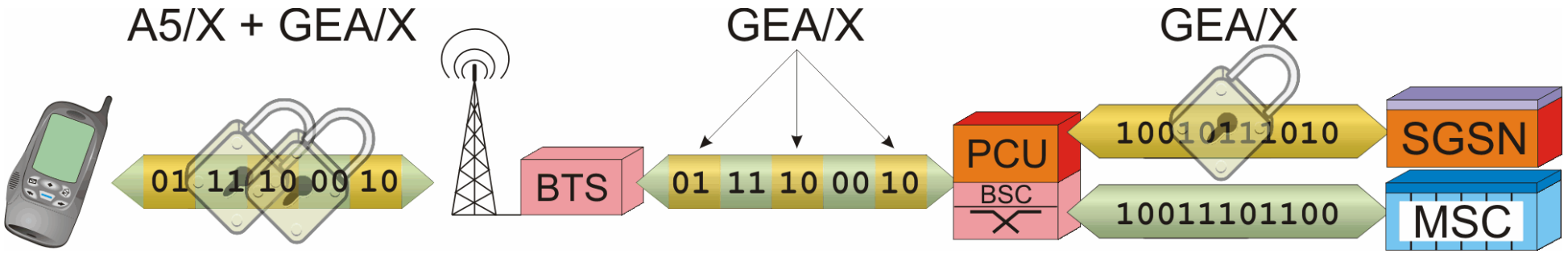
- There may be only one PDCH/H allocated to the mobile station at any given moment in time in both directions (⇔ no bundling of PDCH/H's).
- With Rel. 99, PDCH/H's may not be combined with full rate PDCH's. However, at least for the downlink direction this becomes an option with Rel. 4. We will describe this option later during this section.

⇒ The TCH/H may not be a circuit-switched data channel but most likely it will be used for speech. As mentioned before, the support of the AMR-speech codec is mandatory for the DTM-capable mobile station. In that respect, the network may allocate the following AMR-modes to the mobile station: 4.75 kbit/s, 5.15 kbit/s, 5.9 kbit/s, 6.7 kbit/s, 7.4 kbit/s, 7.95 kbit/s.

⇒ Note that e.g. AMR-mode = 7.95 kbit/s on a half rate channel is possible, because the gross throughput rate on this halfrate channel is 11.4 kbit/s.

[3GTS 43.055 (4.2)]

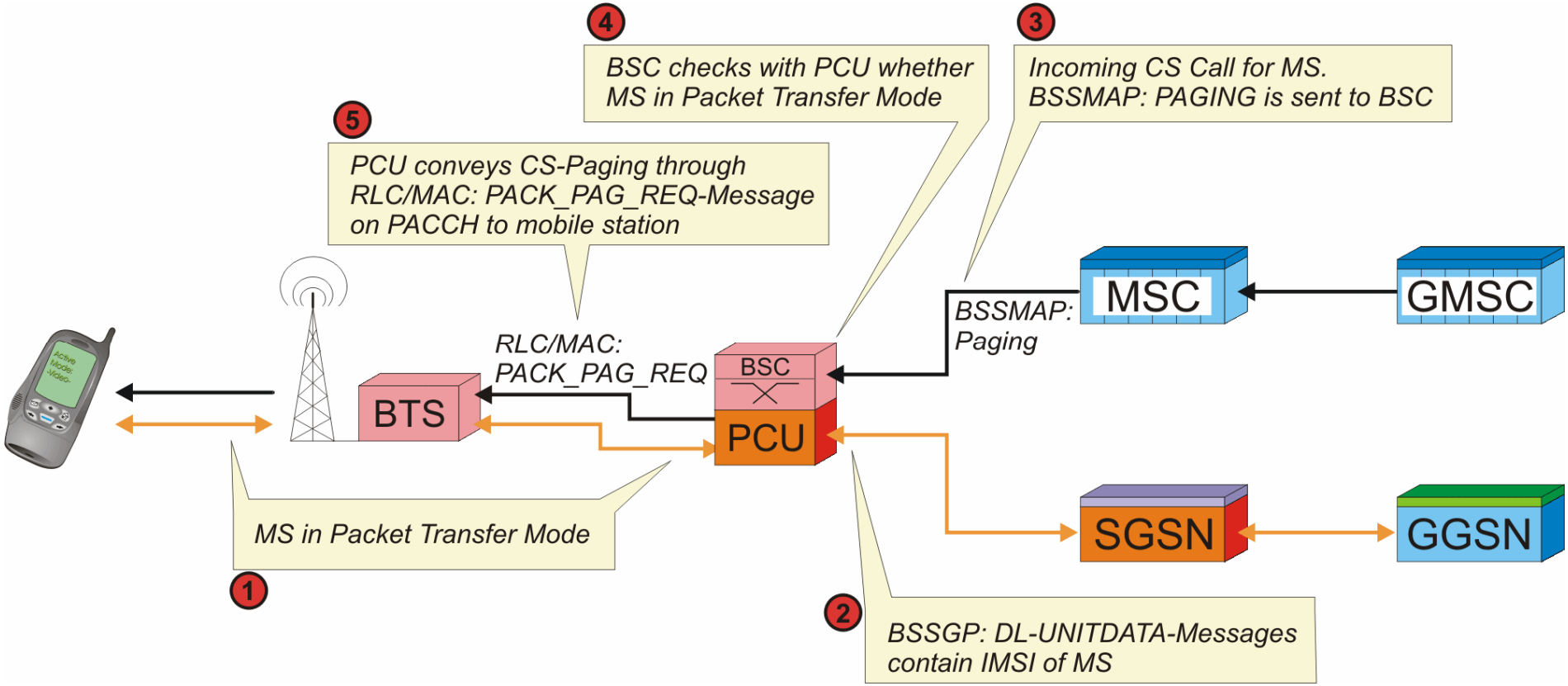
Encryption in Shared Use Operation Mode



Encryption in Shared Use Operation Mode

In shared operation mode (GPRS-signaling data + circuit-switched information over the DCCH), ciphering will most likely be done twice for the GPRS-signaling data: Once by the transmitting higher layer entity (⇔ LLC layer in the SGSN or in the mobile station using the GEA/X-algorithm) and a second time on burst level in the mobile station or in the base station (⇔ A5/X-ciphering). Still, this is no considered to be a problem!

Option 2: MS in Packet Transfer Mode / Incoming Call



Option 2: MS in Packet Transfer Mode / Incoming Call

1. The mobile station is in packet transfer mode, that is, one or two TBF's are setup
2 Whenever the SGSN conveys a BSSGP: DL-UNITDATA-message to the PCU, the IMSI of the mobile station will be included.
3 The G-MSC relays an incoming circuit-switched call for the same mobile station to the serving MSC. In turn, the serving MSC will send a BSSMAP: PAGING-message towards the BSC/PCU.
4 Before paging the mobile station itself, the BSC will check with the PCU whether the mobile station is currently in packet transfer mode.
5 The PCU positively confirms this question and sends the circuit-switched paging message through an RLC/MAC: PACK_PAG_REQ-message over the PACCH to the mobile station.

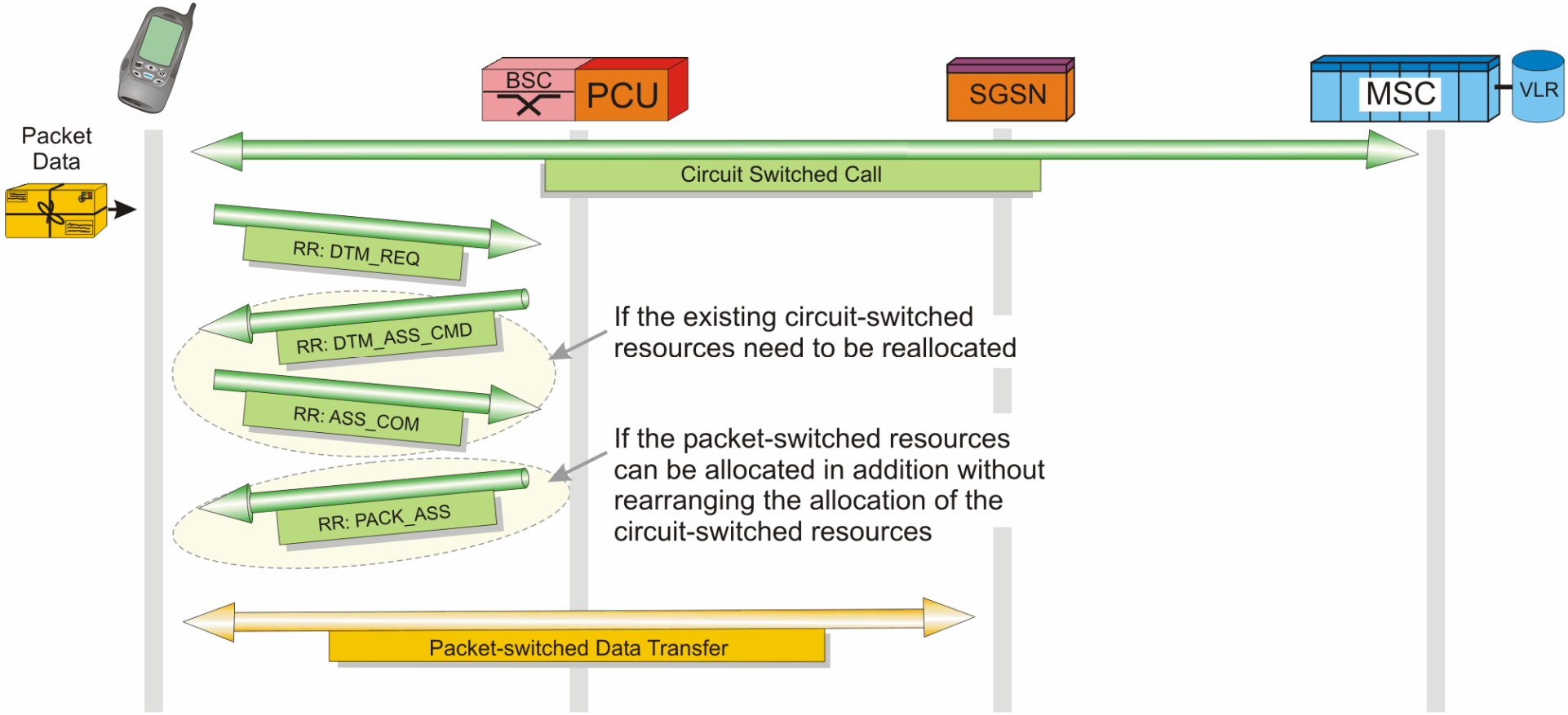
To be able to respond to the incoming circuit-switched paging message, the mobile station needs to release the TBF('s) and establish an SDCCH to transmit an RR: PAG_RSP-message to the BSC. After the DCCH has been established (⇔ RR-dedicated mode), the mobile station may resume GPRS-operation by entering the dual transfer mode.

Note:

- This type of paging coordination (⇔ MS in packet transfer mode / incoming circuit-switched call) also operates if the mobile station is not DTM-capable but if the network supports at least the BSS-based paging coordination function.
- Support for BSS-based paging coordination is communicated towards the mobile stations through the parameter 'BSS_PAGING_COORDINATION' which is part of the GPRS_CELL_OPTIONS-information element.
- This way, NOM I and the Gs-interface become redundant at least with respect to paging coordination but not with respect to the combined operation of GMM/MM-procedures.

[3GTS 04.60 (6.1.3)]

MS establishes PS-Data Transfer while CS-Call is Active (MO)



MS establishes PS-Data Transfer while CS-Call is Active (MO)

Initial Conditions

The mobile station has already established a circuit-switched call towards the MSC.
The mobile station receives data from SNDCP or GPRS-SMS to be transferred to the network.

Applicability of this Procedure

The procedure is only applicable if both, the mobile station and the network support the dual transfer mode.

Description

⇒ After reception of the packet-switched data the mobile station uses the DTM_REQ-message (sent on FACCH) to convey its demand for packet-switched resources (TBF-establishment) to the network.

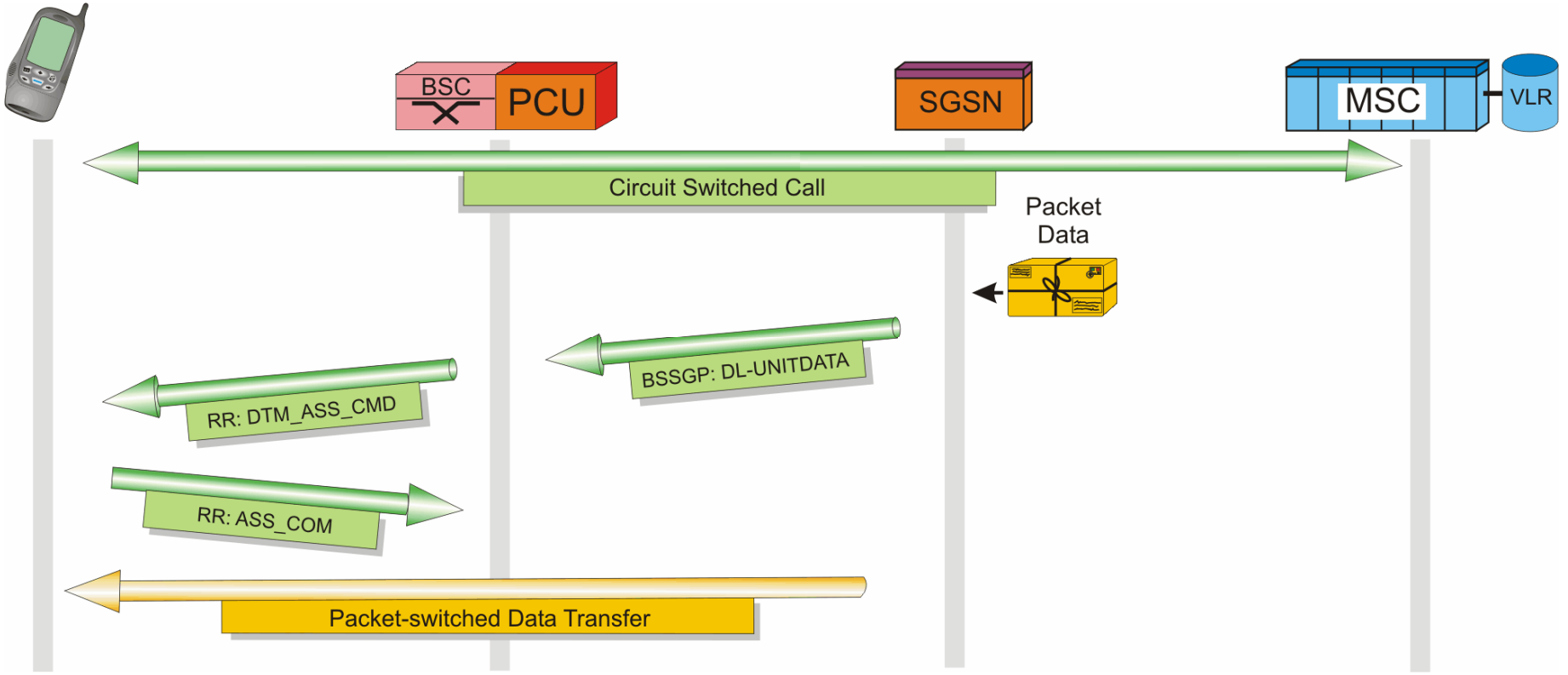
⇒ If the network is able to suit this request it shall use either the DTM_ASS_CMD-message (⇔ if the circuit-switched resources need to be rearranged in order to assign the packet-switched resources) or the PACK_ASS-message (⇔ if the circuit-switched resources don't need to be rearranged in order to allocate the packet-switched resources).

⇒ Consequentially, the mobile station will use the newly allocated packet-switched resources in uplink direction to transmit the packet data.

Note that a DTM-capable mobile station which becomes involved in a circuit-switched call will not suspend GPRS.

[3GTS 43.055 (6.1.2.2)]

DL Packet Data while MS is involved in CS-Call / MS in Ready State



DL Packet Data while MS is involved in CS-Call / MS in Ready State

Initial Conditions

The mobile station has already established a circuit-switched call towards the MSC.
The SGSN receives data from SNDCP or GPRS-SMS to be transferred to that mobile station.
The mobile station is in GMM-ready state (e.g. because a routing area update or cell update scenario occurred recently).

Applicability of this Procedure

The procedure is only applicable if both, the mobile station and the network support the dual transfer mode.

Description

⇒ Since the SGSN is aware of the currently serving cell of the mobile station (⇔ Ready State) it sends a BSSGP: DL-UNITDATA-PDU towards the PCU that serves that cell. The cell is identified inside the DL-UNITDATA-header.

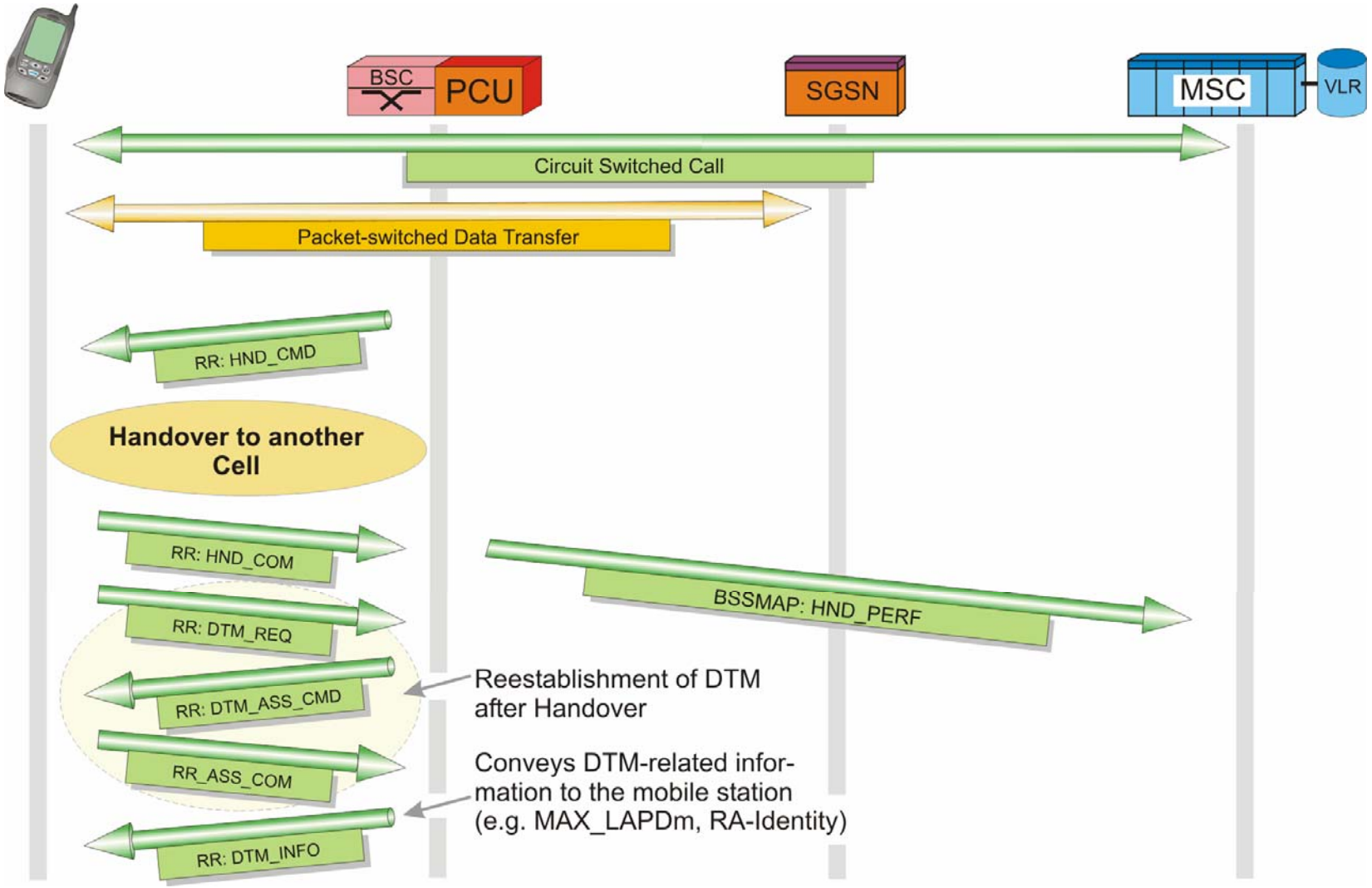
⇒ The PCU communicates with the BSC whether there is a circuit-switched connection with that mobile station (⇔ IMSI-check).

⇒ Consequently, the PCU relays the packet downlink assignment towards the BSC which sends it to the mobile station on FACCH through a DTM_ASS_CMD-message (Note the conditions explained on the previous slide for using either the DTM_ASS_CMD-message or the PACK_ASS-message. In the present case, the BSC could also use the PACK_ASS-message).

⇒ Consecutively, the PCU may use the allocated downlink resources to transmit the packet data towards the mobile station.

[3GTS 43.055 (6.1.2.3.1)]

Handover in Dual Transfer Mode



Handover in Dual Transfer Mode

Initial Conditions

The mobile station has already established a circuit-switched call towards the MSC and it is involved in a packet-switched data transfer in uplink and or downlink direction.
The BSC decides to perform a handover scenario which leads the mobile station into another cell.

Applicability of this Procedure

The procedure is only applicable if both, the mobile station and the network support the dual transfer mode.

Description

⇒ Upon execution of the circuit-switched handover scenario, the mobile station aborts TBF-operation.
⇒ After the circuit-switched handover scenario is completed, the mobile station uses the DTM_REQ-message to initiate the resumption of the packet-switched operation.
⇒ The BSC will consequently assign packet-switched resources in the new cell and the mobile station resumes packet-switched operation.

Considering that the circuit-switched handover scenario allows for an immediate service continuation in the new cell, also the resumption of the packet-switched data transfer service is much faster in DTM than after a regular cell change or a network assisted cell change (NACC).

[3GTS 43.055 (6.3)]