A-DCF Driver Guide

(v0.1)

August 29, 2014

This document will continuously be updated.

1. Overview

The A-DCF module (device driver) is based on ath9k. We extend the `ath9k` module to implement A-DCF and O-DCF. For details on ath9k, refer to http://wireless.kernel.org/en/users/Drivers/ath9k.

2. Building the driver

First, your kernel version should be 2.6.32.

Decompress adcf-driver-0.1.tar.bz2 by typing the following:

```
tar xvjf adcf-driver-0.1tar.bz2
```

Change into the directory by typing the following:

```
cd compat-wireless-2.6.32.16-adcf-0.1
```

Build by typing the following:

```
./scripts/driver-select ath9k
make && make install && make unload
```

To revert, type the following:

```
make uninstall
```

3. Loading the driver

Change into the directory by typing the following:

```
cd adcf_scripts
```

Run the script by typing the following:

```
./setup_adhoc.sh
```

To unload the driver, type the following:

```
rmmod ath9k
```

4. Script and module details

You can change the module configuration by changing values for appropriate variables in `setup_adhoc.sh` script. To use 802.11 DCF, set `MAC` to `0`. To use O-DCF, set `MAC` to `1`. To use A-DCF, set `MAC` to `2`.

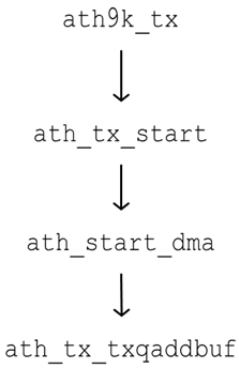
You can get more information on module parameters by typing the following:

```
modinfo ath9k
```

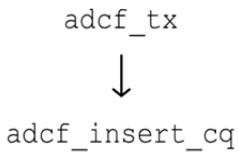
5. Implementation details

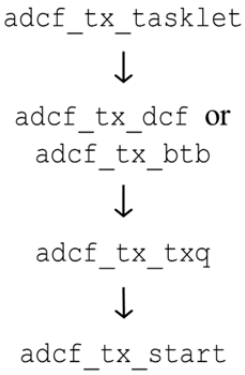
We implement A-DCF and O-DCF by extending the `ath9k` module. You will find source codes for A-DCF and O-DCF in `driver/net/wireless/ath/ath9k/` directory. Main procedures are written in `adcf-*.*` files.

In the original `ath9k` module, the main procedures to transmit frames are as follows:



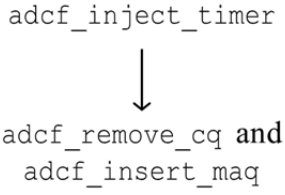
In our modified module, the above procedures are split into two flows as follows:





In the first flow, frames are just inserted into their corresponding CQs. Actual transmissions are started by the second flow, which is ignited when TX interrupts occur or a frame is injected into an empty MAQ.

Source rate control is performed by the following function call:



A. Major data structures

Here, we describe main fields of major data structures and their related functions.

```
struct adcf_data{
        struct sk_buff *mpdu;
        …
        struct timeval time;
}
```

802.11 MAC frame arrived at A-DCF module is inserted into CQ. The frame is wrapped in `struct adcf_data`, which has `struct timeval time` field: time to be inserted CQ.

```
struct adcf_cq_maq{
        struct adcf_data *cq;
        u16 cq_head;
        u16 cq_tail;
        atomic_t cq_depth;
        u16 cq_capacity;

        struct adcf_data *maq;
        u16 maq_head;
        u16 maq_tail;
        atomic_t maq_depth;
        atomic_t maq_byte;
        u16 maq_capacity;
        …
        struct timer_list inject_timer;
        …
        u8 dst_addr[ETH_LEN];
        …
```

```
        struct adcf_tx *adcf;
}
```

`struct adcf_cq_maq` is composed of three parts: CQ, MAQ, and additional information. CQ and MAQ are realized by using the circular queue. The circular queue is constructed from array. The functions to operate CQ and MAQ are as follows.

- `void adcf_insert_cq(struct adcf_cq_maq *adcf_queue, struct ieee80211_hw *hw, struct sk_buff *skb)`
- `struct adcf_data *adcf_remove_cq(struct adcf_cq_maq *adcf_queue)`
- `void adcf_insert_maq(struct adcf_cq_maq *adcf_queue, struct ieee80211_hw *hw, struct sk_buff *skb)`
- `struct adcf_data *adcf_remove_maq(struct adcf_cq_maq *adcf_queue)`
- `struct adcf_data *adcf_peek_maq(struct adcf_cq_maq *adcf_queue)`

These functions internally update `cq_head`, `cq_tail`, `cq_depth`, `maq_head`, `maq_tail`, and `maq_depth`. `struct adcf_cq_maq` is initialized in `int ath_init_softc(u16 devid, struct ath_softc *sc, u16 subsysid)` function (lines 1502-1536 in main.c) where memory with the amount of `cq_capacity` and `maq_capacity` is allocated to each `cq` and `maq`, respectively.

`struct timer_list inject_timer` is the timer for source rate control. When this timer is expired, `void adcf_inject_timer(struct adcf_cq_maq *adcf_queue)` is called. This function moves multiple `struct adcf_data` instances (MAC frames with time tags) from `struct adcf_data *cq` into `struct adcf_data *maq`. The amount of instances is calculated by A-DCF's source rate control algorithm (or DRR).

`u8 dst_addr[ETH_LEN]` is the MAC address of the neighbors for this link. `struct adcf_tx *adcf` is the back pointer to the structure which manages A-DCF.

```
struct adcf_tx{
        struct adcf_cq_maq *adcf_queue;
        …
        bool vmf;
        u16 burst_dur;
        …
```

```
        struct adcf_ta_time *adcf_rts_overheard;
        u32 adcf_v;
        struct timer_list normal_v_timer;
}
```

`struct adcf_tx` is mainly composed of three parts: queue, data for TXOP, and data for adaptive DRR. `struct adcf_cq_maq *adcf_queue` is the array for containing multiple `struct adcf_cq_maq` (link queue). In `int ath_init_softc(u16 devid, struct ath_softc *sc, u16 subsysid)` function (line 1502-1537 in main.c), `adcf_cq_maq`'s with the number of `ADCF_LINK` are allocated, and the address of the memory is assigned to `adcf_queue`. The current prototyping version has the fixed number of link queue (i.e. `ADCF_LINK`), which is determined at compile time. We will update the fixed allocation into dynamic link queue.

When back-to-back transmissions are required, we use TXOP, which is enabled by setting appropriate field in Tx control descriptor. For this end, `bool vmf` and `u16 burst_dur` are used. `vmf` is set to true if the next MAC frame will be transmitted back-to-back. `burst_dur` is set to the duration of SIFS, MAC frame, DIFS, and a slot to reserve the channel for protection. These variables are configured in `void adcf_tx_dcf(struct ath_softc *sc, struct adcf_cq_maq *adcf_queue)` and `void adcf_tx_btb(struct ath_softc *sc, struct adcf_cq_maq *adcf_queue)`. The former function is called for normal access of the HOL frame at MAQ and the latter function for back-to-back transmissions.

For adaptive DRR, `struct adcf_ta_time *adcf_rts_overheard`, `u32 adcf_v`, and `struct timer_list normal_v_timer` are used. These variables are used for detection of hidden nodes, current V, and timer for reverting to normal mode.

B. Major functions

Here, we describe main functions to implement O-DCF and A-DCF.

`int adcf_tx(struct ieee80211_hw *hw, struct sk_buff *skb)`

The interface between the upper layer and MAC is `struct ieee80211_ops`, which has `int(*tx)(struct ieee80211_hw *hw, struct sk_buff *skb)` function pointer. To operate as A-DCF or O-DCF, `tx` is set to `adcf_tx` in `ath_init_sofc(u16 devid, struct ath_softc *sc, u16 subsysid)`

function (lines 1371-1376, main.c), MAC frame transmissions are started when the upper calls `adcf_tx(struct ieee80211_hw *hw, struct sk_buff *skb)`. Note that by default 802.11 DCF sets `tx` to `ath9k_tx` in line 2951, main.c.

In `adcf_tx(struct ieee80211_hw *hw, struct sk_buff *skb)` function, `skb` is inserted to its corresponding CQ, which is obtained by `struct adcf_cq_maq *adcf_intra_sched(struct ath_softc *sc)` function, by default. When its corresponding MAQ is waiting for insertion, `skb` is directly inserted into the MAQ. Overall, `adcf_tx(struct ieee80211_hw *hw, struct sk_buff *skb)` function is responsible for queueing into `skb` its CQ or MAQ.

`void adcf_inject_timer(struct adcf_cq_maq *adcf_queue)`

As explained before, the pair of CQ and MAQ is wrapped in `struct adcf_cq_maq`, which has `struct timer_list inject_timer` variable. Each pair of CQ and MAQ controls source rate control by using this variable. When this timer is expired, `void adcf_inject_timer(struct adcf_cq_maq *adcf_queue)` is called. This function moves multiple `struct adcf_data` instances (MAC frames with time tags) from `struct adcf_data *cq` into `struct adcf_data *maq`. The amount of instances is calculated by A-DCF's source rate control algorithm (or DRR).

`void adcf_tx_tasklet(unsigned long context)`

This function is called when a MAC frame is inserted into empty MAQ or TX interrupt is occurred. In this function, a link is selected by `struct adcf_cq_maq *adcf_intra_sched(struct adcf_tx *adcf)` function call (line 567, adcf_xmit.c). From the selected link, MAC frame transmissions are prepared by DCF (`void adcf_tx_dcf(struct ath_softc *sc, struct adcf_cq_maq *adcf_queue)` function call, line 574, adcf_xmit.c) or back-to-back (`void adcf_tx_dcf(struct ath_softc *sc, struct adcf_cq_maq *adcf_queue)` function call, line 591, adcf_xmit.c). The preparation is performed multiple times until txq is full or remaining transmission length is insufficient.

`void adcf_tx_dcf(struct ath_softc *sc, struct adcf_cq_maq *adcf_queue)`

This function calculates DCF parameters and transmission length according to transmission aggressiveness and calls `int adcf_tx_txq(struct ieee80211_hw *hw, struct sk_buff *skb, u32 dcf_parameters)` function, where DCF parameters is applied in the chipset and `skb` is inserted TXQ.

`void adcf_tx_btb(struct ath_softc *sc, struct adcf_cq_maq *adcf_queue)`

This function configures `burst_dur` and `vmf` field in `struct adcf_tx` for back-to-back transmissions. The values configured are used in `void adcf_setburst(struct ath_softc *sc, struct ath_buf *bf)` function, which is called in `void ath_tx_qaddbuf(struct ath_soft *sc, struct ath_txq *txq, struct list_head *head)` function. `adcf_setburst(struct ath_softc *sc, struct ath_buf *bf)` function sets some fields in `Tx Control Descriptor` for obtaining TXOP. Like `adcf_tx_dcf(struct ath_softc *sc, struct adcf_cq_maq *adcf_queue)` function, this function calls `adcf_tx_txq(struct ieee80211_hw *hw, struct sk_buff *skb, u32 dcf_parameters)` function.

`int adcf_tx_txq(struct ieee80211_hw *hw, struct sk_buff *skb, u32 dcf_parameters)`

This function corresponds to `int ath9k_tx(struct ieee80211_hw *hw, struct sk_buff *skb)` in 802.11 DCF. The difference is as follows. `ath9k_tx(struct ieee80211_hw *hw, struct sk_buff *skb)` function checks whether TXQ is full or not while this operation is omitted in `adcf_tx_txq(struct ieee80211_hw *hw, struct sk_buff *skb, u32 dcf_parameters)` function since the check is already done in `adcf_tx_tasklet(unsigned long context)`. `adcf_tx_txq(struct ieee80211_hw *hw, struct sk_buff *skb, u32 dcf_parameters)` function configures DCF parameters from the parameter `dcf_parameters` while `ath9k_tx(struct ieee80211_hw *hw, struct sk_buff *skb)` function uses the fixed DCF parameters.

Finally, `adcf_tx_txq(struct ieee80211_hw *hw, struct sk_buff *skb, u32 dcf_parameters)` calls `int ath_tx_start(struct ieee80211_hw *hw, struct sk_buff *skb)` function, which processes the remaining operations for transmissions.