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ABSTRACT

Techniques are described herein for optimizing resource reservation at a Radio Access Network (RAN). These techniques apply to Guaranteed Bit Rate (GBR) and/or Guaranteed Flow Bit Rate (GFBR).

DETAILED DESCRIPTION

The use case of dedicated bearer creation in 4G (Guaranteed Bit Rate (GBR)) and GBR flow creation in 5G (Guaranteed Flow Bit Rate (GFBR)) is quite common for Internet Protocol (IP) Multimedia Subsystem (IMS) and Internet Access Point Name (APN) / Data Network Name (DNN). Some application functions such as IMS may trigger GBR/GFBR clean-up upon completing a voice call. However, certain Internet application functions may not trigger GBR/GFBR clean-up when they are not in active use. As GFBR/GBR reserves Radio Access Network (RAN) resources, it is not optimal to retain dedicated resources (GFBR/GBR) when they are not actively being used.

Existing 3rd Generation Partnership Project (3GPP) defined methods for detecting user plane inactivity are at the granularity of a Protocol Data Unit (PDU) session. However, a PDU session may have multiple GBR flows and non-GBR flows. Though a particular GBR flow is idle, the PDU session level user plane inactivity timer is not triggered when there is data consumption over non-GBR flows. Thus, the dedicated RAN resources corresponding to the GBR/GFBR become occupied at the RAN though they are not being actively used. Accordingly, techniques are described herein to address this problem.

A GBR Inactivity Timer is introduced in the N7/Gx interfaces. The Policy Control Function (PCF) / Policy and Charging Rules Function (PCRF) enable the GBR Inactivity Timer during Policy and Charging Control (PCC) rule installation/modification of type GBR 5G Quality of Service (QoS) Indicator (5QI) / QoS Class Identifier (QCI). Optionally,

the GBR Inactivity Timer may be introduced via local configuration on the Session Management Function (SMF) / Packet Data Network (PDN) Gateway (PGW).

Figure 1 below illustrates the GBR Inactivity Timer introduced on the N4/Sx interface in the Packet Detection Information (PDI) Information Element (IE) in the Create Packet Detection Rule (PDR) and Update PDR IEs. The existing IE type Timer may be leveraged.

Octet 1 and 2	PDI IE Type = 2 (decimal)						
Octets 3 and 4	Length = n						
Information elements	**P**	**Condition / Comment**	**Appl.**				**IE Type**
			Sxa	**Sxb**	**Sxc**	**N4**	
GBR Inactivity Timer	C	This IE shall identify the GBR inactivity timer	-	X	-	X	Timer

Figure 1

The SMF / PGW Control plane (PGW-C) may convey the GBR Inactivity Timer to the User Plane Function (UPF) / PGW User plane (PGW-U) in the Packet Forwarding Control Protocol (PFCP) Session Establishment Request and via the PFCP Session Modification Request (when a change has been detected). Accordingly, the UPF/PGW-U monitors the GBR Inactivity Timer received in the Create PDR IE for the respective GBR flow or GBR bearer.

The existing Report type User Plane Inactivity Report (UPIR) in the PFCP Session Report Request message may be enhanced for the UPF to asynchronously report the GBR Inactivity Timer condition back to the SMF. Currently, the UPIR is a bit in the Report Type IE and there is no explicit IE definition for the UPIR, which may convey the session level inactivity. However, in order to convey the session level and flow level user inactivity, an IE type is provided for the UPIR similar to the Downlink Data Report, Usage Report, etc.

The current operations relating to conveying a session level UPIR may continue with the UPIR bit set in the Report Type IE in the PFCP session report request without the UPIR IE. In order to convey GBR flow/bearer level inactivity, the UPIR bit may be set in the Report Type IE in the PFCP session report request. The UPIR IE may be sent with the corresponding PDR IDs. As per 3GPP Technical Specification (TS) 29.244, IE types 159 to 65535 are reserved for future use. IE type 159 may be used for the new UPIR IE. Figure 2 below illustrates the IE structure and definition.

Octet 1 and 2	User Plane Inactivity Report IE Type = 159 (decimal)						
Octets 3 and 4	Length = n						
Information elements	**P**	**Condition / Comment**	**Appl.**				**IE Type**
			Sxa	**Sxb**	**Sxc**	**N4**	
PDR ID	C	This IE shall identify the PDR for which user plane inactivity timer is hit. More than one IE with this type may be included to represent multiple PDRs having hit user plane inactivity timer.	-	X	-	X	PDR ID

Figure 2

The SMF may initiate PCC rule deletion for the GBR bearers associated with the PDR Identifiers (IDs) received from the UPF. As part of the PDU session modification procedure, the RAN may delete the GBR flows, which helps free up the radio resources.

Figures 3 below illustrates an example call-flow for optimization of GFBR resources at a Next Generation RAN (NG-RAN).

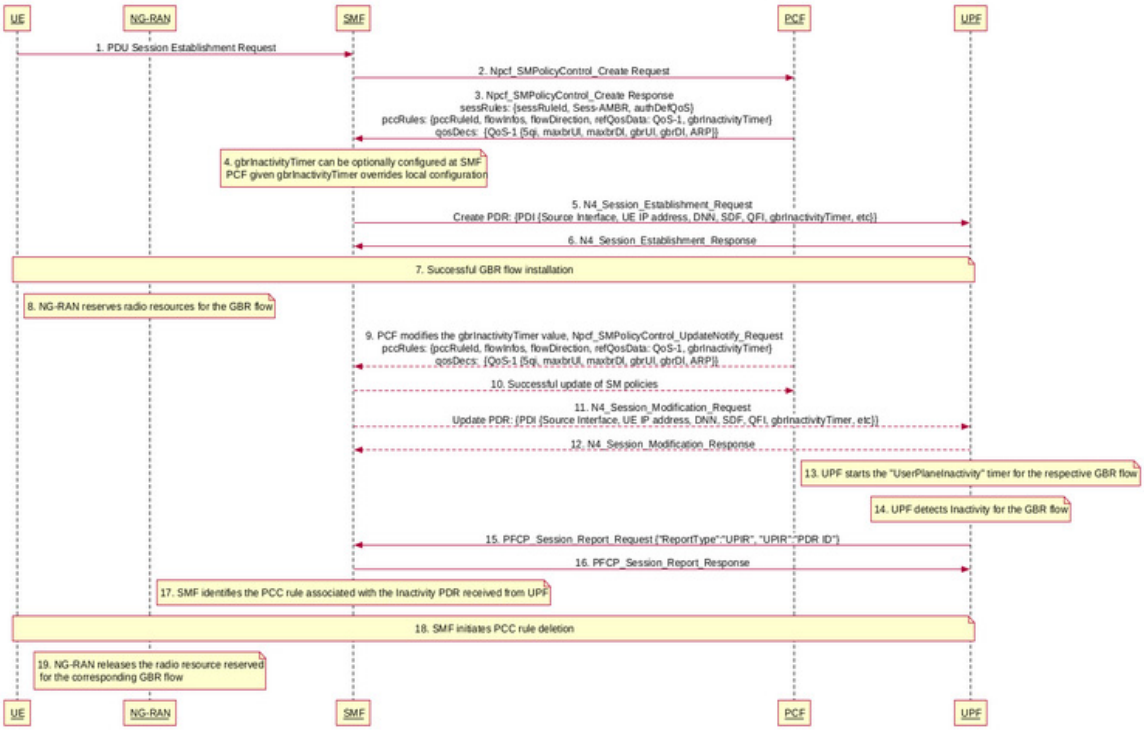

Figure 3

As shown, first the User Equipment (UE) initiates a PDU session establishment request. The then SMF sends an Npcf_SMPolicyControl_Create Request to the PCF. The PCF sends an Npcf_SMPolicyControl_Create Response with sessRules: {sessRuleId, Sess-AMBR, authDefQoS}, pccRules: {pccRuleId, flowInfos, flowDirection, refQosData: QoS-1, gbrInactivityTimer} and qosDecs: {QoS-1 {5qi, maxbrUl, maxbrDl, gbrUl, gbrDl,

ARP}}. The PCF includes the gbrInactivityTimer in the PCC rule. In one example, the gbrInactivityTimer may be configured locally at the SMF. Given the gbrInactivityTimer, the PCF overrides the locally configured value at the SMF.

The SMF initiates an N4_Session_Establishment_Request with the gbrInactivityTimer embedded in the PDI IE via a Create PDR IE. The UPF sends an N4_Session_Establishment_Response, and GBR flow installation is established end-to-end. NG-RAN reserves radio resources for the GBR flow.

Optionally, the PCF may update the gbrInactivityTimer value via the Npcf_SMPolicyControl_UpdateNotify_Request with an updated gbrInactivityTimer value in the PCC rules. In this example, the SMF responds back to the PCF with a successful update of Session Management (SM) policies and initiates an N4_Session_Modification_Request with the gbrInactivityTimer embedded in the PDI IE via the Update PDR IE. The UPF then sends the N4_Session_Modification_Response.

The UPF may start the UserPlaneInactivity timer for the respective GBR flows. When the UPF detects inactivity for the GBR flow, the UPF sends an N4_Session_Report_Request of the Report type with the UPIR bit set. The UPF also sends the UPIR IE with the respective PDR ID. The SMF sends an N4_Session_Report_Response, identifies the PCC rule associated with the inactivity PDR received from the UPF, and initiates PCC rule deletion. Finally, the NG-RAN releases the radio resources reserved for the corresponding GBR flow.

Figure 4 below illustrates a call flow for optimization of GBR resources at the Evolved Universal Mobile Telecommunications System (UMTS) Terrestrial RAN (EUTRAN).

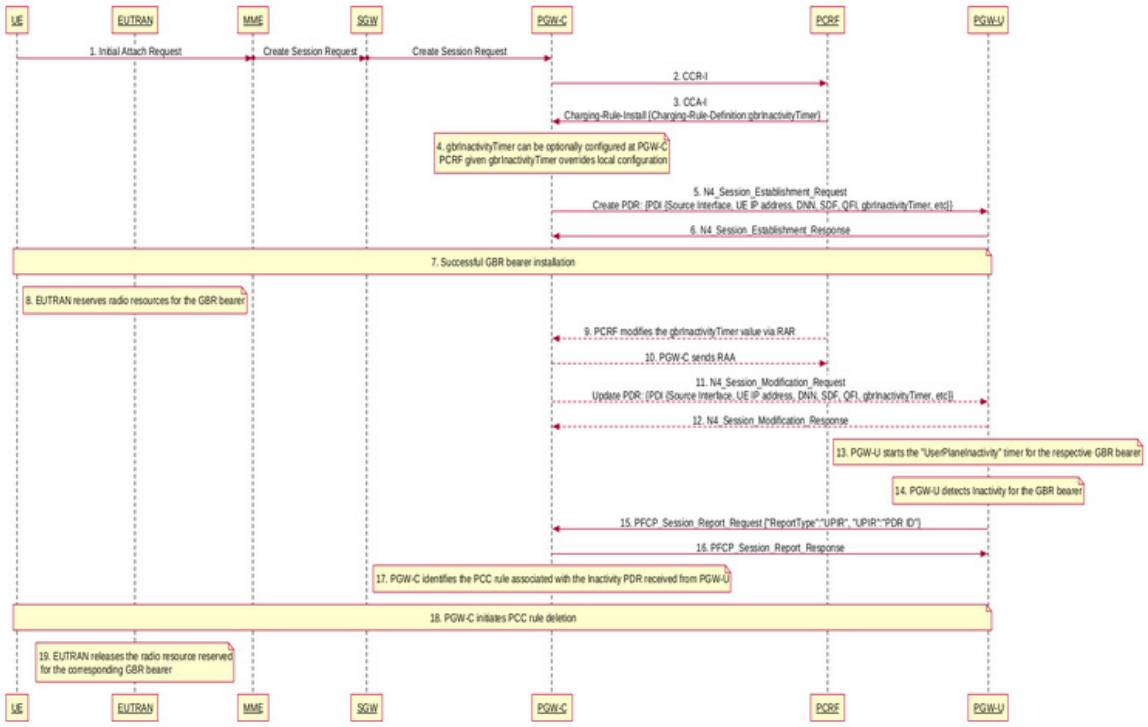

Figure 4

First, the UE initiates an Initial Attach Request procedure and the PGW-C receives a Create Session Request from the Serving Gateway (SGW). PGW-C sends a Credit Control Request (CCR-I) to the PCRF, which sends a Credit Control Answer (CCA-I) with the gbrInactivityTimer in the Charging-Rule-Install to Charging-Rule-Definition IE. The gbrInactivityTimer may be configured locally at the PGW-C. Given the gbrInactivityTimer, the PCF may override the locally configured value at the PGW-C.

The SMF initiates an N4_Session_Establishment_Request with the gbrInactivityTimer embedded in the PDI IE via the Create PDR IE. The UPF sends an N4_Session_Establishment_Response, and the GBR bearer is established end-to-end. The EUTRAN reserves radio resources for the GBR bearer.

Optionally, the PCRF may update the gbrInactivityTimer value via Re-Auth-Request (RAR) with the updated gbrInactivityTimer value in the Charging-Rule-Definition IE. In this example, the PGW-C responds back to the PCRF with successful update of policies, and initiates an N4_Session_Modification_Request with the gbrInactivityTimer embedded in the PDI IE via the Update PDR IE. The UPF may then send an N4_Session_Modification_Response.

The UPF may initiate the UserPlaneInactivity timer for the respective GBR flows. The UPF may detect inactivity for the GBR flow. The UPF sends an N4_Session_Report_Request with the Report type with the UPIR bit set. The UPF also sends the UPIR IE with the respective PDR ID. The PGW-C sends the N4_Session_Report_Response, identifies the PCC rule associated with the inactivity PDR received from PGW-U, and initiates PCC rule deletion. Finally, the EUTRAN releases the radio resources reserved for the corresponding GBR bearer.

In summary, techniques are described herein for optimizing resource reservation at a RAN. These techniques apply to GBR and/or GFBR.