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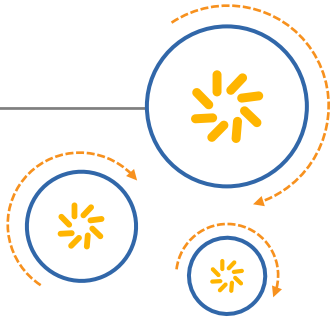

DBDC Repeater with Load Balancing and Handover

Application Note

80-Y9571-11 Rev. A

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Revision history

Revision	Date	Description
A	March 2016	Initial release

Contents

Figures

1 DBDC Repeater

Dual Band Dual Concurrency (DBDC) Repeater AP works on 2.4 GHz and 5 GHz radios concurrently. Each radio can create two VAPs, one acting AP and the other as client. The AP-VAP allows clients to associate to itself. The STA-VAP associates with the Root AP and bridges wireless and wired frames with the Root AP. DBDC Repeater must be configured on WDS/EXTAP/QWRAP mode on both radios.

One of the DBDC Repeater radios is configured as primary radio (2.4 GHz by default) and the other as secondary radio (5 GHz by default). DBDC Repeater can dynamically configure either radio as the primary radio based on user input. The primary radio is used to form the link for Ethernet clients of DBDC Repeater, therefore DBDC Repeater sends Ethernet client traffic only through the STA VAP associated with the primary radio to DBDC Root AP.

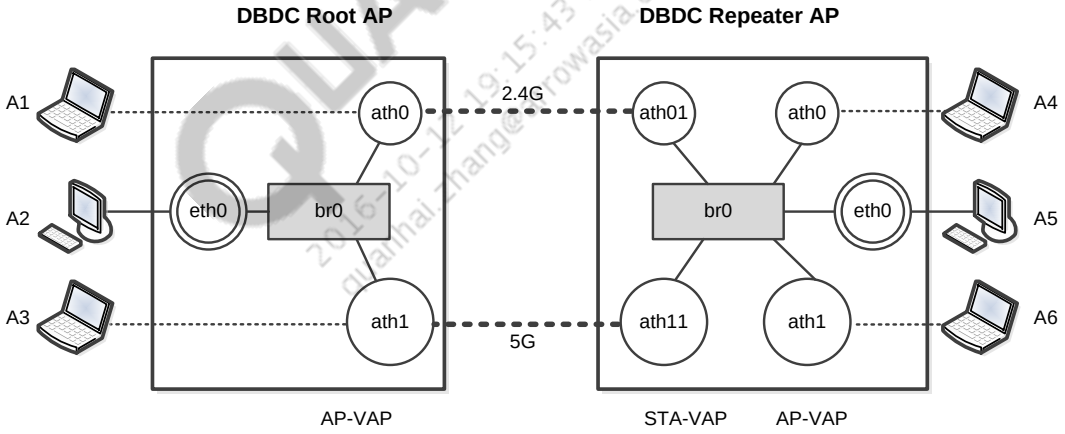


Figure 1-1 DBDC Repeater and RootAP connection

Traffic from clients connected with DBDC Repeater reaches DBDC Root AP through either 2.4 GHz or 5 GHz VAP based on Repeater Bridge learning. For example, if ARP Request (broadcast) is sent from DBDC Root AP on both AP-VAPs, DBDC Repeater will get the packet on both STA-VAPs and updates its forwarding table based on the latest received frame. ARP Reply (unicast) from client connected with DBDC Repeater can be sent on either 2.4 GHz or 5 GHz STA-VAP.

If DBDC Repeater is connected with two different Root APs, packet are forwarded to 2.4 GHz or 5 GHz STA-VAP based on Repeater Bridge learning. DBDC Repeater can identify the connection with DBDC Root APs without user input.

1.1 Packet loop detection

DBDC Repeater detects packet loop by checking whether a received multicast/broadcast packet is sent from itself. Layer 2 Update Frame (L2UF, an 802.2 LLC frame) from WLAN driver is used to achieve this function. The frame is sent from AP with source address (newly associated STA) and destination address (broadcast address). Upon receiving such frames, all layer 2 devices (bridges, switches, or other APs) update their forwarding tables with the correct port to reach the new location of the station.

When the STA-VAP of DBDC Repeater get associated with DBDC Root AP and the STA-VAPs are connected on both radios, L2UFs are sent from both STA-VAPs. If the L2UFs are received on any STA VAP with MAC address of the other radio's STA VAP, packet loop is detected with the root cause identified as connection with DBDC Root AP. The received L2UF frame/multicast frame is used to determine whether packet loops exists or not:

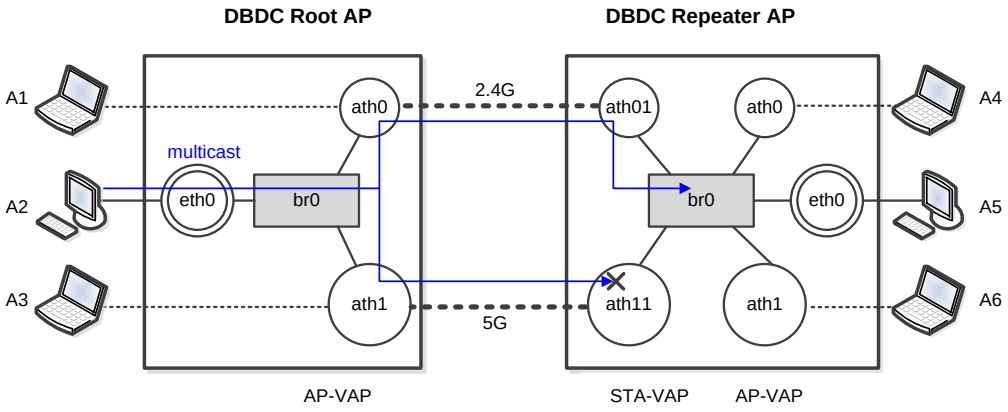
- EXTAP mode – Source MAC address of the multicast packet is checked against the STA VAP address of the other radio. If the address matches, packet loop is detected.
- WDS mode – Source MAC address of the multicast packet is checked against the MAC addresses of all clients connected with the other radio. If match is found, packet loop is detected.
- QWRAP mode – Source MAC address of the multicast packet is checked against all Proxy-STA addresses present in the other radio. If match is found, packet loop is detected.

When any of the STA-VAP disconnects, the loop detection flag is reset so that the loop detection logic is triggered for the next STA-VAP connection.

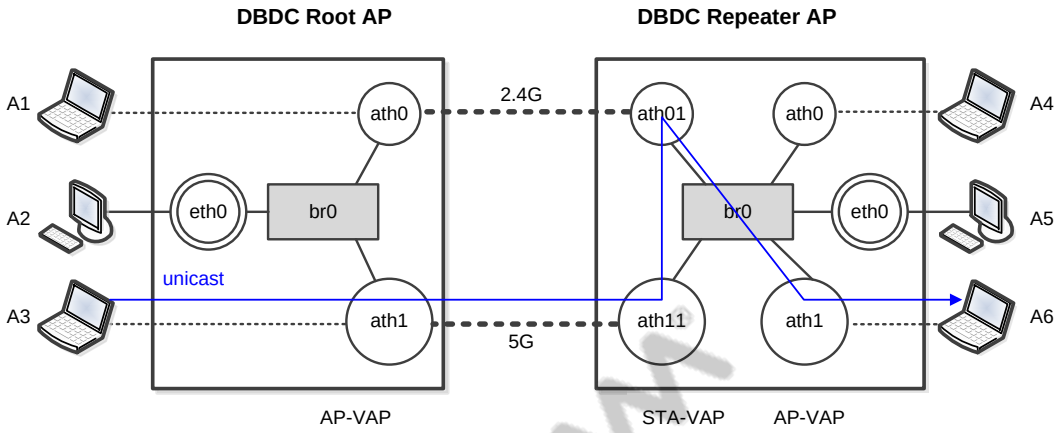
1.2 Loop avoidance and load balancing

When loop is detected, packets received on DBDC Repeater from DBDC Root AP is handled in the following ways:

- The secondary radio STA-VAP ignores multicast/broadcast packets received from DBDC Root AP, making such packets only processed through the primary radio STA-VAP interface.



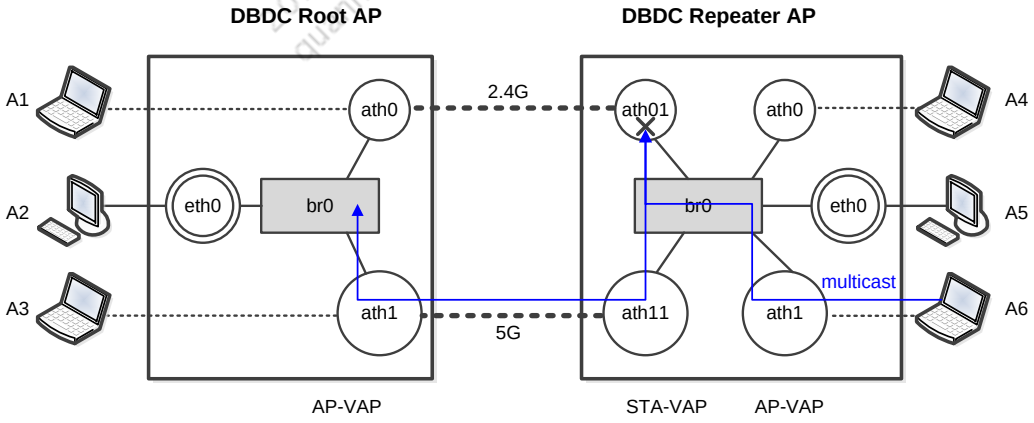
- When unicast packet from DBDC Root AP is received on the secondary radio STA-VAP, the packet header is modified to indicate the Repeater Bridge that the unicast packet comes from the STA-VAP of the primary radio. The Repeater Bridge learns all MAC addresses associated with the DBDC Root AP only through the STA-VAP of the primary radio.



- Packets (unicast/multicast/broadcast) received on the STA-VAP of the primary radio are handled with regular processing.

When loop is detected, packets to be transmitted from DBDC Repeater to DBDC Root AP is handled as the following:

- When the DBDC Repeater Bridge sends multicast packets to the STA-VAP of the primary radio, the packet is discarded if the source MAC address matches any of the client associated with the secondary radio. This means multicast packet is transmitted if the originator of the packet belongs to the AP-VAP of the primary video or Ethernet.
- When the DBDC Repeater Bridge sends multicast packets to the STA-VAP of the secondary radio, the packet is sent only if the source MAC address matches any of the client associate with the secondary radio. This means packets originating from clients of primary radio or Ethernet are dropped.



- Repeater Bridge always hands over unicast packets to the primary radio STA-VAP for transmission to DBDC Root AP. When the primary radio STA-VAP receives unicast packet from the bridge, it performs the following:
  - If packet source address matches any of the associated with the secondary radio, hand over the packet to secondary radio STA-VAP.
  - If the packet belongs to the primary radio STA-VAP or Ethernet network, the packet is transmitted directly.

1.3 DBDC Repeater implementation

New common data structure **global_ic_list** is used to store UMAC radio device structure pointers (struct ieee80211com *ic). This data structure is common for both radios. Using this structure, each radio can check the MAC addresses of clients associated with the other radio.

Received packets are processed on the **dbdc_rx_process** function, which is called from the **osif_deliver_data** function. Packets to be transmitted from Repeater are processed on the **dbdc_tx_process** function, which is called from the **osif_hardstart** function. DBDC Repeater process are done in both direct attach and offload path.

DBDC Repeater changes are included under DBDC_REPEATER_SUPPORT compiler flag.

1.4 DBDC Repeater configuration

- To make Ethernet client traffic sent from DBDC Repeater to DBDC Root AP through the first radio, use the commands:
  ```
  iwpirv wifi0 primaryradio 1
  iwpirv wifi1 primaryradio 0
  ```
- To make Ethernet client traffic sent from DBDC Repeater to DBDC Root AP through the second radio, use the commands:
  ```
  iwpirv wifi1 primaryradio 1
  iwpirv wifi0 primaryradio 0
  ```
- To find out which radio is configured as primary radio, use the command:
  ```
  iwpirv wifiX getprimaryradio
  ```
- To disable special handling of packets (enabled by default) on DBDC Repeater when it is connected with two different Root APs, use the command:
  ```
  iwpirv wifiX dbdc_enable 0
  ```
- To enable special handling of packets on DBDC Repeater, use the command:
  ```
  iwpirv wifiX dbdc_enable 1
  ```
- To get current configuration, use the command:
  ```
  iwpirv wifiX get_dbdc_enable
  ```

2 DBDC Handover and Load Balance in QWRAP Mode

To enable handover and load balancing in QWRAP mode, QWRAP must be enabled on both radios and a single wrapd process is used. When DBDC QWRAP is connected with DBDC Root AP, load balance and packet loop avoidance are handled with changes submitted under DBDC_REPEATER_SUPPORT feature.

2.1 Handover for wireless clients

When MPSTA connection of any radio goes down, PSTAs need to be destroyed on that radio and created on the other radio for wireless and wired clients to send traffic to Root AP. To support handover, the client_mcast flag is enabled in driver by default.

- Multicast packets from 2.4 GHz clients connected with DBDC QWRAP go through 2.4 GHz STA-VAP while 5 GHz client through 5 GHz STA-VAP. This is also applicable when DBDC QWRAP is connected with two different Root APs. With this design, DHCP requests from connected clients are passed on their corresponding radio's STA-VAP.
- Clients are disconnected and reconnected when their corresponding radio's STA-VAP goes up. This makes clients get IP address from Root AP to which their corresponding STA-VAP is associated.
- Client are disconnected and reconnected when their corresponding radio's STA-VAP goes down. This makes clients get IP address from other available Root AP.

2.2 Handover for wired clients

From wrapd application, use ioctl to see which is the primary radio.

Automatically adding Ethernet client to proxySTA is enabled in QWRAP mode to support handover for wired clients.

- When MPSTA VAPs of both radio are disconnected from RootAP, create PSTA for wired client on primary radio.
- When MPSTA VAPs of both radio are connected to RootAP, create PSTA for wired client on primary radio.
- When MPSTA VAP of only one radio is connected to RootAP, create PSTA for wired client on radio which has its MPSTA VAP connected to RootAP.
- When MPSTA VAP connection goes down on any radio, destroy PSTA created for wired client on that radio. During next poll, PSTA is created for wired client upon PSTA create

request on the other radio if its MPSTA VAP is connected to RootAP. If the other radio's MPSTA VAP is also in disconnected state, create PSTA on primary radio.

- When primary radio's MPSTA connects with RootAP and wired PSTA is on the other radio, destroy that wired PSTA. During next poll, PSTA is created for wired client upon PSTA create on primary radio.

2.3 Handover for DBDC QWRAP Bridge

- When MPSTA VAP of any radio connects,
  - Check if it is first MPSTA VAP connection. If yes, set MPSTA VAP MAC address of that radio.
  - Check if it is second MPSTA VAP connection. If yes, overwrite DBDC QWRAP bridge MAC address with current radio's MPSTA VAP MAC address only if current radio is primary radio.
- When MPSTA VAP connection goes down on any radio and if the other radio's MPSTA VAP is in connected state, set the other radio's MPSTA VAP MAC address to DBDC QWRAP Bridge.

2.4 Maximum number of client connection

In DBDC QWRAP mode, number of clients that can be connected to each radio is chip-specific.

To support handover, total number of clients that can be connected on both radios should not exceed the minimum of number of clients that can be connected on each radio.

For example, when AP147 (QCA9531/QCA9533 + QCA9887/QCA9889) is configured in DBDC QWRAP mode, 30 clients can be connected with QCA9531/QCA9533 radio and 14 clients can be connected with QCA9887/QCA9889 radio.

To support handover case on AP147, total number of client connection on both radios should not exceed 14.

3 QWRAP Support for DBDC Range Extender

A single wrapd process is started from the qwrap.sh script to support QWRAP mode on both radios. Changes are made to the following modules:

3.1 Qca-wrapd-10.4

The current version wrapd code can support QWRAP mode only on single radio and it allocates single wrap_demon structure. This wrapd_demon structure holds MPSTA connection info, list of PSTAs and details of network socket connection established with hostapd and wpa_supplicant.

To support DBDC QWRAP, two separate wrap_demon structures will be allocated for each radio.

During network socket connection establishment with global wpa_supplicant, wrapd, hostapd, and MPSTA wpa_supplicant control interfaces, socket connections are registered with the first wrapd_demon structure for the first Wi-Fi interface and the second wrapd_demon structure for the second Wi-Fi interface. This ensures that received events are handled for any Wi-Fi interface with its corresponding wrapd_demon structure.

3.2 qwrap.sh script

In qwrap.sh script, wrapd process will be started based on configurations provided through UCI script as below,

```
wrapd [-P<pid file>] [-D<wifi interface>] [-c<wpa_s conf file>] [-a<ap
ifname>] [-p<psta ifname>] [-g<wrapd ctrl intf>]  [-w<global wpa_s ctrl
intf>] [-b<bridge name>]
```

If QWRAP mode is enabled on both radios, wrapd process will be started as below:

```
wrapd -P /var/run/wrapd-wifi1.pid -D wifi0 -D wifi1 -c
/var/run/wpa_supplicant-ath01.conf -c /var/run/wpa_supplicant-ath11.conf -a
ath0 -a ath1 -p ath01 -p ath11 -g /var/run/wrapd-global-wifi0 -g
/var/run/wrapd-global-wifi1 -w /var/run/wpa_supplicantglobal -b br-lan -i
eth1 -l 20 -t 1 -e 0 -r 0
```

Existing QWRAP configurations:

- If QWRAP enabled only on wifi0:

  ```
  wrapd -P /var/run/wrapd-wifi0.pid -D wifi0 -c /var/run/wpa_supplicant-
  ath01.conf -a ath0 -p ath01 -g /var/run/wrapd-global-wifi0 -w
  /var/run/wpa_supplicantglobal -b br-lan -i eth1 -l 20 -t 1 -e 0 -r 0
  ```

- If QWRAP enabled only on wifi1:

```
wrapd -P /var/run/wrapd-wifi1.pid -D wifi1 -c /var/run/wpa_supplicant-
ath11.conf -a ath1 -p ath11 -g /var/run/wrapd-global-wifi1 -w
/var/run/wpa_supplicantglobal -b br-lan -i eth1 -l 20 -t 1 -e 0 -r 0
```

- DBDC Fastlane (with QWRAP mode on wifi0):

```
wrapd -P /var/run/wrapd-wifi0.pid -D wifi0 -c /var/run/wpa_supplicant-
ath0.conf -a ath1 -p ath0 -g /var/run/wrapd-global-wifi0 -w
/var/run/wpa_supplicantglobal -b br-lan -i eth1 -l 20 -t 1 -e 0 -r 0
```

- DBDC Fastlane (with QWRAP mode on wifi1):

```
wrapd -P /var/run/wrapd-wifi1.pid -D wifi1 -c /var/run/wpa_supplicant-
ath1.conf -a ath0 -p ath1 -g /var/run/wrapd-global-wifi1 -w
/var/run/wpa_supplicantglobal -b br-lan -i eth1 -l 20 -t 1 -e 0 -r 0
```

- QWRAP mode enabled on wifi0. wifi0 has AP and STA-VAP and wifi1 has AP-VAP:

```
wrapd -P /var/run/wrapd-wifi0.pid -D wifi0 -c /var/run/wpa_supplicant-
ath01.conf -a ath0 -a ath1 -p ath01 -g /var/run/wrapd-global-wifi0 -w
/var/run/wpa_supplicantglobal -b br-lan -i eth1 -l 20 -t 1 -e 0 -r 0
```

- QWRAP mode enabled on wifi1. wifi1 has AP and STA-VAP and wifi0 has AP-VAP:

```
wrapd -P /var/run/wrapd-wifi1.pid -D wifi1 -c /var/run/wpa_supplicant-
ath11.conf -a ath0 -a ath1 -p ath11 -g /var/run/wrap - global-wifi1 -w
/var/run/wpa_supplicantglobal -b br-lan -i eth1 -l 20 -t 1 -e 0 -r 0
```

3.3 wpa_supplicant.sh

In DBDC QWRAP mode, when qwrap is enabled on both radios, create wpa_supplicant conf file separately for each MPSTA VAP.

3.4 DBDC QWRAP

In DBDC QWRAP mode, number of clients that can be connected to each radio is chip specific.

For example, when AP147 (QCA9531/QCA9533 + QCA9887/QCA9889) is configured in DBDC QWRAP mode, 30 clients can be connected with QCA9531/QCA9533 radio and 14 clients can be connected with QCA9887/QCA9889 radio.

MPSTA VAP mac address of wifi0 is used as DBDC Repeater Bridge MAC address.

When DBDC QWRAP is connected with DBDC Root AP, load balance and multicast packet loop avoidance is handled with changes submitted under the DBDC_REPEATER_SUPPORT feature.

To send Ethernet client traffic from DBDC QWRAP to DBDC RootAP through wifi0's STA VAP, use below commands,

```
wrapd -S -g /var/run/wrapd-global-wifi0 -a wifi0  -A C8-0A-A9-50-6B-CD
iwpriv wifi0 primaryradio 1
```

To send Ethernet client traffic from DBDC QWRAP to DBDC RootAP through wifi1's STA VAP, use below commands,

```
wrapd -S -g /var/run/wrapd-global-wifi1 -a wifi1  -A C8-0A-A9-50-6B-CD
iwpriv wifi1 primaryradio 1
```

3.5 Limitations

The following limitations will be addressed in future implementation. See Chapter 2 for the workaround.

- Failover cases are not implemented. In DBDC Repeater, if STA-VAP of wifi0 connection goes down, clients of wifi0 cannot send its traffic to DBDC Root AP through STA VAP of wifi1. Similarly, if STA-VAP of wifi1 connection goes down, clients of wifi1 cannot send its traffic to DBDC RootAP through STA VAP of wifi0.
- DBDC Repeater Bridge has mac address of MPSTA VAP of wifi0. If STA VAP of wifi0 connection goes down, then packets originating from DBDC Repeater bridge can't able to reach DBDC RootAP.