KeyStone Training

Network Coprocessor (NETCP)

Packet Accelerator (PA)

Agenda

- Applications
- Hardware Modules
- Firmware
- PA Low Level Driver (LLD)
- Programming Example

Packet Accelerator: Applications

- Applications
- Hardware Modules
- Firmware
- PA Low Level Driver (LLD)
- Programming Example

Packet Accelerator Applications

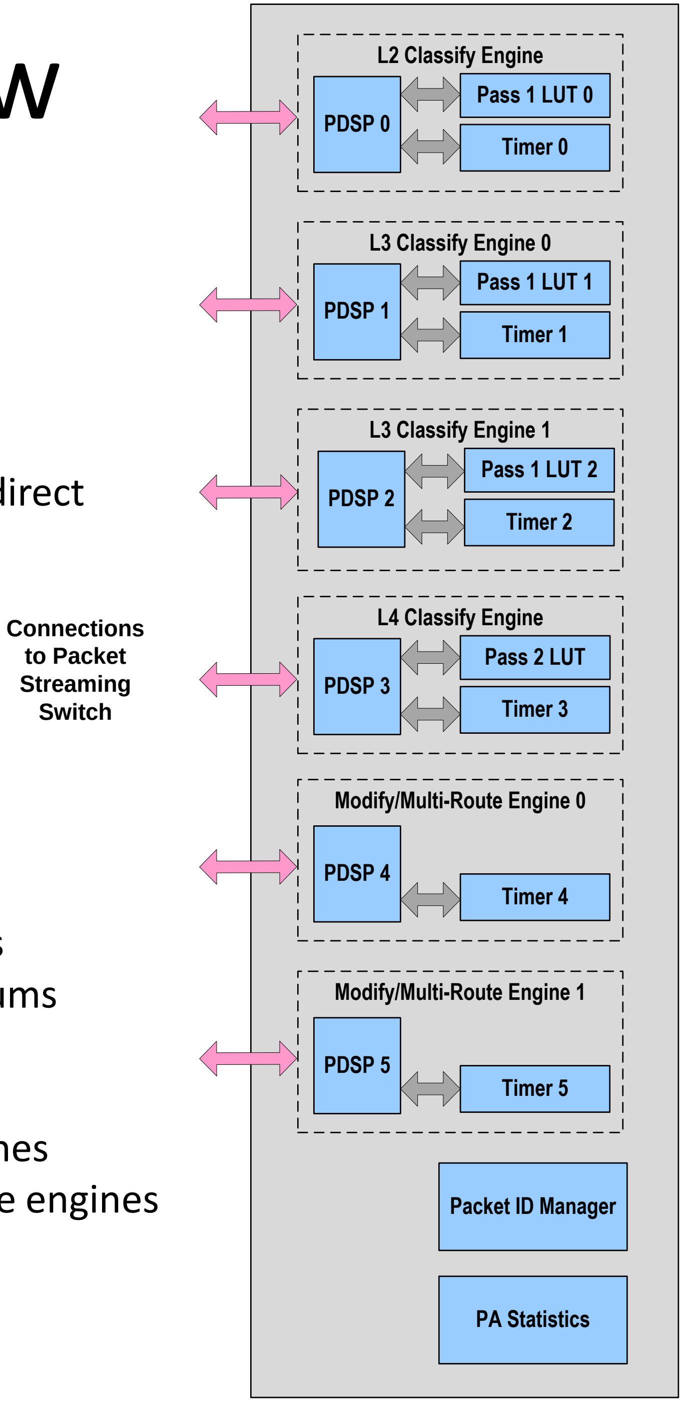
- Packet accelerator saves cycles from host DSP cores.
- Option of single IP address for multi-core device
  - Multicore device internal architecture is abstracted
- 8192 multiple-in, multiple-out HW queues
- UDP (and TCP) Checksum and selected CRCs also for proprietary header formats
  - Verification on ingress and generation on egress
- L2 Support
  - Ethernet: Ethertype and VLAN
  - MPLS
- L3/L4 Support
  - IPv4/6 and UDP port based routing
  - Raw Ethernet or IPv4/6 and Proprietary UDP like protocol support
  - GRE
- QOS
  - Per channel / flow to individual queue towards host DSPs
  - TX traffic shaping
- Access to the Security Accelerator
  - IPSec ESP and AH tunnel, SRTP
- Multicast to multiple queues
  - For example Ethernet broadcast copied and pushed to 1-8 queues
- Timestamps
  - IEEE 1588 timestamps and configurable generic timestamps

Packet Accelerator: Applications

- Applications
- Hardware Modules
- Firmware
- PA Low Level Driver (LLD)
- Programming Example

PA: High-Level Overview

- L2 Classify Engine
  - Used for matching L2 headers
  - Example headers: MAC, VLAN, LLC snap
- L3 Classify Engine 0
  - Used for matching L3 headers
  - Example headers: IPv4, IPv6, Custom L3
  - Also uses Multicore Navigator to match ESP headers and direct packets to SA
- L3 Classify Engine 1
  - Typically used for matching L3 headers in IPsec tunnels
  - Example headers: IPv4, IPv6, Custom L3
- L4 Classify Engine
  - Used for matching L4 Headers
  - Example headers: UDP, TCP, Custom L4
- Modify/Multi-Route Engines
  - Used for Modification, Multi-route, and Statistics requests
  - Modification Example: generate IP or UDP header checksums
  - Multi-route Example: route a packet to multiple queues
- PA Statistics Block
  - Stores statistics for packets processed by the classify engines
  - Statistics requests typically handled by Modify/Multi-route engines
- Packet ID Manager
  - Assigns packet ID to packets

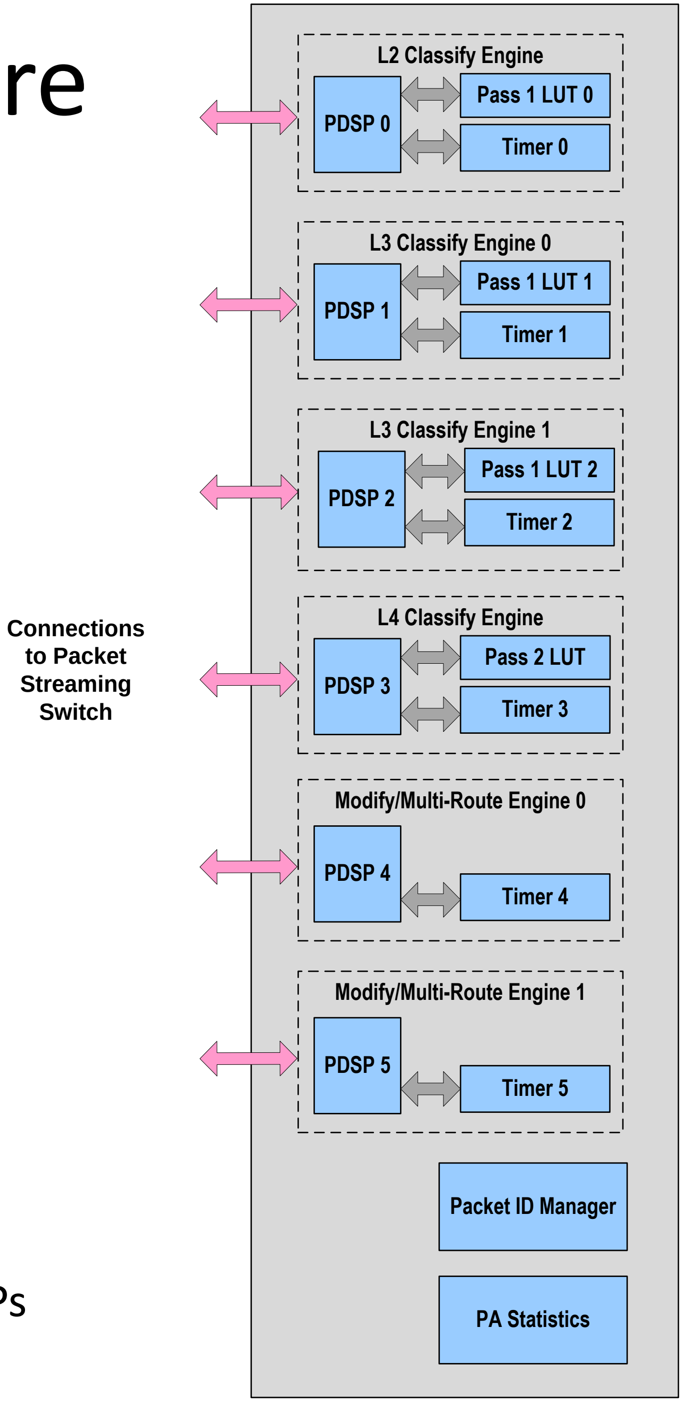


Packet Accelerator: Firmware

- Applications
- Hardware Modules
- Firmware
- PA Low Level Driver (LLD)
- Programming Example

PA: Hardware and Firmware

- One L2 Classify Engine
  - PDSP
  - Pass 1 Lookup Table (LUT1)
  - Timer
  - Classify 1 (c1) firmware image
- Two L3 Classify Engines
  - PDSP
  - Pass 1 Lookup Table (LUT1)
  - Timer
  - Classify 1 (c1) firmware image
- One L4 Classify Engine
  - PDSP
  - Pass 2 Lookup Table (LUT2)
  - Timer
  - Classify 2 (c2) firmware image
- Two Modify/Multi-Route Engines
  - PDSP
  - Timer
  - Modify (m) firmware image
- One Packet ID Manager
- One PA Statistics Block
- NOTE: Firmware images must be loaded onto the PDSPs before using the PA engines.



PA Low Level Driver Overview

- Applications
- Hardware Modules
- Firmware
- PA Low Level Driver (LLD)
- Programming Example

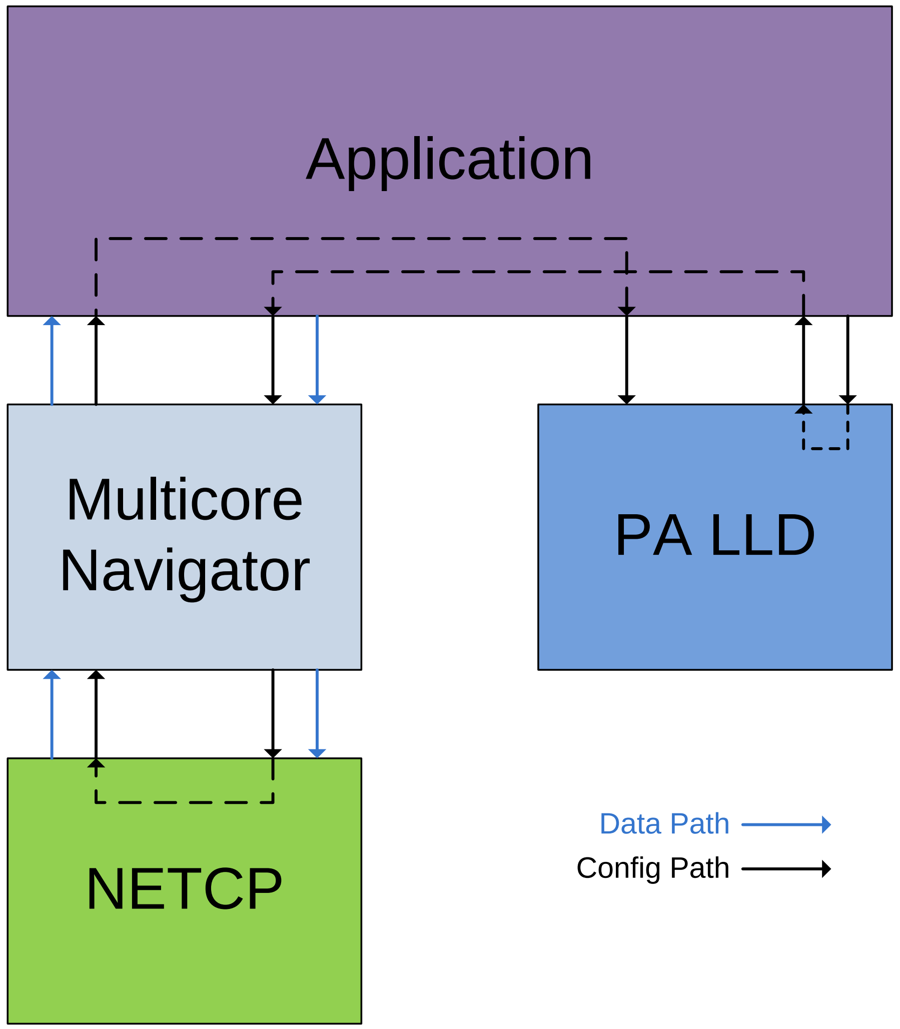
PA LLD Overview

- PA LLD provides an abstraction layer between the application and the PA. It translates packet headers and routing requirements into configuration information that is used by the PA firmware.
- PA LLD provides the command/response interface for PA configurations:
  - LUT1
  - LUT2
  - CRC generation
  - Multi-route

  NOTE: The most general configuration must entered into the PDSPs before any overlapping, more specific configuration
- The PA LLD also handles linking together entries in separate lookup tables. For example, linking an entry in an L2 classify lookup table to an entry in an L3 classify lookup table.
- PA LLD does not provide transport layer; This is handled by the Multicore Navigator.
- API calls are non-blocking
- PA LLD references: pa/docs/paDocs.chm, pa/docs/pa_sds.pdf

PA LLD Functional Diagram

- Benefits
  - Abstracts the operation of the PA from the application
  - OS-independent
  - Multi-instance for multicore
- NOTE:
  - PA LLD runs on the host DSP and is external in the PA.



PA Low Level Drivers (PA LLD)

- Applications
- Hardware Modules
- Firmware
- PA Low Level Driver (LLD)
- Programming Example

PA LLD API: System

paReturn_t	**Pa_getBufferReq** (**paSizeInfo_t** *sizeCfg, int sizes[], int aligns[]) *Pa_getBufferReq returns the memory requirements for the PA driver.*
paReturn_t	**Pa_create** (**paConfig_t** *cfg, void *bases[], **Pa_Handle** *pHandle) *Pa_create creates the PA driver instance.*
paReturn_t	**Pa_close** (**Pa_Handle** handle, void *bases[]) *Pa_close decativates the PA driver instance.*
paReturn_t	**Pa_requestStats** (**Pa_Handle** iHandle, uint16_t doClear, **paCmd_t** cmd, uint16_t *cmdSize, **paCmdReply_t** *reply, int *cmdDest) *Pa_requestStats requests sub-system statistics.*
paSysStats_t *	**Pa_formatStatsReply** (**Pa_Handle** handle, **paCmd_t** cmd) *Pa_formatStatsReply formats a stats request from the PA.*
paSSstate_t	**Pa_resetControl** (**paSSstate_t** newState) *Pa_resetControl controls the reset state of the Sub-system.*
paReturn_t	**Pa_downloadImage** (int modId, void *image, int sizeBytes) *Pa_downloadImage downloads a PDSP image to a sub-system with the packet processing modules in reset.*

PA LLD API: Configuration

paReturn_t	**Pa_addMac** (**Pa_Handle** iHandle, **paEthInfo_t** *ethInfo, **paRouteInfo_t** *routeInfo, **paRouteInfo_t** *nextRtFail, **paHandleL2L3_t** *handle, **paCmd_t** cmd, uint16_t *cmdSize, **paCmdReply_t** *reply, int *cmdDest) *Pa_addMac adds a mac address to the L2 table.*
paReturn_t	**Pa_delHandle** (**Pa_Handle** iHandle, **paHandleL2L3_t** handle, **paCmd_t** cmd, uint16_t *cmdSize, **paCmdReply_t** *reply, int *cmdDest) *Pa_delHandle deletes a MAC or IP handle.*
paReturn_t	**Pa_delL4Handle** (**Pa_Handle** iHandle, **paHandleL4_t** handle, **paCmd_t** cmd, uint16_t *cmdSize, **paCmdReply_t** *reply, int *cmdDest) *Pa_delL4Handle deletes a TCP or UDP handle.*
paReturn_t	**Pa_addIp** (**Pa_Handle** iHandle, **paIpInfo_t** *ipInfo, **paHandleL2L3_t** prevLink, **paRouteInfo_t** *routeInfo, **paRouteInfo_t** *nextRtFail, **paHandleL2L3_t** *retHandle, **paCmd_t** cmd, uint16_t *cmdSize, **paCmdReply_t** *reply, int *cmdDest) *Pa_addIp adds an IP address to the L3 table.*
paReturn_t	**Pa_addPort** (**Pa_Handle** iHandle, uint16_t destPort, **paHandleL2L3_t** linkHandle, **paRouteInfo_t** *routeInfo, **paHandleL4_t** retHandle, **paCmd_t** cmd, uint16_t *cmdSize, **paCmdReply_t** *reply, int *cmdDest) *Pa_addPort adds a destination TCP/UDP port to the L4 table.*
paReturn_t	**Pa_forwardResult** (**Pa_Handle** iHandle, void *vresult, **paHandle_t** *retHandle, int *handleType, int *cmdDest) *Pa_forwardResult examines the reply of the sub-system to a command.*
paReturn_t	**Pa_configRouteErrPacket** (**Pa_Handle** iHandle, int nRoute, int *errorTypes, **paRouteInfo_t** *eRoutes, **paCmd_t** cmd, uint16_t *cmdSize, **paCmdReply_t** *reply, int *cmdDest) *Pa_configRouteErrPacket configures the routing of packets that match error conditions.*

PA LLD API: Custom Configuration

paReturn_t	**Pa_setCustomL3** (**Pa_Handle** iHandle, uint16_t customEthertype, uint16_t parseByteOffset, uint8_t byteMasks[pa_NUM_BYTES_CUSTOM_L3], **paCmd_t** cmd, uint16_t *cmdSize, **paCmdReply_t** *reply, int *cmdDest) *Pa_setCustomL3 performs the global configuration for level 3 custom lookups.*
paReturn_t	**Pa_addCustomL3** (**Pa_Handle** iHandle, uint8_t match[pa_NUM_BYTES_CUSTOM_L3], **paRouteInfo_t** *routeInfo, **paRouteInfo_t** *nextRtFail, **paHandleL2L3_t** prevLink, **paHandleL2L3_t** *retHandle, int nextHdrType, uint16_t nextOffset, **paCmd_t** cmd, uint16_t *cmdSize, **paCmdReply_t** *reply, int *cmdDest) *Pa_AddCustomL3 adds a custom lookup entry to the lookup tables.*
paReturn_t	**Pa_setCustomL4** (**Pa_Handle** iHandle, uint16_t handleLink, uint16_t udpCustomPort, uint16_t byteOffsets[pa_NUM_BYTES_CUSTOM_L4], uint8_t byteMasks[pa_NUM_BYTES_CUSTOM_L4], **paCmd_t** cmd, uint16_t *cmdSize, **paCmdReply_t** *reply, int *cmdDest) *Pa_setCustomL4 performs the global configuration for level 4 custom lookups.*
paReturn_t	**Pa_addCustomL4** (**Pa_Handle** iHandle, **paHandleL2L3_t** prevLink, uint8_t match[pa_NUM_BYTES_CUSTOM_L4], **paRouteInfo_t** *routeInfo, **paHandleL4_t** retHandle, **paCmd_t** cmd, uint16_t *cmdSize, **paCmdReply_t** *reply, int *cmdDest) *Pa_addCustomL4 adds a custom lookup to the lookup tables.*

PA LLD API: Utility Functions

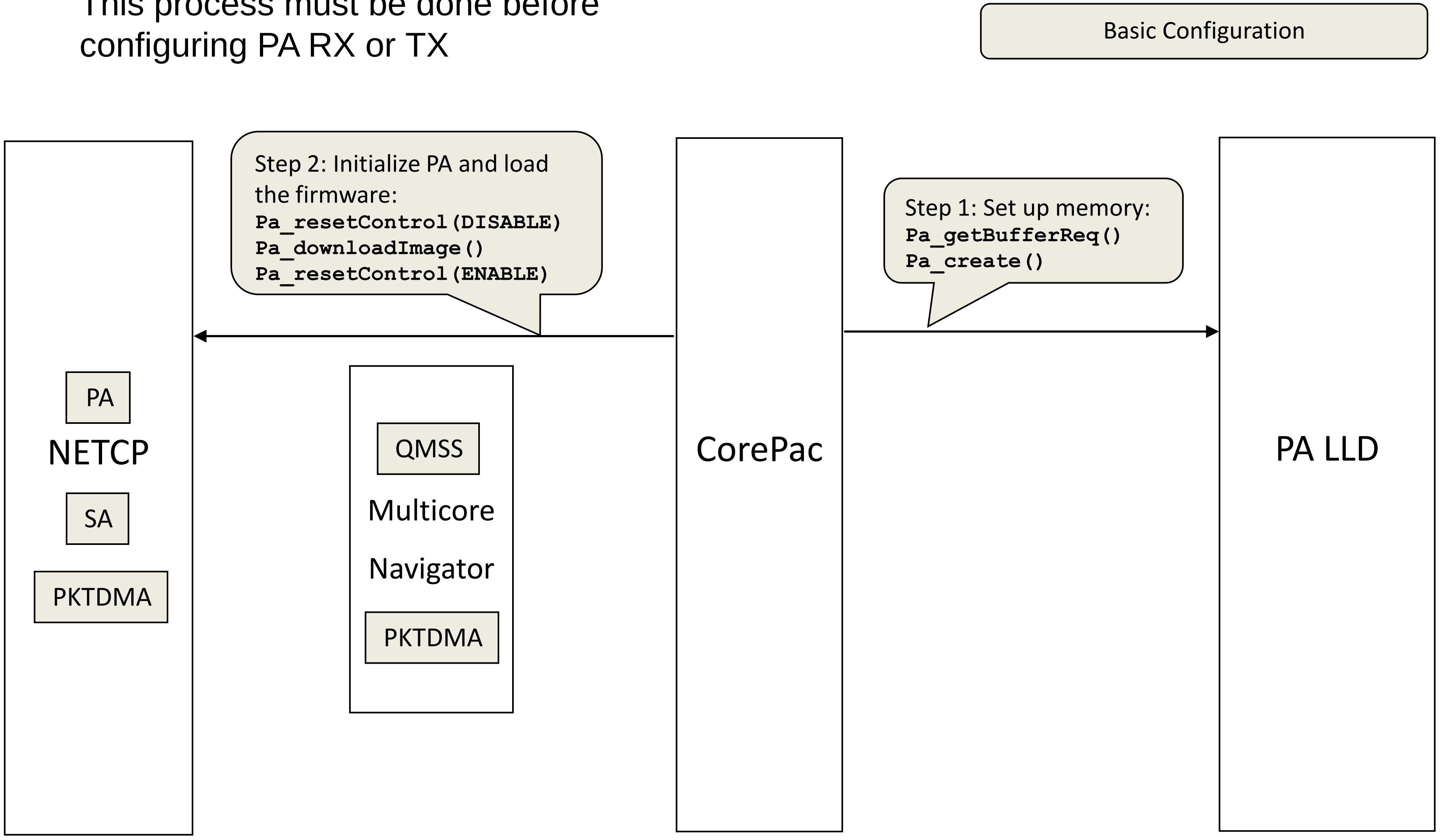
paReturn_t	**Pa_formatTxRoute** (**paTxChksum_t** *chk0, **paTxChksum_t** *chk1, **paRouteInfo_t** *route, void *cmdBuffer, int *cmdSize)
	Pa_formatTxRoute formats the commands to add checksums and route a Tx packet.
paReturn_t	**Pa_formatRoutePatch** (**paRouteInfo_t** *route, **paPatchInfo_t** *patch, void *cmdBuffer, int *cmdSize)
	Pa_formatRoutePatch formats the commands to route a packet and blind patch.

PA LLD: Programming Example

- Applications
- Hardware Modules
- Firmware
- PA Low Level Driver (LLD)
- Programming Example

PA LLD: Basic Configuration

This process must be done before configuring PA RX or TX



PA LLD: PA Routing

- PA LLD provides a routing structure which allows the following parameters to be configured:
  - Destination
  - Flow ID
  - Queue
  - Multi-Route Handle (Index)
  - Software Info 0
  - Software Info 1
- Several possible destinations
  - pa_DEST_HOST
  - pa_DEST_EMAC
  - pa_DEST_SASS0
  - pa_DEST_SASS1
  - pa_DEST_DISCARD
  - pa_DEST_CONTINUE_PARSE

MAC Routing Example:

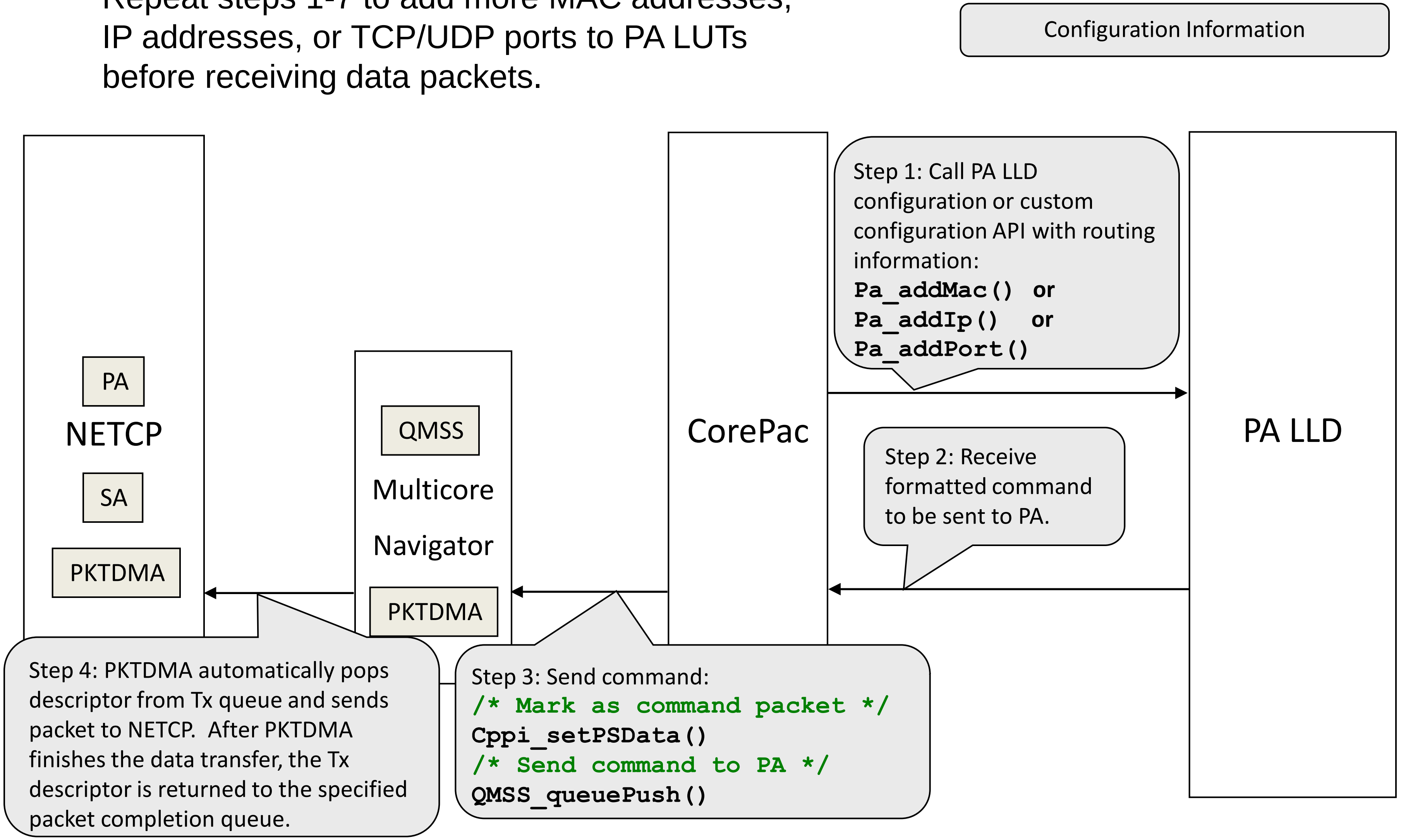
```
paRouteInfo_t macRoute;
/* Continue parsing -- try to match IP handle*/
macRoute.dest = pa_DEST_CONTINUE_PARSE;
macRoute.flowId = 0;
macRoute.queue = 0;
macRoute.mRouteHandle = -1;
macRoute.swInfo0 = 0;       /* Don't Care */
macRoute.swInfo1 = 0;       /* Don't Care */
```

Port Routing Example:

```
paRouteInfo_t portRoute;
/* Send all matches to the queue specified */
portRoute.dest = pa_DEST_HOST;
portRoute.flowId = 5;
portRoute.queue = 900;
portRoute.mRouteHandle = -1;
portRoute.swInfo0 = 0;       /* Don't Care */
portRoute.swInfo1 = 0;       /* Don't Care */
```

PA LLD: Rx Configuration

Repeat steps 1-7 to add more MAC addresses, IP addresses, or TCP/UDP ports to PA LUTs before receiving data packets.



Step 1: Call PA LLD configuration or custom configuration API with routing information:

```
Pa_addMac()  or
Pa_addIp()   or
Pa_addPort()
```

Step 2: Receive formatted command to be sent to PA.

Step 3: Send command:

```
/* Mark as command packet */
Cppi_setPSData()
/* Send command to PA */
QMSS_queuePush()
```

Step 4: PKTDMA automatically pops descriptor from Tx queue and sends packet to NETCP. After PKTDMA finishes the data transfer, the Tx descriptor is returned to the specified packet completion queue.

PA LLD: Rx Configuration

Step 5: The PA LLD will indicate the appropriate transmit queue index. Using the queue returned from **`Pa_addMac()`** in this example.

Q640: PDSP0

Q641: PDSP1

Q642: PDSP2

Q643: PDSP3

Q644: PDSP4

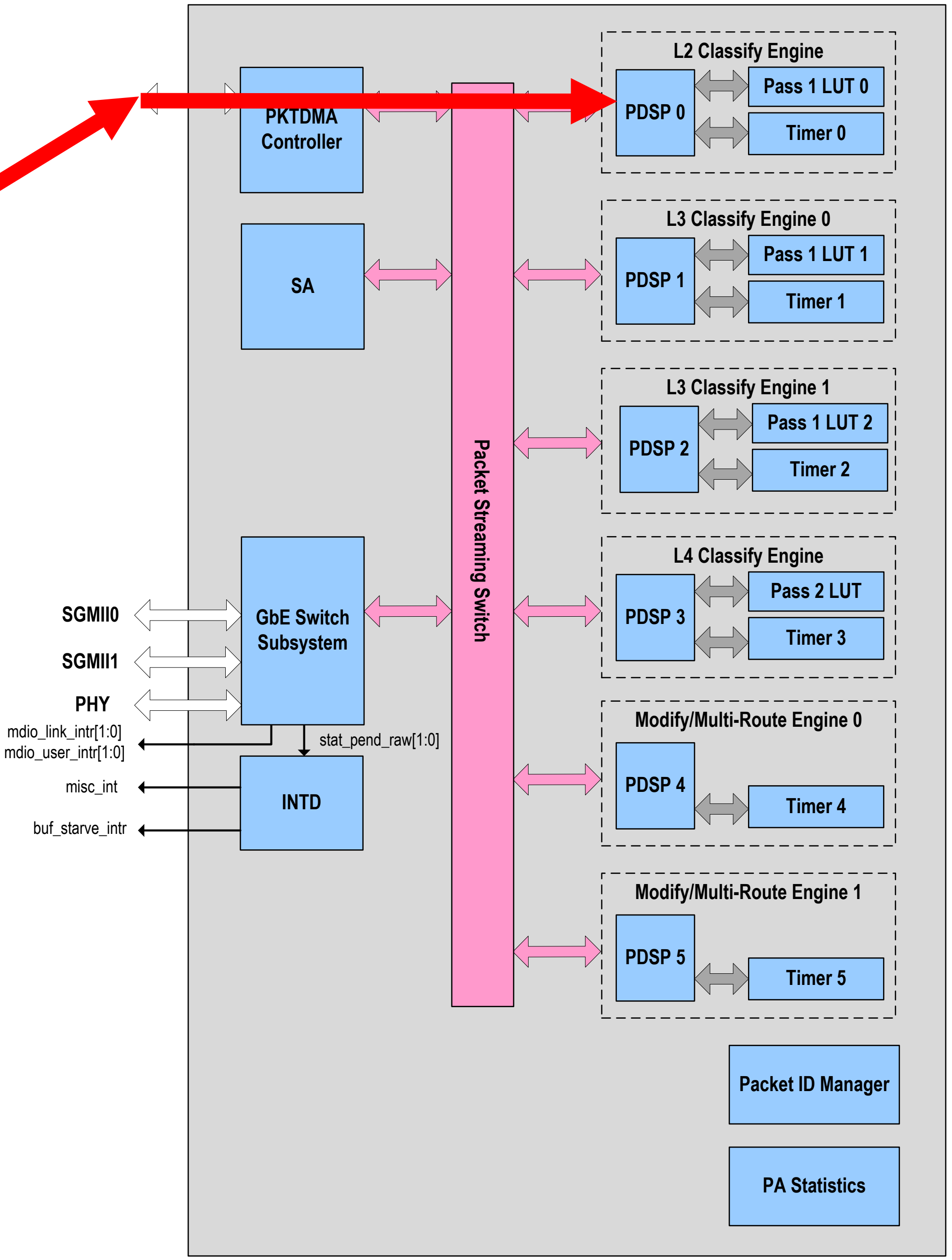
Q645: PDSP5

Q646: SA0

Q647: SA1

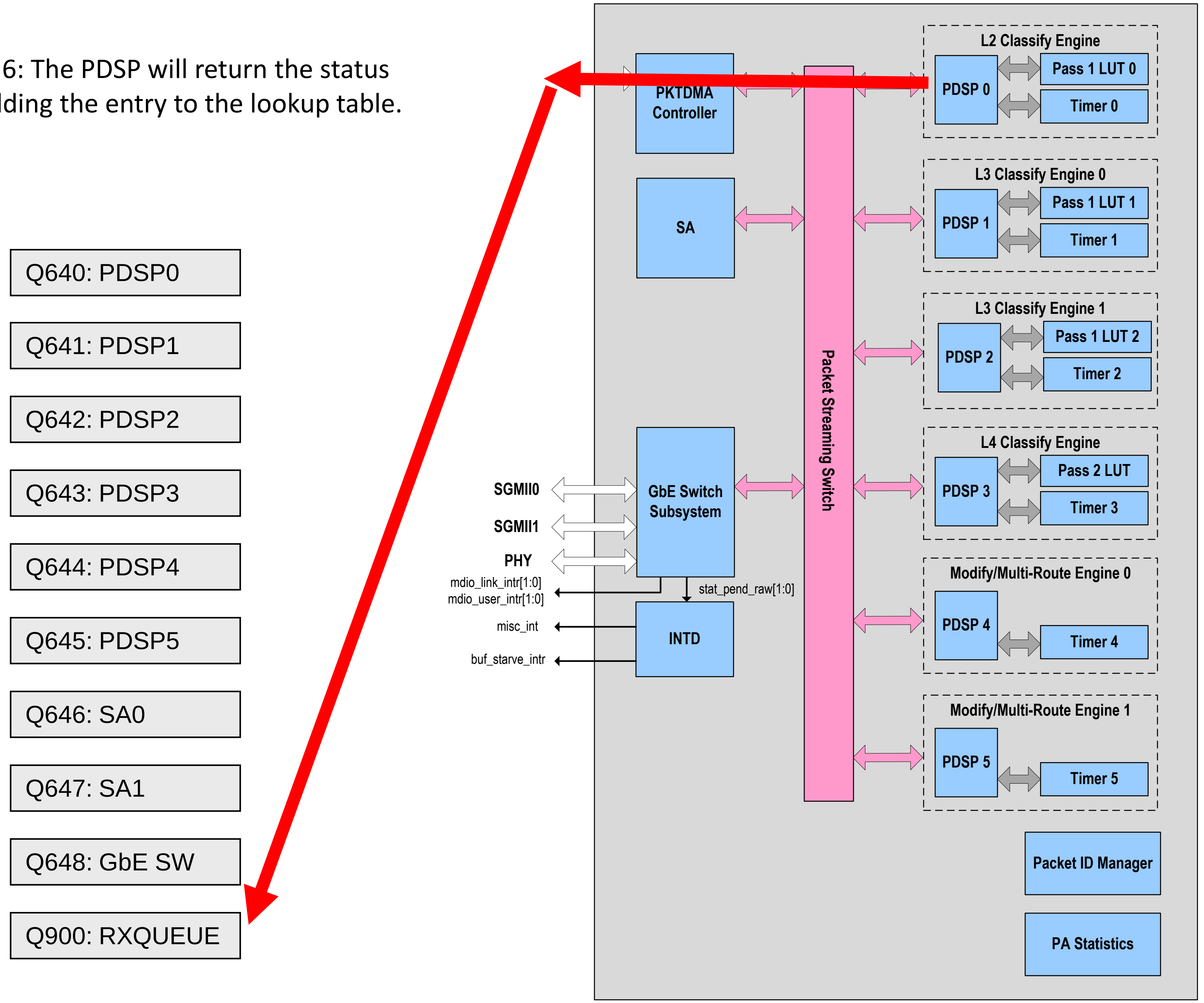
Q648: GbE SW

Q900: RXQUEUE



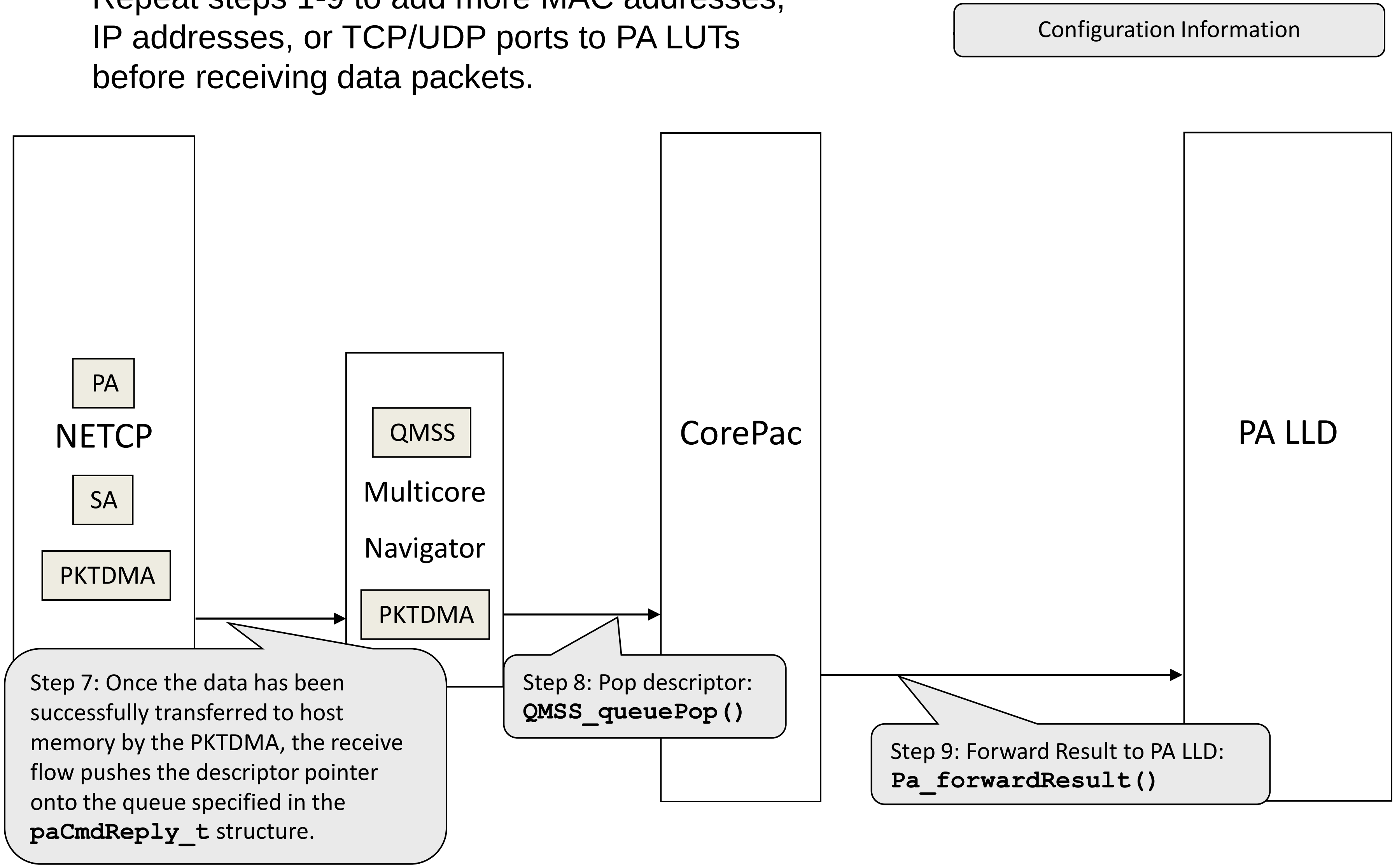
PA LLD: Rx Configuration

Step 6: The PDSP will return the status of adding the entry to the lookup table.



PA LLD: Rx Configuration

Repeat steps 1-9 to add more MAC addresses, IP addresses, or TCP/UDP ports to PA LUTs before receiving data packets.


Configuration Information
PA
NETCP
SA
PKTDMA
QMSS
Multicore
Navigator
PKTDMA
CorePac
PA LLD
Step 7: Once the data has been successfully transferred to host memory by the PKTDMA, the receive flow pushes the descriptor pointer onto the queue specified in the **paCmdReply_t** structure.
Step 8: Pop descriptor: **QMSS_queuePop()**
Step 9: Forward Result to PA LLD: **Pa_forwardResult()**

PA Rx Hardware Processing

Step 1: A packet formatted with MAC, IPv4, and UDP headers arrives from the gigabit Ethernet switch subsystem and is routed over the packet streaming switch to the L2 Classify Engine.

Q640: PDSP0

Q641: PDSP1

Q642: PDSP2

Q643: PDSP3

Q644: PDSP4

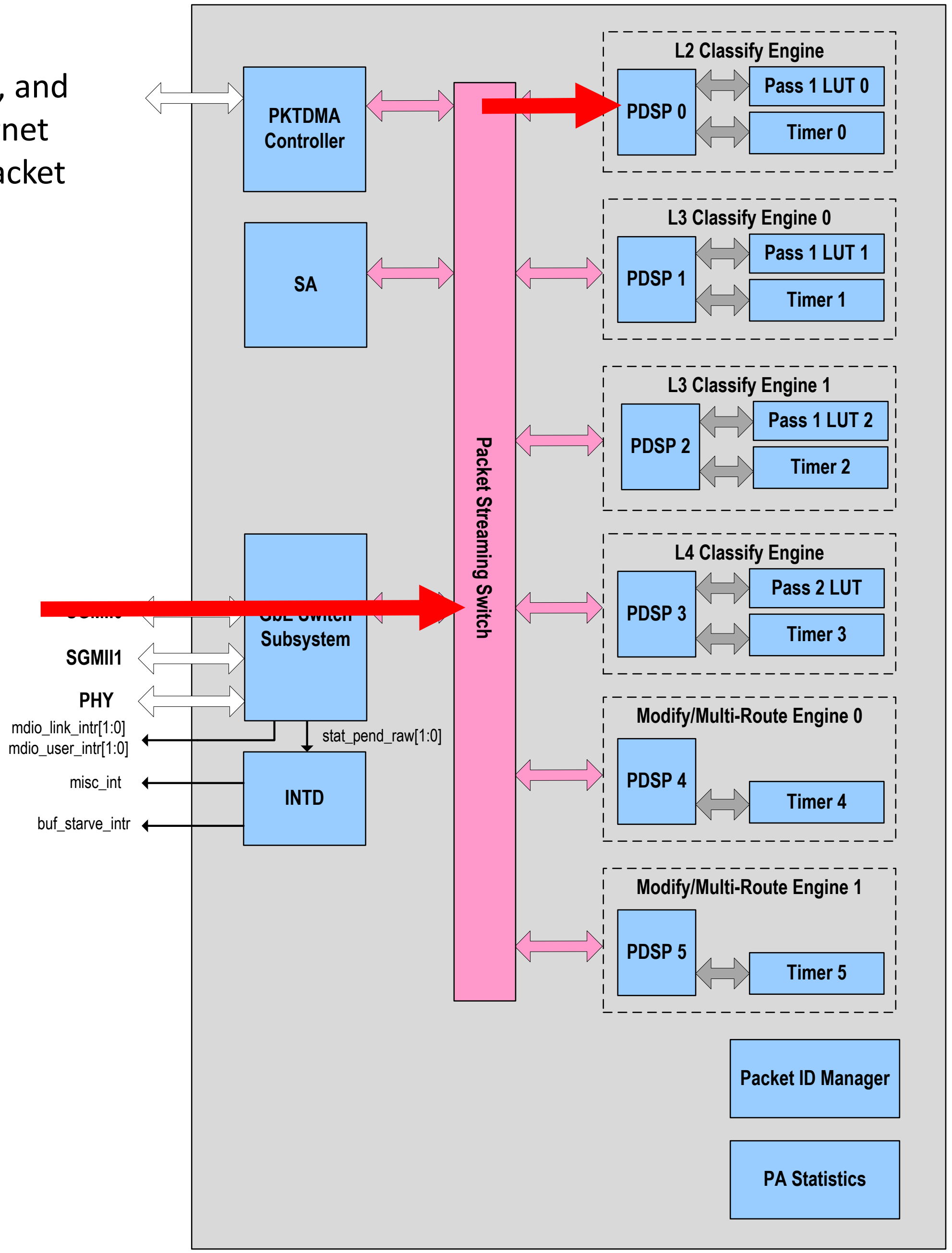
Q645: PDSP5

Q646: SA0

Q647: SA1

Q648: GbE SW

Q900: RXQUEUE



PA Rx Hardware Processing

Step 2: PDSP0 in the L2 Classify Engine submits the MAC header for lookup. Assume that the lookup is successful. The packet will then be routed to its next destination. Assume that the destination is L3 Classify Engine 0.

Q640: PDSP0

Q641: PDSP1

Q642: PDSP2

Q643: PDSP3

Q644: PDSP4

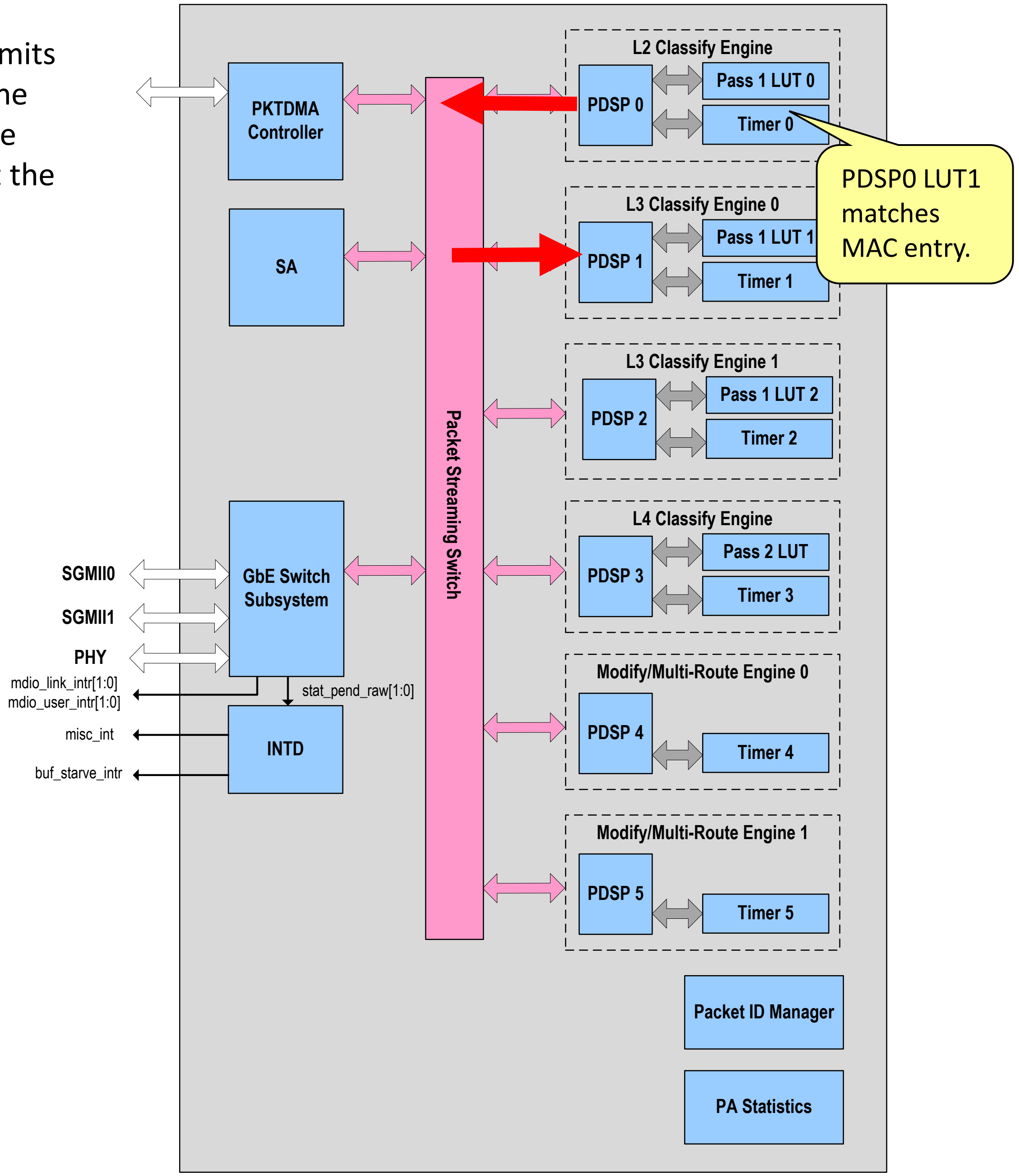
Q645: PDSP5

Q646: SA0

Q647: SA1

Q648: GbE SW

Q900: RXQUEUE



PA Rx Hardware Processing

Step 3: The packet is routed to the L3 Classify Engine 0. PDSP1 submits the IPv4 header for lookup. Assume that the lookup is successful. The packet will then be routed to its next destination. Assume that it is the L4 Classify Engine.

Q640: PDSP0

Q641: PDSP1

Q642: PDSP2

Q643: PDSP3

Q644: PDSP4

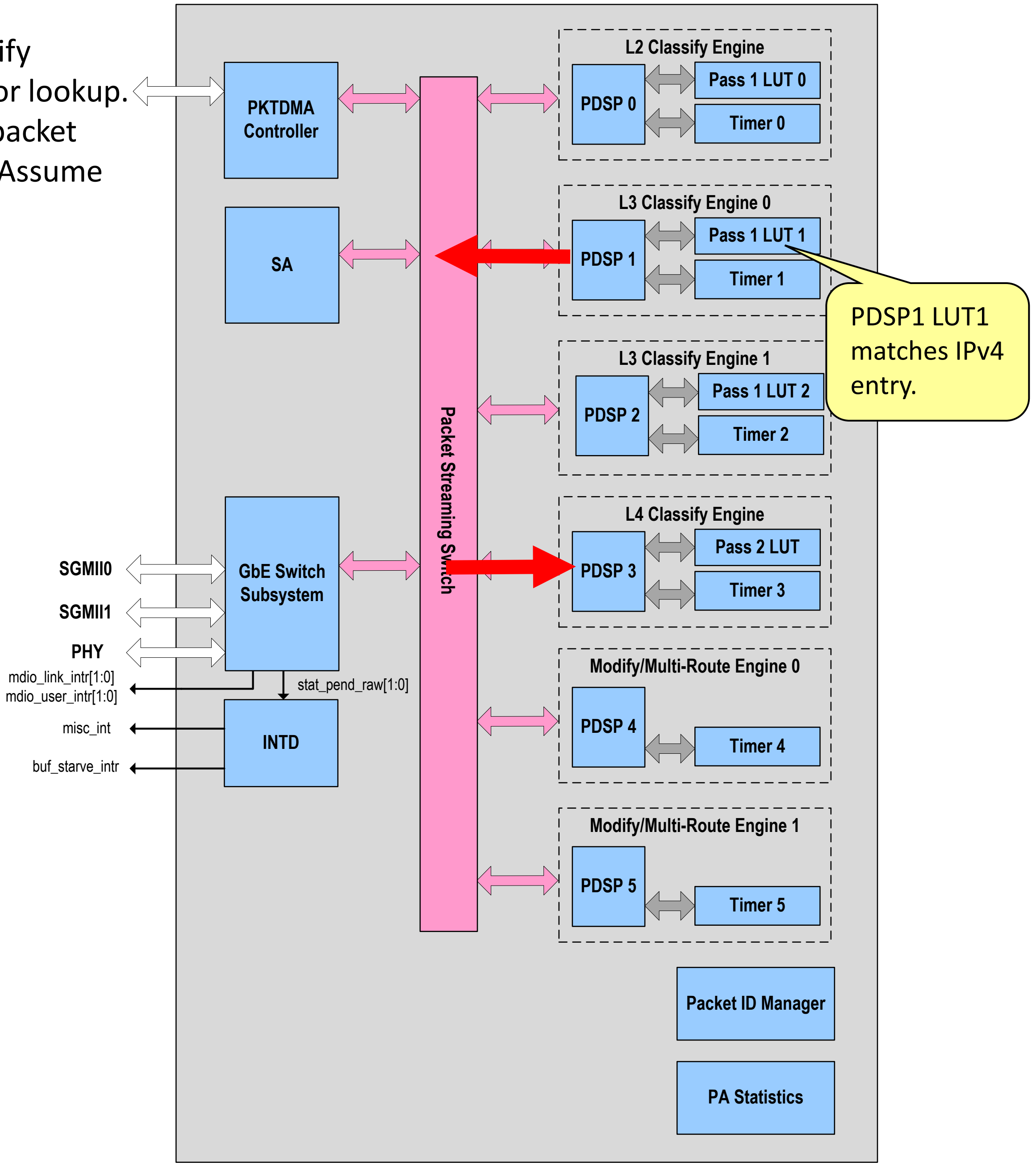
Q645: PDSP5

Q646: SA0

Q647: SA1

Q648: GbE SW

Q900: RXQUEUE



PA Rx Hardware Processing

Step 4: The packet is routed to the L4 Classify Engine. PDSP3 submits the UDP header for lookup. Assume that the lookup is successful. The packet will then be routed to its next destination. Assume that the destination is the host on queue 900.

Q640: PDSP0

Q641: PDSP1

Q642: PDSP2

Q643: PDSP3

Q644: PDSP4

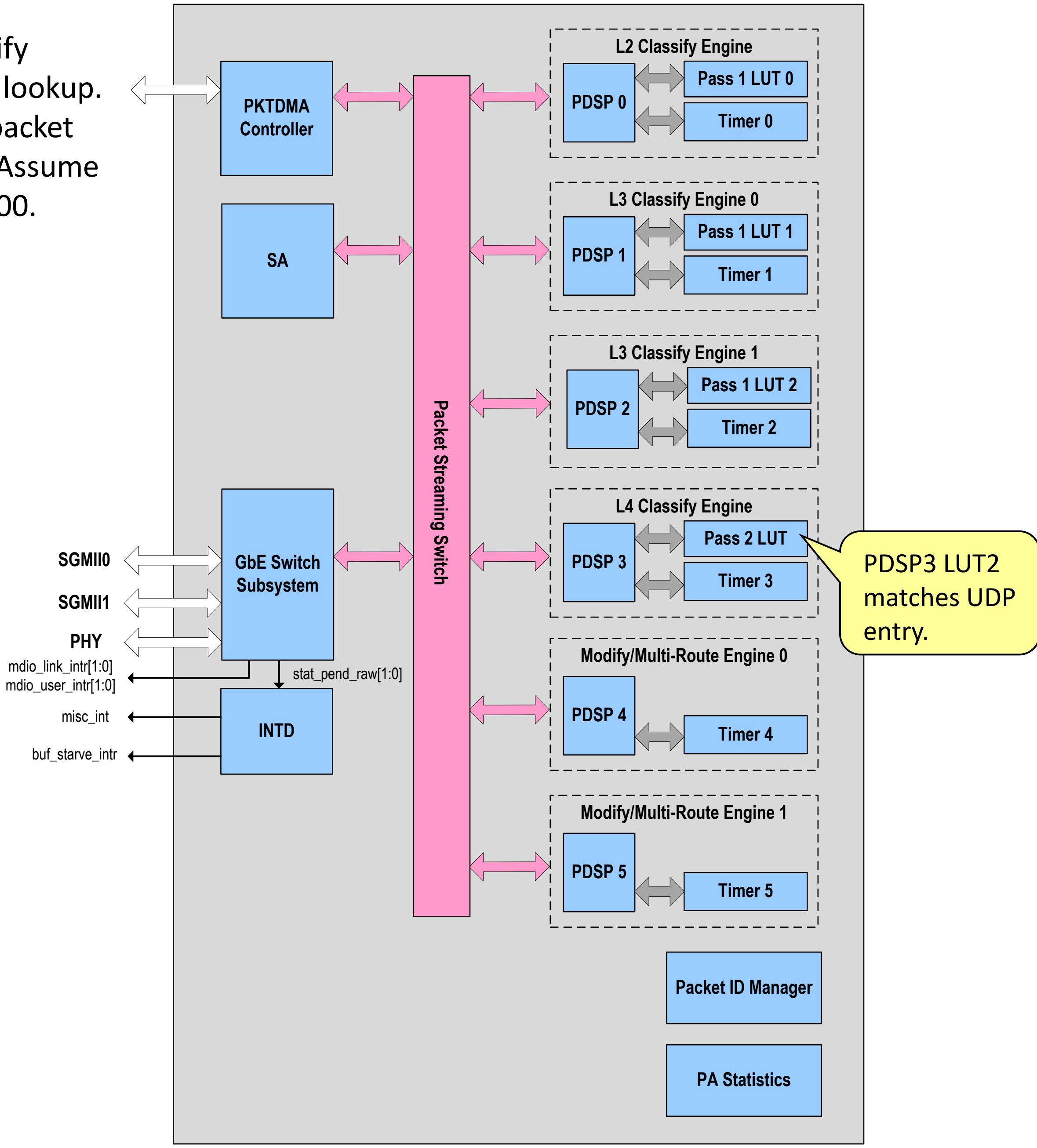
Q645: PDSP5

Q646: SA0

Q647: SA1

Q648: GbE SW

Q900: RXQUEUE



PA Rx Hardware Processing

Step 5: The packet is routed from the L4 Classify Engine, through the packet streaming switch to the PKTDMA controller. The PKTDMA will then transfer the packet from the NETCP to host queue 900.

Q640: PDSP0

Q641: PDSP1

Q642: PDSP2

Q643: PDSP3

Q644: PDSP4

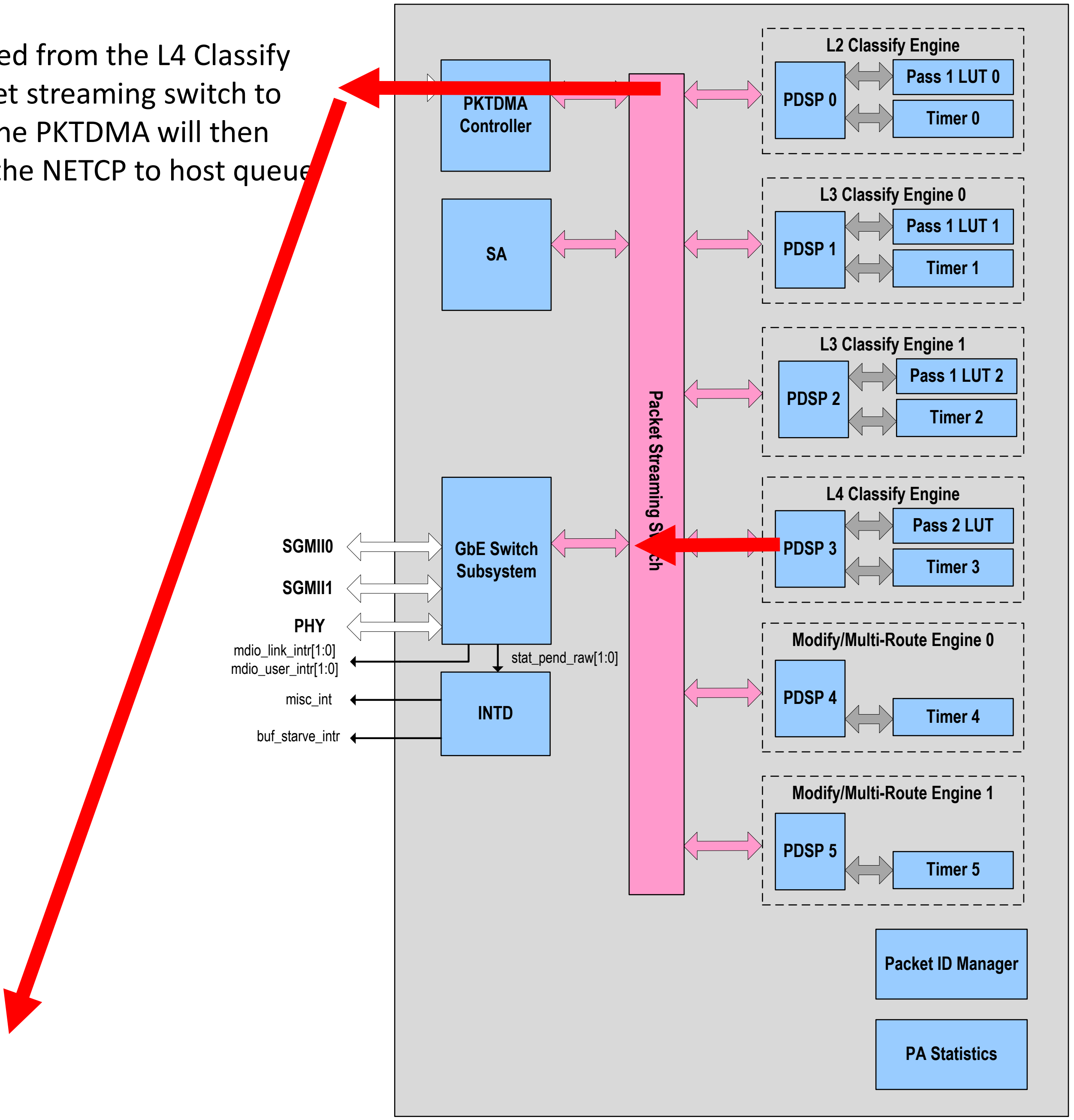
Q645: PDSP5

Q646: SA0

Q647: SA1

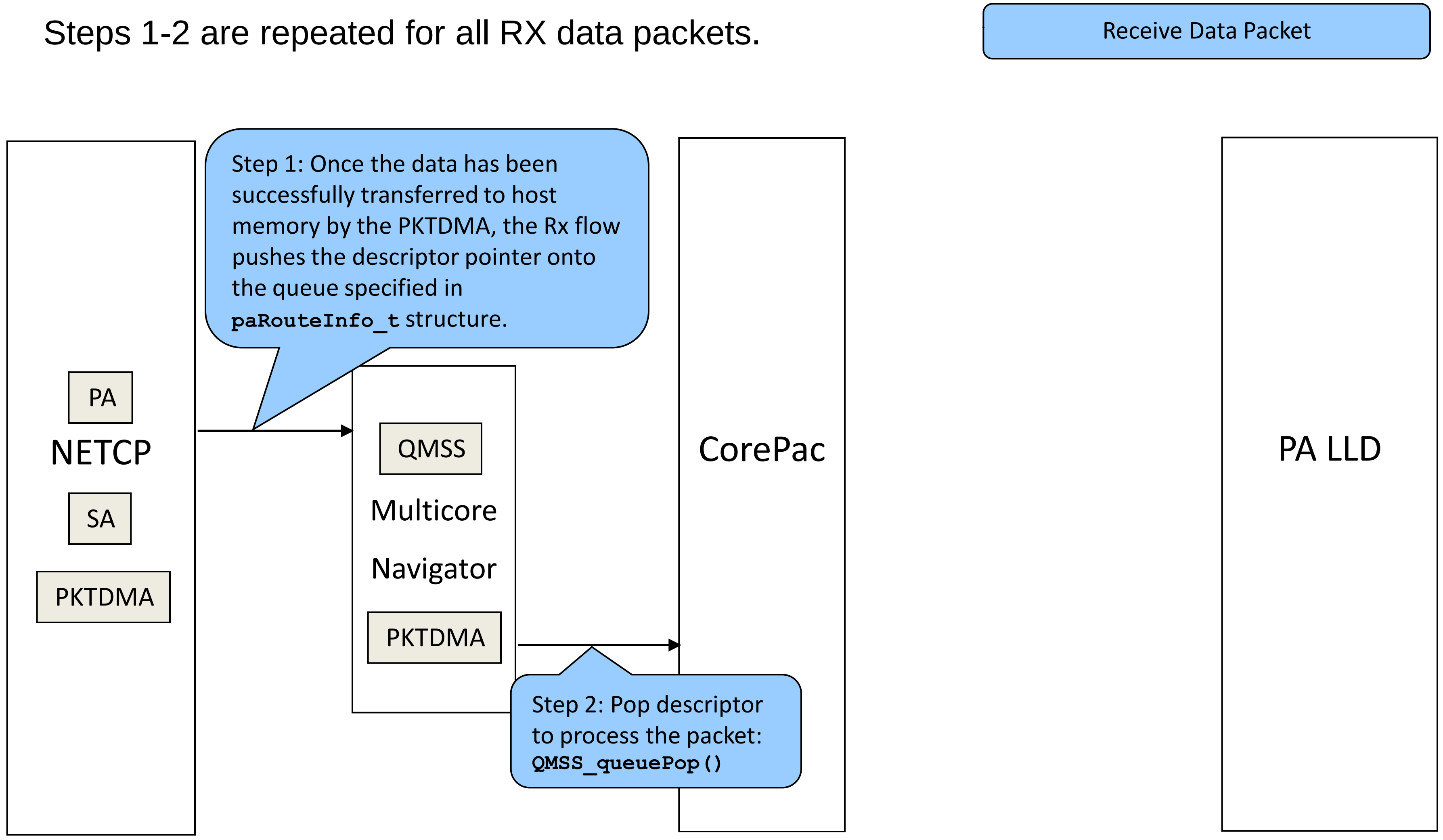
Q648: GbE SW

Q900: RXQUEUE



PA LLD: Receive Packets from Ethernet

Steps 1-2 are repeated for all RX data packets.

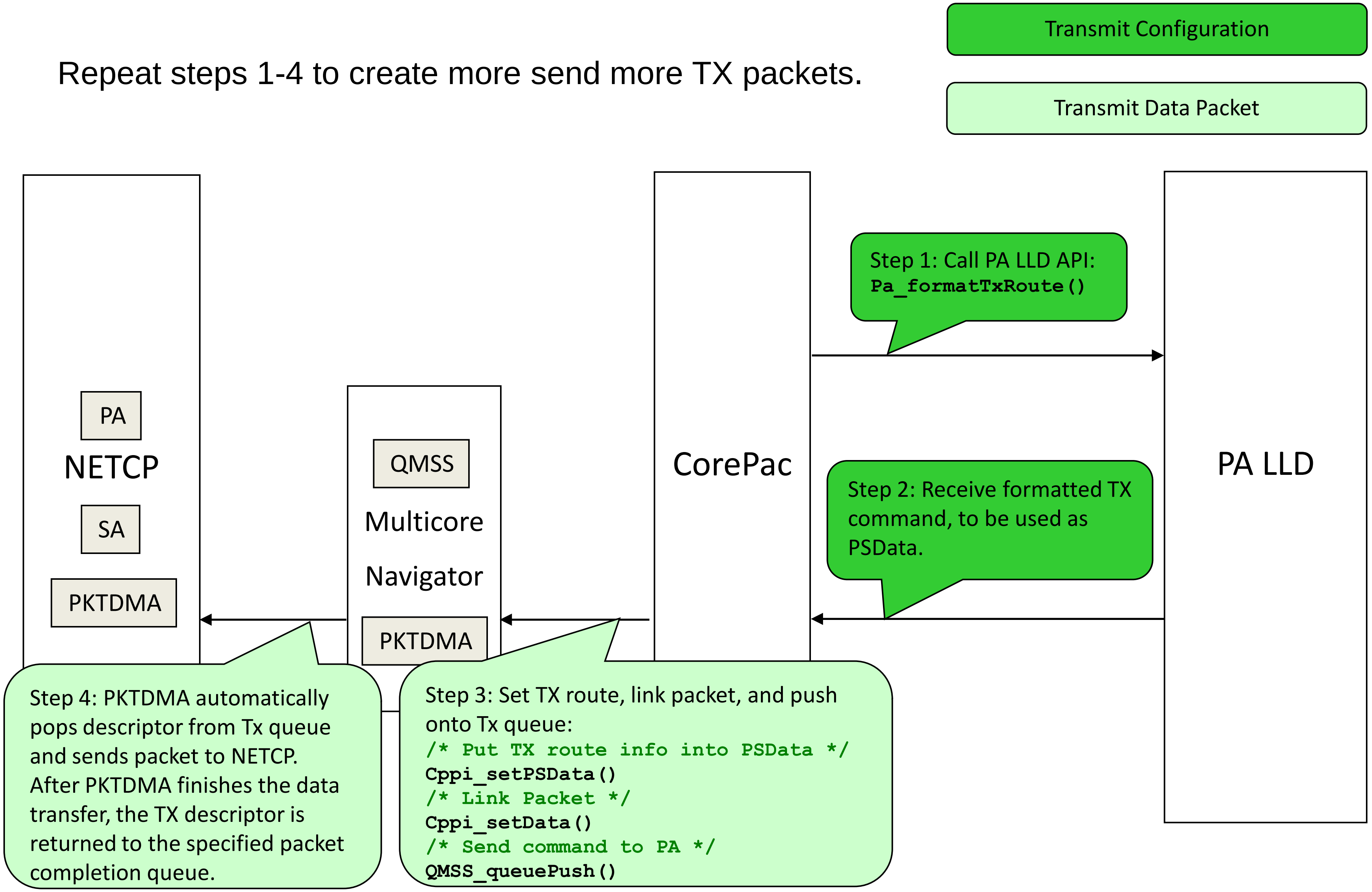


Step 1: Once the data has been successfully transferred to host memory by the PKTDMA, the Rx flow pushes the descriptor pointer onto the queue specified in `paRouteInfo_t` structure.

Step 2: Pop descriptor to process the packet: `QMSS_queuePop()`

PA LLD: Send Transmit Packet

Repeat steps 1-4 to create more send more TX packets.



Step 1: Call PA LLD API: **Pa_formatTxRoute()**

Step 2: Receive formatted TX command, to be used as PSData.

Step 3: Set TX route, link packet, and push onto Tx queue:

```
/* Put TX route info into PSData */
Cppi_setPSData()
/* Link Packet */
Cppi_setData()
/* Send command to PA */
QMSS_queuePush()
```

Step 4: PKTDMA automatically pops descriptor from Tx queue and sends packet to NETCP. After PKTDMA finishes the data transfer, the TX descriptor is returned to the specified packet completion queue.

PA Tx Hardware Processing

Step 1: A packet is placed in the Tx queue for PDSP4. The PKTDMA transfers the packet to the Modify/Multi-route Engine 0.

Q640: PDSP0

Q641: PDSP1

Q642: PDSP2

Q643: PDSP3

Q644: PDSP4

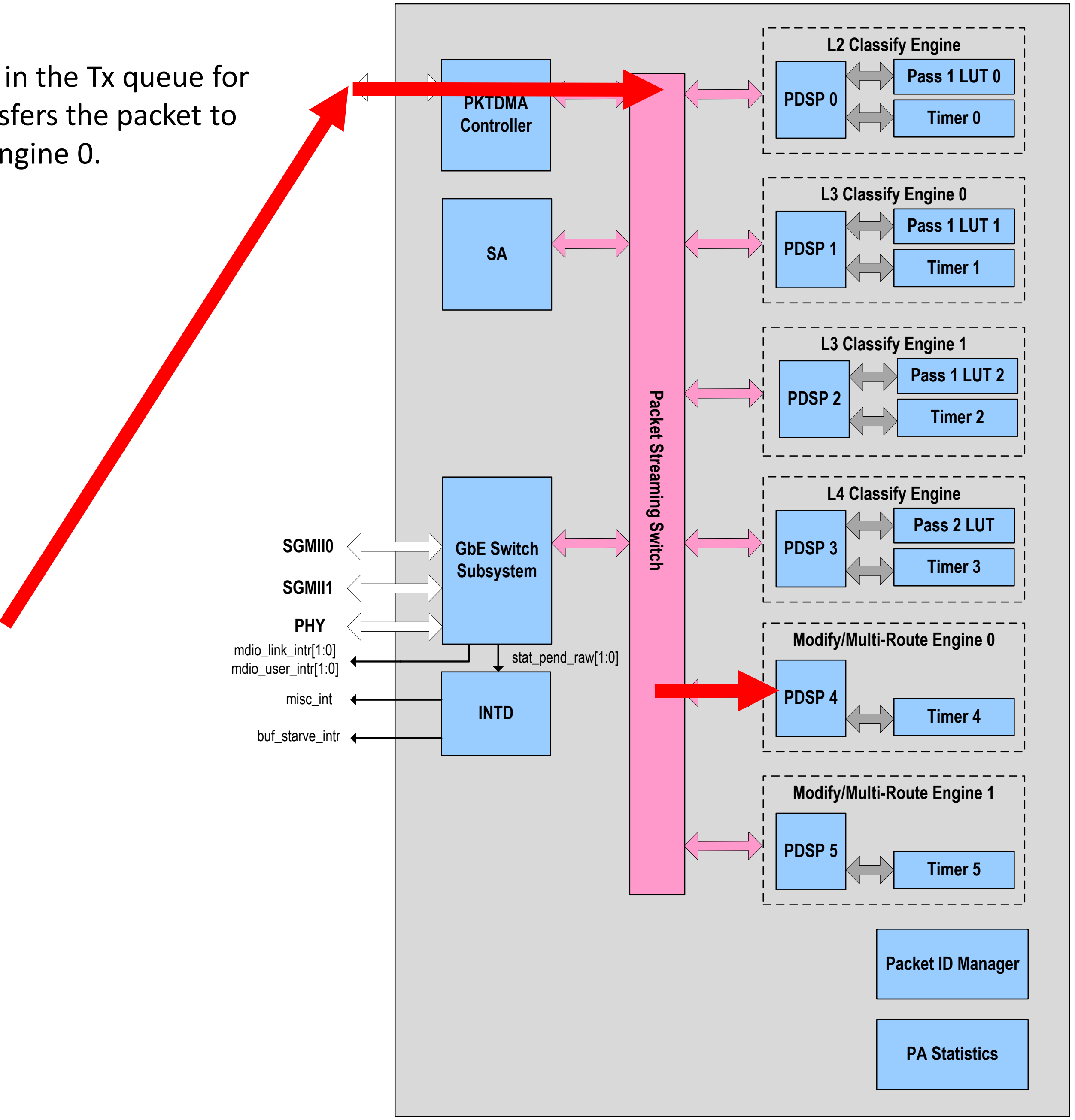
Q645: PDSP5

Q646: SA0

Q647: SA1

Q648: GbE SW

Q900: RXQUEUE



PA TX Hardware Processing Example

Step 2: PDSP4 generates the checksums, writes them to the packet, and transmits the packet to the queue for the GbE switch via the PKTDMA.

Q640: PDSP0

Q641: PDSP1

Q642: PDSP2

Q643: PDSP3

Q644: PDSP4

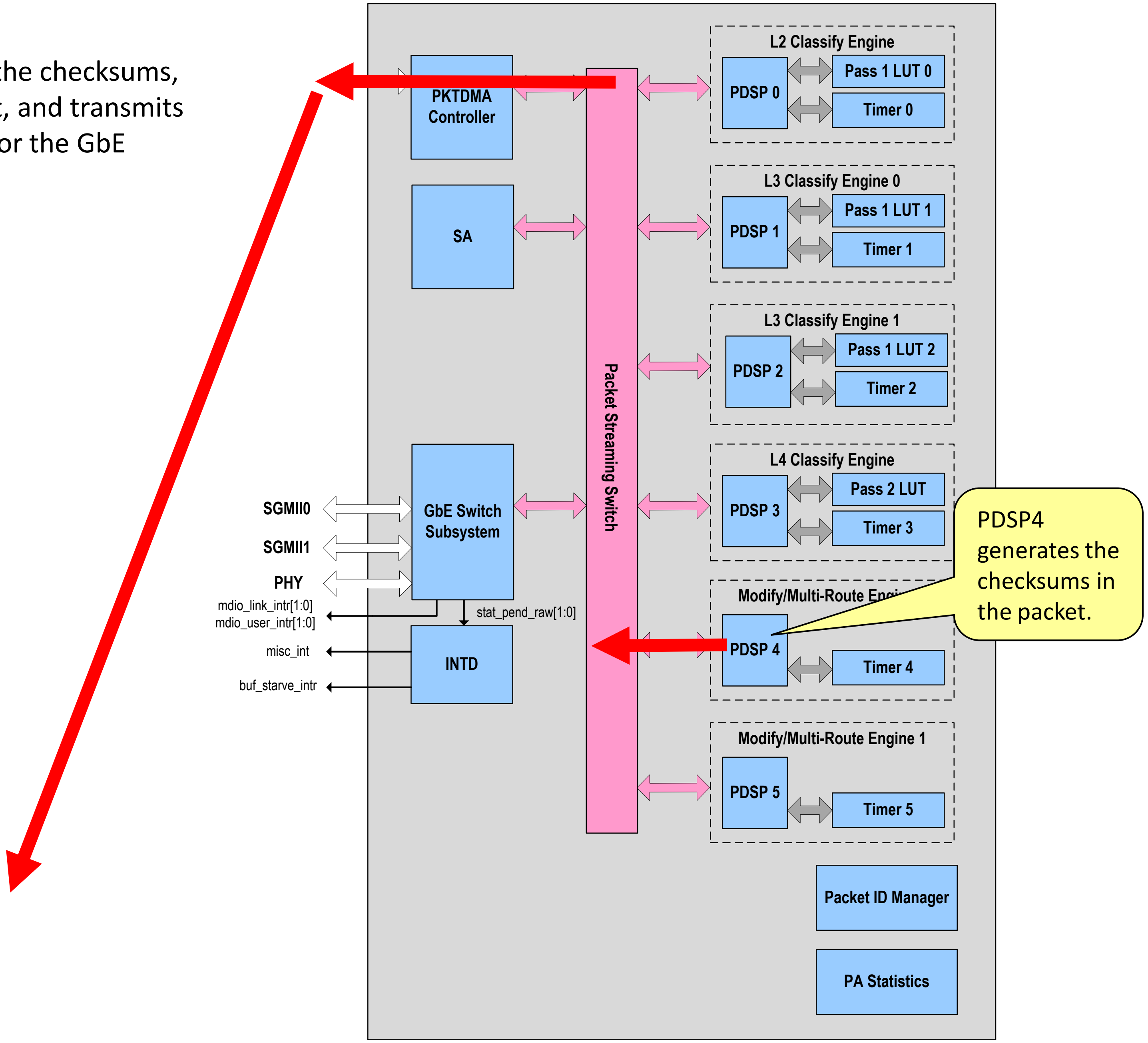
Q645: PDSP5

Q646: SA0

Q647: SA1

Q648: GbE SW

Q900: RXQUEUE



PA TX Hardware Processing Example

Step 3: The PKTDMA will transfer the packet from the GbE switch transmit queue through the PKTDMA controller and the packet streaming switch in the NETCP to the GbE switch subsystem for transmission over the network.

Q640: PDSP0

Q641: PDSP1

Q642: PDSP2

Q643: PDSP3

Q644: PDSP4

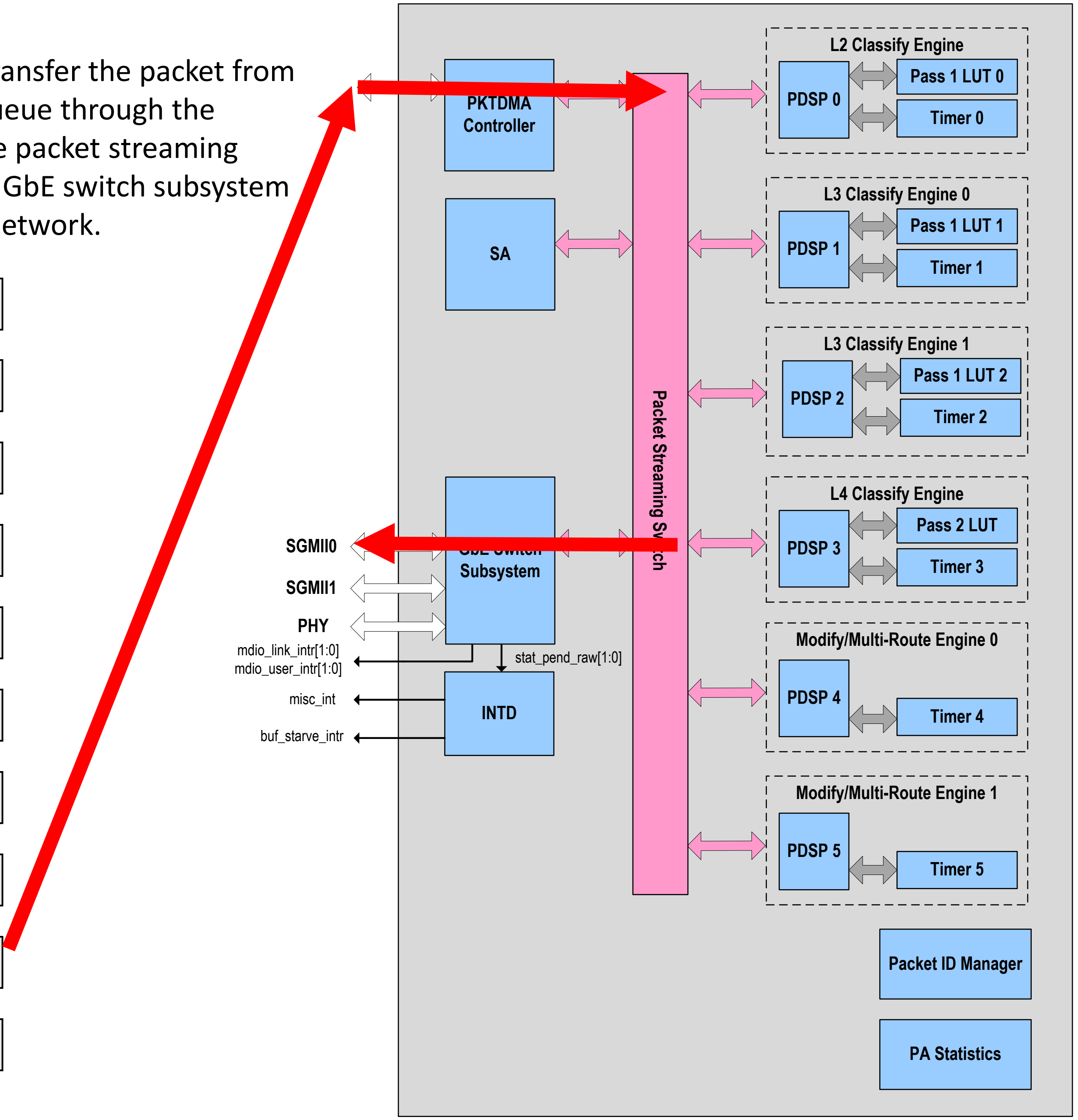
Q645: PDSP5

Q646: SA0

Q647: SA1

Q648: GbE SW

Q900: RXQUEUE



For More Information

- For more information, refer to the following KeyStone device documents:
  - Network Coprocessor (NETCP) User Guide http://www.ti.com/lit/ SPRUGZ6
  - Packet Accelerator (SA) User Guide http://www.ti.com/lit/ SPRUGS4
- For questions regarding topics covered in this training, visit the support forums at the TI E2E Community website.