FAP Traffic Management Operation Guide

CPE-AN400-R

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Revision History

Revision	*Date*	*Change Description*
CPE-AN400-R	1/9/14	Initial release

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About This Document

Purpose and Audience

This document describes the FAP Traffic Manager implementation and APIs. It is aimed for software engineers developing software for the BCM6361, BCM63168, BCM6828, and BCM6818G device families.

Acronyms and Abbreviations

In most cases, acronyms and abbreviations are defined on first use.

For a comprehensive list of acronyms and other terms used in Broadcom documents, go to: http://www.broadcom.com/press/glossary.php.

Document Conventions

The following conventions may be used in this document:

Convention	*Description*
Bold	User input and actions: for example, type **exit**, click **OK,** press **Alt+C**
`Monospace`	Code: `#include <iostream>` HTML: `<td rowspan = 3>` Command line commands and parameters: `wl [-l] <command>`
< >	Placeholders for *required* elements: enter your <username> or `wl <command>`
[ ]	Indicates *optional* command-line parameters: `wl [-l]` Indicates bit and byte ranges (inclusive): [0:3] or [7:0]

Technical Support

Broadcom provides customer access to a wide range of information, including technical documentation, schematic diagrams, product bill of materials, PCB layout information, and software updates through its customer support portal (https://support.broadcom.com). For a CSP account, contact your Sales or Engineering support representative.

In addition, Broadcom provides other product support through its Downloads and Support site (http://www.broadcom.com/support/).

FAP Traffic Manager Overview

The FAP Traffic Manager (FAP TM) provides configurable schedulers (queuing, arbitration and shaping capabilities) for the Ethernet Ports in the BCM6361, BCM63168, BCM6828, and BCM6818G device families. The FAP TM schedulers benefit from the FAP hardware accelerators, adding only a small packet processing overhead.

Any Ethernet port can be configured either as a LAN port or as a WAN port, but only a single WAN port is supported by the FAP TM. Hence, once the WAN port has been defined, all other ports should be configured as LAN ports. Both LAN ports and WAN ports have the same scheduling and queuing capabilities, except for the number of queues.

LAN Ports

- Four Queues
- One Minimum Rate Shaper per queue
- One Maximum Rate Shaper per queue
- 1 or 2-Tier arbitration: SP, WFQ, RR, WRR, SP+WRR
- One Port Rate shaper

WAN Port

- Eight Queues
- One Minimum Rate Shaper per queue
- One Maximum Rate Shaper per queue
- 1 or 2-Tier arbitration: SP, WFQ, RR, WRR, SP+WRR
- One Port Rate shaper

Statistics (LAN and WAN ports)

- Per-queue Instantaneous/Current Rate in bits per second
- Per-queue Instantaneous Level (utilization)
  - Number of packets currently stored in a queue
- Per-queue Packet Counter
- Per-queue Packet Drop Counter

The FAP TM queues are implemented in DDR memory, so a large number of packets can be stored in each queue, where the only constraint is the size of the DDR memory. The standard depth is set to 512 packets per queue.

The port rate shaper determines the maximum overall rate that will be transmitted to the corresponding Ethernet port. Each queue supports a minimum rate shaper and a maximum rate shaper. The minimum queue rates have precedence over the maximum queue rates among queues of a given port. The minimum queue rates are guaranteed as long as the sum of the minimum queue rates is smaller than or equal to the port's maximum rate. When the sum of the minimum queue rates is smaller than the port's rate, the remaining bandwidth (after satisfying the minimum rate of each queue) is distributed amongst the queues based on the configured port arbitration scheme (SP, WRR, etc), and is capped at the maximum rate configured to each queue.

The shapers are implemented as Token Buckets, and, in addition to the rate, support a Maximum Burst Size (MBS) setting specified in bytes. The MBS specifies the amount of bytes that are allowed to be transmitted above the configured shaper rate when the input rate exceeds the configured shaper's rate. Once the MBS is achieved, no bursts will be allowed until the input bit rate becomes lower than the shaper bit rate.

Since the WAN scheduler supports more queues than the switch (on a per-port basis) for most devices, a configurable mapping from each FAP TM queue to a Switch TX Queue is provided. This also allows more complex scheduling schemes to be implemented by the FAP TM than the switch is capable of, where all TM queues would be mapped to a single Switch queue, or each TM queue could be mapped to a specific Switch queue.

FAP TM Management

The FAP Driver maintains two sets of configuration parameters for the FAP TM schedulers, one for the Automatic (AUTO) mode, and another for the Manual mode.

The AUTO mode settings are managed autonomously by the Ethernet driver based on the auto-negotiated PHY rates. The internal Ethernet Switch provides relatively shallow queue depths for the TX queues, which can cause packet loss in the Switch due to CPU burstiness or Traffic burstiness. The Ethernet driver uses the FAP TM schedulers solely to address the Ethernet Switch shallow queues by simply configuring the Port Rate shaper to 99% of the PHY auto-negotiated rate. By doing this, packets sent to the switch ports by either the Host CPU or the FAP will always be at a slight lower rate than the target Ethernet port. The FAP TM also implements low bursting rate shapers, which also contributes to avoiding packet drops inside the switch.

The MANUAL settings allow the user to configure the FAP TM schedulers without affecting the AUTO settings, and vice-versa.

The operation mode can be set dynamically on a per-port basis between AUTO and MANUAL, without affecting each mode's settings. Changing the mode will not apply the corresponding settings into the FAP. The settings corresponding to the current mode will only take effect once explicitly applied to the FAP(s) via a dedicated API. This allows the API user to have a complete configuration before activating it to the FAP(s).

FAP TM Queues and Switch Queues

Since the FAP TM provides more queues than the Switch as well as more elaborate schedulers, there is a user configurable table that allows mapping FAP TM Queues to Switch Queues (see "Queue Mapping" on page 14 and "Show Queue Mappings" on page 15.

The queue mapping feature also allows the user to fine tune the Switch QoS configuration. For instance, for prioritizing WAN-to-LAN traffic over LAN-to-LAN traffic, the user could map the FAP TM Queues of a given port to Switch Queue 1 (or use more than one high priority Switch Queue), and all LAN-to-LAN traffic classified by the Switch to Switch Queue 0.

By default, all FAP TM Queues are mapped to Switch Queue 0.

Switch Ports and Linux Interfaces

The FAP TM driver API and MIPS 4ke firmware were specified based on Switch Ports numbers, as this is how the FAPs see the system. However, the mapping of Linux® Interfaces to Switch Ports can be different between Broadcom devices and reference boards.

For instance, the eth4 Linux Interface will be mapped to the Switch Port number 4 in some devices, while the same eth4 Linux Interface will be mapped to Switch Port number 6 in other devices. In order to simplify the usage of the FAP TM API, both the user space FAP TM dynamic library and the FAP TM CLI were implemented based on Linux Interfaces, abstracting the Linux Interface to Switch Port mappings from the user.

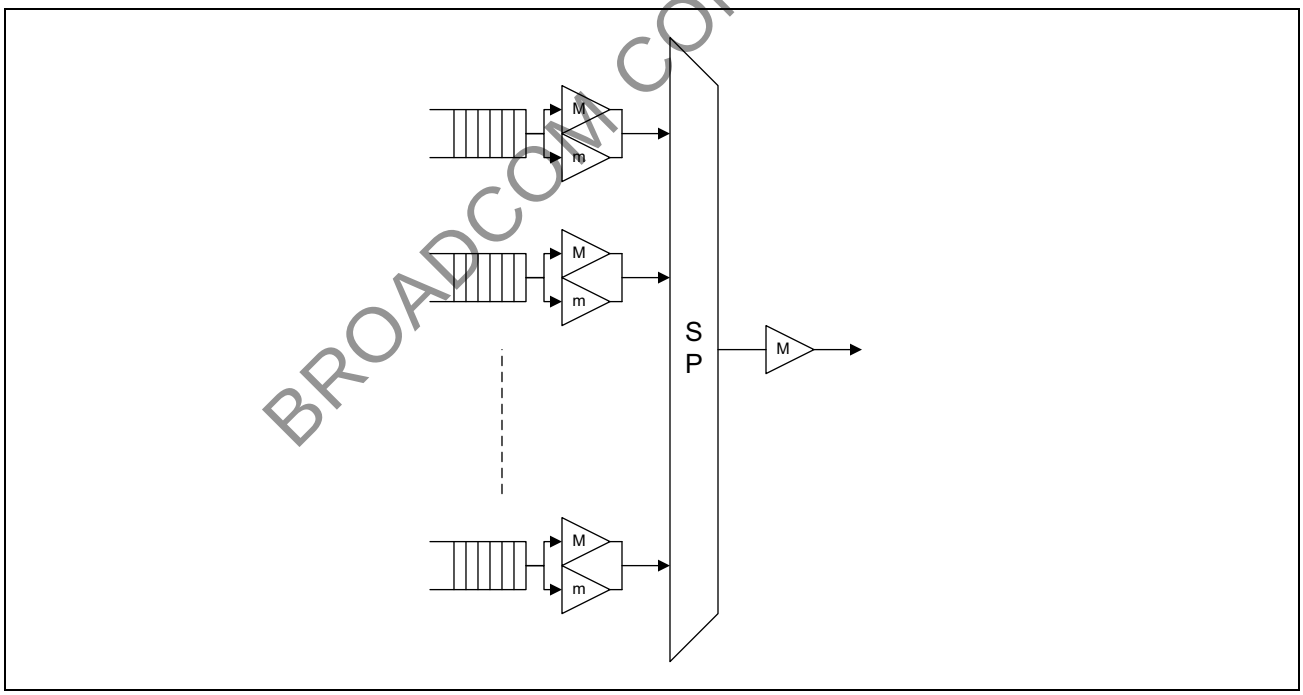
Arbitration Modes

The FAP TM supports five arbitration modes: SP, WRR, SP+WRR, WFQ, and RR.

Strict Priority

In Strict Priority (SP) mode all queues are connected to a single-tier Strict Priority arbiter (see Figure 1). Per port maximum shaping (M), and per queue minimum (m) and maximum (M) shaping is supported.

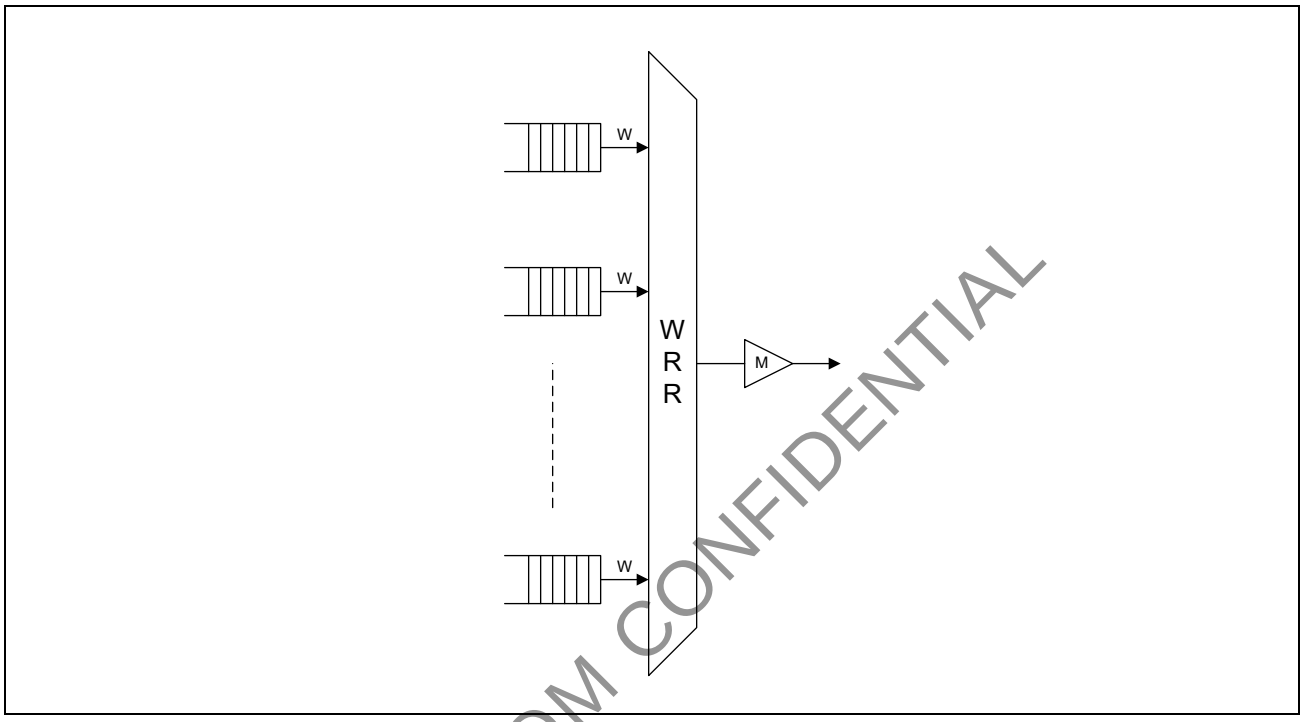
Figure 1: SP Arbiter



Weighted Round-Robin

In Weighted Round-Robin (WRR) mode all queues are connected to a single-tier Weighted Round-Robin arbiter (see Figure 2). Per port maximum shaping (M), and per queue weight is supported. Note that per queue shaping is disabled in this mode.

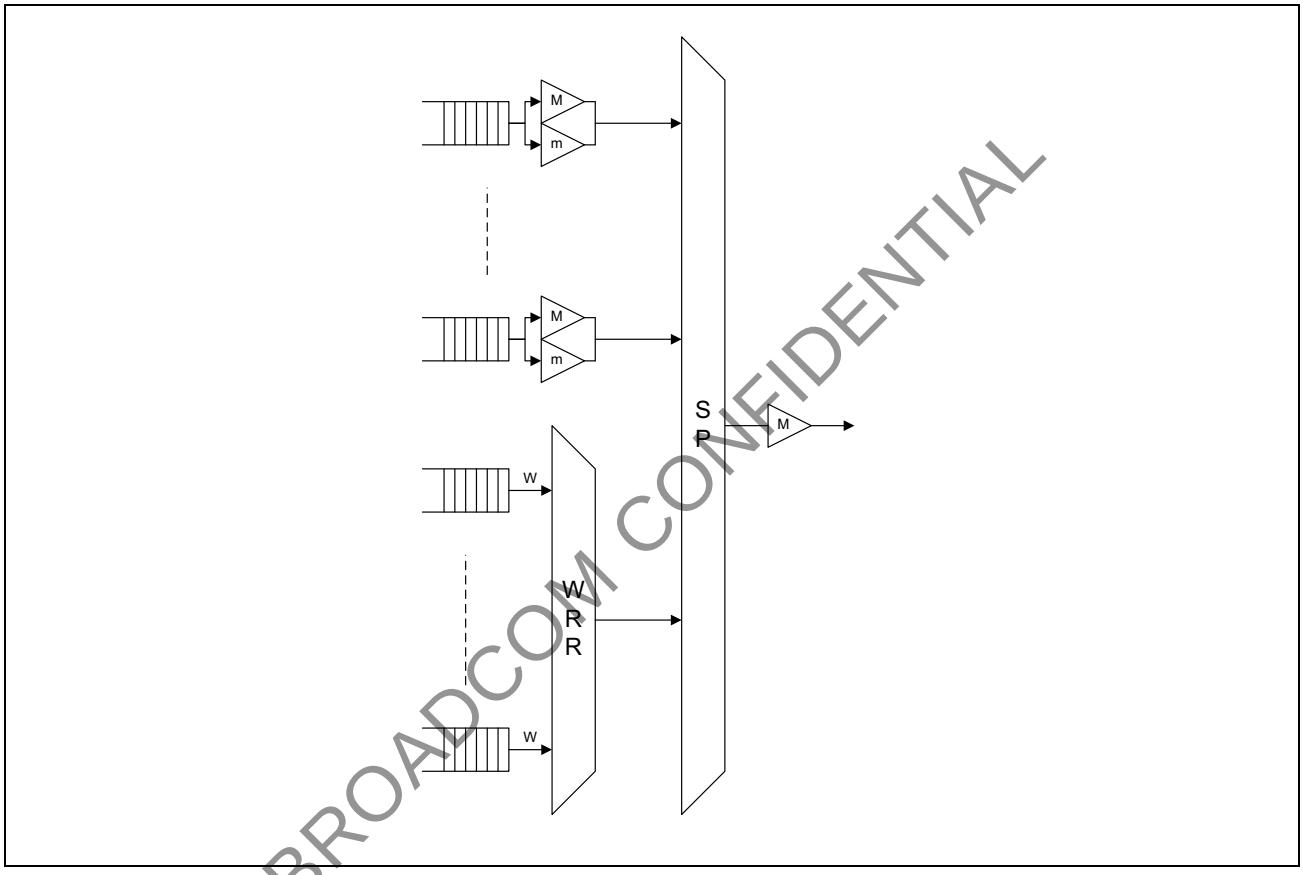
Figure 2: WRR Arbiter



Strict Priority + Weighted Round-Robin

In Strict Priority + Weighted Round-Robin (SP+WRR) mode, a configurable number of queues are connected directly to the Tier 1 Strict priority arbiter, while the remaining queues are connected to the Tier 2 Weighted Round-Robin arbiter (see Figure 3). On the SP arbiter, per port maximum shaping (M), and per queue minimum (m) and maximum (M) shaping is supported. On the WRR arbiter, only per queue weight is supported. The SP arbiter schedules the WRR arbiter as the lowest priority queue. Hence, all queues mapped to the WRR arbiter will have lower priority than the queues mapped to the SP arbiter.

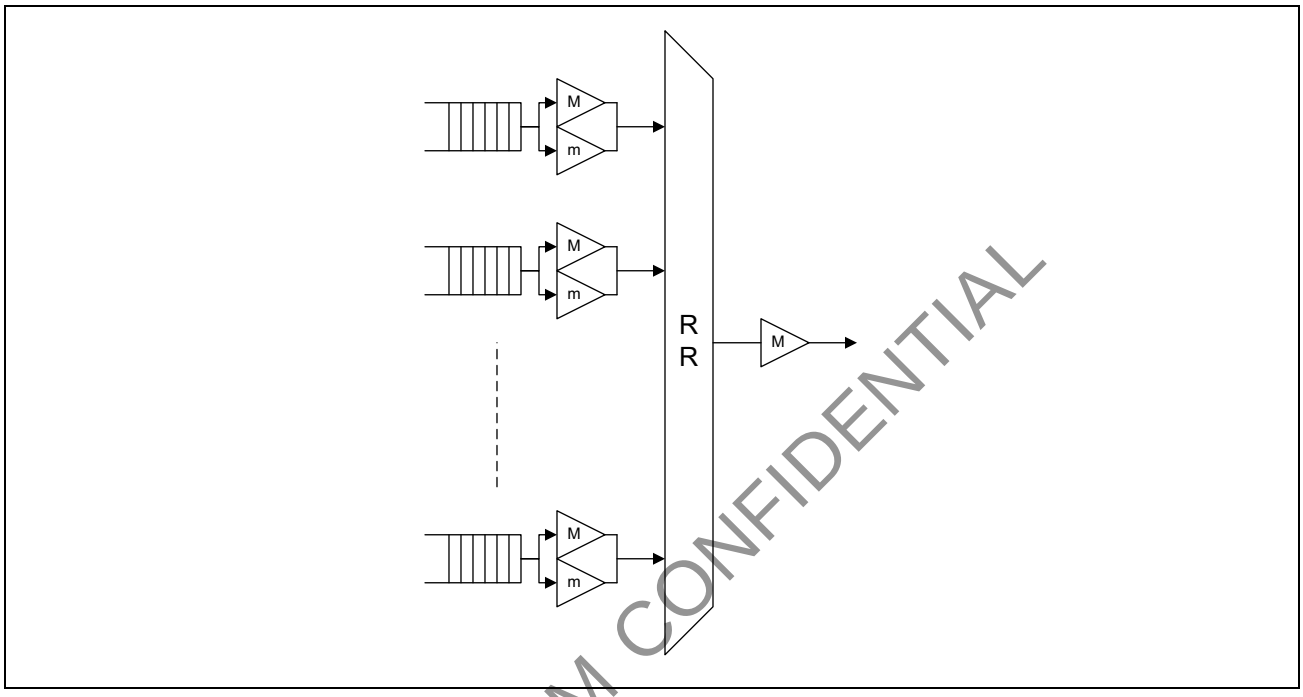
Figure 3: SP+WRR Arbiter



Weighted Fair Queuing

In Weighted Fair Queuing (WFQ) mode all queues are connected to a single-tier Round-Robin arbiter (see Figure 4). Per port maximum shaping (M) is supported. The per queue minimum (m) and maximum (M) shapers are used to implement the rate distribution amongst the queues.

Figure 4: WFQ Arbiter



Round-Robin

Round-Robin (RR) arbitration is achieved by configuring the WFQ arbiter with all minimum queue shapers to zero, and all maximum queue shapers to the port shaper rate, effectively bypassing the queue shapers and relying on the Round-Robin scheduler to service the queues.

FAP TM CLI

The FAP TM CLI provides complete access to the management API provided by the FAP TM driver. The FAP TM CLI is implemented on top of the FAP TM dynamic library (libfapctl.so), which can be used directly by user space applications to gain full control of the FAP TM functionality (e.g., Broadcom's TR-98 implementation).

Forwarding Assist Processor (FAP) Control Utility:

```
::::::  Usage  ::::::

fapctl tm [ --stats (--if <ifName>) ]
   [ --status ]
   [ --maps ]
   [ --on ]
   [ --off ]
   [ --ifcfg --if <ifName> [--auto | --manual] --kbps <kbps> --mbs <bytes> (--rate | --ratio) ]
   [ --mode --if <ifName> [--auto | --manual] ]
   [ --type --if <ifName> [--lan | --wan] ]
   [ --reset --if <ifName> [--auto | --manual] ]
   [ --enable --if <ifName> [--auto | --manual] ]
   [ --disable --if <ifName> [--auto | --manual] ]
   [ --apply --if <ifName> ]
   [ --queuecfg --if <ifName> [--auto | --manual] --queue <queue> [--min | --max] --kbps <kbps> --
   mbs <bytes> ]
   [ --queueweight --if <ifName> [--auto | --manual] --queue <queue> --weight <weight> ]
   [ --arbitercfg --if <ifName> [--auto | --manual] [--sp | --wrr | --spwrr | --wfq ] (--lowprioq) ]
   [ --tmq2swq --if <ifName> --queue <queue> --swqueue <queue> ]
```

Global Enable/Disable

The global enable/disable API (fap tm --on / --off) allows all schedulers to be enabled or disabled in a single command. When the global disable command is issued, packets currently enqueued will be forwarded as configured, but new packets will bypass the TM queues and will be forwarded promptly. Hence, until the TM queues are flushed, out-of-order can occur.

Existing configurations will not be lost on a global disable command, and will be re-applied automatically when the global enable command is issued.

```
# fap tm --on
# fap tm --off
```

Port Shaping Configuration

This API configures the port parameters of a given mode (AUTO or MANUAL). It allows setting the port Shaper Rate (in Kbps), the port MBS (in bytes), and the queue shaping configuration mode. The supported queue shaping modes are:

- Rate Based: `--rate` CLI option

  The minimum and maximum shaper values are explicitly configured by the user (see "Queue Shaping Configuration" on page 14).

- Ratio Based: `--ratio` CLI option

  In this mode, the FAP TM driver autonomously configures the shapers of all queues associated to the port. The minimum shaper of each queue is calculated based on the queue weight values configured by the user and the port shaper rate. For instance, if a LAN port shaper is configured to 100 Mbps and its queue weights are configured as 20, 40, 60, and 80, the minimum shaper configurations assigned by the FAP TM driver would be 10 Mbps, 20 Mbps, 30 Mbps and 40 Mbps, respectively. The maximum shaper of each queue is effectively disabled, being configured to the port shaper rate.

- Disabled: omit CLI option

  In this mode, queue shaping is disabled. The FAP driver sets all queue minimum shapers to zero, and all queue maximum shapers to the configured port shaper rate.

The configuration will only take place once explicitly applied to the FAPs.

```
fap tm --ifcfg --if <ifName> [--auto | --manual] --kbps <kbps> --mbs <bytes> (--rate | --ratio)
```

Port Mode Selection

This API selects the current mode (AUTO or MANUAL) of the given port. The current mode indicates which configuration set to use when applied to the FAPs (AUTO or MANUAL).

```
fap tm --mode --if <ifName> [--auto | --manual]
```

Port Type Selection

This API selects the type of the given port (LAN or WAN). The configuration will only take place once explicitly applied to the FAPs.

```
fap tm --type --if <ifName> [--lan | --wan]
```

Mode Reset

This API resets the configuration of the given port and mode to the default values. Once reset, the given mode can only be applied to the FAPs when re-configured.

```
fap tm --reset --if <ifName> [--auto | --manual]
```

Port Enable/Disable

```
This API updates the state of the given port and mode (enabled or disabled). The configuration
will only take place once explicitly applied to the FAPs.

fap tm --enable --if <ifName> [--auto | --manual]
fap tm --disable --if <ifName> [--auto | --manual]
```

Queue Shaping Configuration

This API configures the queue shaping parameters of a given port and mode (AUTO or MANUAL). It allows setting the queue Minimum or Maximum Shaper Rate (in Kbps) and MBS (in bytes). The configuration will only take place once explicitly applied to the FAPs.

```
fap tm --queuecfg --if <ifName> [--auto | --manual] --queue <queue> [--min | --max] --kbps <kbps>
--mbs <bytes>
```

Queue Weight Configuration

This API configures the queue weight of a given port and mode (AUTO or MANUAL). The configuration will only take place once explicitly applied to the FAPs. The minimum allowed weight is 1, and the maximum allowed weight is 255.

```
fap tm --queueweight --if <ifName> [--auto | --manual] --queue <queue> --weight <weight>
```

Arbiter Configuration

This API configures the arbitration method a given port and mode (AUTO or MANUAL). The configuration will only take place once explicitly applied to the FAPs. The --lowprioq parameter is only required for the SP+WRR method (--spwrr), where it indicates the lowest priority queue connected to the Tier 1 SP arbiter. All other queues lower than --lowprioq are connected to the Tier 2 WRR arbiter.

```
fap tm --arbitercfg --if <ifName> [--auto | --manual] [--sp | --wrr | --spwrr | --wfq ] (--
lowprioq)
```

Apply

This API applies the configuration corresponding to the current mode of the given port to the FAP(s).

```
fap tm --apply --if <ifName>
```

Queue Mapping

This API maps a TM Queue (--queue) of the given port to a Switch Queue (--swqueue).

```
fap tm --tmq2swq --if <ifName> --queue <queue> --swqueue <queue>
```

Show Queue Mappings

This API dumps to the console the current TM Queue to Switch Queue mappings for all enabled ports.

```
fap tm --maps
```

Statistics

The statistics API dumps to the console the statistics and debugging information of all ports that are enabled. When an interface name is specified, the API shows the statistics information about the specific port.

```
fap tm --stats (--if <ifName>)
```

Status

The status API dumps to the console the scheduler type (LAN or WAN), the current selected mode (AUTO or MANUAL), and the AUTO and MANUAL mode configurations for all enabled ports. It also displays the Instantaneous Bandwidth measurements of each queue.

```
fap tm --status
```

Configuration Example

This example shows the configuration of port 4's MANUAL mode settings and associated queues.

- Configure the port shaper to 100 Mbps, in queue rate shaping mode

```
fap tm --ifcfg --if eth4 --manual --kbps 100000 --mbs 2000 --rate

Configure the Minimum and Maximum Shapers of queues 7 to 2

fap tm --queuecfg --if eth4 --manual --queue 7 --min --kbps 10000 --mbs 3000
fap tm --queuecfg --if eth4 --manual --queue 7 --max --kbps 20000 --mbs 3000

fap tm --queuecfg --if eth4 --manual --queue 6 --min --kbps 10000 --mbs 3000
fap tm --queuecfg --if eth4 --manual --queue 6 --max --kbps 30000 --mbs 3000

fap tm --queuecfg --if eth4 --manual --queue 5 --min --kbps 10000 --mbs 3000
fap tm --queuecfg --if eth4 --manual --queue 5 --max --kbps 50000 --mbs 3000

fap tm --queuecfg --if eth4 --manual --queue 4 --min --kbps 10000 --mbs 3000
fap tm --queuecfg --if eth4 --manual --queue 4 --max --kbps 30000 --mbs 3000

fap tm --queuecfg --if eth4 --manual --queue 3 --min --kbps 10000 --mbs 3000
fap tm --queuecfg --if eth4 --manual --queue 3 --max --kbps 50000 --mbs 3000

fap tm --queuecfg --if eth4 --manual --queue 2 --min --kbps 10000 --mbs 3000
fap tm --queuecfg --if eth4 --manual --queue 2 --max --kbps 50000 --mbs 3000
```

- Select Strict Priority Scheduling

```
fap tm --arbitercfg --if eth4 --manual --sp
```

- Select MANUAL mode

```
fap tm --mode --if eth4 --manual
```

- Select WAN type scheduler

```
fap tm --type --if eth4 --wan
```

- Set the MANUAL mode state to enabled

```
fap tm --enable --if eth4 --manual
```

- Apply settings to the FAPs

```
fap tm --apply --if eth4
```

- Map TM queues to Switch Queues

```
fap tm --if eth4 --tmq2swq --queue 0 --swqueue 0
fap tm --if eth4 --tmq2swq --queue 1 --swqueue 0
fap tm --if eth4 --tmq2swq --queue 2 --swqueue 0
fap tm --if eth4 --tmq2swq --queue 3 --swqueue 0
fap tm --if eth4 --tmq2swq --queue 4 --swqueue 0
fap tm --if eth4 --tmq2swq --queue 5 --swqueue 0
fap tm --if eth4 --tmq2swq --queue 6 --swqueue 0
fap tm --if eth4 --tmq2swq --queue 7 --swqueue 0
```

- Send 50 Mbps worth of traffic to each of queues 7 to 2, then check the queue current rates

```
# fap tm --status

FAP TM Status: ON

        Port[04]: ENABLED, WAN, MANUAL, schedulerIndex 5
                     AUTO: CONFIGURED, SP (0), Kbps 990000 (tokens 49500), MBS 2000 (bucketSize
51500), qShaping DISABLED
                           Queue[0]: MIN: Kbps 0 (tokens 0), MBS 0 (size 0), Weight: 0
                                     MAX: Kbps 990000 (tokens 49500), MBS 2000 (size 51500)
                                     Rate: 0 Kbps (0 bps)
                           Queue[1]: MIN: Kbps 0 (tokens 0), MBS 0 (size 0), Weight: 0
                                     MAX: Kbps 990000 (tokens 49500), MBS 2000 (size 51500)
                                     Rate: 0 Kbps (0 bps)
                           Queue[2]: MIN: Kbps 0 (tokens 0), MBS 0 (size 0), Weight: 0
                                     MAX: Kbps 990000 (tokens 49500), MBS 2000 (size 51500)
                                     Rate: 0 Kbps (0 bps)
                           Queue[3]: MIN: Kbps 0 (tokens 0), MBS 0 (size 0), Weight: 0
                                     MAX: Kbps 990000 (tokens 49500), MBS 2000 (size 51500)
                                     Rate: 0 Kbps (0 bps)
                           Queue[4]: MIN: Kbps 0 (tokens 0), MBS 0 (size 0), Weight: 0
                                     MAX: Kbps 990000 (tokens 49500), MBS 2000 (size 51500)
                                     Rate: 0 Kbps (0 bps)
                           Queue[5]: MIN: Kbps 0 (tokens 0), MBS 0 (size 0), Weight: 0
                                     MAX: Kbps 990000 (tokens 49500), MBS 2000 (size 51500)
                                     Rate: 0 Kbps (0 bps)
                           Queue[6]: MIN: Kbps 0 (tokens 0), MBS 0 (size 0), Weight: 0
                                     MAX: Kbps 990000 (tokens 49500), MBS 2000 (size 51500)
                                     Rate: 0 Kbps (0 bps)
                           Queue[7]: MIN: Kbps 0 (tokens 0), MBS 0 (size 0), Weight: 0
                                     MAX: Kbps 990000 (tokens 49500), MBS 2000 (size 51500)
                                     Rate: 0 Kbps (0 bps)
                    MANUAL: CONFIGURED, SP (255), Kbps 100000 (tokens 5000), MBS 2000 (bucketSize
7000), qShaping RATE
                           Queue[0]: MIN: Kbps 0 (tokens 0), MBS 0 (size 0), Weight: 0
                                     MAX: Kbps 990000 (tokens 49500), MBS 2000 (size 51500)
                                     Rate: 0 Kbps (0 bps)
                           Queue[1]: MIN: Kbps 0 (tokens 0), MBS 0 (size 0), Weight: 0
                                     MAX: Kbps 990000 (tokens 49500), MBS 2000 (size 51500)
                                     Rate: 0 Kbps (0 bps)
                          Queue[2]: MIN: Kbps 10000 (tokens 500), MBS 3000 (size 3500), Weight: 0
                                     MAX: Kbps 50000 (tokens 2000), MBS 3000 (size 5000)
                                     Rate: 9997 Kbps (9997440 bps)
```

```
                        Queue[3]: MIN: Kbps 10000 (tokens 500), MBS 3000 (size 3500), Weight: 0
                                  MAX: Kbps 50000 (tokens 2000), MBS 3000 (size 5000)
                                  Rate: 9997 Kbps (9997440 bps)
                        Queue[4]: MIN: Kbps 10000 (tokens 500), MBS 3000 (size 3500), Weight: 0
                                  MAX: Kbps 30000 (tokens 1000), MBS 3000 (size 4000)
                                  Rate: 9997 Kbps (9997440 bps)
                        Queue[5]: MIN: Kbps 10000 (tokens 500), MBS 3000 (size 3500), Weight: 0
                                  MAX: Kbps 50000 (tokens 2000), MBS 3000 (size 5000)
                                  Rate: 20019 Kbps (20019264 bps)
                        Queue[6]: MIN: Kbps 10000 (tokens 500), MBS 3000 (size 3500), Weight: 0
                                  MAX: Kbps 30000 (tokens 1000), MBS 3000 (size 4000)
                                  Rate: 29992 Kbps (29992320 bps)
                        Queue[7]: MIN: Kbps 10000 (tokens 500), MBS 3000 (size 3500), Weight: 0
                                  MAX: Kbps 20000 (tokens 500), MBS 3000 (size 3500)
                                  Rate: 19994 Kbps (19994880 bps)
```

- Dump the statistics

```
# fap tm --stats --if eth4

[FAP0] FAP TM: ON

[FAP0] Port[4]: ENABLED, WAN, SP (0), Index 5, Level 3053, Tokens 5000, Bucket 540 (out of 7000)
[FAP0]          Queue[0]: Level 0, Packets 1, Dropped 0, Weight 0
                          MIN: Tokens 0, Bucket 0 (out of 0)
                          MAX: Tokens 49500, Bucket 51500 (out of 51500)
[FAP0]          Queue[1]: Level 0, Packets 0, Dropped 0, Weight 0
                          MIN: Tokens 0, Bucket 0 (out of 0)
                          MAX: Tokens 49500, Bucket 51500 (out of 51500)
[FAP0]          Queue[2]: Level 509, Packets 156157, Dropped 622106, Weight 0
                          MIN: Tokens 500, Bucket 1472 (out of 3500)
                          MAX: Tokens 2000, Bucket 5000 (out of 5000)
[FAP0]          Queue[3]: Level 509, Packets 156157, Dropped 622158, Weight 0
                          MIN: Tokens 500, Bucket 1472 (out of 3500)
                          MAX: Tokens 2000, Bucket 5000 (out of 5000)
[FAP0]          Queue[4]: Level 510, Packets 156158, Dropped 621952, Weight 0
                          MIN: Tokens 500, Bucket 1472 (out of 3500)
                          MAX: Tokens 1000, Bucket 4000 (out of 4000)
[FAP0]          Queue[5]: Level 508, Packets 311805, Dropped 466269, Weight 0
                          MIN: Tokens 500, Bucket 1472 (out of 3500)
                          MAX: Tokens 2000, Bucket 3476 (out of 5000)
[FAP0]          Queue[6]: Level 507, Packets 467449, Dropped 310867, Weight 0
                          MIN: Tokens 500, Bucket 1472 (out of 3500)
                          MAX: Tokens 1000, Bucket 904 (out of 4000)
[FAP0]          Queue[7]: Level 510, Packets 311804, Dropped 466117, Weight 0
                          MIN: Tokens 500, Bucket 1472 (out of 3500)
                          MAX: Tokens 500, Bucket 1472 (out of 3500)
[FAP0] Done
```

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