Qualcomm Technologies, Inc.

Modem IPA

Feature Specification

80-NP527-28 Rev. B

December 31, 2019

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Revision history

Revision	Date	Description
A	April 2015	Initial release
B	December 2019	Document restructured with editorial changes; to be read in its entirety.

Contents

Figures

1 Introduction to modem IPA

This document describes key features, capabilities, and functionalities of modem IPA, and logging on HexagonQualcomm® Hexagon™ processor and Arm Cortex-A7.

1.1 Conventions

Function declarations, function names, type declarations, attributes, and code samples appear in a different font, for example, `cp armcc armcpp`.

Code variables appear in angle brackets, for example, `<number>`.

Commands to be entered appear in a different font, for example, **copy a:*.* b:**.

Button and key names appear in bold font, for example, click **Save** or press **Enter**.

1.2 Technical assistance

For assistance or clarification on information in this document, submit a case to Qualcomm Technologies, Inc. (QTI) at https://createpoint.qti.qualcomm.com/.

If you do not have access to the CDMATech Support website, register for access or send email to support.cdmatech@qti.qualcomm.com.

1.3 Modem IPA functions

Modem IPA is a standalone hardware block that is accessible from both MPSS and APSS. It replaces A2 PER blocks from previous generation mobile data modem (MDM) chipsets.

Key functions of modem IPA

- Creates a direct hardware path from the modem subsystem to apps and peripheral interfaces
- Performs deciphering
- Performs IP packet filtering, routing, and header addition and removal
- Aggregates and de-aggregates RNDIS
- Performs Network address translation (NAT)
- Offloads Wi-Fi mobile hotspot
- Supports XLAT (RFC 6877)
- Bridges Ethernet

1.4 Modem IPA system architecture

The following figure shows the modem IPA system architectre:

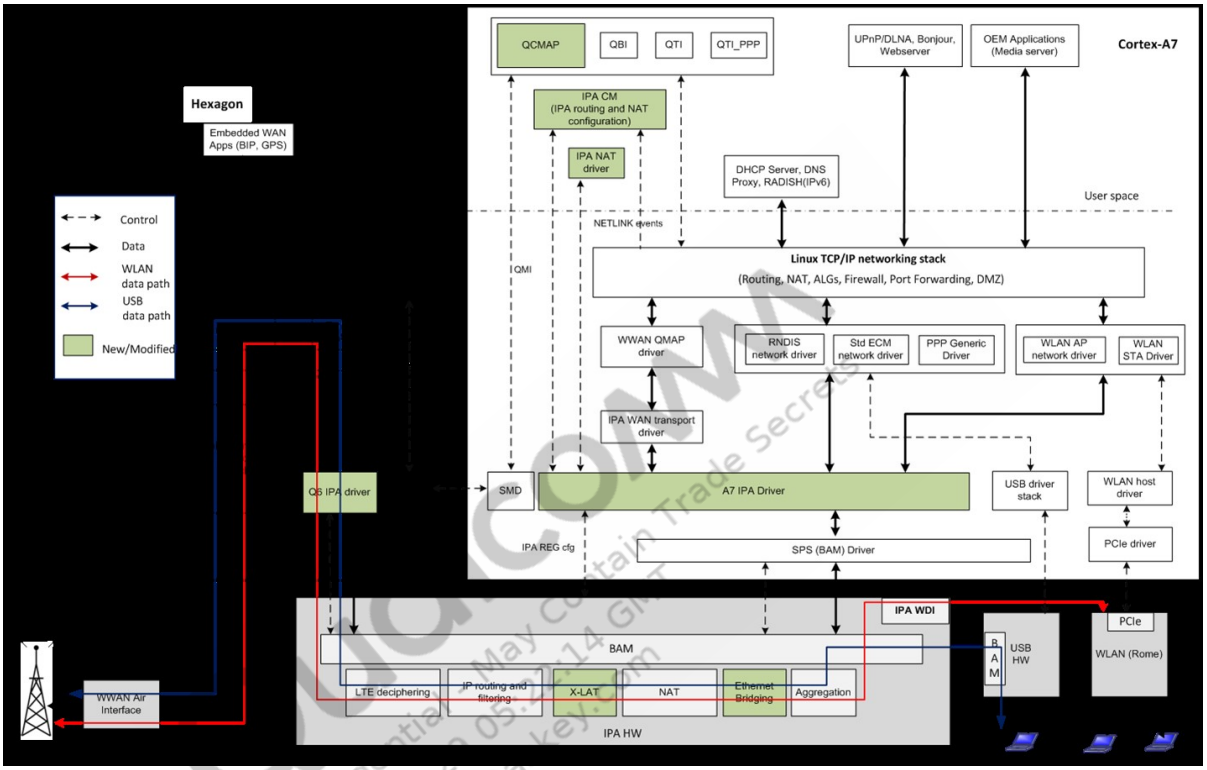

Figure 1-1 Modem IPA system architecture

See *Modem IPA Configuration Manager User Guide* (80-NC254-64) for details.

2 IPA functionalities and logging on Hexagon

This chapter details various IPA features and functionalities on Hexagon.

2.1 Hexagon IPA driver features

The following are the features of Hexagon IPA driver:

- Replaces A2 PER driver used in previous MDMs
- Manages all data paths over WWAN/Hexagon through IPA

The following are the functionalities of Hexagon IPA driver:

- Manages IPA↔Hexagon BAM pipes
- Manages WAN DL filter/route tables
- Manages header insertion table for RmNet/MBIM calls
- Manages UL filter/route table for RmNet/MBIM calls
- Manages deciphering rules table
- IPA clock voting based on activity
- IPA debugging support
- Data/control path statistics logging
- End-to-end flow control on RmNet or MBIM calls
- Inter-driver communication through Qualcomm modem interface (QMI)
- Uses IPA filtering to offload below packet inspection use cases in UL software path
  - DHCP/IP fragment packets
  - QoS match
  - Packet prioritization (TCP ACK)
  - IPv6 prefix comparison

2.2 Enable IPA log packets

The log packet is generated when a QMI call is connected. Navigate in QXDM ProfessionalQXDM Professional™ using the following path and select the entities as shown in the following figure to enable IPA log packets:

Category > Log Packets > Common > Data Services > IPA

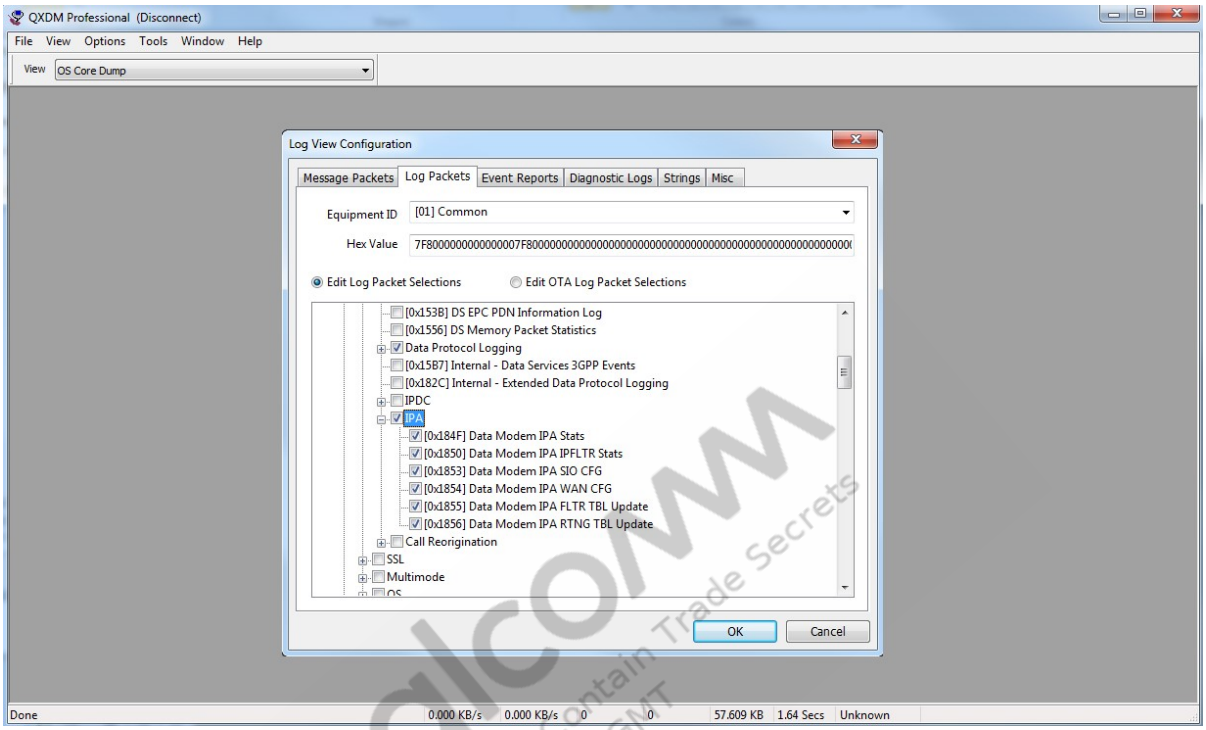

Figure 2-1 Enable log packets using QXDM Professional

The following are the types of IPA log packets:

- IPA_STATS
  - Log code – 0x184F
  - Description – periodic log with snapshot of all IPA driver statistics
- IPA_IPLFTR_STATS
  - Log code – 0x1850
  - Description – periodic log with snapshot of all IPA driver filter hit statistics
- IPA_SIO_CFG
  - Log code – 0x1853
  - Description – event-triggered log when a new QMI call is established; captures SIO configurations. For example, aggregation parameters.
- IPA_WAN_CFG
  - Log code – 0x1854
  - Description – event-triggered log when a new bearer is brought up; captures bearer configurations. For example, DPL-enabled.
- IPA_FLTR_TBL_UPDATE
  - Log code – 0x1855
  - Description – event-triggered log when a new filter rule is added; dumps the new filter table

- IPA_RTNG_TBL_UPDATE
  - Log code – 0x1856
  - Description – event-triggered log when a new route rule is added; dumps the new route table

2.3 Analyze IPA_STATS log packet

The IPA_STATS log packet has the following sections:

- CFG – the IPA driver maintains the top-level configuration information
- CTL – the IPA driver maintains all CTL statistics
- DL – the IPA driver maintains all DL statistics
- UL – the IPA driver maintains all UL statistics
- MHI – the IPA driver maintains all MHI statistics

Every statistic section has a warnings subsection at the top, which highlights statistics that indicate some system errors.

2.4 Analyze the IPA download warning statistics

The IPA DL warning statistics are as follows:

- num_p_drop_excep_pkts – number of packets dropped by the IPA driver due to IP exceptions
- num_p_drop_excep_bytes – number of bytes dropped by the IPA driver due to IP exceptions
- num_p_drop_holb_pkts – number of packets flushed out by the IPA driver on QMI call disconnect
- num_p_drop_holb_bytes – number of bytes flushed out by the IPA driver on QMI call disconnect
- num_ooo_frag_drops – number of IPv4 out-of-order fragments dropped after timeout
- num_desc_pipe_full – number of times IPA driver could not program a DL packet to IPA hardware because the hardware BAM descriptor queue is full
- num_imm_cmd_buf_full – number of times IPA driver could not program a DL packet to IPA hardware because the hardware immediate command queue is full
- num_pdcp_wm_dne_pkts – cumulative number of packets dropped in the PDCP→IPA watermark due to queue overflow
- num_pdcp_wm_dne_bytes – cumulative number of bytes dropped in the PDCP→IPA watermark due to queue overflow
- num_sio_wm_dne_pkts – cumulative number of packets dropped in the DS→IPA watermark due to queue overflow
- num_sio_wm_dne_bytes – cumulative number of bytes dropped in the DS→IPA watermark due to queue overflow
- num_ds_wm_dne_pkts – cumulative number of packets dropped in the IPA→DS watermark due to queue overflow (filtered or unbridged data)
- num_ds_wm_dne_bytes – cumulative number of bytes dropped in the IPA→DS watermark due to queue overflow (filtered or unbridged data)

2.5 Analyze IPA upload warning statistics

The following are various IPA DL warning statistics:

- num_p_drop_pkts – number of packets dropped by IPA driver
- num_p_drop_bytes – number of bytes dropped by IPA driver
- num_p_drop_excep_pkts – number of packets dropped by IPA driver due to IP exceptions
- num_sio_wm_dne_pkts – number of packets dropped in IPA→DS watermark due to queue overflow
- num_sio_wm_dne_bytes – number of bytes dropped in IPA→DS watermark due to queue overflow

2.6 Analyze IPA_SIO_CFG log packet

The following are the important log packet parameters:

- DL_PER_CFG – shows the DL aggregation parameters negotiated for the call on the peripheral pipe
  - Header type – QMAP, QMAPv3, MBIM, and so on.
  - max_aggr_pkts – aggregation maximum packet limit
  - max_aggr_bytes – aggregation maximum byte limit
- UL_PER_CFG – shows the UL aggregation parameters negotiated for the call on the peripheral pipe
  - Header type – QMAP, QMAPv3, MBIM, and so on.
  - max_aggr_pkts – aggregation maximum packet limit
  - max_aggr_bytes – aggregation maximum byte limit

2.7 Enable IPA event reports

Navigate in QXDM Professional using the following path and select the entities as shown in the following figure to enable IPA event reports:

Category > Event Reports > Common > Data Services > IPA

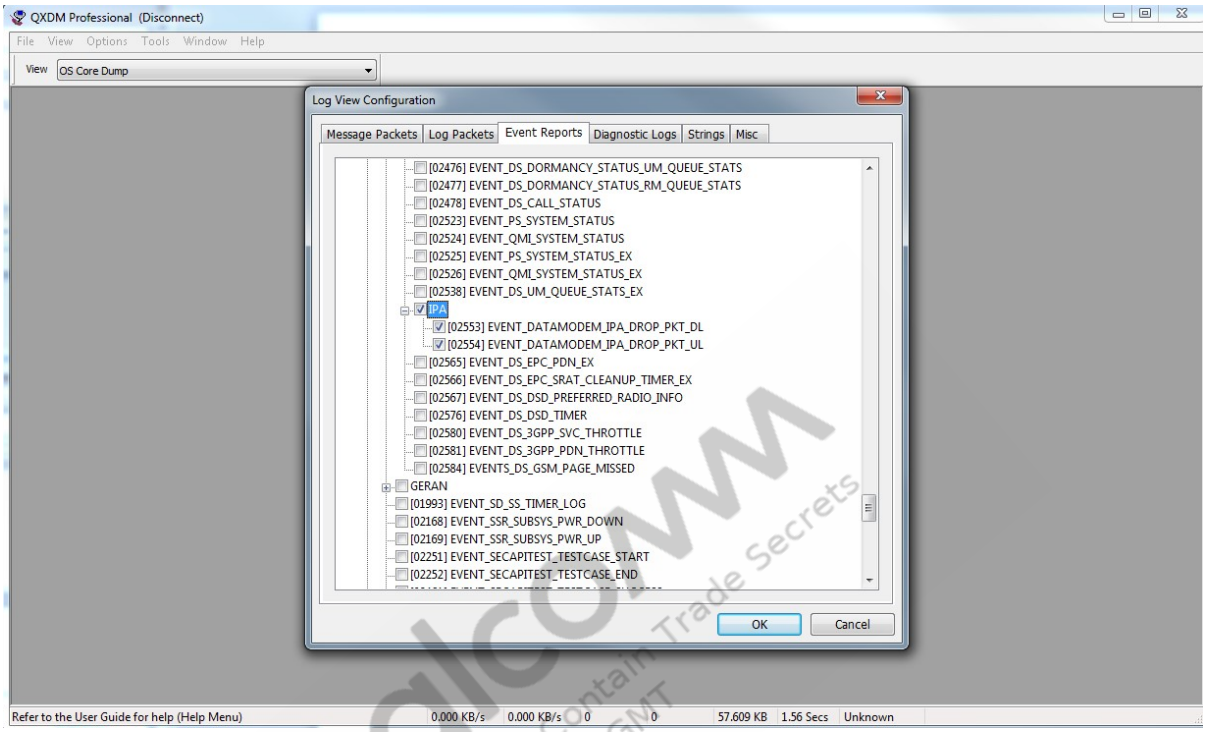

Figure 2-2 Enable IPA event reports using QXDM Professional

The following are the IPA event reports:

IPA_DROP_PKT_DL

- Event code – 0x09F9
- Description – event raised whenever a packet is dropped in DL; drop reason and packet length are captured in the event

IPA_DROP_PKT_UL

- Event code – 0x09FA
- Description – event raised whenever a packet is dropped in UL; drop reason and packet length are captured in the event

3 IPA functionalities and logging on Arm Cortex-A7

This chapter details various IPA features and functionalities on Arm Cortex-A7 and logging.

3.1 Arm Cortex-A7 IPA software features

The Arm Cortex-A7 IPA software features are as follows:

- Power-up initialization of hardware
- IPA shared memory management
- IPC with Hexagon IPA driver
- Data path configuration
- Manages LAN/WAN filtering on WLAN and USB endpoints
- Manages packet routing destined to LAN clients
- Manages NAT table
- Manages (in conjunction with Hexagon IPA driver) packet routing to/from modem data path
- BAM-to-BAM and/or BAM-to-SYS mode data path setup with peripherals
- Data transport through IPA for software data path
- Power-save
- Coordinates IPA clock gating with peripheral drivers
- Votes (independently) for IPA clock on/off with RPM

3.2 Enable logging of IPA packets on Arm Cortex-A7

This section describes on how to collect various logs on IPA.

To collect the kernel dmesg log, use one of the following commands:

- `adb shell dmesg | tee dmesg_log.txt`
- Type `dmesg > /etc/dmesg_log.txt` in the serial port and ADB pulls the collection.

To collect the IPA information log, run the following:

- `cat /sys/kernel/debug/ipa/hdr` – shows headers registered in IPA
- `cat /sys/kernel/debug/ipa/ip4_rt` – shows IPv4 routing rules in IPA
- `cat /sys/kernel/debug/ipa/ip4_flt` – shows IPv4 filtering rules in IPA
- `cat /sys/kernel/debug/ipa/ip6_rt` – shows IPv6 routing rules in IPA
- `cat /sys/kernel/debug/ipa/ip6_flt` – shows IPv6 filtering rules in IPA
- `cat /sys/kernel/debug/ipa/stats` – shows IPA statistics. See Section IPA statistics output description for details.
- `cat /sys/kernel/debug/ipa/msg` – displays messages WLAN sends to IPA
- `cat /sys/kernel/debug/ipa/ip4_nat` – displays IPA NAT table
- `cat /sys/kernel/debug/ipa/wstats` – shows IPA statistics for WLAN call. See section WLAN statistics output description for details.

To gather general information from Cortex-A7 (A7), run the following:

```
ifconfig

route -n

brctl show

conntrack -L
```

To collect TCPDUMP from iface on A7, run the following:

```
tcpdump -i bridge0 -w bridge0.pcap
```

TCPDUMP from iface, such as bridge0 is collected in the preceding command. The IPACM log can be collected through the QXDM Professional with Linux Data Msg Pkt log mask enabled.

To start IPACM manually and get the complete IPACM log from bootup, run the following:

1. Power on the device
   a. `adb shell or in serial port` – serial port is used when issue is related to USB cable plug-in/out operation.
   b. `cd etc/init.d`
   c. `mv start_ipacm_le start_ipacm_le_bk` – disables the Daemon mode
   d. `reboot`
   e. `ps -ef` – ensures IPACM is not running
   f. `adb shell or in serial port`
   g. `cd /usr`
   h. `ipacm > ipacm_log.txt &` – issue this command to start IPACM and write to file under /usr
2. Run IPACM before bringing up any interface.

To collect resource manager log detailed driver operations, run the following:

```
mount -t debugfs none /sys/kernel/debug/
klogd -c 8
echo "file ipa_rm.c +p" > /sys/kernel/debug/dynamic_debug/control
echo "file ipa_rm_resource.c +p" > /sys/kernel/debug/dynamic_debug/control
echo "file ipa_client.c +p" > /sys/kernel/debug/dynamic_debug/control
echo "file ipa_utils.c +p" > /sys/kernel/debug/dynamic_debug/control
echo "file ipa_rm_dependency_graph.c +p" > /sys/kernel/debug/dynamic_debug/
control
```

Then collect dmesg log

`cat /sys/kernel/debug/ipa/rm_stats` – prints all producer resources, their consumers' dependencies, and states.

To collect ECM_IPA driver log detailed driver operations, run the following:

```
mkdir /d
mount -t debugfs none /d
echo "module ecm_ipa +pmflt" > /d/dynamic_debug/control
cat /d/ecm_ipa/outstanding – Current outstanding counter (this shows how many
Tx [Device→Host] packets were not proceeded by hardware)
```

To collect RNDIS_IPA driver log detailed driver operations, run the following:

```
mkdir /d
mount -t debugfs none /d
echo "module rndis_ipa +pmflt" > /d/dynamic_debug/control
cat /d/rndis_ipa/outstanding – Current outstanding counter (this shows how
many Tx [Device→Host] packets were not proceeded by hardware)
```

To collect tethering bridge driver log, enable debug logs:

```
mount -t debugfs none /sys/kernel/debug
echo 'file teth_bridge.c +p' > /sys/kernel/debug/dynamic_debug/control
```

3.3 IPA statistics output description

The following is the output from `cat /sys/kernel/debug/ipa/stats`:

- `sw_tx` – number of ECM/RNDIS packets sent from A7
- `hw_tx` – number of QMAP packets sent from A7
- `tx_compl` – number of Tx completions received
- `wan_rx` – number of packets received from Hexagon at A7

- `stat_compl` – number of packets from ECM/RNDIS/WLAN on hardware path
- `lan_aggr_close` – number of times aggregation closed on the LAN Rx pipe
- `wan_aggr_close` – number of times aggregation closed on the WAN Rx pipe
- `act_clnt` – number of up-votes for IPA clock from the applications processor side
- `con_clnt_bmap` – bitmap of connected clients; bit n corresponds to EP n
- `lan_rx_excp[0: IPA_EXCP_DEAGGR]` – number of deaggregation exceptions
- `lan_rx_excp[2: IPA_EXCP_IP]` – number of non-IP packet exceptions
- `lan_rx_excp[3: IPA_EXCP_IHL]` – number of bad IP packet header length exceptions
- `lan_rx_excp[4: IPA_EXCP_FRAG_MISS]` – number of fragment miss exceptions
- `lan_rx_excp[5: IPA_EXCP_SW]` – number of software exceptions
- `lan_rx_excp[6: IPA_EXCP_NAT]` – number of NAT exceptions
- `lan_rx_excp[7: IPA_EXCP_NONE]` – number of LAN Rx packets actually destined to the applications processor

3.4 WLAN statistics output description

The following is the output from `cat /sys/kernel/debug/ipa/wstats`:

- Client IPA_CLIENT_WLAN1_PROD statistics
  - `Avail FIFO Desc` – number of free descriptors available
  - `Rx Pkts Rcvd` – packets sent by the WLAN driver to IPA
  - `Rx Pkts Status Rcvd` – status packets received from the IPA hardware in UL
  - `Rx DH Rcvd` – data descriptors sent by WLAN
  - `Rx DH Processed` – data descriptors processed by IPA
  - `Rx DH Sent Back` – data descriptors sent back to the WLAN driver from IPA for recycling
  - `Rx Pkt Leak` – packets that have not received status from the IPA hardware, which results in memory leak
  - `Rx DP Fail` – packets failed to transfer from the IPA driver to the IPA hardware
- Client IPA_CLIENT_WLANx_CONS statistics
  - `Tx Pkts Received` – packets received from the IPA hardware
  - `Tx Pkts Sent` – packets sent to WLAN by IPA
  - `Tx Pkts Dropped` – packets dropped by IPA
- All WLAN consumer pipes statistics
  - `Tx Comm Buff Allocated` – total buffers allocated in DL
  - `Tx Comm Buff Avail` – empty buffers available in DL
  - `Total Tx Pkts Freed` – recycled buffers count

A References

A.1 Acronyms and terms

Acronym or term	Definition
ADB	Android debug bridge
BAM	Bus access manager
DL	Downlink
IPA	IP accelerator
MBIM	Mobile broadband interface model
MHI	Modem host interface
NAT	Network address translation
QMI	Qualcomm modem interface
QoS	Quality of service
RNDIS	Remote network driver interface specification
RmNet	Remote wireless wide area network
TCP	Transfer control protocol
UL	Uplink

A.2 Related documents

Title	Number
Qualcomm Technologies, Inc.	
Modem IPA Configuration Manager User Guide	80-NC254-64