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Research on User Plane Redundant Transmission Technology for Highly Reliable 5G URLLC

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ABSTRACT. *Based on the research of the fifth generation of mobile communications, this paper focuses on supporting the reliable transmission technology of URLLC, and studies how to achieve transmission with higher reliability than the single-user plane channel and network function in the user plane path. Supports highly reliable transmission schemes through redundant transmission in the user plane. This transmission scheme focuses on the improvement of backhaul reliability, that is, there is no need to change the radio interface and related protocols; only a single UE is required, that is, no UE redundancy, the network nodes and related interfaces and the redundancy of concurrent PDU sessions are introduced into the network; network transmission The transport layer on the protocol is redundant, with a single network node, without UE influence.*

KEYWORDS: *Reliable Transmission, URLLC, Higher Reliability, User Plane, PDU Session*

1. Introduction

ITU and the 3rd Generation Partnership Project formally defined 3 typical application scenarios of 5G (5rd generation): (1) Enhanced Mobile BroadBand (e MBB). (2) Massive Machine Type Communications (m MTC). (3) Ultra-reliable and low-latency communications (URLLC). As one of the three application scenarios of 5G mobile communication network, URLLC is suitable for autonomous driving, Internet of Vehicles, smart home, augmented reality (AR), virtual reality (VR), industrial control and other highly delay-sensitive types Widespread application of business is critical. If the network delay is high, the normal operation of URLLC services will be affected, and there will be control errors. In view of this, 3GPP has defined the indicators of URLLC delay and reliability.

The uplink and downlink user plane delay target for URLLC services is reduced to 0.5 ms. The reliability requirements of URLLC are: the reliability of transmitting 32-byte packets within 1 ms of the user plane delay is 1*10-5. The eMBB service is the basic service in the future 5G network and occupies a dominant position. It is characterized by a large amount of data and high requirements for transmission rates. In contrast, the data packets of URLLC services are small, and the requirements for delay and error rate are very strict. Therefore, on the premise of the existing e MBB

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service, how to design a transmission scheme that can meet the requirements of the URLLC based on the 5G unified system framework, especially the design of a more reliable user plane transmission scheme, so as to ensure the service quality requirements of the URLLC service It is an urgent problem to be solved. It has important research significance. Based on the business requirements of URLLC and the 5G standard, this paper discusses the user plane redundant transmission technology to improve the reliability of URLLC.

2. Methodology

2.1 Redundant user plane path based on dual connectivity

The 3GPP network provides two paths from the device: the first PDU session spans from the UE via gNB1 to UPF1 serving as a PDU session anchor, and the second PDU session spans from the UE via gNB2 to UPF2 serving as a PDU session anchor. Based on these two independent PDU sessions, two independent paths are established, even across the 3GPP network..

Figure 1 is the architecture diagram of the program. A single UE has a user plane connection with the primary gNB (MgNB) and secondary gNB (SgNB). The RAN control plane and N1 are handled by MgNB. MgNB controls the selection of SgNB and the setting of the dual connection function through the Xn interface. The UE establishes two PDU sessions, one serving as a PDU session anchor through MgNB to UPF1, and the other serving as a PDU session anchor through SgNB to UPF2. UPF1 and UPF2 are connected to the same data network (DN), even though the traffic passing through UPF1 and UPF2 may be routed through different user plane nodes within the DN. UPF1 and UPF2 are controlled by SMF1 and SMF2, respectively. SMF1 and SMF2 can overlap, depending on the operator configuration selected by SMF.

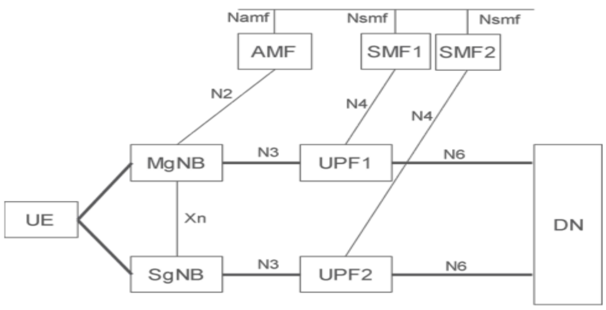

Figure. 1 Solution architecture

The solution does not affect the selection of SMF, and the solution can be applied regardless of whether the same or different SMF is selected, even if the existing

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mechanism based on DNN or S-NSSAI can be used to influence whether a different SMF is selected or whether the same SMF is selected. In the case of two SMFs, SMF knows that the session is redundant (two different sessions). In the case of using multiple SMFs, the SMFs are configured to have different UPF pools to prevent different SMFs from reusing the same UPF. The solution does not affect the selection of SMF, and the solution can be applied regardless of whether the same or different SMF is selected, even if the existing mechanism based on DNN or S-NSSAI can be used to influence whether a different SMF is selected or whether the same SMF is selected. In the case of two SMFs, SMF knows that the session is redundant (two different sessions). In the case of using multiple SMFs, the SMFs are configured to have different UPF pools to prevent different SMFs from reusing the same UPF.

SMF learns about redundant sessions based on the new indication provided by the UE in the PDU session establishment request message, the redundancy sequence number (RSN). RSN. There is an indication of redundant processing, and the value of RSN indicates whether the first or second PDU session is being established. As a fallback solution when the UE does not provide an RSN, SMF can also use DNN or S-NSSAI in conjunction with operator configuration to determine whether the first or second PDU session is being established for redundancy. SMF uses knowledge about whether the first or second PDU session is being established during UPF selection and the appropriate provisioning

2.2 There are multiple redundant UEs for the user plane

This solution utilizes multiple UEs to be integrated into the device and assumes RAN deployment, where redundant coverage of multiple gNBs can usually be obtained. Establish multiple PDU sessions from the UE, which use independent RAN (gNB) and CN (UPF) entities. Figure 2 is the architecture diagram of the program. UE1 and UE2 are connected to gNB1 and gNB2 respectively, UE1 establishes a PDU session through gNB1 to UPF1, and UE2 establishes a PDU session through gNB2 to UPF2. UPF1 and UPF2 are connected to the same data network (DN), even though the traffic passing through UPF1 and UPF2 may be routed through different user plane nodes within the DN. UPF1 and UPF2 are controlled by SMF1 and SMF2, respectively.

This solution uses a separate gNB to implement user plane redundancy on the 3GPP system. However, the deployment and configuration of operators can use and use separate gNB. If a separate gNB is not available for the device, the solution can still be applied to provide a user plane redundant plane node for routing between the rest of the network and the device using multiple UEs and the gNB. UPF1 and UPF2 are controlled by SMF1 and SMF2, respectively.

The terminal equipment integrates multiple UEs, and these UEs can be connected to different gNBs independently. RAN coverage is redundant in the target

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area: multiple gNBs can be connected from the same location. In order to ensure that two UEs are connected to different gNBs, the gNB needs to be operated so that the selection of gNB can be different from each other. Core network UPF deployment is consistent with RAN deployment, and supports redundant user plane paths

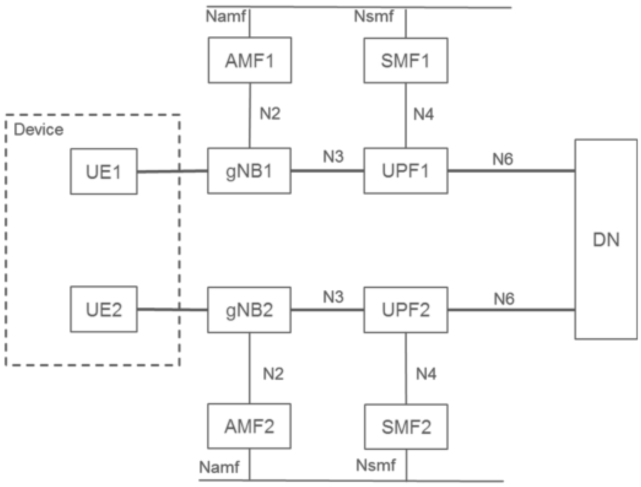

Figure. 2 Multiple UEs for user plane redundancy architecture

In the case of connected mode mobility, the serving gNB prioritizes candidate target cells belonging to a different reliability group from the UE. Therefore, usually the UE is only handed over to the cells in the same reliability group. If the cell in the same reliability group is unavailable (the UE is outside the coverage of the cell of its own reliability group or the link quality is below a given threshold), the UE can also switch to a cell in another reliability group. In the case that the UE is connected to a cell in the wrong reliability group, whenever such a suitable cell is available, the gNB initiates a handover to a cell in the appropriate reliability group. If redundant RAN coverage is available at a specific location, UEs belonging to the same terminal device will connect to different gNBs based on the reliability group classification using the above-mentioned connection mode mobility scheme. If a cell that is not in the same reliability group as the UE is available, the UE can connect to a cell in another RG. Choose a different UPF for each UE in the device. The existing mechanism can be used to select different UPFs for the two UEs. The selection can be based on UE configuration or network configuration of different DNNs, or based on different slices of two UEs. Optionally, the RG of the aforementioned UE can also be used as an input for UPF selection.

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3. Results and Discussion

The redundant user plane path scheme based on dual connectivity can provide disjoint redundant user plane paths through the 3GPP system including RAN and CN. It does not affect the application process itself, because the replication can be performed through a network protocol such as IEEE TSN FRER, which runs on the Ethernet layer of the intermediate Ethernet switch or end host. Other replication agreements also apply, such as DetNet or proprietary agreements. It expands dual connectivity through CN triggers to request dual connectivity settings based on each session. It uses a single UE in the terminal, so it does not provide redundant UEs. Table 1 Experimental data of sensor measurement accuracy.

There are multiple UEs for the user plane redundancy scheme, which can provide disjoint redundant user plane paths through the 3GPP system including RAN and CN. It provides the same level of redundancy as commonly used in today's fixed industrial deployments. It uses multiple UEs in the terminal, so it also provides redundant UEs. It requires equipment manufacturers to integrate multiple UEs.

4. Conclusion

The solution proposed in this paper uses a separate gNB to implement user plane redundancy on the 3GPP system. However, the deployment and configuration of operators can use and use separate gNB. If a separate gNB is not available for the device, the solution can still be applied to provide user plane redundancy between the rest of the network and the device using multiple UEs and the gNB. The terminal equipment integrates multiple UEs, and these UEs can be connected to different gNBs independently. RAN coverage is redundant in the target area: multiple gNBs can be connected from the same location. In order to ensure that two UEs are connected to different gNBs, the gNB needs to be operated so that the selection of gNB can be different from each other.

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