Network/Content Synchronisation for MBSFN Transmission in 3GPP Networks

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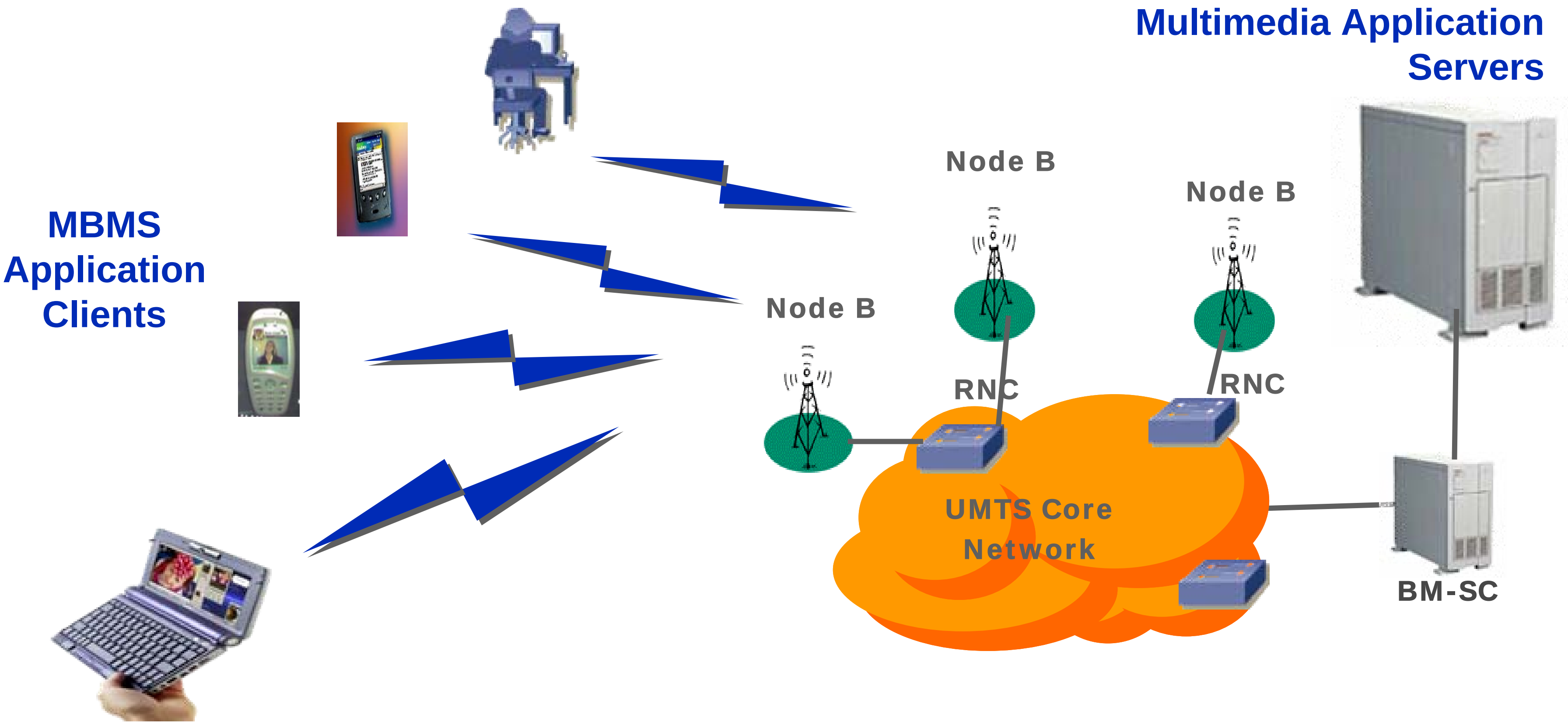
3GPP Multimedia Broadcast/Multicast Service (MBMS)



- Provided over shared resource
  - Enables several users to receive the same service provided via a single radio bearer

3GPP Multimedia Broadcast/Multicast Service (MBMS)

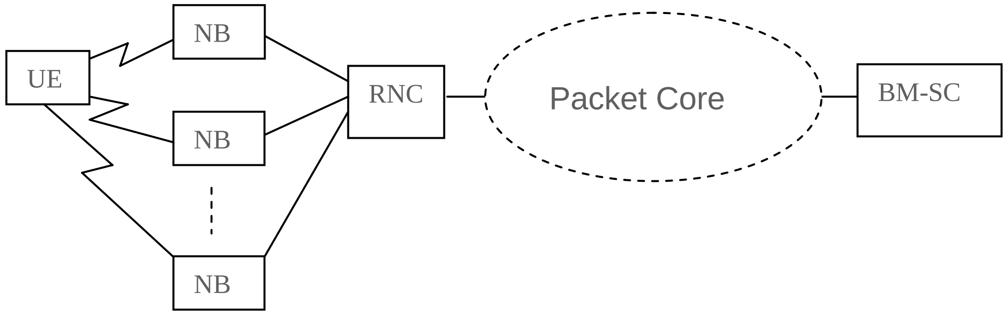
- MBMS service may be provided over a single cell or a group of cells
- Transmission combining techniques
  - Transmission synchronised across group of cells
  - simulcast combining, L1 combining, L2 (selective) combining, MBSFN
  - Provide:
    - Improved QoS,
    - extended cell range
    - increase in available service bit rate
    - increase in number of services that can be supported

IPWireless Generations Ahead

3GPP MBMS Single Frequency Network (MBSFN)

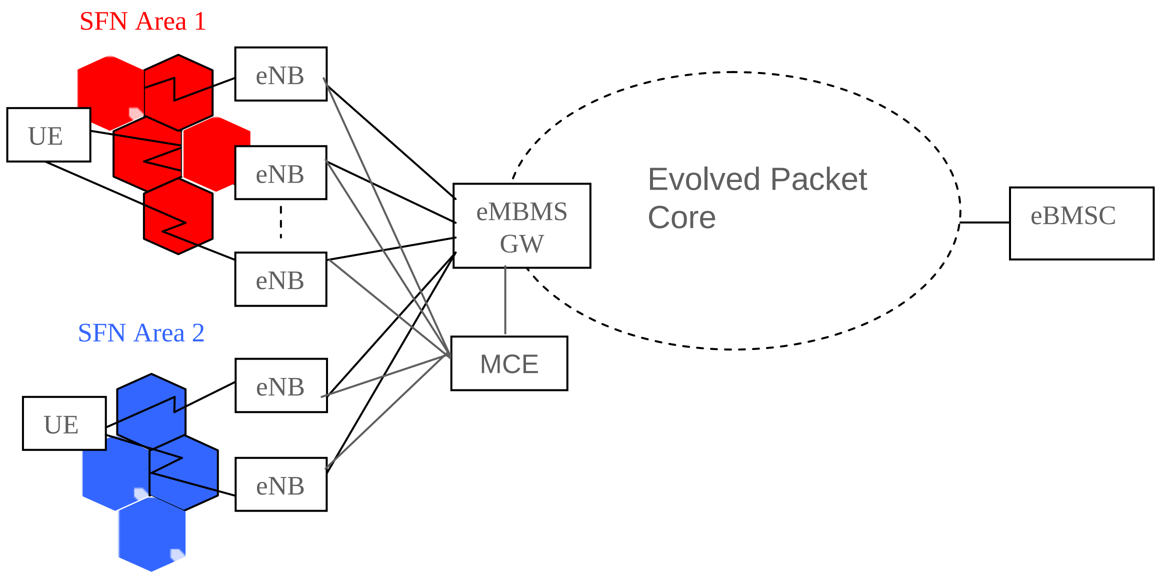
- Simulcast transmission technique realised by transmission of identical waveforms at the same time from multiple cells.
- Signals from multiple cells combined as multi-path components of a single cell
  - Terminal sees group as a single cell
- Requires all transmissions to be very tightly synchronised (within a few µs) with exactly the same content delivered to each base station for transmission
  - UEs can tolerate up to 33 µs but the majority of this is required to accommodate propagation delays from contributing sites
- Advantages
  - More spectrally efficient than other combining techniques (3x)
  - Simpler receiver implementation

MBMS (MBSFN) Architecture in UMTS



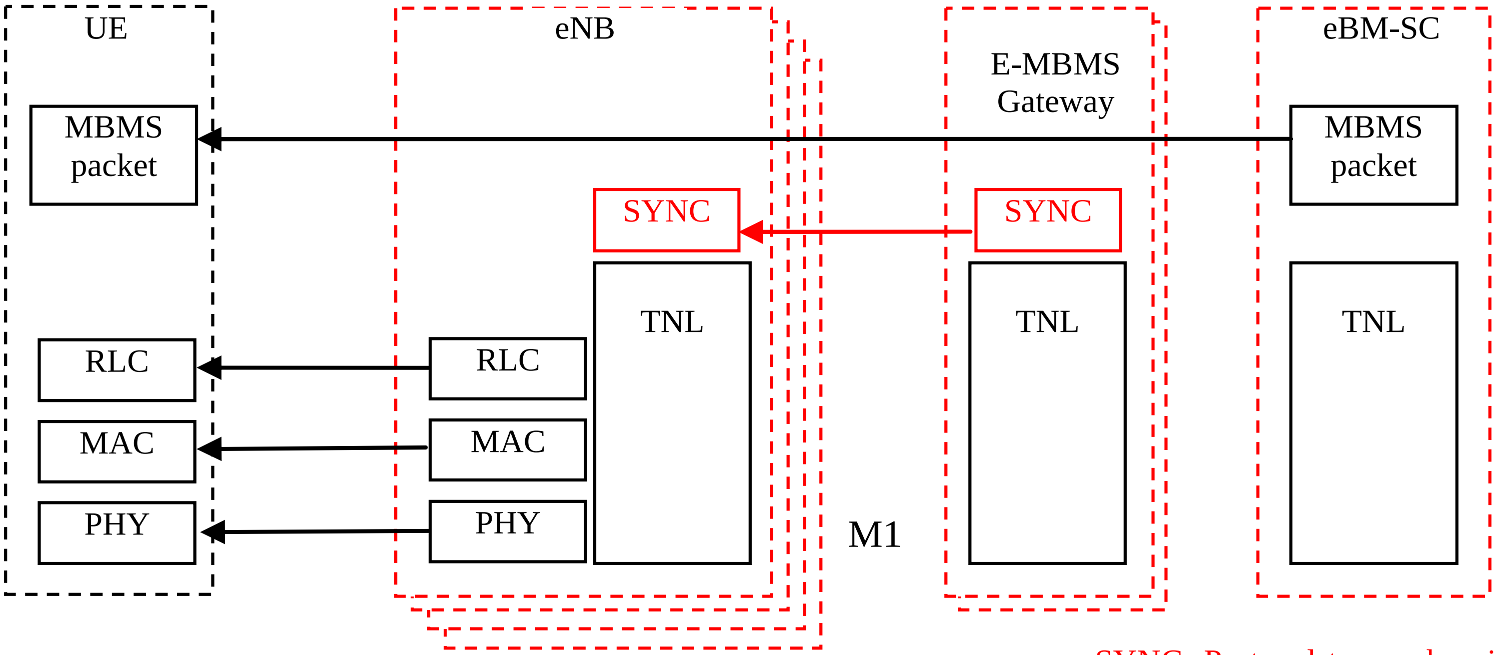
- Synchronisation provided with regard to transmissions in cells controlled by **single** Radio Network Controller (RNC)
- RNC responsible for radio resource management and mapping service content to radio bearer
- Same radio bearer content delivered by frame protocol to each Node B to ensure identical radio transmissions
  - Frame numbering enables Node Bs to work out transmission timing to ensure synchronised transmissions

eMBMS (MBSFN) Architecture in EUTRAN



- All radio related functions (including radio resource management) now provided by eNB
- Delivering radio frames with time-stamp to control transmission is not an option unless we duplicate certain radio functions in the eMBMS GW
- The principle of content delivery via a suitably designed synchronisation protocol is agreed

Protocol Architecture



SYNC: Protocol to synchronise data used to generate a certain radio frame

MBMS content synchronization user-plane architecture

MBSFN: content synchronization principles

- To transmit identical radio frames simultaneously
  - Synchronised radio frame timing is required
  - Each eNB must be provided with same RLC/MAC/PHY configuration for the MBMS service
  - eNBs must deal uniformly with the intermittent arrival of packets plus delay variation and packet loss on M1
  - Segmentation/concatenation must be provided by the RLC/MAC layer uniformly by all eNBs
- SYNC protocol provides
  - Information related to transmission timing
  - Means to detect and recover packet loss

SYNC Protocol Assumptions

- Synchronised radio framing by eNBs guaranteed via use of GPS or equivalent accurate timing technology
- Each eNB has buffer memory
  - to accommodate for short periods where the service bit rate is higher than the configured radio bearer bit rate
  - to store SYNC PDUs until the time when they are to be transmitted
- Mean service bit rate < configured radio bearer bit rate
- eMBMS GW has knowledge of configured bearer bit rate

eMBMS SYNC Protocol Features

- Use of cumulative byte count and packet sequence numbers
- Timing information is sent to indicate when eNB should commence transmission of subsequently received service data
  - Indicates start of a data burst (block of packets)
  - Provides means of detecting end of data burst (previously received block of packets)
- PDUs are sent significantly in advance, well before they are to be transmitted, in order to enable eNB to compensate for PDU loss

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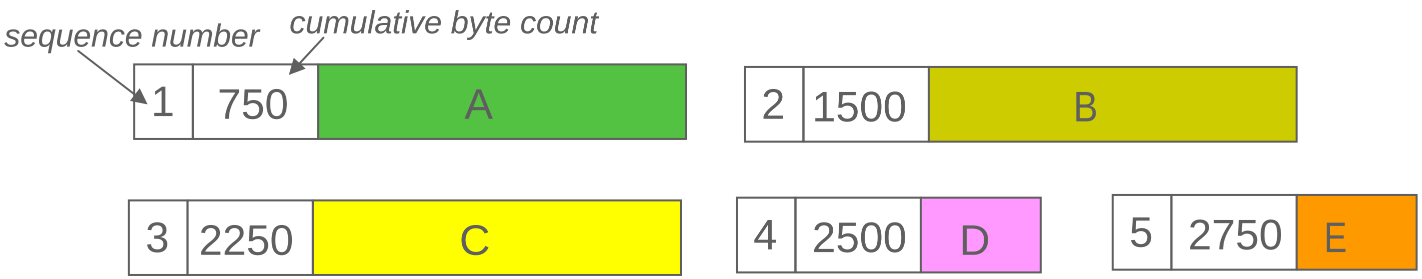
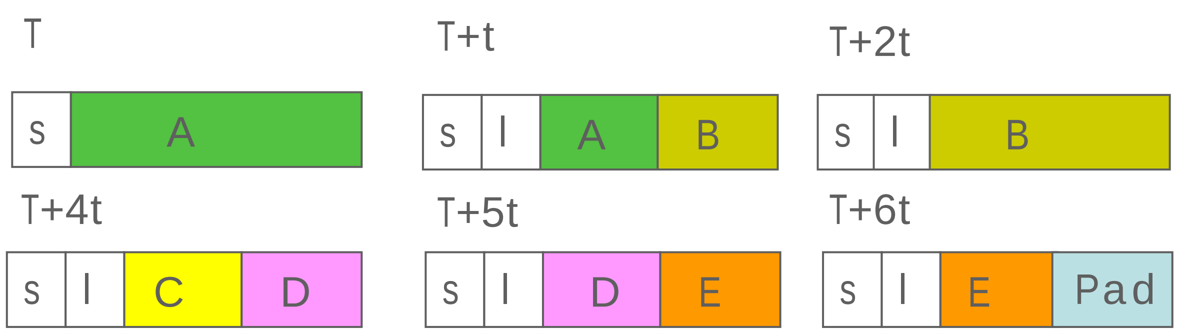
Examples illustrating SYNC protocol operation

Assume packets A, B, C, D,E are received from the eBM-SC and that A, B, C are each 750 bytes and that D and E are each 250 bytes in length



SYNC PDUs



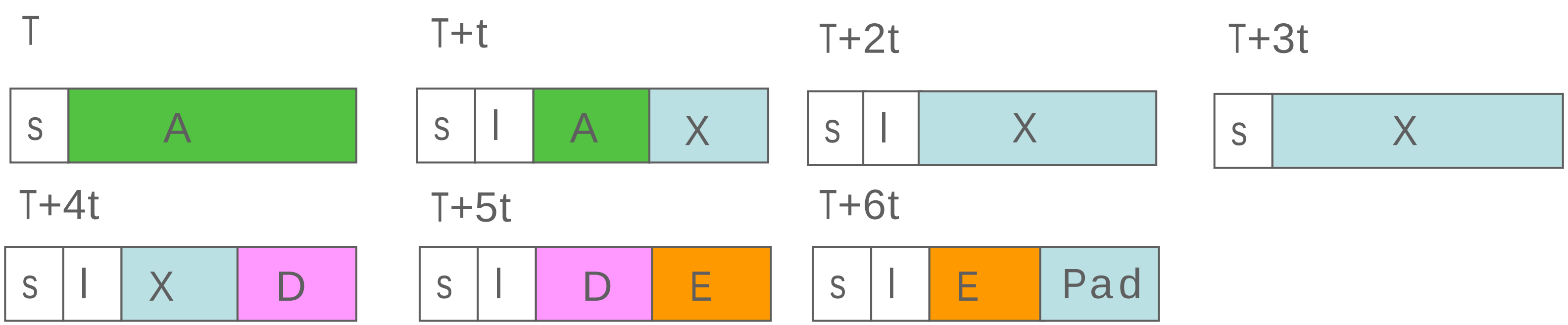
S = RLC sequence number

l = RLC length indicators

Radio frames transmitted at T, T + t, T + 2t etc.

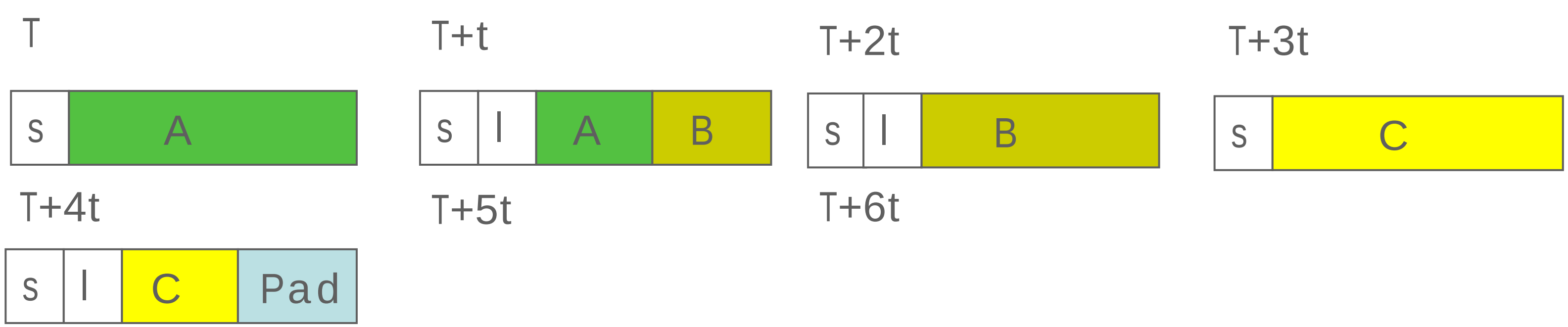
Examples illustrating SYNC protocol operation: packet loss recovery (1)

- Assume packets B and C are not received then it can be determined that 2 packets containing a total of 1500 bytes have not been received
- The exact length of each missing packet cannot be accurately determined but an eNB can make an appropriate decision regarding how to generate an appropriate set of RLC/MAC PDUs
  - From sequence numbers and cumulative byte counts of received packets
- RLC/MAC PDUs containing X (missing information) are not transmitted and the eNB does not transmit at time intervals T+t, T+2t, T+3t and T+4t



Examples illustrating SYNC protocol operation: loss recovery when packet loss at end of a burst (2)

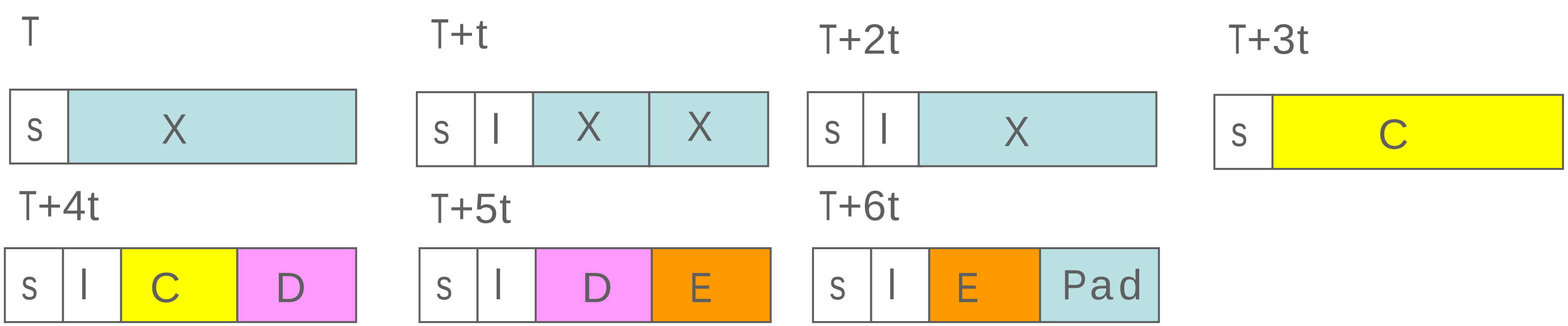
- If an eNB's packet buffer is empty then it simply doesn't transmit
- If it has packets buffered for transmission but the value T associated with those packets has not yet been reached then it does not transmit
- If packets are lost at the end of a burst then the eNB may interfere with transmissions from other base stations in one transmission time interval. For example if packets D and E are not received then the following RLC/MAC PDUs are generated



- There is no transmission at time intervals T+5t and T+6t. Only the transmission at T+4t causes some interference with the transmissions by other eNBs which received packets D and E correctly

Timing (T) and Packet Loss (1)

- Several options currently under discussion:
  - Include T in every PDU carrying application data?
  - Send it via separate PDU, before a burst of data?
  - Send T periodically?
- If a eNB has a valid T then if packets are lost at the start of a burst then RLC/MAC PDUs can be generated from information contained in the first received PDU
  - In the example (shown below) RLC/MAC PDUs containing X (missing information) are not transmitted and the eNB does not transmit at time intervals T, T+t and T+2t



Timing (T) and Packet Loss (2)

- Need some rules to enable eNB to determine if T is valid for a group of packets
  - otherwise one eNBs transmissions might interfere with the transmissions of another eNB
- Possible rules (to be applied by eNB):
  - When T is received:
    - Contents of SYNC PDUs subsequently received transmitted in sequence when time T is reached
    - There is no impact on transmission of packets previously received
  - When time T is reached and the packet buffer is empty then there are no subsequent transmissions (until new value of T is received and SYNC PDUs subsequently received)
  - If no T has been received within a period T_K then there should be no subsequent transmissions (until new value of T is received and SYNC PDUs subsequently received)
  - When time T is reached then packets associated with a previous value of T are discarded

IPWireless Generations Ahead

Conclusions and Way Forward

- eMBMS SYNC protocol
  - Seems to provide means of fulfilling LTE MBSFN architecture principles
- Way Forward (some ideas):
  - Send T periodically (every 1sec, 2 secs?)
  - 2 x before start of a new burst
  - Always include T in the first SYNC PDU of a burst
  - Reset sequence numbering every time a new value of T is sent
    - This provides a further means to enable the eNB to determine if its current T is valid (e.g. if sequence number of received < previous received packet and no new value for T received then do not transmit received packet)

Some Key References

TS 22.246 Multimedia Broadcast/Multicast Service (MBMS) user services; stage 1 (Release 7)

TS 23.246 Multimedia Broadcast/Multicast Service (MBMS); Architecture and functional description; Stage 1 (Release 7)

TS 25.346 Multimedia Broadcast/Multicast Service (MBMS) in the Radio Access Network (RAN); Stage 2 (Release 7)

TR 25.905 Improvement of Multimedia Broadcast/Multicast Service (MBMS) in the UTRAN (Release 7)

TS 36.300 Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2 (Release 8)

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R3-070630 "MBMS L2 content synchronization", Ericsson, RAN3#55bis, St. Julian, Malta, 27 – 30 March 2007

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