

Uplink Frame structure of Short TTI system

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Abstract— The study item on latency reduction techniques was considered with shorter TTI length along with reduced processing times. When TTI length is shortened, the allowed processing times should be reduced linearly to achieve optimal gains. This needs to rely on new channel design. Latency reduction techniques is important KPI. 5G requirement LTE-evo needs low latency to fulfil 5G requirements, User plane latency <0.5ms end to end, reliability 99.999% in < 1ms. There are many shorted TTI length, now days, it is discussed on symbol 2, 4, 7 length.

In this paper, the frame structure supports the Legacy LTE system and low latency. UEs, NodeBs which support the low latency system, it can support the legacy LTE system. Low latency system can support one way end to end latency 1ms.

Keywords— Short TTI, LTE, Uplink, low latency

I. INTRODUCTION

Recently, the transmission of user data within 1 ms is one of the vision for next generation 5G mobile communication and presented by domestic and foreign organizations have. This is different from previous generations of mobile communications, and in this paper, to support the recently mentioned low-latency services Analyze trends related to required low delay requirements. On the basis of this, a delay due to the TTI (Transmit Time Interval) Time was analyzed quantitatively and shows the frame structure, procedure, BLER results.

A shorter TTI is directly proportional to the air interface delay. Shortening the TTI by reducing the number of symbols is the most promising approach when seeking to maintain backward compatibility and usability in existing LTE band, the current 1ms TTI produces in practice a 10-20ms round trip time and less than 1ms one-way delay. In this paper, shows the approach that offers further reduction end-to-end delay in content delivery. It needs 1ms from NodeB MAC to UE MAC, and UE MAC to NodeB MAC. NodeB and UEs that can support the low latency, It can support the legacy LTE system. Now we discuss of low latency system which made of 2, 4, 7 symbol. This paper shows the subslot made of 2 symbol and resource mapping. The system which supports Short TTI, can share the frequency resource with legacy LTE system. Subslot channel is designed for supporting 1ms processing time. one subslot made of 2 symbols, so 7 subslots are included in one

subframe. In this paper, shows the low latency uplink frame structure and procedure, performance analysis results.

II. DL/UL FRAME STRUCTURE

DL/UL subslot include 2 symbols, in 1ms LTE subframe, it has 7 subslot. This frame structure can support the legacy LTE system. Middle of downlink system bandwidth, legacy downlink signal is mapping on this area. PSS, SSS, PBCH, PDCCH, PDSCH, PHICH, PCFICH, CRS can be mapped.

When the UE accesses the NodeB supporting the low latency and legacy LTE systems, the UE can operate in the low latency mode after receiving the PSS, SSS, and PBCH of the legacy system first.

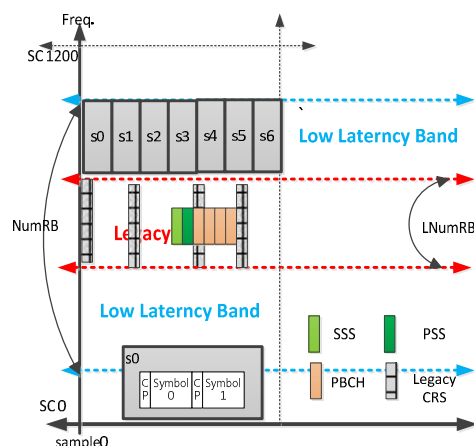


Figure 1. Downlink Resource & channel mapping

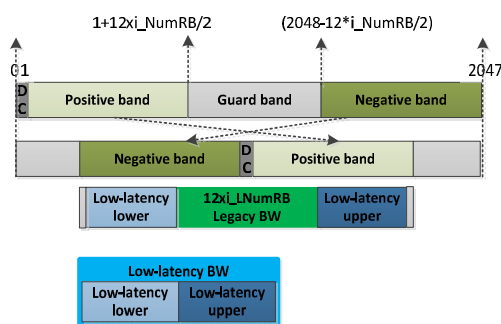


Figure 2. Downlink Bandwidth mapping

Figure 2 shows the allocation of resources for legacy LTE bandwidth mapping and low latency resources. Both sides of the legacy bandwidth include guard bands when LTE system BW is odd numbered RB

Figure 3 shows uplink resource & channel mapping. Legacy physical channel mapped in the middle of system BW. PUCCH is mapped on each end of legacy Bandwidth and it is frequency hopped at slot boundary. The low latency system uses frequency resources on both sides of the total uplink bandwidth. The control channel that transmits the uplink ACK / NACK and CQI of the low latency system uses both end frequency resources of the low latency frequency resource

Figure 4 shows the uplink system BW mapping to low latency and legacy LTE system. Both side of Legacy system. Covered by guard band to prevent interference each system.

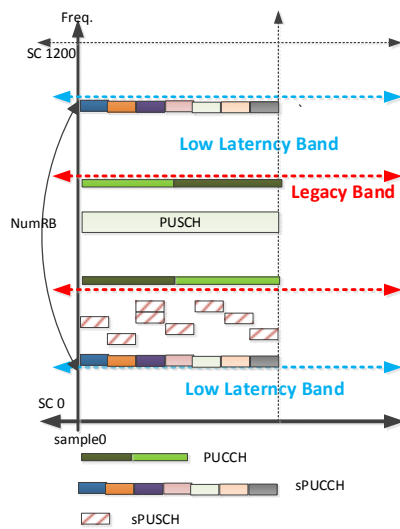


Figure 3. Uplink resource and Channel mapping

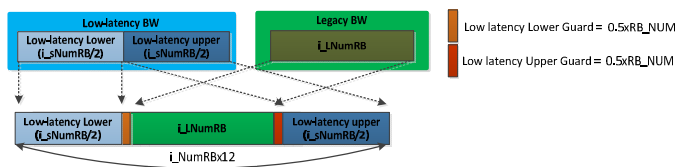


Figure 4. Uplink bandwidth mapping

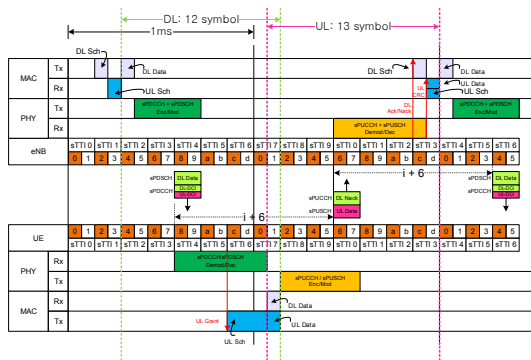


Figure 5. DL/UL low Latency system end-to-end processing Time

Figure 5 shows the end-to-end low-delay channel transmission and processing time. The downlink channel, sPDSCH, sPDCCH that started to prepare for transmission in subslot # 2 is transmitted from subslot 4 to the air. The UE receives the sPDSCH, sPDCCH in subslot 4 and demodulates sPDCCH, sPDSCH for 2.5 slot times. The ack / anck for the demodulated sPDSCH is transmitted through the sPUCCH and the sPDCCH including the uplink DCI is received, thereby transmitting the sPUSCH.

III. UPLINK DATA CHANNEL STRUCTURE

The low latency uplink data channel is transmitted in subslot units consisting of two consecutive symbols. The first symbol in a subslot maps to a reference signal every 3 subcarrier indexes.

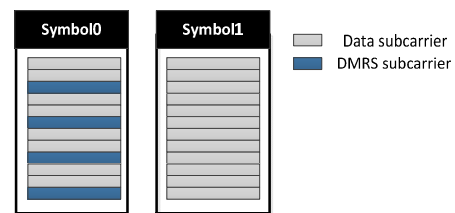


Figure 6. DMRS and Data mapping in short Uplink TTI

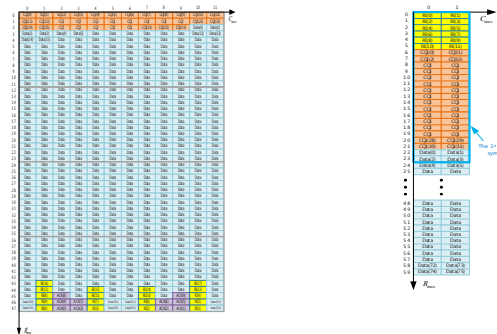


Figure 7. Resource mapping LTE PUSCH vs sPUSCH

Figure 7 shows the placement of resources that can be mapped to the sPUSCH in one subslot. The sPUSCH can transmit the CQI and RI information in addition to the uplink data. However, the ACK / NACK information is transmitted only through the sPUCCH. The CQI, RI, and UL-SCH information are sequentially mapped according to available subcarrier indexes. The following formula shows the TB size that can be transmitted in one subslot. TBS 'is the TB size of legacy LTE.

$$TBS = 8 \times \left\lceil \frac{TBS'}{7} \right\rceil / 8$$

sPUSCH transport channel encoding is the same as legacy LTE PUSCH channel except for channel interleaver mapping.

Encoded data are scrambled then symbol mapping, layer mapping is done after symbol mapping, then it mapped DFT engine. First symbol of sPUSCH has 8 subcarrier resource per 1 resource block, the second has 12 subcarriers. So the DFT engine size is $8 \times N$ size for first symbol, $12 \times N$ for second symbol. The DFTed symbol is mapped to a valid resource in a symbol not allocated to the DMRS in one subslot. The sPUSCH demodulation reference signal sequence is defined by

$$r_{\text{sPUSCH}}^{(\lambda)}(n) = w^{(\lambda)}(m) r_{u,v}^{(\alpha_{\lambda})}(\lfloor n / L_{\text{occ}} \rfloor)$$

$L_{\text{occ}}=1$ and $w^{(\lambda)}(m)=1$ for DCI format 0, if the higher-layer parameter Activate-DMRS-with OCC is not set.

The following simulation results show the low latency uplink data channel. The simulation results are similar with LTE Uplink Data channel.

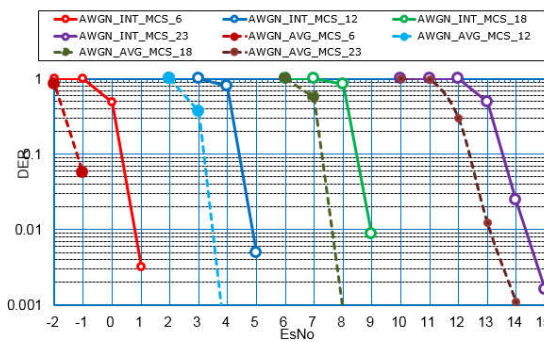


Figure 8. AWGN sPUSCH simulation results

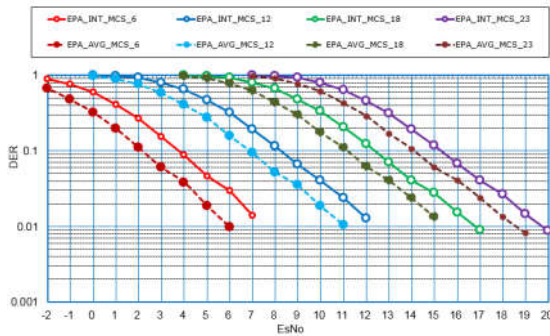


Figure 9. EPA sPUSCH simulation results

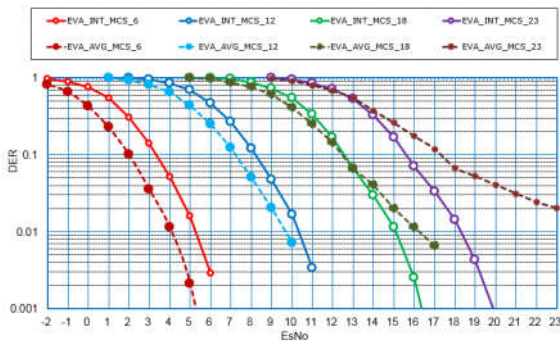


Figure 10. EVA sPUSCH simulation results

IV. UPLINK CONTROL CHANNEL STRUCTURE

Figure 11 shows the sPUCCH resource mapping in Uplink frequency, time resources. sPUCCH use the both side of low latency bandwidth. Reference symbol is mapped on even subcarrier index at the first symbol. Reference signal generation is the same as Legacy LTE system.

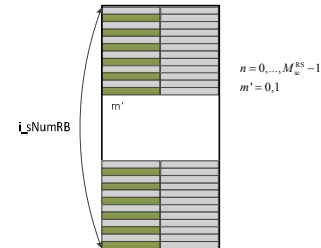


Figure 11. sPUCCH Format 0 structure

The complex-valued symbol $d(0)$ shall be multiplied with cyclically shifted length $N_{\text{seq},l}^{\text{sPUCCH}}$ sequence $r_{u,v}^{(\alpha_{\bar{p}})}(n)$ for each of the P antenna ports used for sPUCCH transmission according to

$$y^{(\bar{p})}(n_l) = \frac{1}{\sqrt{P_{\text{scale},l}}} d(0) \cdot r_{u,v}^{(\alpha_{\bar{p}})}(n_l), \quad n_l = 0, 1, \dots, N_{\text{seq},l}^{\text{sPUCCH}} - 1$$

$$N_{\text{seq},l}^{\text{sPUCCH}} = \begin{cases} 6 & \text{if } l = 0 \\ 12 & \text{if } l = 1 \\ 0 & \text{otherwise} \end{cases}, \quad P_{\text{scale},l} = \begin{cases} 2P & \text{if } l = 0 \\ P & \text{if } l = 1 \end{cases}$$

Generation of complex valued symbol $d(0)$ is same as Legacy LTE system. The block of complex valued symbol $y^{(\bar{p})}(0), \dots, y^{(\bar{p})}(N_{\text{seq},l}^{\text{sPUCCH}} - 1)$ shall be scrambled by $S(m')$ according to

$$z^{(\bar{p})}\left(m' \cdot \sum_{l=0}^{L-1} N_{\text{seq},l}^{\text{sPUCCH}} + l \cdot N_{\text{seq},l}^{\text{sPUCCH}} + n_l\right) = S(m') \cdot y^{(\bar{p})}(n_l)$$

Scramble code $S(m')$ is same as legacy LTE system. Resource used for transmission of sPUCCH format 1,1a,1b are identified by a resource index $n_{\text{sPUCCH}}^{(1,\bar{p})}$ from which the cyclic shift $\alpha_{\bar{p}}(n_{\text{ss}}, m', l)$ is determined according to

$$\alpha_{\bar{p}}(n_{\text{ss}}, m', l) = 2\pi \cdot n_{\text{cs}}^{(\bar{p})}(n_{\text{ss}}, m', l) / N_{\text{seq},l}^{\text{sPUCCH}}$$

$$n_{\text{cs}}^{(\bar{p})}(n_{\text{ss}}, m', l) = \left\{ n_{\text{cs}}^{\text{cell}}(n_{\text{ss}}, m', l) + (l+1) \cdot \Delta_{\text{shift}}^{\text{sPUCCH}} \cdot n_{\bar{p}}'(m') \right\} \bmod N_{\text{seq},l}^{\text{sPUCCH}}$$

DeltaPUCCH shift $\Delta_{\text{shift}}^{\text{sPUCCH}}$ is provide by higher layer.

The resource indicis within the two short resource blocks in a subslot to which the sPUCCH is mapeed are given by fro $m' = 0$

$$n_{\bar{p}}'(m') = n_{\text{sPUCCH}}^{(1,\bar{p})} \bmod \left(N_{\text{seq},0}^{\text{sPUCCH}} / \Delta_{\text{shift}}^{\text{sPUCCH}} \right)$$

Otherwise

$$n'_p(m') = \left\{ \left(n'_p(m'-1) + 1 \right) \cdot N_{\text{seq},0}^{\text{sPUCCH}} / \Delta_{\text{shift}}^{\text{sPUCCH}} \right\} \bmod \left(N_{\text{seq},0}^{\text{sPUCCH}} / \Delta_{\text{shift}}^{\text{sPUCCH}} + 1 \right) - 1$$

Figure 12 shows the DER of sPUCCH format 1. Its simulation results are similar with Legacy LTE system.

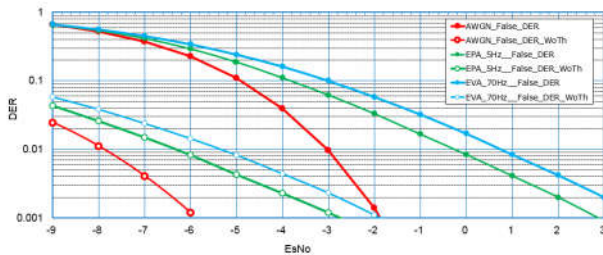


Figure 12. DER of sPUCCH Format 1

V. CONCLUSIONS

The transmission of user data within 1 ms is one of the vision for next generation 5G mobile communication. This is different from previous generations of mobile communications, and in this paper shows low latency system structure and signal processing. It is based on Legacy LTE system and share the resources. The low latency system in this paper can be supports 1ms end-to-end transmission and show performance analysis results that similar with Legacy LTE system

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