[0001] MULTI-CELL COORDINATION FOR MULTIMEDIA BROADCAST MULTICAST SERVICES IN A WIRELESS COMMUNICATION SYSTEM

[0002] FIELD OF INVENTION

[0003] The present invention is related to a wireless communication system. More particularly, the present invention is related to multi-cell coordination for multimedia broadcast multicast services (MBMS) in a wireless communication system.

[0004] BACKGROUND

[0005] The third generation partnership project (3GPP) Release 6 defines MBMS, which is a counterpart of other multicast services operating in other communication standards, such as digital video broadcast-handheld (DVB-H). MBMS allows downlink data to be transmitted from a single source to multiple recipients in broadcast or multicast modes. The existing 3GPP release also defines the MBMS channels, scheduling, bearers, procedures, and the like.

[0006] In the 3GPP long term evolution (LTE) project, a new universal mobile telecommunication system (UMTS) evolved universal terrestrial radio access network (E-UTRAN) and evolved core network are introduced. This inevitably requires changes to the current specifications for MBMS so that the new architecture can support MBMS efficiently.

[0007] LTE requires the support of single cell and multi-cell MBMS transmissions. For multi-cell transmission, MBMS, (e.g., mobile TV), is transmitted on the coverage of a group of cells, MBMS may be transmitted on a multicast channel (MCH), soft combining of MBMS data at the receiver may be supported within a particular service group (i.e., single frequency network (SFN)), and synchronous transmission of MBMS data from multiple cells is possible.

[0008] To achieve synchronous data transmission in multiple cells in the LTE architecture, inter-cell scheduling is required. In Release 6, the

synchronization is performed by a radio network controller (RNC). However, without an RNC in the new LTE architecture, alternative procedures have to be provided to facilitate multi-cell transmission.

[0009] SUMMARY

[0010] The present invention is related to a method and system for multi-cell coordination for MBMS in a wireless communication system. An MBMS coordination unit is provided to coordinate a plurality of evolved Node-Bs (eNodeBs), (i.e., cells), for transmission of MBMS data synchronously in multiple cells. The MBMS coordination unit may be located in an access gateway or in an eN odeB. An MBMS multi-cell scheduling scheme may be preconfigured for the eNodeBs for synchronization. Alternatively, the eNodeBs may be synchronized dynamically.

[0010a] In one aspect the present invention provides an access gateway for controlling a plurality of evolved Node-Bs (eNodeBs), the access gateway including:

a control plane;

a user plane; and

a multimedia broadcast multicast services (MBMS) multi-cell coordination unit including at least one control part located in the control plane of the access gateway for coordinating control signaling to the eNodeBs, and at least one data part located in the user plane of the access gateway for coordinating data signaling to the eNodeBs.

[0011] BRIEF DESCRIPTION OF THE DRAWINGS

[0012] A more detailed understanding of the invention may be had from the following description of a preferred embodiment, given by way of example and to be understood in conjunction with the accompanying drawings wherein:

[0013] Figure 1 shows an MBMS coordination unit located in an access gateway in accordance with the present invention;

[0014] Figure 2 shows an MBMS coordination unit located in an eNodeB in accordance with the present invention;

[0015] Figure 3 is a signal flow diagram for pre-configuring scheduling to synchronize a group of eNodeBs in accordance with one embodiment of the present invention;

[0016] Figure 4 is a signal flow diagram for hand-shaking scheduling to dynamically synchronize a group of eNodeBs in accordance with another embodiment of the present invention;

[0017] Figure 5 illustrates MBMS control channel (MCCH) information scheduling in accordance with the present invention;

[0018] Figure 6 shows an exemplary configuration of an eNodeB that operate in accordance with the present invention; and

[0019] Figure 7 shows an exemplary configuration of an MBMS multi-cell coordination unit that operates in accordance with the present invention.

[0020] DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0021] When referred to hereafter, the terminology "wireless transmit/receive unit (WTRU)" includes but is not limited to a user equipment (UE), a mobile station, a fixed or mobile subscriber unit, a pager, a cellular telephone, a personal digital assistant (PDA), a computer, or any other type of user device capable of operating in a wireless environment. When referred to hereafter, the terminology "base station" includes but is not limited to an eNodeB, a site controller, an access point (AP), or any other type of interfacing device capable of operating in a wireless environment.

[0022] The present invention addresses issues to support multi-cell transmission of MBMS in the proposed LTE architecture. The present invention defines a multi-cell coordination unit, proposes the location of the MBMS coordination unit and different scheduling procedures, defines how the existing MBMS functionalities, (such as notification and counting), may be modified in the new architecture, and defines the new scheduling for the MBMS control channel.

[0023] Figure 1 shows an access gateway 100 in communication with a plurality of eNodeBs, (i.e., cells) 105_1, 105_2, 105_3 and 105_4. The access gateway 100 includes an MBMS multi-cell coordination unit 110, (i.e., an MBMS server), configured in accordance with the present invention. The MBMS multi-cell coordination unit 110 is a logical entity that controls the eNodeBs 105 and coordinates multi-cell scheduling and transmission when the eNodeBs 105 belong to the same cell group. Functions of MBMS coordination unit 110 may include scheduling and timing control, counting, eNodeB registration and feedback. For each SFN, the MBMS multi-cell coordination unit 110 also configures the

common scrambling code of each eNodeB 105 in the SFN. For different MBMS, the SFN may be different (consisting of different cells/eNodeBs).

[0024] Still referring to Figure 1, the MBMS multi-cell coordination unit 110 includes at least one control part 115 located in a control plane 120 of the access gateway 100 for coordinating control signaling, and at least one data part 125 located in a user plane 130 of the access gateway 100 for coordinating data signaling. Both the control part 115 and the data part 125 may have multiple instances, each of which corresponds to a particular service group, (i.e., SFN). The access gateway 100 further includes a system architecture evolution (SAE) bearer control unit 135, a mobility management entity (MME) 140 and a packet data convergence protocol (PDCP) unit 145.

[0025] The SAE bearer control unit 135 is the LTE counterpart of the old "radio access bearer control" or "RAB control" in wideband code division multiple access (WCDMA). It controls the configuration of the radio access bearers. The MME unit 140 hosts the following functionalities: distribution of paging messages to the eNodeBs, security control, idle state mobility control, and ciphering and integrity protection of non-access stratum (NAS) signaling. The main services and functions of the PDCP unit 145 include header compression and decompression, transfer of user data, (i.e., the PDCP receives a PDCP service data unit (SDU) from the NAS and forwards it to the radio link control (RLC) layer and vice versa, reordering of the downlink RLC SDUs at least during inter-eNodeB mobility, in-sequence delivery of upper layer protocol data units (PDUs) at handover (HO) in the uplink (for further study (FFS)), duplicate detection of lower layer SDUs, and ciphering of user plane data and control plane data (NAS signaling).

[0026] The MBMS multi-cell coordination unit 110 may be located between the E-UTRAN, (i.e., an eNodeB), and the access gateway 100. The physical location of the MBMS multi-cell coordination unit 110 depends on the particular implementation. As described above, Figure 1 shows an MBMS multi-cell coordination unit 110 that is co-located with an access gateway 100. In this scenario, there are multiple instances in the control plane 120 of the access

gateway 100 for the control signaling, and multiple instances in the user plane 130 of the access gateway 100 for the data traffic.

[0027] When there are mixed MBMS between the LTE and the current UMTS system, an inter-access MBMS coordination unit needs to be located at the inter-access anchor node. The inter-access MBMS coordination unit interacts with the MBMS multi-cell coordination unit 110 at the access gateway 100 for LTE and MBMS functions in the RNC for UMTS.

[0028] In an alternate embodiment, the MBMS multi-cell coordination unit 110 may be located in an eNodeB, as shown in Figure 2. This solution may have some potential issues, such as how to determine which eNodeB(s) will be a "master" eNodeB that contains an MBMS multi-cell coordination unit 110. The "master" eNodeB may be determined statically by pre-configuration or dynamically, so the "master" eNodeB may change for different services. Furthermore, extra "hand-shaking" signalings among the eNodeBs are required.

[0029] When MBMS data arrives at the access gateway 100, it is scheduled such that it is transmitted synchronously to all of the eNodeBs 105 in a particular cell group. In accordance with the present invention, the eNodeBs 105 execute the actual scheduling, while the MBMS multi-cell coordination unit 110 insures that the transmission is synchronized among the eNodeBs. It is assumed that the eNodeBs are synchronized in terms of time.

[0030] Figure 3 shows a signal flow diagram for implementing a pre-configuring scheduling procedure 300 for synchronizing a group of eNodeBs in a wireless communication system including a plurality of WTRUs 305, a plurality of eNodeBs 310, an MBMS multi-cell coordination unit 315, an operations, administration and maintenance (OAM) system 320 and an access gateway 325 in accordance with one embodiment of the present invention. In step 330, the MBMS multi-cell coordination unit 315 obtains MBMS multi-cell scheduling criteria before the MBMS begin, such as from the OAM system 320. The criteria can be, for example, the eNodeBs transmitting MBMS data at a predetermined amount of time after notification of MBMS data. Alternatively, the scheme can be for the eNodeBs to transmit MBMS data at a predetermined amount of time

after MBMS data first arrives at the eNodeBs 310. Each scheme is set by the signalings, and triggered by the transmission criteria, such as the arrival of MBMS data.

[0031] Still referring to Figure 3, the eNodeBs 310 register with the MBMS multi-cell coordination unit 315 before the MBMS begin (step 335). The registration can be part of the system start/restart procedure at the eNodeBs, whereby an eNodeB that wants to provide a particular MBMS service needs to be registered with the MBMS coordination unit 315 first. If there is no indication of resource reservation from the MBMS multi-cell coordination unit 315, the eNodeBs 310 inform the MBMS multi-cell coordination unit 315 of the availability of resources. The MBMS transmission time stamp and information on required resources for MBMS data will be passed to the eNodeBs 310. The scheme may be restarted or modified during the MBMS service.

[0032] Still referring to Figure 3, after an eNodeB 310 is registered with the MBMS multi-cell coordination unit 315, the MBMS multi-cell coordination unit 315 will notify the eNodeB 310 regarding the details of a particular MBMS scheduling scheme (step 340). The MBMS scheduling scheme notification may include information including MBMS service type, data rate, start time, end time and the like. When MBMS service starts in step 345, the MBMS data arrives at the eNodeBs 310 from the access gateway 325 (step 350). Finally, in step 355, the eNodeBs 310 will transmit the MBMS data to the WTRUs 305 in accordance with the MBMS scheduling scheme notified in step 340.

[0033] Figure 4 is a signal flow diagram for implementing a hand-shaking scheduling procedure 400 for dynamically synchronizing a group of eNodeBs in a wireless communication system including a plurality of WTRUs 405, a plurality of eNodeBs 410, an MBMS multi-cell coordination unit 415, and an access gateway 420 in accordance with another embodiment of the present invention. Each of the eNodeBs 410 is controlled by the MBMS multi-cell coordination unit 415. In step 425, the access gateway 420, (or the MBMS multi-cell coordination unit 415), notifies the eNodeBs 410 that an MBMS session starts. In step 430, each eNodeB 410 sends an estimated time stamp and resource availability

information to the MBMS multi-cell coordination unit 415. The time stamp suggests the time that each eNodeB 410 can start an MBMS transmission. Based on received information, the MBMS multi-cell coordination unit 415 determines a coordinated time when MBMS data should be transmitted to the WTRUs by all eNodeBs 410 in the same SFN. In step 435, the MBMS multi-cell coordination unit 415 informs the eNodeBs 410 about the time when the transmission of MBMS data to the WTRUs should start by sending a coordinated scheduling time stamp. Then, the MBMS service starts in step 440. In step 445, the eNodeBs 410 receive MBMS data from the access gateway 420. In step 450, the eNodeBs 410 provide MBMS by transmitting the MBMS data to the WTRUs 405 according to the coordinated scheduling time stamp sent by the MBMS multi-cell coordination unit 415. The hand-shaking signaling described above may need to be repeated, whereby in step 455, the MBMS continue, and steps 460, 465 and 470 are implemented in the same manner as corresponding steps 430, 435 and 450, respectively.

[0034] In accordance with another embodiment of the present invention, it is important that the MBMS multi-cell coordination unit 110 of Figure 1 receives sufficient information from the eNodeBs 105 so that the MBMS multi-cell coordination unit 110 can schedule transmissions accordingly. The MBMS multi-cell coordination unit 110 may have, but is not limited to, the following information:

1) the eNodeB identification: the MBMS multi-cell coordination unit 110 may use it to check if the eNodeB 105 has registered for the service group or to get other preloaded information about the eNodeB 105, such as a previous counting record, and the like;

2) the eNodeB type: information such as if the eNodeB 105 controls mixed or dedicated cells for MBMS;

3) the number of users interested in the MBMS;

4) the eNodeB status for MBMS, (e.g., whether or not resources are allocated for MBMS); and

5) existing MBMS: when there are multiple MBMS in a cell.

[0035] The information is sent from the eNodeB 105 to the MBMS multi-cell coordination unit 110 via the control signaling between them.

[0036] The MBMS multi-cell coordination unit 110 also keeps track of the resources availability at any given time. If the resources are not used, the eNodeBs 105 are allowed to use it for dedicated service. However, the priority of the resources should be for MBMS.

[0037] In accordance with yet another embodiment of the present invention, the MBMS notification mechanism is used to inform WTRUs of an upcoming change in critical MBMS control channel (MCCH) information. An MBMS notification indicator is sent from the eNodeB to a plurality of WTRUs. However, the notification message may be created at the access gateway or the MBMS multi-cell coordination unit. With no MBMS indicator channel (MICH), the information is sent over the MCCH. The WTRUs should be informed if an RRC connection is required. WTRUs at idle or RRC connected mode receive an MBMS notification. Upon detecting the MBMS notification indication for a service group, those WTRUs interested in a service corresponding to this group start reading the MCCH at the beginning of the next modification period. When a feedback mechanism is used, the type of feedback information should be included, such as counting, channel quality, completion of service, and the like.

[0038] In Release 6, notification is an RRC operation performed by an RNC. In the LTE architecture, the notification function may be performed at an eNodeB. However, for eNodeBs that belong to the same service group and are in the same SFN, notification should be synchronized by the MBMS multi-cell coordination unit.

[0039] In accordance with yet anther embodiment of the present invention, an MBMS counting procedure is used by a WTRU to inform the E-UTRAN about the number of WTRUs that are interested in receiving MBMS. A request for counting is indicated in the notification, and achieved by requesting WTRUs belonging to the same MBMS service group to respond to the counting request. The exact number of WTRUs responding to the counting request is a radio resource management (RRM) issue.

[0040] WTRUs with different LTE states react as follows: A WTRU in an LTE_IDLE state requests an RRC connection establishment procedure. The WTRUs will remain RRC connected until they receive the MBMS. A WTRU in an LTE_ACTIVE state will just need to inform the E-UTRAN of its interest in the MBMS. Within the WTRU, the response of interest to the MBMS will "lock" any attempts to release the RRC connection or to change the WTRU state from LTE_ACTIVE to LTE_IDLE.

[0041] In Release 6, upon reception of the MBMS ACCESS INFORMATION, the WTRU draws a random number and decides if it will respond to the counting procedure. If the WTRU should not respond this time period, the WTRU continues to acquire the MBMS ACCESS INFORMATION and repeats the above process again.

[0042] The present invention provides a modification of the procedure. Upon receiving the counting indication, the LTE active WTRU always notifies the E-UTRAN its interest in the advertised MBMS. Thus, the E-UTRAN will know immediately how many WTRUs are interested in receiving MSMS, and this information can be passed to a core network and a broadcast multicast service center (BM-SC) as well. The WTRU may also notify the E-UTRAN about its current connection status.

[0043] Then, for the idle WTRU, the WTRU will perform a random draw to decide when to establish the RRC connection. The random draw will stagger the RRC connection procedures in a cell to avoid overload. This information can be passed to the E-UTRAN as well so that the E-UTRAN knows when to expect to start the MBMS.

[0044] The present invention provides a method to improve uplink access and resource allocation for a counting procedure in accordance with yet another embodiment of the present invention. The counting is performed in two steps. The first step is to count WTRUs in an LTE_Active state. If there are not enough WTRUs in the LTE_Active mode, WTRUs in an LTE_Idle mode are counted. The advantage of this scheme is that WTRUs in an LTE_idle mode do not need to send an indication about their interest in a certain MBMS service when there are

WTRUs in a connected mode response. It will save uplink resources (and/or downlink resources) that will be needed to support counting for WTRUs in an LTE_idle state.

[0045] The method to achieve this is described as follows:

1) MBMS service notification packet indicates that only LTE_active WTRUs need to respond for counting.

2) Optional: Change the counting parameters, (such as probability of response), so that probability of WTRUs responding back increases.

3) If there are not enough WTRUs in an LTE_Active response back for the service, the MBMS service notification package should indicate that WTRUs in an LTE_Idle state need to respond for counting.

[0046] In the LTE system, two logical channels are proposed for MBMS in yet another embodiment of the present invention. An MCCH is used for control information and an MBMS traffic channel (MTCH) is used for traffic. In LTE, the MCCH will be the only logical channel to handle MBMS control information. The previous notification transported on an MBMS indicator channel (MICH) and scheduling information on an MBMS scheduling channel (MSCH) can be sent over the MCCH.

[0047] Figure 5 illustrates the MCCH information scheduling in accordance with the present invention. It is based on the current scheduling in Release 6 with some updates. In accordance with the present invention, the eNodeB sends MBMS notification information over the MCCH to the WTRUs during a notification period 505, such that the eNodeB can notify the WTRUs that MBMS data will be provided in the upcoming downlink frames. The eNodeB may send the MBMS notification information to the WTRUs a predetermined number of times. After the notification period 505, the MBMS control information may be sent over an MCCH. The scheduling information previously sent over the MSCH can be updated during the notification period 505 by sending "change information". Following the notification period 505, a first modification period 510 starts. The MCCH information transmitted in the first modification period 510 contains more detailed information about the MBMS, including MBMS

service type, the indices of sub-frames (or TTIs) where a particular MBMS service will be transmitted, radio bearer (RB) configuration of MBMS and the like. Another modification period 515 may occur after the first modification period 510. During repetition period 520, the non-MBMS access information is periodically transmitted. Each repetition period is shorter than the modification period.

[0048] Figure 6 shows an exemplary configuration of an eNodeB 600 that operates in accordance with the present invention. The eNodeB 600 comprises a receiver 605, a transmitter 610, a processor 615 and an antenna 620. The receiver 605 is configured to receive a notification that an MBMS session has started via the antenna 620. The transmitter 610 is configured to transmit a time stamp and resource availability information via the antenna 620 in response to the receiver 605 receiving the notification, as determined by the processor 615. The estimated time stamp indicates the time that the eNodeB 600 can start an MBMS transmission. The receiver 605 is further configured to receive via the antenna 620 a coordinated scheduling time stamp that indicates a coordinated time when MBMS data should be transmitted by the eNodeB 600 in the same SFN to at least one WTRU. The receiver 605 is also configured to receive MBMS data, and the transmitter 610 is further configured to transmit the MBMS data to the at least one WTRU in accordance with the coordinated scheduling time stamp. The transmitter 610 is also configured to transmit registration information via the antenna 620, and the receiver 605 is further configured to receive via the antenna 620 the details of a particular MBMS scheduling scheme.

[0049] Figure 7 shows an exemplary configuration of an MBMS multi-cell coordination unit 700 that operates in accordance with the present invention. The MBMS multi-cell coordination unit 700 comprises a receiver 705, a transmitter 710, a processor 715 and an antenna 720. The receiver 705 is configured to receive via the antenna 720 a time stamp and resource availability information that indicates the time that an eNodeB can start an MBMS transmission. Under the control of the processor 715, the transmitter 710 is

configured to transmit, via the antenna 720, a coordinated scheduling time stamp that indicates a coordinated time when MBMS data should be transmitted by the eNodeB in the same SFN to at least one WTRU. The receiver 705 is further configured to receive registration information transmitted by at least one eNodeB via the antenna 720, and the transmitter 710 is further configured to transmit, via the antenna 720 to a registered eNodeB, the details of a particular MBMS scheduling scheme. The receiver 705 is further configured to receive the scheduling scheme from an OAM system.

[0050] Embodiments

1. A method of coordinating the provision of multimedia broadcast multicast services (MBMS) in a wireless communication system including a plurality of wireless transmit/receive units (WTRUs) and a plurality of evolved Node-Bs (eNodeBs), wherein the eNodeBs are synchronized to provide MBMS to the WTRUs, the method comprising:

providing an MBMS coordination unit for coordinating the transmission of MBMS by the eNodeBs to the WTRUs.

2. The method of embodiment 1 further comprising:

the eNodeBs registering with the MBMS coordination unit;

the MBMS coordination unit providing the registered eNodeBs with information for scheduling the transmission of MBMS data; and

the eNodeBs receiving MBMS data; and

the eNodeBs transmitting the MBMS data to the WTRUs in accordance with the scheduling information.

3. The method as in any one of embodiments 1 and 2 wherein the MBMS coordination unit is located in an access gateway.

4. The method as in any one of embodiments 1 and 2 wherein the MBMS coordination unit is located in an eNodeB.

5. The method as in any one of embodiments 1-4 wherein a first subset of the eNodeBs belongs to a first single frequency network (SFN) and a second subset of the eNodeBs belongs to a second SFN.

6. The method of embodiment 5 wherein at least one the eNodeBs belongs to both of the first and second SFNs.

7. The method as in any one of embodiments 1-6 wherein the MBMS coordination unit includes at least one control part located in a control plane of an access gateway for coordinating control signaling, and at least one data part located in a user plane of the access gateway for coordinating data signaling.

8. The method of embodiment 7 wherein both the control part and the data part have multiple instances, each of which corresponds to a particular single frequency network (SFN).

9. The method as in any one of embodiments 1-8 further comprising:

providing eNodeB identification information to the MBMS coordination unit.

10. The method as in any one of embodiments 1-9 further comprising:

providing eNodeB type information to the MBMS coordination unit.

11. The method as in any one of embodiments 1-10 further comprising:

providing information to the MBMS coordination unit regarding the number of WTRU users interested in receiving the MBMS data.

12. The method as in any one of embodiments 1-11 further comprising:

providing eNodeB status information for MBMS to the MBMS coordination unit.

13. The method as in any one of embodiments 1-12 further comprising:

providing existing MBMS information to the MBMS coordination unit.

14. A method of coordinating the provision of multimedia broadcast multicast services (MBMS) in a wireless communication system including a plurality of wireless transmit/receive units (WTRUs) and a plurality of evolved Node-Bs (eNodeBs), wherein the eNodeBs are synchronized to provide MBMS to the WTRUs, the method comprising:

providing an MBMS coordination unit;

the eNodeBs receiving a notification that an MBMS session has started;

each of the eNodeBs sending a time stamp and resource availability information to the MBMS coordination unit, the estimated time stamp indicating the time that the eNodeB can start an MBMS transmission;

the eNodeBs receiving a coordinated scheduling time stamp generated by the MBMS coordination unit that indicates a coordinated time when MBMS data should be transmitted by the eNodeBs in the same single frequency network (SFN) to the WTRUs;

the eNodeBs receiving MBMS data; and

the eNodeBs transmitting the MBMS to the WTRUs in accordance with the coordinated scheduling time stamp.

15. The method of embodiment 14 wherein the MBMS coordination unit is located in an access gateway.

16. The method of embodiment 14 wherein the MBMS coordination unit is located in an eNodeB.

17. The method as in any one of embodiments 14-16 wherein a first subset of the eNodeBs belongs to a first SFN and a second subset of the eNodeBs belongs to a second SFN.

18. The method of embodiment 17 wherein at least one the eNodeBs belongs to both of the first and second SFNs.

19. The method as in any one of embodiments 14-18 wherein the MBMS coordination unit includes at least one control part located in a control plane of an access gateway for coordinating control signaling, and at least one data part located in a user plane of the access gateway for coordinating data signaling.

20. The method of embodiment 19 wherein both the control part and the data part have multiple instances, each of which corresponds to a particular SFN.

21. The method as in any one of embodiments 14-20 wherein the eNodeBs receive the MBMS data from the access gateway.

22. A wireless communication system for coordinating the provision of multimedia broadcast multicast services (MBMS), the system comprising:

an MBMS coordination unit;

a plurality of wireless transmit/receive units (WTRUs); and

a plurality of evolved Node-Bs (eNodeBs), wherein each of the eNodeBs are configured to (i) register with the MBMS coordination unit, (ii) receive information from the MBMS coordination unit for scheduling the transmission of MBMS data, (iii) receive MBMS data, and (iv) transmit the MBMS data to the WTRUs in accordance with the scheduling information.

23. The system of embodiment 22 wherein the MBMS coordination unit is located in an access gateway.

24. The system of embodiment 22 wherein the MBMS coordination unit is located in an eNodeB.

25. The system as in any one of embodiments 22-24 wherein a first subset of the eNodeBs belong to a first single frequency network (SFN) and a second subset of the eNodeBs belong to a second SFN.

26. The system of embodiment 25 wherein at least one the eNodeBs belongs to both of the first and second SFNs.

27. The system as in any one of embodiments 22-26 wherein the MBMS coordination unit includes at least one control part located in a control plane of an access gateway for coordinating control signaling, and at least one data part located in a user plane of the access gateway for coordinating data signaling.

28. The system of embodiment 27 wherein both the control part and the data part have multiple instances, each of which corresponds to a particular single frequency network (SFN).

29. The system as in any one of embodiments 22-28 further comprising:

an access gateway configured to provide the MBMS data to the eNodeBs for transmission to the WTRUs; and

an operations, administration and maintenance (OAM) system configured to provide MBMS multi-cell scheduling criteria to the MBMS coordination unit.

30. A wireless communication system for coordinating the provision of multimedia broadcast multicast services (MBMS), the system comprising:

an MBMS coordination unit;

a plurality of wireless transmit/receive units (WTRUs); and

a plurality of evolved Node-Bs (eNodeBs), wherein each of the eNodeBs are configured to (i) receive a notification that an MBMS session has started and send a time stamp and resource availability information to the MBMS coordination unit, the estimated time stamp indicating the time that the eNodeB can start an MBMS transmission, (ii) receive a coordinated scheduling time stamp generated by the MBMS coordination unit that indicates a coordinated time when MBMS data should be transmitted by the eNodeBs in the same single frequency network (SFN) to the WTRUs, (iii) receive MBMS data, and (iv) transmit the MBMS data to the WTRUs in accordance with the coordinated scheduling time stamp.

31. The system of embodiment 30 wherein the MBMS coordination unit is located in an access gateway.

32. The system of embodiment 30 wherein the MBMS coordination unit is located in an eNodeB.

33. The system as in any one of embodiments 30-32 wherein a first subset of the eNodeBs belongs to a first SFN and a second subset of the eNodeBs belongs to a second SFN.

34. The system of embodiment 33 wherein at least one the eNodeBs belongs to both of the first and second SFNs.

35. The system as in any one of embodiments 30-34 wherein the MBMS coordination unit includes at least one control part located in a control plane of an access gateway for coordinating control signaling, and at least one data part located in a user plane of the access gateway for coordinating data signaling.

36. The system of embodiment 35 wherein both the control part and the data part have multiple instances, each of which corresponds to a particular SFN.

37. The system as in any one of embodiments 30-36 further comprising:

an access gateway configured to provide the MBMS data to the eNodeBs for transmission to the WTRUs; and

an operations, administration and maintenance (OAM) system configured to provide MBMS multi-cell scheduling criteria to the MBMS coordination unit.

38. An access gateway for controlling a plurality of evolved Node-Bs, the access gateway comprising:

a control plane;

a user plane; and

a multimedia broadcast multicast services (MBMS) multi-cell coordination unit including at least one control part located in the control plane of the access gateway for coordinating control signaling to the eNodeBs, and at least one data part located in the user plane of the access gateway for coordinating data signaling to the eNodeBs.

39. The access gateway of embodiment 38 wherein both the control part and the data part have multiple instances, each of which corresponds to a particular single frequency network (SFN).

40. The access gateway as in any one of embodiments 38 and 39 further comprising:

a system architecture evolution (SAE) bearer control unit;

a mobility management entity (MME); and

a packet data convergence protocol (PDCP) unit.

41. The access gateway of embodiment 40 wherein the SAE bearer control unit controls the configuration of radio access bearers.

42. The access gateway of embodiment 40 wherein the MME unit hosts at least one of distribution of paging messages to the eNodeBs, security control, idle state mobility control, and ciphering and integrity protection of non-access stratum (NAS) signalings.

43. The access gateway of embodiment 40 wherein the PDCP unit performs header compression and decompression, transfer of user data, duplicate detection of lower layer service data units (SDUs), and ciphering of user plane data and control plane data.

44. An evolved Node-B (eNodeB) comprising:

a receiver configured to receive a notification that a multimedia broadcast multicast services (MBMS) session has started; and

a transmitter configured to transmit a time stamp and resource availability information in response to receiving the notification, the estimated time stamp indicating the time that the eNodeB can start an MBMS transmission.

45. The eNodeB of embodiment 44 wherein the receiver is further configured to receive a coordinated scheduling time stamp that indicates a coordinated time when MBMS data should be transmitted by the eNodeB in the same single frequency network (SFN) to at least one wireless transmit/receive unit (WTRU).

46. The eNodeB of embodiment 45 wherein the receiver is further configured to receive MBMS data, and the transmitter is further configured to transmit the MBMS data to the at least one WTRU in accordance with the coordinated scheduling time stamp.

47. The eNodeB of embodiment 44 wherein the transmitter is further configured to transmit registration information, and the receiver is further configured to receive the details of a particular MBMS scheduling scheme.

48. A multimedia broadcast multicast services (MBMS) multi-cell coordination unit comprising:

a receiver configured to receive a time stamp and resource availability information that indicates the time that an evolved Node-B (eNodeB) can start an MBMS transmission; and

a transmitter configured to transmit a coordinated scheduling time stamp that indicates a coordinated time when MBMS data should be transmitted by the eNodeB in the same single frequency network (SFN) to at least one wireless transmit/receive unit (WTRU).

49. The MBMS multi-cell coordination unit of embodiment 48 wherein the receiver is further configured to receive registration information transmitted by at least one eNodeB, and the transmitter is further configured to the transmit the details of a particular MBMS scheduling scheme to a registered eNodeB.

50. The MBMS multi-cell coordination unit of embodiment 49 wherein the receiver is further configured to receive the scheduling scheme from an operations, administration and maintenance (OAM) system.

[0051] Although the features and elements of the present invention are described in the preferred embodiments in particular combinations, each feature or element can be used alone without the other features and elements of the preferred embodiments or in various combinations with or without other features and elements of the present invention. The methods or flow charts provided in the present invention may be implemented in a computer program, software, or firmware tangibly embodied in a computer-readable storage medium for execution by a general purpose computer or a processor. Examples of computer-readable storage mediums include a read only memory (ROM), a random access memory (RAM), a register, cache memory, semiconductor memory devices, magnetic media such as internal hard disks and removable disks, magneto-optical media, and optical media such as CD-ROM disks, and digital versatile disks (DVDs).

[0052] Suitable processors include, by way of example, a general purpose processor, a special purpose processor, a conventional processor, a digital signal processor (DSP), a plurality of microprocessors, one or more microprocessors in association with a DSP core, a controller, a microcontroller, Application Specific Integrated Circuits (ASICs), Field Programmable Gate Arrays (FPGAs) circuits, any other type of integrated circuit (IC), and/or a state machine.

[0053] A processor in association with software may be used to implement a radio frequency transceiver for use in a wireless transmit receive unit (WTRU), user equipment (UE), terminal, base station, radio network controller (RNC), or any host computer. The WTRU may be used in conjunction with modules, implemented in hardware and/or software, such as a camera, a video camera module, a videophone, a speakerphone, a vibration device, a speaker, a microphone, a television transceiver, a hands free headset, a keyboard, a Bluetooth® module, a frequency modulated (FM) radio unit, a liquid crystal display (LCD) display unit, an organic light-emitting diode (OLED) display unit,

a digital music player, a media player, a video game player module, an Internet browser, and/or any wireless local area network (WLAN) module.

* * *

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. An access gateway for controlling a plurality of evolved Node-Bs (eNodeBs), the access gateway including:

a control plane;

a user plane; and

a multimedia broadcast multicast services (MBMS) multi-cell coordination unit including at least one control part located in the control plane of the access gateway for coordinating control signaling to the eNodeBs, and at least one data part located in the user plane of the access gateway for coordinating data signaling to the eNodeBs.

2. The access gateway of claim 1 wherein both the control part and the data part have multiple instances, each of which corresponds to a particular single frequency network (SFN).

3. The access gateway of claim 1 further including:

a system architecture evolution (SAE) bearer control unit;

a mobility management entity (MME); and

a packet data convergence protocol (PDCP) unit.

4. The access gateway of claim 1 wherein the SAE bearer control unit controls the configuration of radio access bearers.

5. The access gateway of claim 1 wherein the MME unit hosts at least one of distribution of paging messages to the eNodeBs, security control, idle state mobility control, and ciphering and integrity protection of non-access stratum (NAS) signalings.

6. The access gateway of claim 1 wherein the PDCP unit performs header compression and decompression, transfer of user data, duplicate detection of lower layer service data units (SDUs), and ciphering of user plane data and control plane data.

7. The access gateway of claim 1 wherein each eNodeB includes:

a receiver configured to receive a notification that an MBMS session has started; and

a transmitter configured to transmit a time stamp and resource availability information in response to receiving the notification, the estimated time stamp indicating the time that the eNodeB can start an MBMS transmission.

8. The access gateway of claim 7 wherein the receiver is further configured to receive a coordinated scheduling time stamp that indicates a coordinated time when MBMS data should be transmitted by the eNodeB in the same single frequency network (SFN) to at least one wireless transmit/receive unit (WTRU).

9. The access gateway of claim 8 wherein the receiver is further configured to receive MBMS data, and the transmitter is further configured to transmit the MBMS data to the at least one WTRU in accordance with the coordinated scheduling time stamp.

10. The access gateway of claim 7 wherein the transmitter is further configured to transmit registration information, and the receiver is further configured to receive the details of a particular MBMS scheduling scheme.

11. The access gateway of claim 1 and substantially as hereinbefore described with reference to the accompanying Figure.