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Understanding QoS Scheduling

RUGGEDCOM WIN v4.3

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1 Introduction

1.1 About This Document

This document provides a high-level overview of the RUGGEDCOM WIN system‘s QoS scheduling mechanism. This document DOES NOT contain equipment configuration. For configuration instructions, refer to the user manual.

1.2 Abbrevations & Aconyms

Table 1-1

Abbreviation/Acronym	Definition
RF	Radio Frequency
CPE	Subscriber Station
BS	Base Station
IP-CS	IP Convergence Sublayer
System	RUGGEDCOM WIN BS and RUGGEDCOM WIN CPE
QoS	Quality of Service
KPI	Key Performance Indicator
BW	Bandwidth
CIR	Committed Information Rate
MIR	Maximum Information Rate
PDU	Protocol Data Unit
PHS	Packet Header Suppression
MCS	Modulation and Coding Scheme

2 Data Delivery Services

2.1 Downlink

Data delivery service refers to a specific set of BS QoS parameters for downlink service flow, according to the table below.

All the definitions for the service flows parameters are listed in the Appendix.

Table 2-1

Delivery Service	Meaning	Service definition	Service Flow parameters
BE	Best-Effort service	BE service is intended for applications with no rate or delay requirements.	1. Maximum Sustained Traffic Rate 2. Traffic Priority 3. Request/Transmission Policy
NRT-VR	Non real-time variable rate service	NRT-VR is intended to support applications that require a guaranteed data rate but are insensitive to delays.	1. Minimum Reserved Traffic Rate 2. Maximum Sustained Traffic Rate 3. Traffic Priority 4. Request/Transmission Policy
RT-VR	Real-time variable rate service	RT-VR is intended to support real-time data applications with variable bit rates, which require guaranteed data rate and delay.	1. Minimum Reserved Traffic Rate 2. Maximum Sustained Traffic Rate 3. Traffic Priority 4. Request/Transmission Policy 5. Maximum Latency
UGS	Unsolicited grant service	UGS is intended to support real- time applications generating fixed-rate data. This data can be provided as either fixed- or variable-length PDUs.	1. Minimum Reserved Traffic Rate (equals Maximum Sustained Traffic Rate) 2. Traffic Priority 3. Request/Transmission Policy 4. Maximum Latency
ERT-VR	Extended real-time variable rate service.	ERT-VR service is intended to support real-time applications with variable data rates, which require guaranteed data and delay, for example VoIP with silence suppression.	1. Minimum Reserved Traffic Rate 2. Traffic Priority 3. Request/Transmission Policy 4. Maximum Latency

A detailed explanation of the parameters is listed further in the document (See the Appendix, chapter 5).

2.2 Uplink

In uplink, the CPE will ask for BW before it starts transmitting data or will enjoy a constant allocation in case of UGS/ertPS.

An UL BW request (or BW grant) scheduling is performed by the BS in order to provide each CPE with bandwidth for either uplink data transmissions or opportunities to request bandwidth. By specifying a scheduling type and its associated QoS parameters, the BS scheduler can anticipate the throughput and latency needs of the uplink traffic and provide polls and/or grants at appropriate times. The table below lists the scheduling services and the relevant supported parameters.

Table 2-2

Scheduling Service	Meaning	Service Definition	Service Flow Parameters
BE	Best Effort service	The intent of the BE grant scheduling type is to provide efficient service for BE traffic in the UL. The CPE is using contention-based BW request opportunities as well as unicast request opportunities and also uses data transmission frames to send bandwidth requests (piggy-backing). Consequently, BE traffic can be “starved” during network congestion.	1. Maximum Sustained Traffic Rate 2. Traffic Priority 3. Request/Transmission Policy

Scheduling Service	Meaning	Service Definition	Service Flow Parameters
NRT-PS	Non real- Time polling service	The nrtPS offers unicast polls on a regular basis, which assures that the UL service flow receives request opportunities even during network congestion. The BS polls nrtPS connections on an interval according to the Unsolicited Polling Interval parameter. The CPE is using contention-based BW request opportunities as well as unicast request opportunities and also uses data transmission frames to send bandwidth requests (piggy-backing).	1. Minimum Reserved 2. Traffic Rate Maximum Sustained Traffic Rate 3. Traffic Priority 4. Request/Transmission Policy 5. Unsolicited Polling Interval

Scheduling Service	Meaning	Service Definition	Service Flow Parameters
RT-PS	Real-time polling service	The rtPS algorithm is designed to support real-time service flows that generate variable size data packets periodically. The BS assigns every certain period of time uplink resources that are sufficient for unicast bandwidth requests to the CPE. This period is defined by the Unsolicited Polling Interval parameter and is configured as a part of service flow provisioning. Because this algorithm always uses a bandwidth request process for suitable size grants, it transports data more efficiently than the UGS algorithm. However, this bandwidth request process always causes MAC overhead and access delay causing rtPS to be slower than UGS.	1. Minimum Reserved Traffic Rate 2. Maximum Sustained Traffic Rate 3. Traffic Priority 4. Request/Transmission Policy 5. Maximum Latency 6. Unsolicited Polling Interval

Scheduling Service	Meaning	Service Definition	Service Flow Parameters
UGS	Unsolicited grant service	The UGS algorithm is designed to support real time service flows that generate fixed-size data packets periodically. The base station (BS) periodically assigns fixed-size grants to the subscriber station (SS). These fixed-size grants are sufficient to send voice data packets. The grant size and grant period are configured as a part of service flow provisioning.	1. Minimum Reserved Traffic Rate (equals Maximum Sustained Traffic Rate) 2. Traffic Priority 3. .Request/Transmission Policy 4. Maximum Latency 5. Unsolicited Grant Interval
ERT-PS	Extended real-time polling service	Extended rtPS is a scheduling mechanism which builds on the efficiency of both UGS and rtPS. The BS shall provide unicast grants in an unsolicited manner like in UGS, thus saving the latency of a BR. However, whereas UGS allocations are fixed in size, ertPS allocations are dynamic. During a voice talk, the BS behaves as UGS to grant unsolicited bandwidth to the CPE periodically. During voice silence, ertPS decreases the grant size to save bandwidth.	1. Minimum Reserved Traffic Rate 2. Maximum Sustained Traffic Rate 3. Traffic Priority 4. Request/Transmission Policy 5. Maximum Latency 6. Unsolicited Grant Interval 7. Unsolicited Polling Interval

3 Scheduler Principles

3.1 Traffic Classes

3.1.1 BS

All the service flow traffic in the BS is divided into two traffic classes:

1. A guaranteed traffic class which is called "below CIR". "Below CIR" means that the actual traffic rate of the SF is under or equal to CIR. This class is further divided into two sub-classes:
   a. Maximum Latency Non-Null.
   b. Maximum Latency Null (i.e. no Maximum Latency is configured).
2. A best-effort class which is called "above CIR". "Above CIR" means that the actual traffic rate of the SF is over CIR.

In terms of prioritization between the traffic classes, there is a strict priority hierarchy as follows (the order is from the highest priority to lowest):

1. 802.16e MAC messages (exchanged between the CPE and BS)
2. Guaranteed traffic class with non-null maximum latency
3. Guaranteed traffic class with null maximum latency
4. Best-effort class (all the "above CIR" traffic)

3.1.2 CPE

All the service flows traffic in the CPE is divided into two traffic classes:

1. A guaranteed traffic class which is called "below CIR". "Below CIR" means that the actual traffic rate of the SF is under or equal to CIR.
2. A best-effort class which is called "above CIR". "Above CIR" means that the actual traffic rate of the SF is over CIR.

In terms of prioritization between the traffic classes, there is a strict priority hierarchy as follows (the order is from the highest priority to lowest):

1. 802.16e MAC messages (exchanged between the CPE and BS)
2. UGS and ertPS traffic.
3. All the other service flows are treated in the following way:
   a. A service flow that requested BW and received an allocation will be scheduled before SF that hasn’t asked for BW yet.
   b. A guaranteed traffic class will be treated before a best-effort class (all the "above CIR" traffic)

3.2 Traffic Priority Inside Traffic Class

3.2.1 BS

Within the traffic class, the traffic is prioritized in one of the following ways:

1. Strict priority:
   a. Each SF is assigned a traffic priority. The highest priority SF will be served before any low priority SF.
   b. Possible priority values are : 0-7
   c. Two service flows with equal priority will be served in round-robin fashion.

2. Weighted-Fair scheduling:
   a. Each SF is assigned a traffic priority and each priority is assigned a weight.
   b. The BW is shared relatively according to the weights given. For example, there are 2 SFs, one with weight=2 and the other one with weight=1. The first SF will get 2/3 of the available BW and the second one will get 1/3 of the BW.
   c. Two service flows with equal priority will have the same weights.
   d. Two service flows with same weight will receive the same BW.

3.2.2 CPE

In CPE, only a strict priority is used (in a similar way as explained in chapter 3.2.1).

3.3 Traffic Shaping

Traffic shaping is performed by the BS in DOWNLINK and by the CPE in the uplink.

When the traffic reaches the maximum rate, the packets are shaped and not dropped. When shaping is done, the excessive packet transmission is simply delayed (as they are buffered). Shaping is especially effective for TCP traffic that is sensitive to packet loss, permitting to smooth the TCP “saw tooth” performance graph and improve the throughput.

3.4 Fairness

The BS applies the fairness algorithm to address the situation in which there are a number of CPEs that are connected to the BS under different RF conditions.

For example, there is one CPE that is very close to the BS and enjoys good RF conditions leading to high MCS. On the other hand, there is another CPE that is far from the BS and its RF conditions are significantly worse than of the first CPE. Both CPEs are configured to get 300kbit/sec of UGS traffic (again as an example).

The BS basically supports 3 approaches to treat this situation:

1. Byte fairness – both CPE will receive the required bitrate, but for the far CPE it will “cost” more frame resources than for the close one.
2. Resource fairness – both CPEs will get an equal part of the frame.

   Combined fairness – the above approaches are mixed according to a certain percentage (for example, 50% resource and 50% byte fairness).

Fairness approach can be applied per traffic class. Traffic class definition is in chapter 3.1.1.

The BS applies “byte fairness” mode for both below and above CIR traffic classes.

For a full list of system KPIs, refer to chapter 4.

4 System KPIs

1. The table below lists default values for all the relevant uplink and downlink parameters per service type.
2. Parameters in red are configurable using the BS webGUI.
3. Parameters in blue are hard-coded (not configurable).
4. A value of 0 means “unlimited”.
5. The letter “M” under the parameter values means that the parameter is mandatory for this service type, thus an error will be generated in webGUI if not configured.
6. For UGS and ertPS, the maximum sustained traffic rate has to be equal to the minimum reserved traffic rate (by definition) and is automatically set to the value configured for the minimum reserved traffic rate.

Table 4-1

Services	BE		NRT		RT		UGS		ERT	
Parameters	**UL**	**DL**	**UL**	**DL**	**UL**	**DL**	**UL**	**DL**	**UL**	**DL**
Minimum Reserved Traffic Rate (CIR)	n/a	n/a	0	0	0	0	0[M]	0[M]	0[M]	0[M]
Maximum Sustained Traffic Rate (MIR)	0	0	0	0	0	0	0	0	0	0
Traffic Priority	0	0	1	1	5	5	7	7	7	7
Request/ Transmission Policy	n/a	0x10	n/a	0x10	n/a	0x10	n/a	0x10	n/a	0x10
Unsolicited Polling Interval [msec]	n/a	n/a	1000	n/a	20	n/a	n/a	n/a	1000	n/a
Unsolicited Grant Interval [msec]	n/a	n/a	n/a	n/a	n/a	n/a	0 [M]	n/a	0 [M]	n/a
Maximum Latency [msec]	0	0	0	0	30	30	30	30	30	30
HARQ Max. retries	3	3	3	3	0	0	0	0	0	0

7. The table below summarizes all the additional QoS related KPIs.

Table 4-2

KPI	BS	CPE
Services supported	BE, nRT, RT, UGS, eRT	BE, nRT, RT, UGS, eRT
Scheduling method inside the traffic class	Below CIR – Strict priority Above CIR – Strict priority	Strict priority
Traffic shaping	Enabled	Enabled
Fairness	Byte Fairness (not configurable)	n/a

5 Service Flow Parameters

The table below defines the service flow parameters used in Table 2-2.

Service Flow Parameter	Explanation
Minimum Reserved Traffic Rate [CIR]	Minimum rate reserved for a certain service flow. The BS and CPE must be able to guarantee this rate per service flow (assuming the sum of all the minimum reserved rates is not more than total throughput capability)
Maximum Sustained Traffic Rate [MIR]	Peak information rate for a certain service flow. Traffic above the maximum rate will be shaped and then eventually dropped (if the congestion pertains).
Traffic Priority	Traffic priority of a certain service flow. A higher number indicates higher priority.
Request/Transmission Policy	Specifies the policy transmission request value for the associated service flow. This value includes options for PDU formation, for uplink service flows, and restrictions on the types of bandwidth request options that may be used. An attribute is enabled by setting the corresponding bit position to 1. Here is the bitmap: Bit 0: If this bit is set to “1”, the service flow shall not use broadcast BR opportunities. (UL only) Bit 1: If this bit is set to “1”, the service flow shall not use multicast BR opportunities. (UL only) Bit 2: If this bit is set to “1”, the service flow shall not piggyback requests with data. (UL only) Bit 3: If this bit is set to “1”, the service flow shall not fragment data. Bit 4: If this bit is set to “1”, the service flow shall not suppress payload headers (CS parameter). If bit 4 is set to “0” and both the SS and the BS support PHS, each SDU for this service flow shall be prefixed by a PHSI field, which may be set to “0”. If bit 4 is set to “1”, none of the SDUs for this service flow shall have a PHSI field. Bit 5: If this bit is set to “1”, the service flow shall not pack multiple SDUs (or fragments) into single MAC PDUs. Bit 6: If this bit is set to “1”, the service flow shall not include CRC in the MAC PDU. Bit 7: If this bit is set to “1”, the service flow shall not compress payload headers using ROHC.
Unsolicited Polling Interval	Specifies the maximum nominal interval between successive polling grant opportunities for this service flow.

Service Flow Parameter	Explanation
Unsolicited Grant Interval	Specifies the nominal interval between the successive data grant opportunities for this service flow.
Maximum Latency	Indicates the period of time between the reception of the packet on the network interface and delivering the packet to the RF interface. In other words, how long a certain packet can be in the system without being transmitted?