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Title: Definitions and Characteristics of Multicast Channels

Document for: Proposal of Multicast Channels

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1. Overview

In this contribution, we describe the operation of multicast service, and we propose new transport and physical channels for multicast service. The outline of this proposal is the following:

- Introduction or Background
- Descriptions of the characteristics of multicast logical, transport and physical channels
- Necessity of new transport and physical channels for multicast service
- The structures of newly introduced multicast transport and physical channels.
- Summary

Glossary

MTCH – Multicast Traffic Channel (logical channel)

MCH – Multicast Channel (transport channel)

MCCH – Multicast Control Channel (transport channel)

PMCH – Physical Multicast Channel (physical channel)

IMGI - International Mobile Group Identity

PTM – Point to Multipoint

GPRS – General Packet Radio Service

(Note) Unlike the multicast description in current S2.01, in this contribution Multicast Traffic channel is used as a logical channel for multicast service. Multicast Traffic Channel can be generalised as Common Traffic Channel for usage extension (e.g. group call).

2. Reference

[1] 3GPP S2.04, UE Procedures in Idle Mode

[2] 3GPP S2.01, Radio Interface Protocol Architecture

[3] 3GPP S2.21, MAC protocol specification

[4] 3GPP S2.02 Services provided by the physical layer

[5] GSM 01.60 Version 6.0.0 Digital cellular telecommunications system (Phase 2+); General Packet Radio Service (GPRS); Requirements specification of GPRS

[6] GSM 02.60 Version 7.0.0 Digital cellular telecommunications system (Phase 2+); General Packet Radio Service (GPRS); Service Description; Stage 1

[7] TIA/EIA/637-A Short Message Service for Spread Spectrum Systems

[8] 3GPP TSG RAN WG2 #2 99/075, Definitions of multicast service and requirement

[9] 3GPP TSG RAN WG2 #2 99/077, Multicast data transmission and reception procedures

3. Introduction

The definition of Multicast service in current GPRS specifications is as follow [6]:

Multicast service: A unidirectional point-to-multpoint service in which a message is transmitted from a single source entity to all subscribers currently located within a geographical area. The message contains a group identifier indicating whether the message is of interest to all subscribers or to only the subset of subscribers belonging to a specific multicast group.

In the UMTS based 3G system, basically the same definition can be applied. However, considering the requirements of 3G system and the capabilities of UMTS, we slightly modified some detailed characteristics, and also added some new characteristics for better multicast service. This change is described in our companion contribution [8].

According to the definition above, the multicast service is classified by the group identity or **IMGI(**International mobile group identity), which is used to identify the receivers. The exact definition of IMGI described in current GPRS specification is as follow [6].

IMGI: A PTM group is identified by the International Mobile Group Identity IMGI which shall support two levels of identification: a service provider level and an application level. It shall be possible to store the IMGI on the SIM and in addition as an option in the ME. Adequate protection of the storage on the SIM and for the transmission over the radio interface is required. A SIM storage capacity of 50 (or more) IMGIs and the capability to securely modify the IMGI via the SIM-Toolkit is required. The IMSI shall be used for authentication of the individual subscriber.

It is assumed that Multicast service is provided in idle mode as described in [1]. Therefore, the UTRAN does not have the knowledge of the presence of the instantaneous, actual receiver group members within the service area as described in [1]. The multicast service support in the connected mode is for further study.

According to the most up-to-date 3GPP specification, particularly, [2] and [4], we only have a logical channel for multicast service. Moreover, the detailed description for multicast data transmission is not there, yet. That gives us a motivation to think about how to do multicast data transmission and the necessity of multicast dedicated transport channel(s) and even physical channel(s) together with those characteristics that transport channel and physical channel for multicast service should have. In the following sections, we first derive the characteristics of those channels, and provide justification for our proposal.

4. Characteristics of Multicast Logical Channel (or MTCH)

We consider the following characteristics or features for multicast logical channel based upon the definition in [2]:

1) Point to multipoint
2) Unidirectional
3) Transfer of multicast data information
4) A group of specified users (Subscription based)

Mobile users get multicast service based on the subscription of specific multicast service. **IMGI** (International Mobile Group Identity) is used for the multicast group identification as defined in current GPRS.

5. Transport Channels for Multicast Traffic

The characteristics of multicast transport channel are as follows:

1) **Downlink only.**
2) **Possibility of broadcast in the entire coverage area of the cell**
3) **Possibility of fast rate change –** multiple different classes of multicast data will be transmitted, some multicast data rate such as video can vary fast.
4) **Possibility of sleep mode support -** UE receives multicast data during the idle mode. UE extracts only particular multicast data from the multicast traffic channel, which is destined to the multicast group that the UE belongs to, rather than receiving other multicast data belonging to other multicast group. UE gets into sleep mode while the transmission of other group multicast traffic is on-going. In order to achieve this sleep mode, UE has to

be able to extract only selected data. Multicast Control Channel will be used for this control. The details are described below.

5) **No power control -** The multicast service is an unidirectional point-to-multipoint service, in which multiple users use common radio link to receive the multicast data,. Therefore, power control is not required.

6) **Reliable/unreliable data transfer (ffs)**. The higher layer may or may not require multicast data to be transferred in a reliable fashion. The reliable multicast data transmission is for further study.

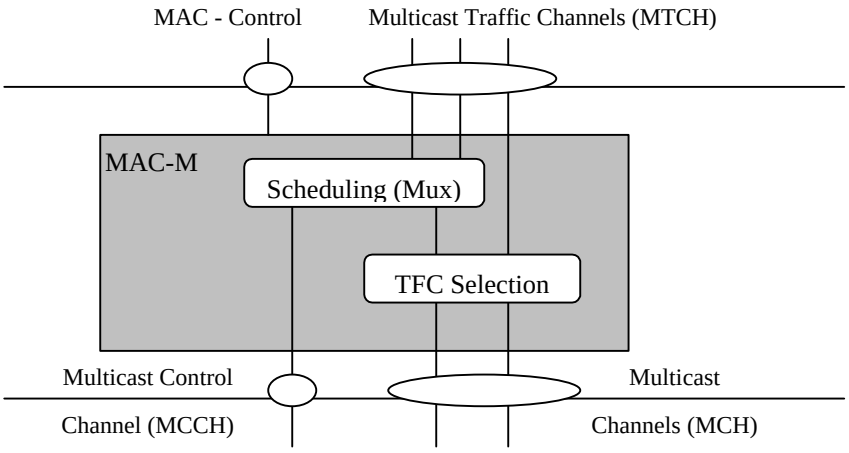
7) **No requirement for in-band group identification –** In order to support the sleep mode, the layer 23 or signaling based group identification should be prohibited.

In the current specification [2], the DCH and FACH are mapped into MCH. However, DCH is used in connected mode. As we mentioned above, we consider multicast service operation as a idle mode task for UE. Therefore, DCH is not appropriate at this moment. Using DCH for the multicast is left for further study for the case multicast service is also provided in connected mode. Similarly, DSCH channel is not suitable because it is also for the connected mode.

Meanwhile, FACH does not suit for the multicast service, either, since current FACH does not meet the above requirements of 3), 4), 5), 6), and 7). For example, FACH cannot provide fast rate change because it doesn't have TFCI field in it. For 5), current FACH may provide slow power control for a certain uplink channel while multicast service doesn't. For 4) and 7), in order to support the sleep mode operation, UE should not be required to decode all the data transmitted on the multicast channel. However, the current addressing mechanism for FACH requires UE to decode all the data transmitted over FACH since the addressing is performed in Layer 2/3. Consequently, we need a new transport channel for multicast service to meet all the requirements above. We call this new transport channel **Multicast Channel (MCH)**.

Multiple Logical Channels

We consider multiple Multicast Traffic Channels. Multicast data is transmitted over the Multicast Channels (MCH). Different Multicast Channels may have different QoS(such as coding, repetition time and interleaving depth) depending on the characteristics of the multicast data being carried. Each Multicast Traffic Channel transfers the multicast data with each bearer capability. It is expected that a various number of multicast services will be provided. In that case, scheduling or multiplexing between different Multicast Traffic Channels is needed. Figure 1 shows the MAC layer model for multicast service. This figure also shows the scheduling or multiplexing among several Multicast Traffic Channels.



[Figure 1 MAC layer entity for multicast service]

We first consider periodic and non-periodic multicast data transmission without Multicast Control Channel (this channel will be defined later on). In the case of multicast data transmission in periodic fashion, we don't need to insert IMGI value explicitly. In this case, UE can know in advance or implicitly when the multicast data destined to the UE is being transmitted over Multicast Traffic Channel, thus, the overhead of IMGI processing can be removed. However, this scheme provides no flexibility of the multicast data transmission in terms of data rate and period change, which may result in inefficient downlink code usage.

On the other hand, for flexibility of multicast data transmission in terms of scheduling and code usage, it is possible for UTRAN to send multicast data in non-periodic fashion. However, in this case, the UE cannot change its mode to sleep mode while other group multicast data is being transmitted since there is no way for UE to know when and which multicast group data is being transmitted. In other words, each UE has to decode all the data being transmitted together with the IMGI field, and filter the data destined to the UE somewhere in higher layer such as layer 2 or 3.

Even if both schemes above have their own advantages, they are not optimal because of the reasons described above. As an optimal scheme whereby we can achieve both flexibility and sleep mode support, we propose to use a new transport channel, which is called **Multicast Control Channel(MCCH).** It is similar to the current Paging Channel in that it has a cycle, which is the period corresponding to the number of IMGI groups. However, the data contained in this new channel is the control information for Multicast Channel (MCH). UE can know when to decode the Multicast Channel (MCH) based on the information contained in the Multicast Control Channel(MCCH). The control information contained in Multicast Control Channel (MCCH) indicates that when the multicast data is transmitted, and how long the multicast data burst is. By using this scheme, we can achieve both flexibility and sleep mode support. Multicast Control Channel(MCCH) has the following characteristics.

Characteristics of Multicast Control Channel (MCCH)

1) downlink only

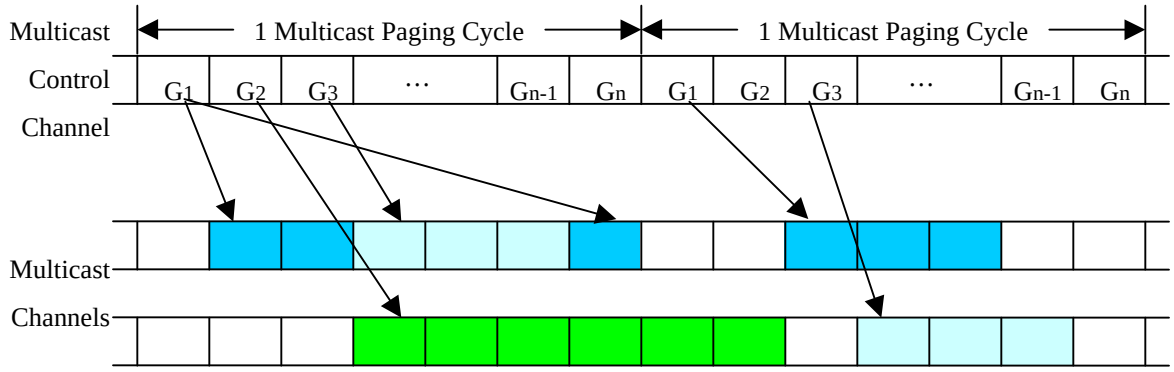
2) broadcast in the entire coverage area of the cell

3) Possibility of sleep mode procedure

4) No power control

5) Periodic

As explained above, with the Multicast Control Channel (MCCH) and Multicast Channel (MCH), sleep mode can be enabled as shown in figure 2. Control information contained in Multicast Control Channel(MCCH) points the location and duration of multicast data transmitted on the Multicast Channel.



(Note) Multicast service is idle mode procedure currently

(Note) Gn: n^{th} IMGI group

[Figure 2 Multicast service scenario]

In summary our proposed scheme using periodic Multicast Control Channel (MCCH) and non-periodic Multicast Channel (MCH) provides the system for more dynamic radio resource management.

For multicast service, users need to have knowledge of multicast service configuration. Some of those informations are suggested to be transmitted on the BCH, while others are transmitted on the Multicast Control Channel (MCCH). To provide multicast service, the network transmits the following information on the MCCH such as Multicast Channel(MCH) configuration.

Control Information contained in Multicast Control Channel (MCCH)

1) Code assignment for Multicast Channel(MCH). Multicast Channel (MCH) may be used using multi-code mechanism. In that case, it should be indicated to users as Multicast Control Channel (MCCH) information.

2) Frame assignment for Multicast Channel(MCH). Multicast data can be transmitted in consecutive frames on the Multicast Channel (MCH). The Multicast Control Channel notify the user how many frames are involved in the particular multicast data burst.

Information to be contained in the Multicast Channel (MCH) is multicast data only.

The information to be included in the Broadcast Channel(BCH) is defined as follows.

Information to be contained in Broadcast channel

1) Availability of multicast service. Multicast service is restricted to a geographical area. This means that there are cells, which do not provide multicast service. Therefore, UE need to know whether the cell in which the UE is located currently provides multicast service or not.

2) Available multicast service groups (IMGI). As mentioned earlier, different set of multicast service is provided in different geographical areas. This means that available multicast service set may change depending on the cell or sector, whichever the service area unit is. Consequently, the UE can know which multicast services are available by decoding BCH.

3) Configuration for Multicast Control Channel(MCCH). Network has to notify users the information about Multicast Control Channel (MCCH) such as code used for Multicast Control Channel (MCCH), or the period of Multicast Control Channel (MCCH) cycle.

4) Code tree for Multicast Channel(MCH). This information is needed when Multicast service use multi code. This option is used when the multicast data to be transmitted has high data rate, or variable data rate, e.g., multimedia services.

6. Multicast Service Scenario

Multicast data reception procedures:

1) UE knows its IMGI and when to listen to Multicast Control Channel (MCCH) in advance based on the agreement between UE and UTRAN, and the information from BCH.

2) If the multicast service that the user subscribes to is available, the user decodes only the frame belonging to the IMGI group block from the Multicast Control Channel(MCCH) (Cyclic period).

3) User decodes multicast data being transmitted on Multicast Channel (MCH) using the information received from Multicast Control Channel (MCCH) indicating the location of multicast data and duration.

4) Repeats 2) and 3)

7. Physical Channels for Multicast Channels (MCH) and Multicast Control Channel (MCCH)

Let’s consider a physical channel for multicast. According to the characteristics of the Multicast Channel (MCH), the physical channel for Multicast Channel (MCH) must have the following characteristics.

Characteristics of Physical Channel for Multicast Channel (MCH)

1) No power control - As described in the previous section, power control field is not needed, because multicast service is provided in idle mode meaning there is no uplink to be power-controlled.

2) Possibility of dynamic rate change - The rate of multicast data transmitted on the air can vary fast or slow because a variety of simultaneous multicast services are expected in the future.

Let’s check if any existing channel meets the requirements described above. DPCH (DPDCH/DPCCH) is not appropriate because it has TPC field. Secondary CCPCH is not suitable, either, because it cannot support fast rate change. For PDSCH or PSCCCH, even though PSCCCH structure is under discussion, it seems that it will have power control information. Therefore, PSCCCH is not suitable for multicast. PDSCH has no pilot and no support for fast rate change. Besides, it must be always associated with PSCCCH. Consequently, we need a new physical channel for Multicast Channel. This channel will be called Physical Multicast Channel, PMCH in short.

Multicast data on Multicast Channel (MCH) can be transmitted in consecutive frames. Therefore, Pilot is required in the Physical Multicast Channel to perform channel estimation. Meanwhile, because the data rate of Multicast Channel can vary frame by frame basis, TFCI information is needed, too.

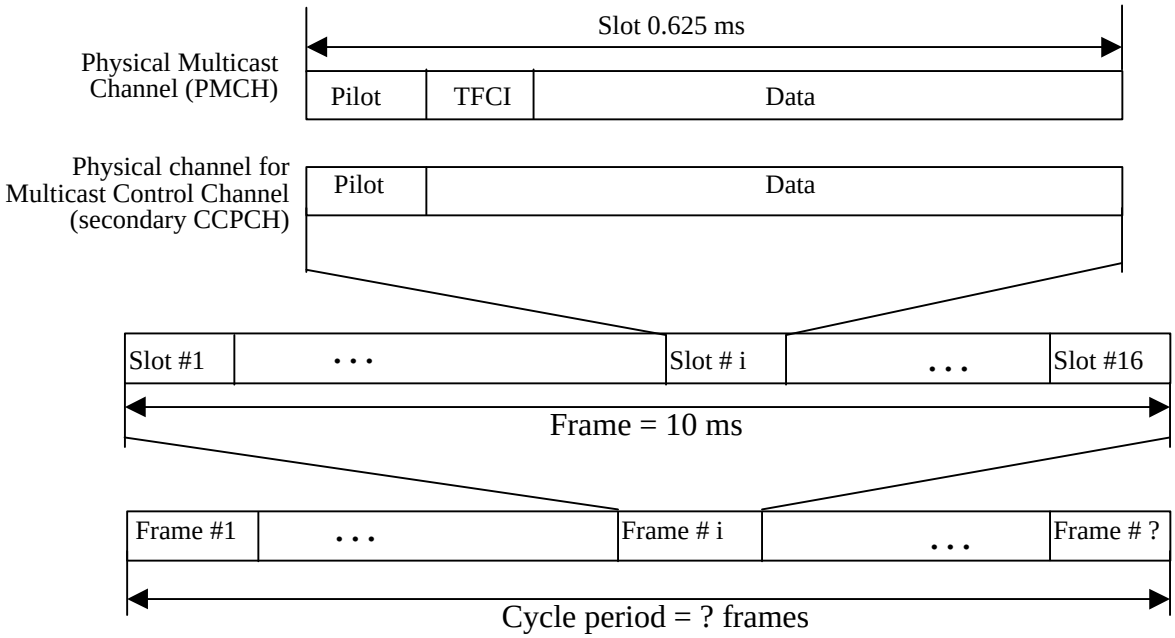
The physical channel for Multicast Control Channel has the following characteristics:

Characteristics of Physical Channel for Multicast Control Channel (MCCH)

1. Constant rate,
2. cell-specific (or service area specific)
3. No power control

Considering above characteristics, Secondary CCPCH seems to meet these requirements at this moment.

The figure 3 shows the physical channel formats for multicast including Physical Multicast Channel.



[Figure 3 Physical Channel Structure for multicast]

PMCH is can be transmitted using the multi-code scheme, and interleaved frame by frame basis. The contents of the physical channel for MCCH is repeated periodically like paging channel (that is, it has a cycle with key = IMGI), and that period depends on the service area (e.g. cell)

TFCI information may be contained in the physical channel for Multicast Control Channel (MCCH) or Physical Multicast Channel (PMCH) depending on whether the rate of multicast data changes fast or slow. If the multicast data rate changes frame by frame basis, the TFCI field must be included in the Physical Multicast Channel (PMCH). This TFCI field is added by Layer 1. Whereas TFCI field must be included in the physical channel for Multicast Control Channel (MCCH) if the multicast data rate does not change during multicast data burst transmission in a multicast paging cycle. However, it looks more flexible and reasonable to put TFCI into the Physical Multicast Channel (PMCH).

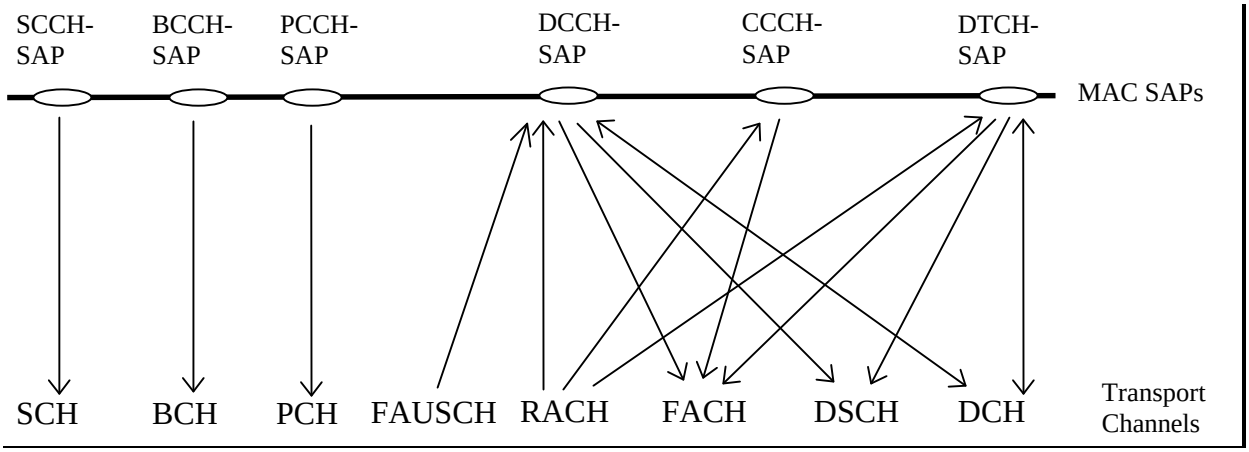
8. Proposed modifications to S2.01

The conclusion is that there is a need for two new transport channels, which are as follows:

1) Multicast Channel (MCH) A downlink channel shared by several multicast group to carry multicast data.

2) Multicast Control Channel (MCCH) A downlink channel used for the broadcast of Multicast Channel control information over an entire cell to allow efficient UE sleep mode procedure.

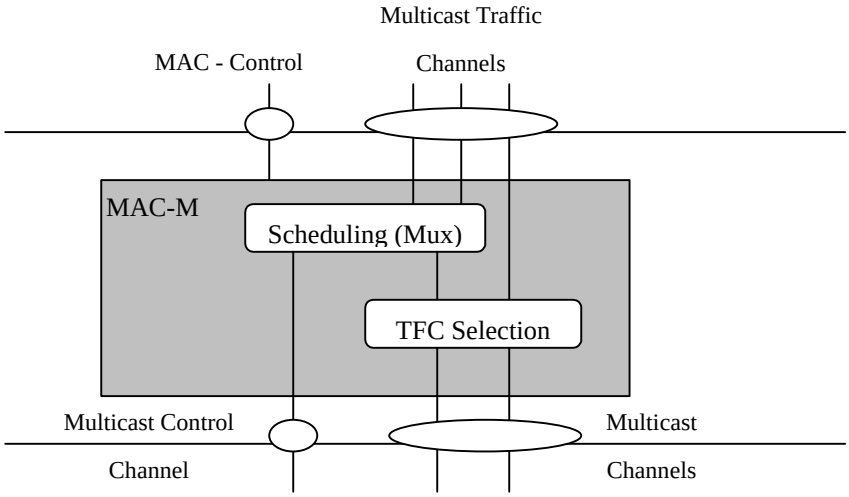
Mapping between Logical Channels and Transport Channels



[Figure 4 Logical Channels to Transport Channels, UTRAN side]

9. Proposed modifications to S2.21

MAC Architecture (UTRAN side)



(Note) MAC-M Multicast entity

[Figure 5 MAC-M entity]

Multiple Multicast Traffic Channels (MTCH) are scheduled and multiplexed in the MAC sublayer. MAC-M

(Multicast) entity has functions, scheduling and TFC selection.

11. Conclusion

In this proposal, two new transport channels for multicast service, namely, Multicast Channel (MCH) for multicast data and Multicast Control Channel (MCCH) for Multicast Channel (MCH) control data. On top of that, a new physical channel, namely, Physical Multicast Channel (PMCH) is proposed whereby efficient multicast data transmission is achieved.