WiFi overview

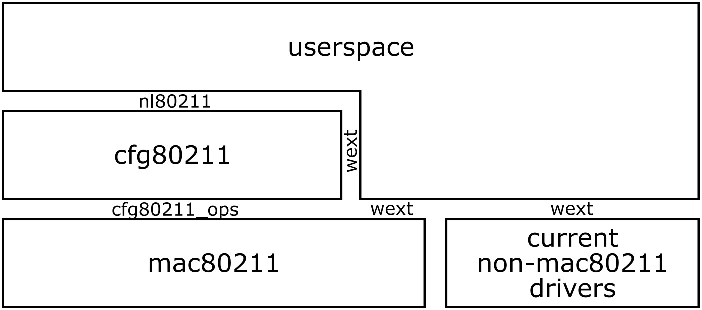
Johannes Martin Berg

2009-02-29

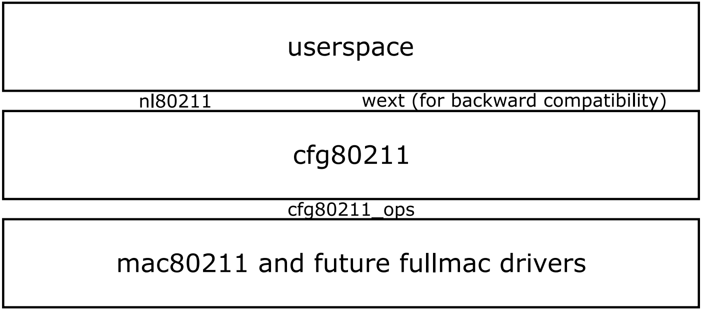
We'll cover

- mac80211
- wext (and quickly forget about it)
- cfg80211/nl80211
- wpa_supplicant
- hostapd

Architecture – current



Architecture – planned



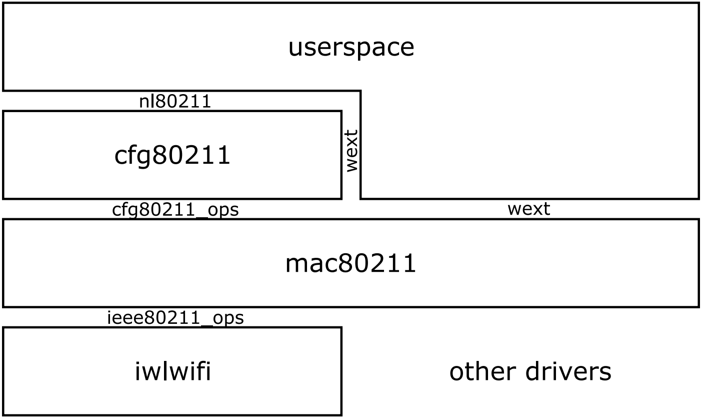
mac80211

- 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

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	Kalle Valo (Nokia)

Architecture



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

- 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

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

- 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

- 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

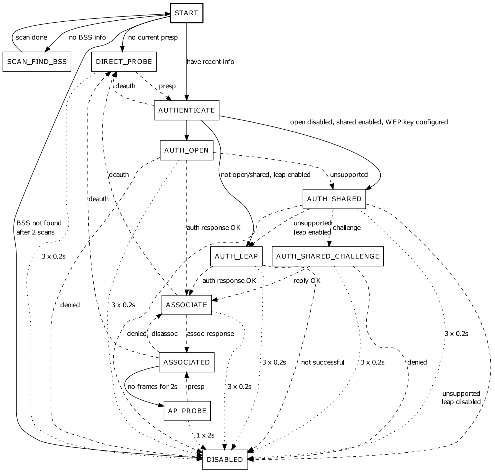
Main flows – transmit path

- 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

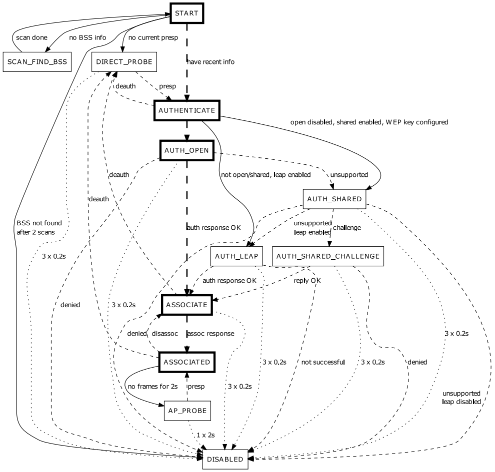
Main flows – transmit path

- 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



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

- requests from user are translated to internal variables
- state machine runs on user request
- normal procedure:
    - probe request/response
    - auth request/response
    - assoc request/response
    - notification to userspace

Simpler for IBSS:

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

Three main points

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

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

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

- 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

Quick questions on mac80211?

- all code is in net/wireless/wext.c
- not much code – drivers need to implement a lot
- userspace sets each parameter one by one
- driver tries to work with these parameters
- problem: is the user going to send a BSSID after the SSID?

Wireless extensions – handoff points

- netdev.wireless_handlers
  - contains array of standard and private handlers
  - handlers called by userspace via ioctl
- drivers send events via netlink
- a lot already handled in cfg80211 wext-compat

- thin layer between userspace and drivers/mac80211
- mainly sanity checking, protocol translations
- thicker than wext – sanity checking, bookkeeping, compat layer, ...

- userspace access to cfg80211 functionality
- defined in include/linux/nl80211.h
- currently used in userspace by iw, crda, wpa_supplicant, hostapd

- drivers register a struct wiphy with cfg80211
- this includes hardware capabilities like
    - bands and channels
    - bitrates per band
    - HT capabilites
    - supported interface modes
- needs to be done before registering netdevs
- netdev ieee80211_ptr links to registered wiphy

- still work in progress
- relies on userspace helper (crda) to provide restriction information
- will update the list of registered channels and (optionally) notify driver

- create/remove virtual interfaces
- change type of virtual interfaces (provides wext handler)
- change ‘monitor flags’
- keeps track of interfaces associated with a wireless device
- will set all interfaces down on rfkill

- optional
- mostly for mac80211, though other appropriate uses exist
- only matching PHY parameters possible, all virtual interfaces are on one channel
- driver responsible for rejecting impossible configurations like IBSS+IBSS or similar

- ad-hoc (IBSS)
- managed
- AP and AP_VLAN
- WDS
- mesh point
- monitor
  - can set monitor flags: control frames, other BSS frames
  - special case: cooked monitor
  - cooked monitor sees all frames no other virtual interface consumed

- monitor (replacing things like CONFIG_IPW2200_PROMISCUOUS and module parameter)
- switching modes like with iwconfig
- allow multiple interfaces, combining e.g. WDS and AP for wireless backhaul

- many more features than wext:
  - multiple SSIDs
  - channel specification
  - allows IE insertion

- NetworkManager/connman
- wpa_supplicant
- hostapd
- “userspace SME”

- internally modular architecture, supports multiple backends
- current version supports nl80211, wext no longer required
- current version can try nl80211 and fall back to wext
- actively maintained by Jouni Malinen (Atheros)

Userspace – hostapd

- implements (almost) the entire AP MLME
- works with mac80211 through nl80211
- requires working radiotap packet injection
- requires many of the nl80211 callbacks
- requires ‘cooked’ monitor interfaces
- actively maintained by Jouni Malinen (Atheros)

Userspace – “userspace SME”

- API has separate auth/assoc
- needs to support multiple authentications simultaneously (WIP)
- supports adding arbitrary IEs into auth/assoc frames
- together this allows 802.11r
- auth/assoc state machine needed in cfg80211 for wext
- to do: add SME to cfg80211 for wext

Thanks for listening.

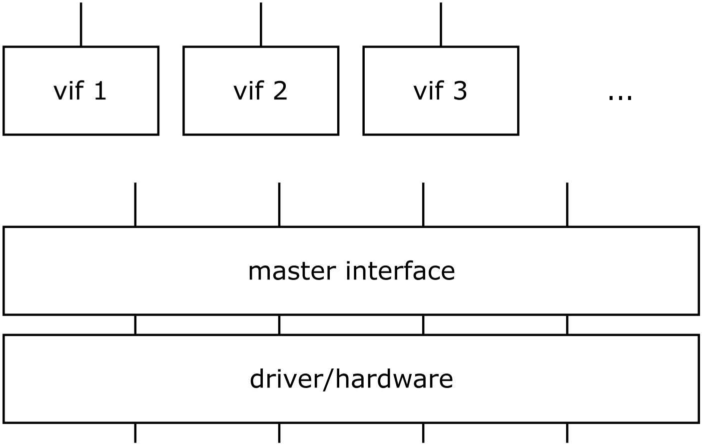
Questions?

http://wireless.kernel.org/

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

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)

relevance 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

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.