mac80211 overview

Johannes Martin Berg

2009-02-25

Introduction

mac80211

- is a subsystem to the Linux kernel
- implements shared code for soft-MAC/half-MAC wireless devices
- contains MLME and other code, despite the name

Introduction – History (non-technical)

January 2006	John Linville starts as wireless maintainer
April 2006	First wireless summit (Beaverton)
May 1, 2006	Devicescape press release (Advanced Datapath Driver as GPLv2)
May 2006 - May 2007	Lots of work on stack (initially much by Jiri Benc/SuSE) including rename from d80211 to mac80211
May 5, 2007	Merged for 2.6.22
Oct 23, 2007	I first 'officially' take mac80211 responsibility

Introduction – History (technical)

Some notable additions to mac80211:

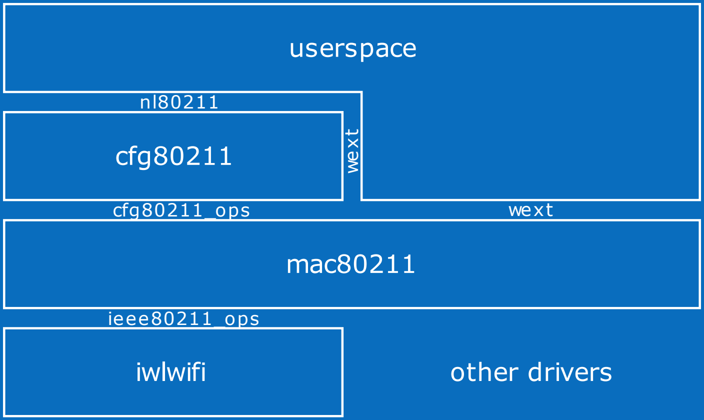
HT/aggregation support	Intel
802.11s draft support	cozybit through o11s.org
802.11w draft support	Jouni Malinen (Atheros)
PS (infrastructure mode)	Kalle Valo (Nokia)
	Vivek Natarajan (Atheros)
beacon processing offload (WIP)	Kalle Valo (Nokia)

Introduction – History (technical)

beacon processing offload

- beacon processing
  - beacon miss actions
  - signal strength monitoring
  - beacon change monitoring
- offload
  - don't use software for above tasks
  - have device (firmware) do this
  - results in much fewer CPU wakeups

Architecture



Architecture

internally

- TX/RX paths (including software en-/decryption)
- control paths for managed, IBSS, mesh
- some things for AP (e.g. powersave buffering)
- ...

Code structure

Most important for driver authors:

include/net/mac80211.h

This file defines the API to mac80211 from below.

Code structure

All files except the header file are in **net/mac80211/**.

Kconfig, Makefile	build system
ieee80211_i.h	most internal data structures
main.c	main module entry points
	main entry points for driver calls (reg/dereg)
iface.c	virtual interface handling
key.c, key.h	key management
sta_info.c, sta_info.h	Station (peer) management
pm.c	power management (suspend/hibernate)
rate.c, rate.h	internal rate control functions
rc80211*	rate control algorithms
rx.c	frame receive path
tx.c	frame transmit path
scan.c	software scanning code

Code structure

ht.c, agg-rx.c, agg-tx.c	HT/aggregation code
mesh{,_hwmp,_plink,_pathtbl}.{c,h}	802.11s mesh
mlme.c	Station/managed mode MLME
ibss.c	IBSS MLME
cfg.c, cfg.h, wext.c	configuration entry points
event.c	events to userspace
spectmgmt.c	spectrum management code
aes*, tkip.*, wep.*, michael.*, wpa.*	WPA/RSN/WEP code
wme.c, wme.h	some QoS code
util.c	utility functions
led.c, led.h	LED handling
debugfs*	debugfs code

Data structures

- ieee80211_local/ieee80211_hw
- sta_info/ieee80211_sta
- ieee80211_conf
- ieee80211_bss_conf
- ieee80211_key/ieee80211_key_conf
- ieee80211_tx_info
- ieee80211_rx_status
- ieee80211_sub_if_data/ieee80211_vif

Data structures – ieee80211_local/ieee80211_hw

- each instance of these (hw is embedded into local) represents a wireless device
- ieee80211_hw is the part of ieee80211_local that is visible to drivers
- contains all operating information about a wireless device

Data structures – sta_info/ieee80211_sta

- represents any station (peer)
- could be mesh peer, IBSS peer, AP, WDS peer
- would also be used for DLS peer
- ieee80211_sta is driver-visible part
- ieee80211_find_sta for drivers
- lifetime managed mostly with RCU

Data structures – ieee80211_conf

- hardware configuration
- most importantly - current channel
- intention: hardware specific parameters

Data structures – ieee80211_bss_conf

- BSS configuration
- for all kinds of BSSes (IBSS/AP/managed)
- contains e.g. basic rate bitmap
- intention: per BSS parameters in case hardware supports creating/associating with multiple BSSes

Data structures – ieee80211_key/ieee80211_key_conf

- represents an encryption/decryption key
- ieee80211_key_conf given to driver for hardware acceleration
- ieee80211_key contains internal book-keeping and software encryption state

Data structures – ieee80211_tx_info

- most complicated data structure
- lives inside skb's control buffer (cb)
- goes through three stages (substructure for each)
    - initialisation by mac80211 (control)
    - use by driver (driver_data/rate_driver_data)
    - use for TX status reporting (status)

Data structures – ieee80211_rx_status

- contains status about a received frame
- passed by driver to mac80211 with a received frame

Data structures – ieee80211_sub_if_data/ieee80211_vif

- contains information about each virtual interface
- ieee80211_vif is passed to driver for those virtual interfaces the driver knows about (not monitor, VLAN)
- contains sub-structures depending on mode
  - ieee80211_if_ap
  - ieee80211_if_wds
  - ieee80211_if_vlan
  - ieee80211_if_managed
  - ieee80211_if_ibss
  - ieee80211_if_mesh

Main flows

- configuration
- receive path
- transmit path
- management/MLME

Main flows – configuration

- all initiated from userspace (wext or nl80211)
- for managed and IBSS modes: triggers statemachine (on workqueue)
- some operations passed through to driver more or less directly (e.g. channel setting)

Main flows – receive path

- packet received by driver
- passed to mac80211's rx function (ieee80211_rx) with rx_status info
- for each interface that the packet might belong to
  - RX handlers are invoked
  - data: converted to 802.3, delivered to networking stack
  - management: delivered to MLME

Main flows – transmit path

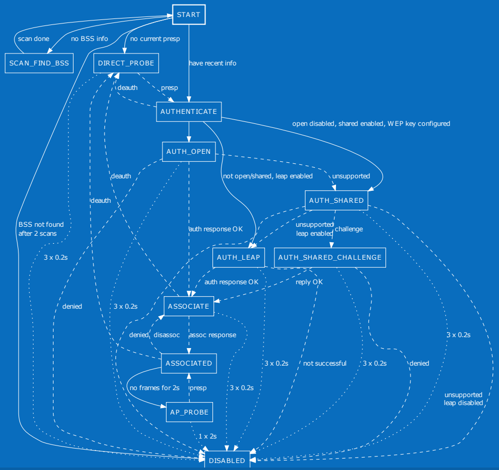
- packet handed to virtual interface's ieee80211_subif_start_xmit
- converted to 802.11 format
- sent to master interface
- packet handed to ieee80211_master_start_xmit
- transmit handlers run, control information created
- packet given to driver

Main flows – transmit path

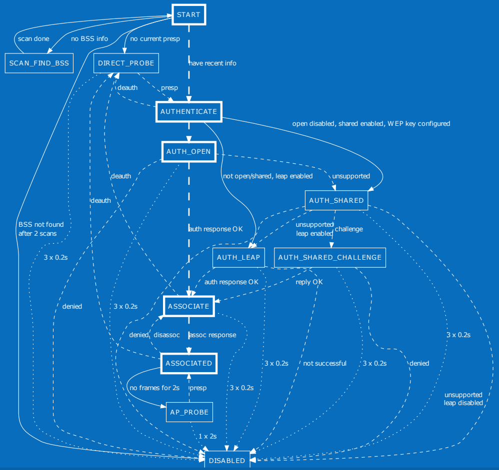
transmit handlers

- ieee80211_tx_h_check_assoc
- ieee80211_tx_h_ps_buf
- ieee80211_tx_h_select_key
- ieee80211_tx_h_michael_mic_add
- ieee80211_tx_h_rate_ctrl
- ieee80211_tx_h_misc
- ieee80211_tx_h_sequence
- ieee80211_tx_h_fragment
- ieee80211_tx_h_encrypt
- ieee80211_tx_h_calculate_duration
- ieee80211_tx_h_stats

Main flows – management/MLME



Main flows – management/MLME



Main flows – management/MLME

Ok, so you didn't want to know **that** precisely.

- requests from user are translated to internal variables
- state machine is run depending on user request
- normal way looks like this:
  - probe request/response
  - auth request/response
  - assoc request/response
  - notification to userspace

Main flows – management/MLME

For IBSS (wasn't on the state machine slide) it's simpler

- try to find IBSS
- join IBSS or create IBSS
- if no peers periodically try to find IBSS to join

Handoff points

Three main points

- configuration (from userspace)
- mac80211/rate control
- mac80211/driver

Handoff points – configuration

- Wireless extensions (wext)
- cfg80211 (which userspace talks to via nl80211)

Handoff points – configuration – wext

Currently still includes

- setting SSID, BSSID and other association parameters
- setting RTS/fragmentation thresholds
- encryption keys in managed/IBSS modes

Handoff points – configuration – cfg80211

Is being extended, already has

- scanning
- station management (AP)
- mesh management
- virtual interface management
- encryption keys in AP mode

(See more in cfg80211/nl80211/userspace talk.)

Handoff points – from mac80211 to rate control

- Rate control is semantically not part of driver
- per-driver selection of rate control algorithm
- rate control fills ieee80211_tx_info rate information
- rate control informed of TX status

Handoff points – from mac80211 to driver

- many driver methods (ieee80211_ops)
- mac80211 also has a lot of exported functions
- refer to include/net/mac80211.h

Execution contexts

- config flows: userspace process context
- state machine flows: workqueue context
- packet processing flows: tasklet context
- some callbacks: interrupt context (_irqsafe functions)

Synchronisation mechanisms

background – RCU

- **r**ead - **c**opy - **u**pdate
- think read/write locks without locking reads
- instead, copy structure, and atomically publish
- problem: when to get rid of old copy

Synchronisation mechanisms

background – rtnl

- “big networking lock”, global lock
- used to protect all configuration calls, e.g. interface start/stop
- consequently used by wireless extensions to protect config calls

Synchronisation mechanisms

- config flows: mostly rtnl
- a lot of RCU-based synchronisation (sta_info, key management)
- mutex for interface list management
- spinlocks for various tightly constrained spots like sta list management, sta_info members etc.
- some more specialised locks

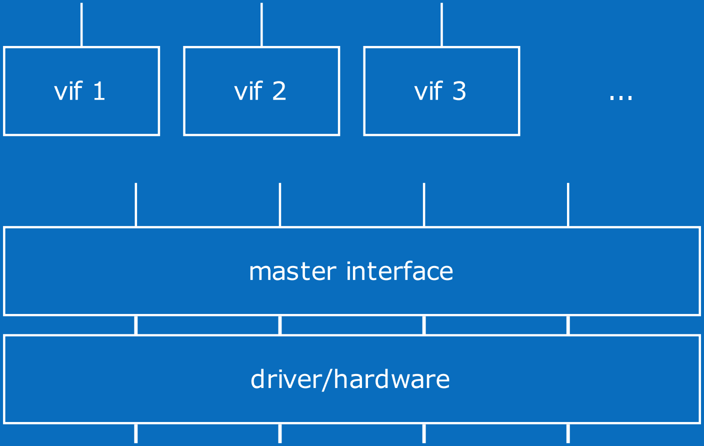
Stay up-to-date

- http://wireless.kernel.org/en/developers/Documentation/mac80211
- especially
  http://wireless.kernel.org/en/developers/Documentation/mac80211/API
- also http://wireless.kernel.org/en/developers/todo-list/
- subscribe to wiki changes on these pages
- follow patches going in: git log -- net/mac80211/
- read the wireless list
  (http://wireless.kernel.org/en/developers/MailingLists)

Thank you for your attention.

Questions?

virtual interfaces



virtual interfaces

- allow, in theory, multiple network interfaces on single hardware
- for example WDS and AP interfaces (to be bridged)
- for example multiple AP interfaces (multi-BSS)
- any number of monitor interfaces
- any number of AP_VLAN interfaces (to implement multi-SSID with single BSSID)

virtual interfaces

supported interface types

- ad-hoc (IBSS)
- managed
- AP and AP_VLAN
- WDS
- mesh point
- monitor

virtual interfaces

relevancy to drivers

- drivers need to allow each interface type
- drivers need to support certain operations for certain interface types
- drivers can support multiple virtual interfaces
- **but:** drivers not notified of monitor interfaces

filter flags

- used to configure hardware filters
- best-effort, not all filter flags need to be supported
- best-effort, not all filters need to be supported
- filter flags say which frames to pass to mac80211 – thus a filter flag is supported if that type of frames passed to mac80211
- passing more frames than requested is always permitted but may affect performance

filter flags

monitor interfaces

- handled entirely in mac80211
- may affect filters depending on configuration
- it is possible to create a monitor interface that does not affect filters, can be useful for debugging (iw phy phy0 interface add moni0 type monitor flags none)

Even backup slides end somewhere.