WiFi control plane overview

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2009-02-26

Introduction

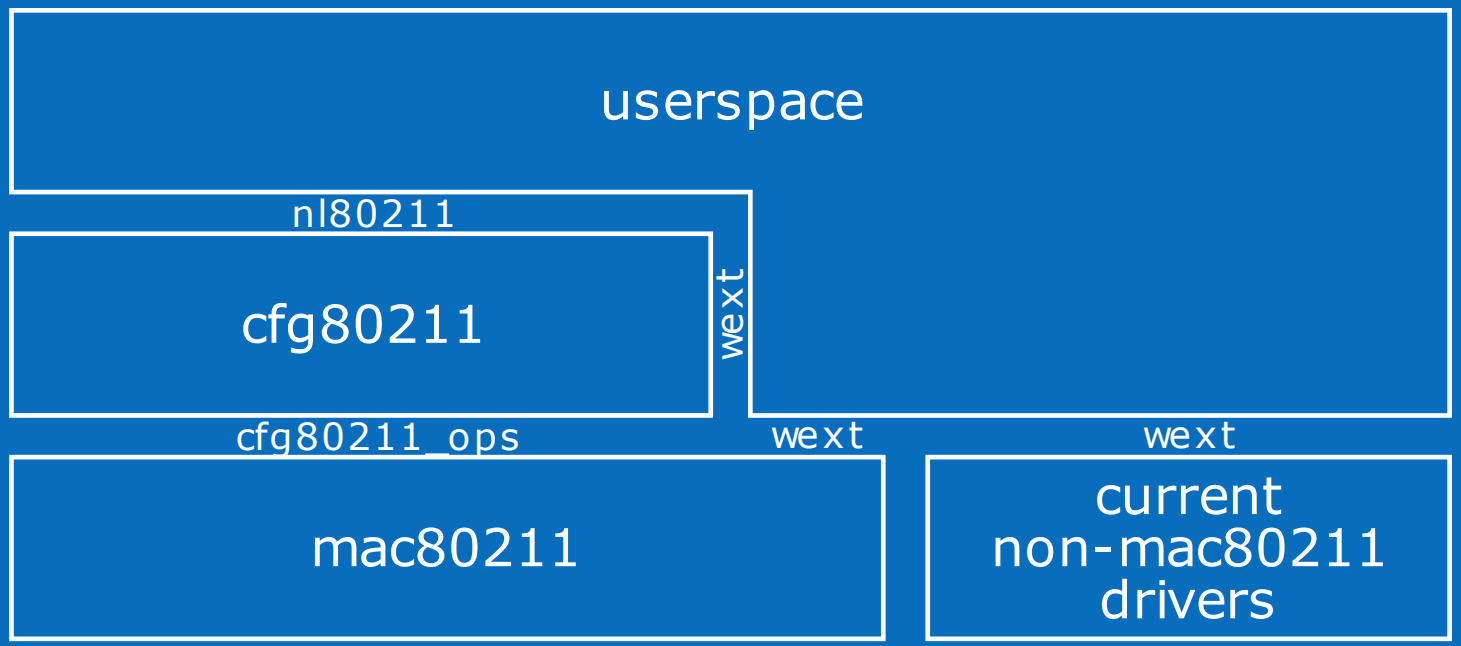
We'll cover

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

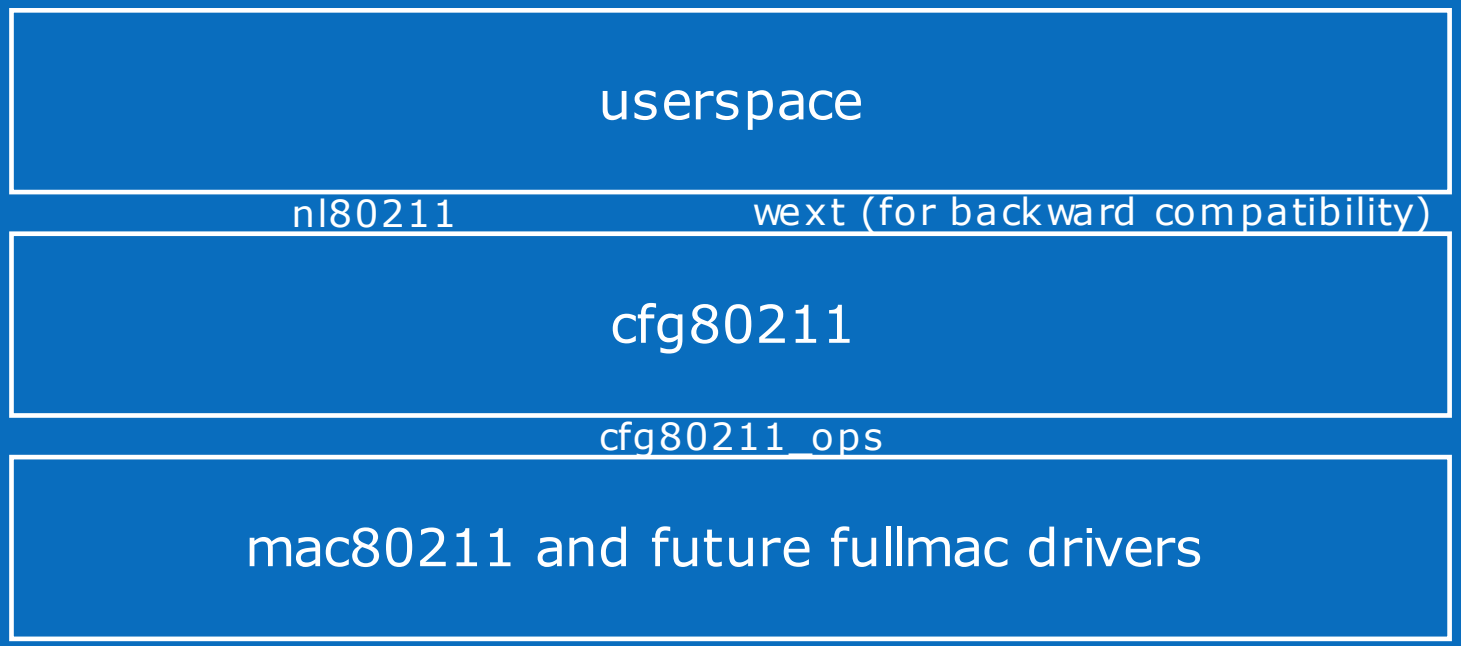
Introduction – History (non-technical)

1996 or so	Jean Tourrilhes creates wireless extensions
? - today	userspace MLME used by Jouni Malinen
during mac80211 cleanup	wireless extensions deemed unsuitable for future configuration needs
late 2006	initial cfg80211/nl80211 work (myself)
since then	many extensions in nl80211, mesh, HT, ...
February 2009	userspace MLME idea dropped

Architecture – current



Architecture – planned



background

netlink

- RFC 3549
- used to communicate with kernel (in theory also userspace to userspace)
- TLV-based protocol
- implements “families”
- one specific family: generic netlink
- easily extensible, discoverable

Wireless extensions – code structure

- all code is in net/wireless/wext.c
- not much code – drivers need to implement a lot

Wireless extensions – main flows

- 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

Wireless extensions

- all executed under rtnl
- callbacks all run in process context (from userspace)
- event sending can be done in any context

cfg80211

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

cfg80211 – code structure

All files except the header files (include/net/cfg80211.h and include/net/wireless.h) are in **net/wireless/**.

Kconfig, Makefile	build system
core.c, core.h	core code
nl80211.c	nl80211 generic netlink code
scan.c	scan code
reg.c	regulatory enforcement code
util.c	some utility functions for cfg80211 and drivers
radiotap.c	a radiotap parser (for injection)
wext-compat.c	wext compatibility code
sysfs.c	sysfs representation

cfg80211 – nl80211

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

cfg80211 – main flows

- device registration
- regulatory enforcement
- station management (AP)
- key management (AP only)
- mesh management
- virtual interface management
- scanning

cfg80211 – main flows

device registration

- 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

cfg80211 – main flows

regulatory enforcement (overview)

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

cfg80211 – main flows

regulatory enforcement

- default: restrictive 'world' regulatory domain
- driver/user/AP (11d) tells us where we are (iso 3166 code like 'US')
- create a uevent to notify userspace
- udev runs crda, which parses database and uploads information via nl80211 to kernel
- depending on origin of hint, information may be postprocessed
- channel lists of all wireless devices are updated with regulatory flags
- future channel use will take new restrictions into account, e.g. while scanning

cfg80211 – main flows

station management

- add/remove/modify stations
- dump station list
- works with a few callbacks:
  - .add_station
  - .del_station
  - .change_station
  - .get_station
  - .dump_station (races!)

cfg80211 – main flows

mesh management

- mesh path handling to station handling
- mesh parameters can be set/retrieved

cfg80211 – main flows

virtual interface management

- create/remove virtual interfaces
- change type of virtual interfaces (provides wext handler)
- change 'monitor flags'
- keeps track of interfaces associated with a wireless device

cfg80211 – main flows

virtual interface basics

- optional
- mostly for mac80211, though other appropriate uses exist
- only matching PHY parameters possible, e.g. all virtual interfaces are on one channel
- driver responsible for rejecting impossible configurations

cfg80211 – main flows

virtual interface types

- 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 used

cfg80211 – main flows

virtual interface use

- monitor (replacing things like IPW2200_PROMISCUOUS and module parameter)
- switching modes like with iwconfig
- allow multiple interfaces, combining e.g. WDS and AP for wireless backhaul

cfg80211 – main flows

scan features

- many more features than wext:
  - multiple SSIDs
  - channel specification
  - allows IE insertion
- extensible via generic netlink attributes

cfg80211 – main flows

scan flow

- userspace request (nl80211 or wext)
- handed to .scan handler in a structure specifying what to do
- mac80211/driver scans according to the request
- beacons/probe responses handed to cfg80211 to fill BSS list (cfg80211_inform_bss_frame())
- request struct given back to cfg80211 with indication whether scan was successful or not (cfg80211_scan_done())
- userspace notified via nl80211/wext that scan is done
- userspace requests BSS list

cfg80211 – synchronisation

- global lock held for list/regulatory management
- per-device lock held for callbacks, device data structures
- configuration calls to drivers executed under rtnl
- this synchronises against interface callbacks (start, stop, etc.)

Userspace

most common tools

- NetworkManager
- wpa_supplicant
- hostapd
- “userspace MLME”

Userspace – NetworkManager

- GUI tool for GNOME and KDE
- uses hal/d-bus
- more importantly, uses wpa_supplicant (except for scanning, uses wext)
- therefore no big concern – look at wpa_supplicant instead

Userspace – wpa_supplicant

- internally modular architecture, supports multiple backends
- current git version supports nl80211 scanning
- current git version can try nl80211 and fall back to wext
- nl80211 backend ('driver') still uses some wext calls
- 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 MLME”

- misleading name for “client-MLME in userspace”
- initially seen as only/easiest way to implement 802.11r (due to auth frame processing)
- hard to do right
  - kernel needs to know assoc status for packet flow
  - quite backwards – userspace creating e.g. HT or rate information based on what device supports and then passing it through
  - software scanning in userspace doesn't go too well with firmware
  - configuration big problem – wext/nl80211 no longer applicable

Userspace – “userspace MLME”

What to do about it?

- remember wext
  - can set only SSID/BSSID
  - either operation can trigger authentication/association
- discussion with Jouni about further move to nl80211
- initial idea: just associate with parameters
- problem: deauth still needed, but associate vs. deauth and disassoc is asymmetric

Userspace – “userspace MLME”

What to do about it? (2)

- will implement auth/assoc separately
- support multiple authentications simultaneously
- support adding arbitrary IEs into auth/assoc frames
- together this allows 802.11r
- tools need to implement auth/assoc, provide example in iw
- no need to put more of the MLME into userspace
- auth/assoc state machine needed in cfg80211 for wext
- open question: what to do with drivers that don’t support separate auth/assoc?

Stay up-to-date

- see wiki: http://wireless.kernel.org/en/developers/todo-list/ and http://wireless.kernel.org/en/developers/todo-list/cfg80211/
- subscribe to wiki changes on these pages
- follow patches going in:
  git log -- net/wireless/ include/linux/nl80211.h
- read the wireless list
  (http://wireless.kernel.org/en/developers/MailingLists)

Thank you for your attention.

Questions?