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Application Note

Pspretend

802.11 Pspretend

43XX-AN1900-R

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Revision History

Revision	*Date*	*Change Description*
43XX-AN1900-R	05/26/15	Initial release

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About This Document

Purpose and Audience

This document describes the features and usage of Pspretend (Power Save Pretend). Pspretend is an access point-specific feature that helps achieve 0% packet errors. It is intended for engineers and developers who developing Wi-Fi products.

Acronyms and Abbreviations

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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]

References

The references in this section may be used in conjunction with this document.

Note: Broadcom provides customer access to technical documentation and software through its Customer Support Portal (CSP) and Downloads and Support site (see Technical Support).

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Document (or Item) Name	***Number***	***Source***
Broadcom Items		
[1] WLAN Packet Queue Statistics (PKTQ_STATS)	*43XX-AN200x-R*	CSP

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Introduction

Pspretend stands for *Power Save Pretend*. It is an AP-specific feature, the purpose which is to help achieve 0% PER. That is, no packets lost over Wi-Fi (subject to usage conditions). Pspretend only functions on transmissions from an access point (AP) to a wireless client (STA). It works like the Wi-Fi power save feature on a STA, but the AP manages the operation.

When there is a temporary outage, for example, when STA reception is temporarily down, there is no point in sending packets from the AP that will not be received. In that case, it is better to queue them until the STA is ready to receive.

Pspretend transitions the AP to believe the STA is in power save mode (the STA is *not* in power-save mode) and makes no further attempts to send packets to the STA: they are queued instead.

When the AP receives something from the STA the system reverts to normal mode and the queued packets are transmitted.

The AP can also send probe packets at rapid intervals to detect that STA reception has resumed.

Because traffic to the unresponsive STA is suspended, AP transmit ability is not compromised and it can continue to deliver traffic to other STAs.

Pspretend and Packet Loss

Wi-Fi packet loss can occur because of momentary disturbances such as:

- Interference
- Noise
- Calibration
- Fading
- Temporary radio link impairment

When one of these situations occurs, the AP:

- Sends RTS but does not receive CTS. This is repeated until the RTS count is reached

  or
- Receives CTS, but fails to receive ACK status (hole in the block ACK). RTS continues until the retry count is reached, after which the packet fails and dropped.

When a packet fails and is dropped, the next packet is sent. If that subsequent packet is to the same STA the same problem may occur. However, if the subsequent packet to the same destination works, the previous packet loss is considered to be a momentary problem that will resolve itself.

During the time that the STA is in this false power save mode (from the access point perspective), the following happens:

1. No traffic is sent to this STA
2. Failed packet(s) are recovered and saved to the power save queue
3. New incoming traffic is buffered in the AP AMPDU queues

This happens on the first packet failure. Sometime later, the STA recovers and:

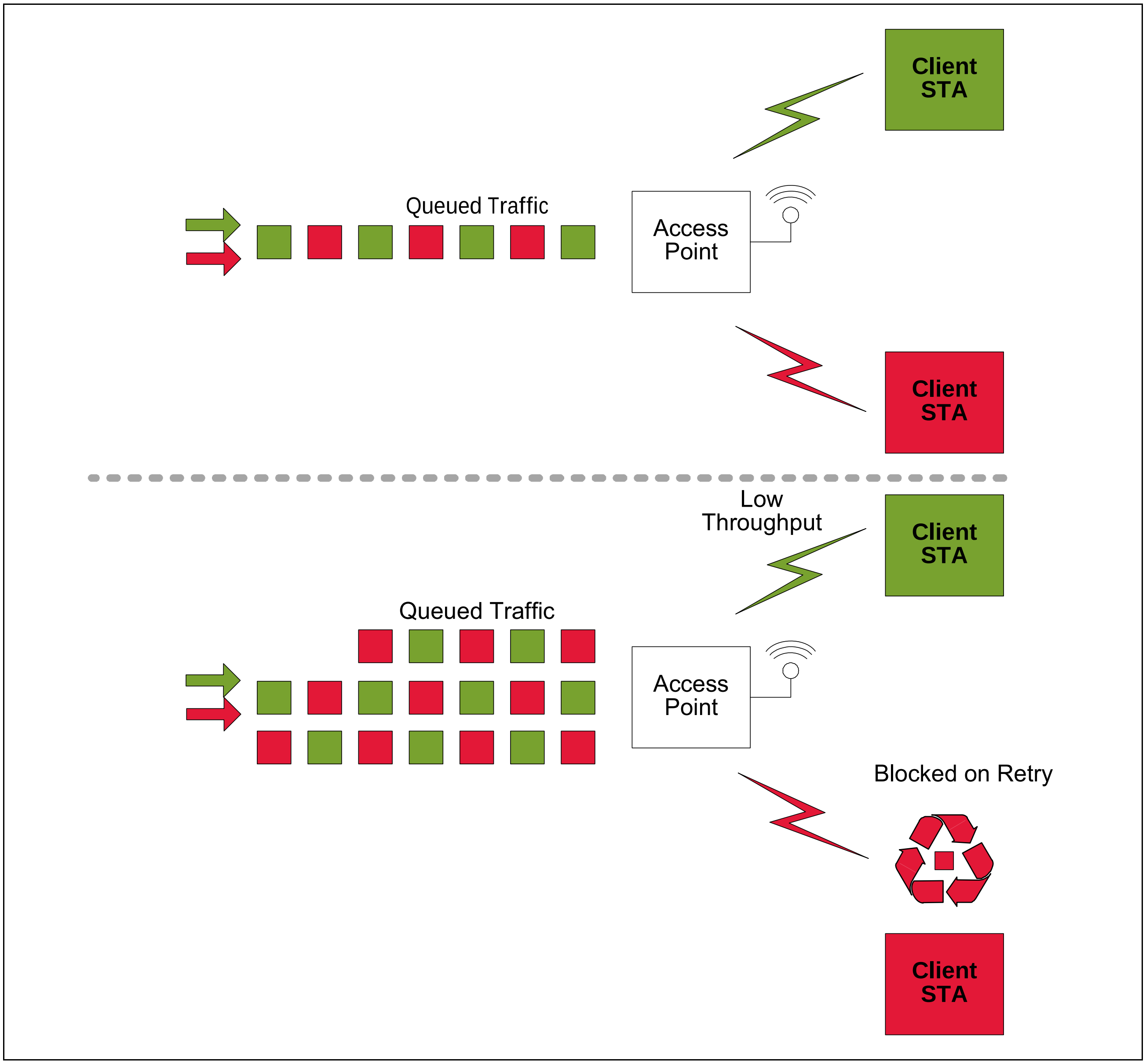
- All saved packets in the power save queue are sent
- Buffered traffic in the AMPDU queues is released

There is an interruption but traffic resumes as if nothing happened. Latency is increased as a consequence. However, that cannot be helped because the link was broken anyway.

Pspretend In Multilink Networks

Figure 1 shows a network with multiple links. When one of those links stops working the AP spends time retransmitting to that STA and the throughput of the other link(s) suffers.

Figure 1: Multilink Network with a Bad Link



Using Pspretend suspends the bad link: no further data is transmitted to it—instead, the data is queued for later transmission and the existing good link continues to work normally, unaware of the problem (Figure 3 on page 10).

When the bad link recovers the buffered traffic is sent to the front of the queue and transmitted to the formerly bad STA at maximum throughput until the queue is empty.

At that point normal operation returns for all links (Figure 3).

Figure 2: Buffering Data to be Sent to a Broken Link

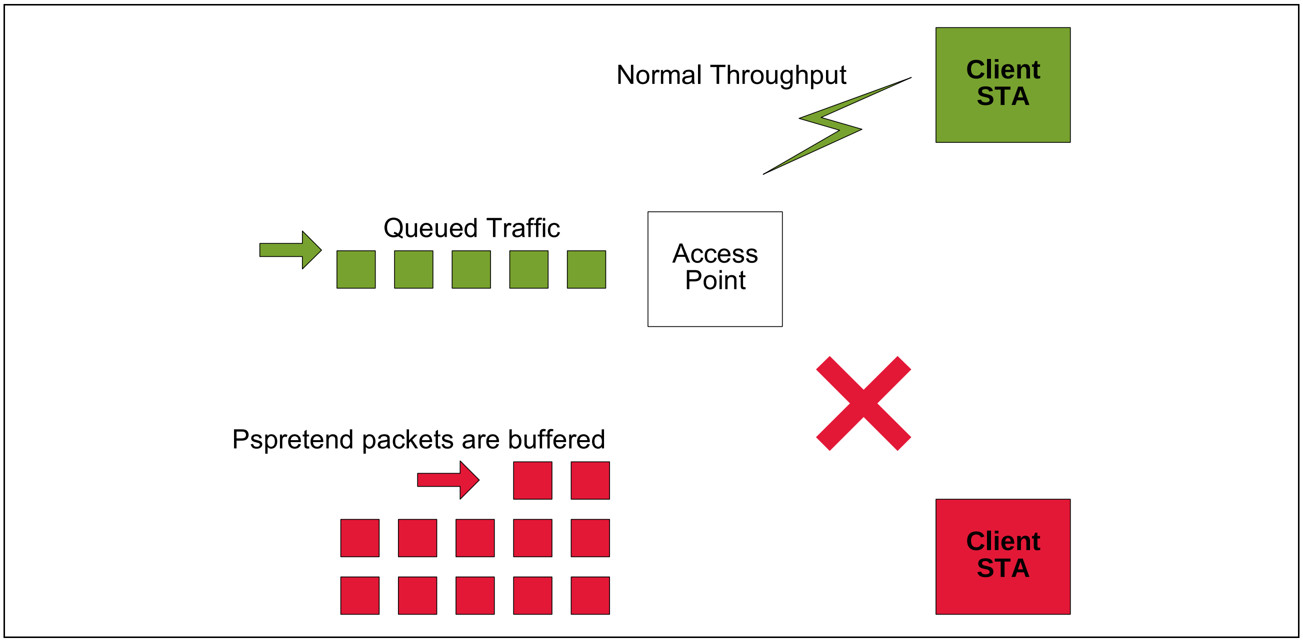
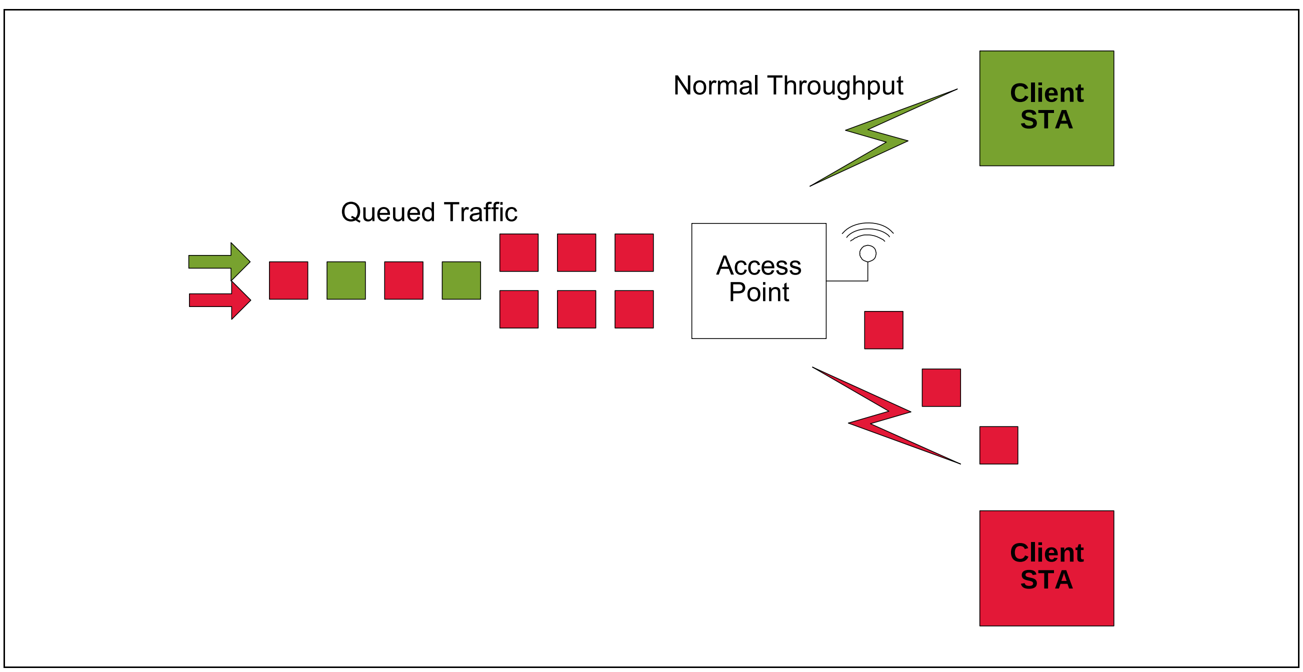


Figure 3: Link Recovered, Buffered Data Transmitted



Recovery of the Link

When Pspretend activates, data to the link stops. Transmission resumes when conditions improve. The goals are to avoid:

- Latency impact
- Reduction in performance
- Input buffer overflow

If the link *never* recovers because:

1. The STA has gone out of range or has been powered off

   or

2. The link is not resumed but other links continue working. In that case the AP will detect the dead link and clear the buffered data as if the STA went into real power save mode and never returned.

Recovery Mechanism One

The *ps* portion of Pspretend advertises on the AP beacon that there is traffic pending for the STA. If the STA hears the beacon the link is functional and the STA responds with PS-poll. The AP receives PS poll and exits Pspretend. In this case, latency may be no better than the beacon interval (e.g., 100 milliseconds).

Recovery Mechanism Two

When Pspretend happens, the AP begins probing. A probe is a single short data packet (empty payload) sent at the lowest modulation. It has a small impact in the multilink scenario.

If the AP receives a MAC-level ACK in response to the probe, then the STA has recovered and Pspretend exits. If an ACK is *not* received, probing continues at regular intervals (e.g., 20 milliseconds). This mechanism has shorter latency than Recovery Mechanism One.

Pspretend and Repeated Failures

If Pspretend exits, and the transmission fails again, Pspretend restarts, because the goal is to have 0% loss.

A counter tracks the number of times a link breaks. If the problem link continues to break repeatedly the counter will reach its maximum value and Pspretend will stop. When the system seems to be working well again, Pspretend is re-enabled.

Note: Pspretend buffers packets when conditions are bad so that those packets can be sent when conditions are good. If the conditions are never good enough, Pspretend is ineffective. It cannot eliminate interference; it works around bad conditions but will eventually give up if conditions do not improve.

Pspretend Operation

When Pspretend is enabled the Pspretend state is entered as soon as the first packet is dropped. The packet that triggered Pspretend is saved, as are all subsequent packets. The aim is to achieve 0% packet loss under all transmission conditions, including individual lost packets. The only case where this is not possible is if the air bandwidth is insufficient to send the data, because then packets are dropped at the input buffer: all other packets that go to air are guaranteed to be delivered.

When Pspretend activates, it clears the queued traffic and restarts the queue. This is potentially disruptive to throughput figures if packets are lost on a frequent basis. On the other hand, at least for TCP, overall throughput may be higher because the TCP algorithm does not have to retransmit and backoff.

The retry limit prevents Pspretend from indefinitely trying to send a packet.

Note: Pspretend is disabled by default.

Pspretend IOVAR

Pspretend_retry_limit configures the number of times to do successive Pspretend. The suggested value is 5 (typical). In some cases, higher values (for example, 10 or more) may be beneficial.

A value of 0 disables normal mode.This sets the threshold of failed transmissions before activating Pspretend (valid values 0-255 - uchar). This threshold applies to all traffic, not just AMPDU. A packet will go through the retry procedure (up to the normal limits). Normally the packet is then discarded and the BAR is sent.

When the Pspretend_retry_limit is non-zero, the AP pretends the STA is in power-save mode, and schedules a probe. When the STA communicates with the AP normally or as a result of the probe, packet transmission resumes. This prevents packet loss in situations of temporary outage. The pspretend_retry_limit sets the maximum number of times this can happen before the feature disables itself.

UDP Versus TCP

UDP is prone to losing packets, because there is no retry protocol. TCP re-sends failed packets automatically. UDP is often used for time-critical data (video) where TCP retry is too slow. Pspretend is designed for and targets 0% PER of UDP traffic.

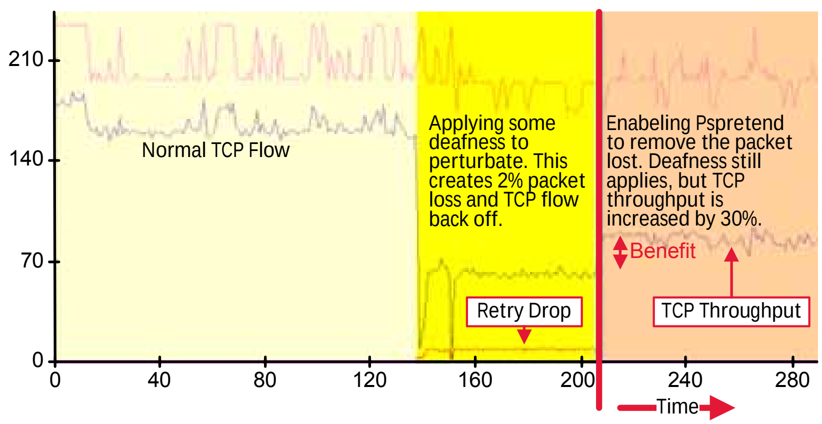
Pspretend is faster than TCP protocol re-transmit for a failure. TCP reduces the throughput when there is packet loss. Pspretend stabilizes TCP traffic. Despite taking time to stop and start the transmission, Pspretend often gives improved TCP throughput and stability in bad link conditions.

Benefits for TCP

Improved Throughput

In tests where TCP packet loss is 2%, TCP throughput goes down because of backoff. When Pspretend is enabled throughput can increase as much as 30% (Figure 4).

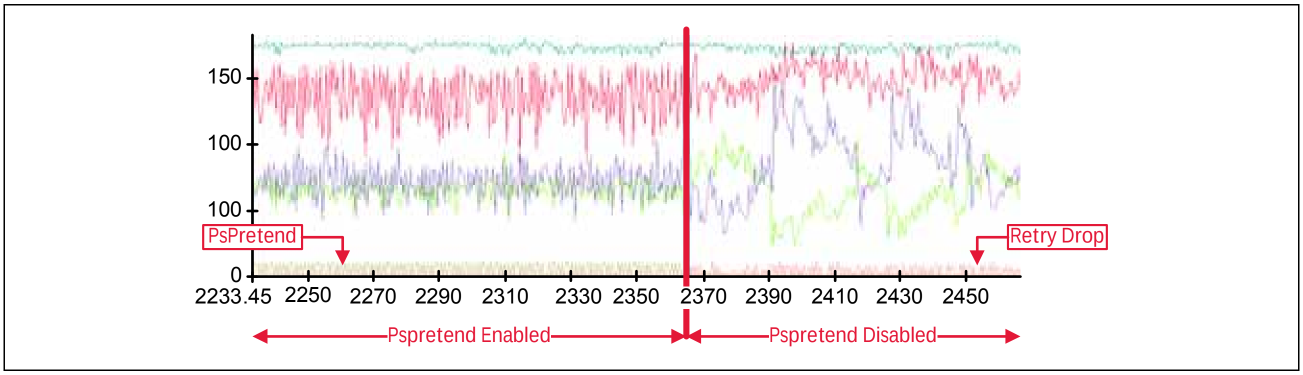
Figure 4: Pspretend Increases TCP Throughput



Multilink

When packet loss occurs the link throughputs are unstable. In the example shown in Figure 5, the green and blue lines are the throughput for each link.

Figure 5: Dual-Link TCP Example



Check if Pspretend is Working

When Pspretend is activated, there should be no packet loss unless the input queue is full.

The `pktq_stats` feature distinguishes between packet loss caused by transmission failure and that caused by input buffer data overflow.

When Pspretend is working normally the `rtrydrop` column of data should always be zero. If the input buffer overflows, there will be some non-zero number in the `dropped` column, which is the normal form of packet loss that Pspretend cannot prevent.

When Pspretend activates, there will be some non-zero counters in the `psretry` column. This counter is incremented every time the Pspretend state is activated.

To test the `pktq_stats` feature:

Using iperf, set up a UDP stream with the access point sending data to the client station:

- Bandwidth = 20 Mbits/second
- Physical link capability of ≥50 Mbits/second
- `wl pktq_stats` setup up to run on a second-by-second basis on the AP

1. Start with Pspretend not activated. Use `iperf` to send some traffic from the access point to the client station with some packet loss. Check the packet loss report on the `iperf` UDP server (receiver).See Figure 6.

Figure 6: Package Stats with Pspretend Disabled

```
AMPDU queue 40:6C:8f:19:63:74
prec:   rqstd,   stored,  dropped,  retried,  rtsfail, rtrydrop,  psretry,   acked,  utlisatn,  q length, Data M/bits/s
04:      7223,     7223,        0,      978,       94,      13,         0,    7210,        39,      1536,         50.90
```

Packets in the air that were dropped because the retry limit was reached .

2. Enable Pspretend (`wl Pspretend_retry_limit 5`) and repeat the step above.

There should be no packet loss in the `iperf` UDP server, and a non-zero count in the `psretry` column of the `wl pktq_stats` on the AP (Figure 7).

Figure 7: Packet Stats with Pspretend Enabled

```
AMPDU queue 40:6C:8f:19:63:74
prec:   rqstd,   stored,  dropped,  retried,  rtsfail, rtrydrop,  psretry,   acked,  utlisatn,  q length, Data M/bits/s
04:      6568,     6568,        0,      919,       80,       0,        19,    6567,        53,      1536,         50.99
```

No packets dropped | Packets saved by Pspretend

On STA side, simulate in someway that the link is broken and go off-line for T ms, once per second.

`iperf` will show zero packet loss and the `psretry` column will have a non-zero count.

Average Time Spent In Pspretend

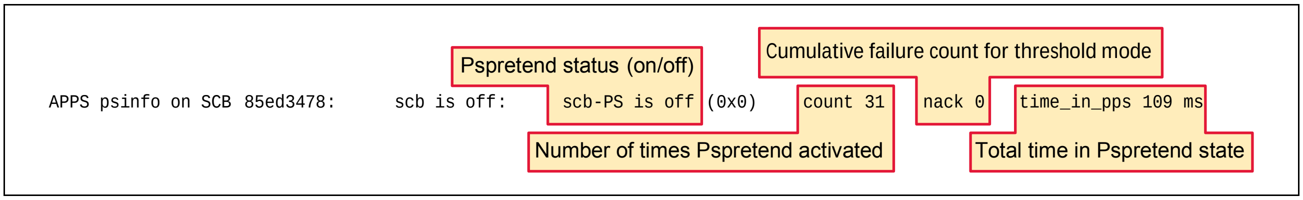
The length of time spent in Pspretend has minimal impact on overall performance.

To determine the average amount time per activation spent in Pspretend run `wl dump scb` and divide the total time spent in Pspretend by the number of times Pspretend activated (Figure 8).

(`time_in_pps` / `count`) = (109 / 31) = 3.5 milliseconds) in the example shown in Figure 8.

Note: Bad air conditions will make increase the average time spent in Pspretend.

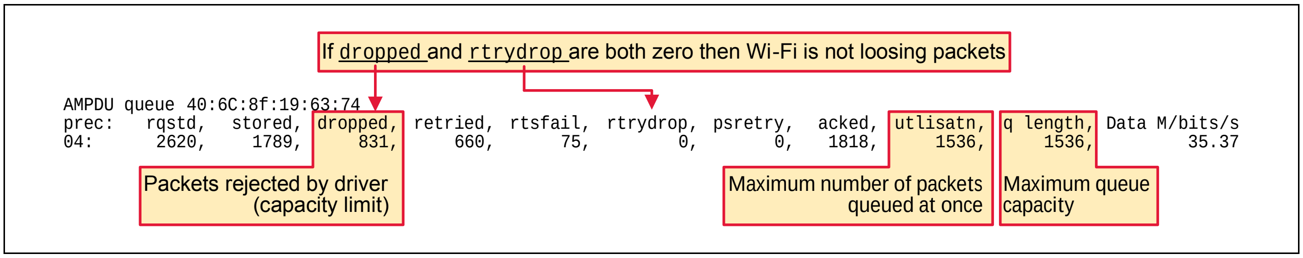
Figure 8: wl dump scb



Additional Points

- If `dropped` and `rtrydrop` are both zero then Wi-Fi is not losing packets (Figure 9).
- If Wi-Fi is not losing packets but the application reports loss:
  - The loss is occurring outside of Wi-Fi
  - The application is sensitive to latency and drops late-arriving packets
- If `rtrydrop` is non-zero and Pspretend is enabled:
  - The Pspretend limit is being reached: try increasing the limit.
  - Establish the cause of the excessive loss

Figure 9: Check Input Data Rate



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