

“802.11 as a component”
Available OAM interface specifications

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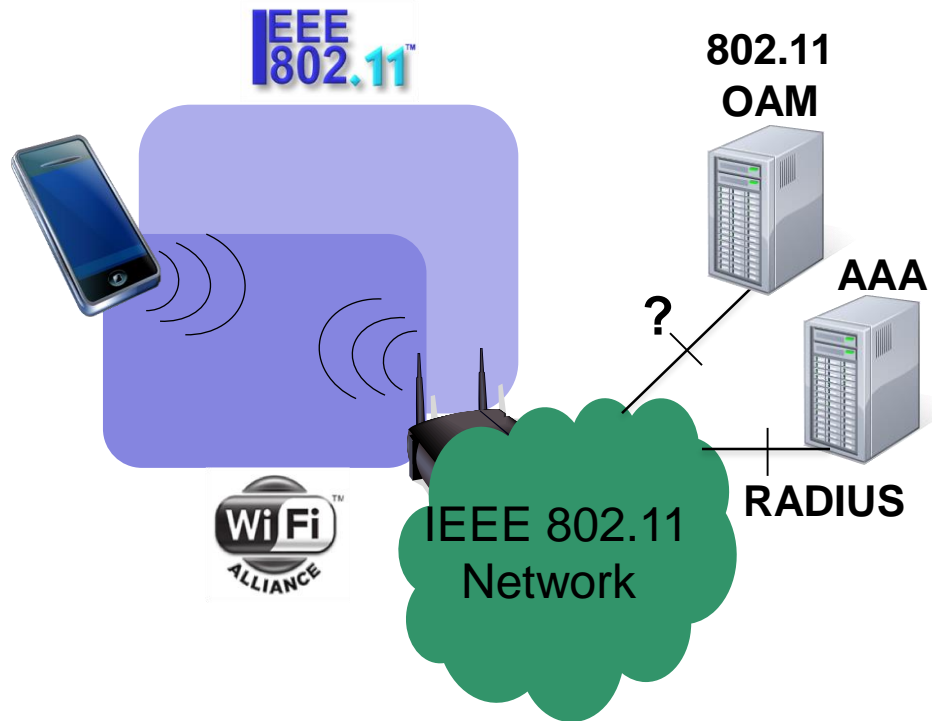
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Abstract

- **The presentation provides an overview about available specifications of open OAM interfaces for implementations of IEEE 802.11.**
- **In a particular sense all the specifications describe ‘802.11 as a kind of component’.**
- **The material may provide insights into today’s requirements and capabilities, as the presented specifications are all widely deployed.**

IEEE 802.11 Standards Environment



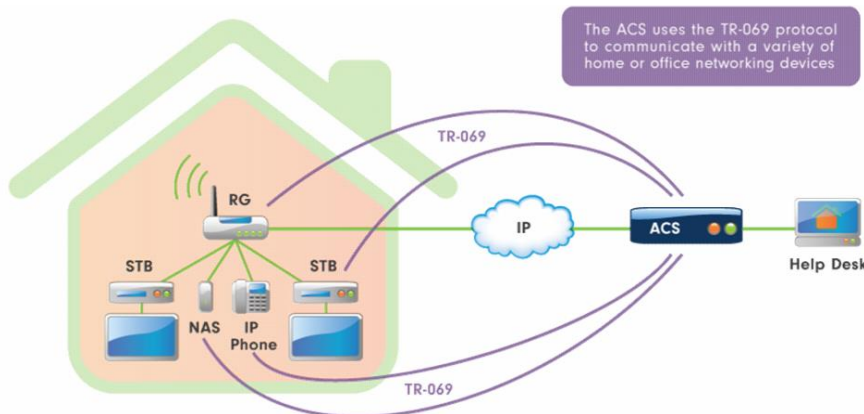
- IEEE 802.11 defines a radio interface
- Wi-Fi Alliance ensures compliance of the radio interface by certification
- OAM of the 802.11 radio interface is described by a comprehensive MIB
- A couple of organizations developed special variants of OAM interfaces for 802.11
- However there is a single solution for AAA: RADIUS

'OAM' Interface Specifications for 802.11

- **BroadBandForum**
 - Wi-Fi model and attributes of Device Data Model 2 (TR-181) for CPE WAN Management Protocol (TR-069)
- **CableLabs**
 - Wi-Fi Provisioning Framework Specification (WR-SP-WiFi-MGMT)
- **IETF CAPWAP**
 - Control And Provisioning of Wireless Access Points (CAPWAP) Protocol Specification (RFC5415) and Binding for IEEE 802.11 (RFC5416)
- **LINUX Wireless**
 - mac80211 Wi-Fi driver architecture with cfg80211 kernel configuration module and nl80211 netlink user space interface
- **IETF RADIUS**
 - IEEE 802.1X Remote Authentication Dial In User Service (RADIUS) Usage Guidelines (RFC3580), RADIUS Attributes for IEEE 802 Networks (RFC7268) and Carrying Location Objects in RADIUS and Diameter (RFC5580)

BroadBand Forum CWMP

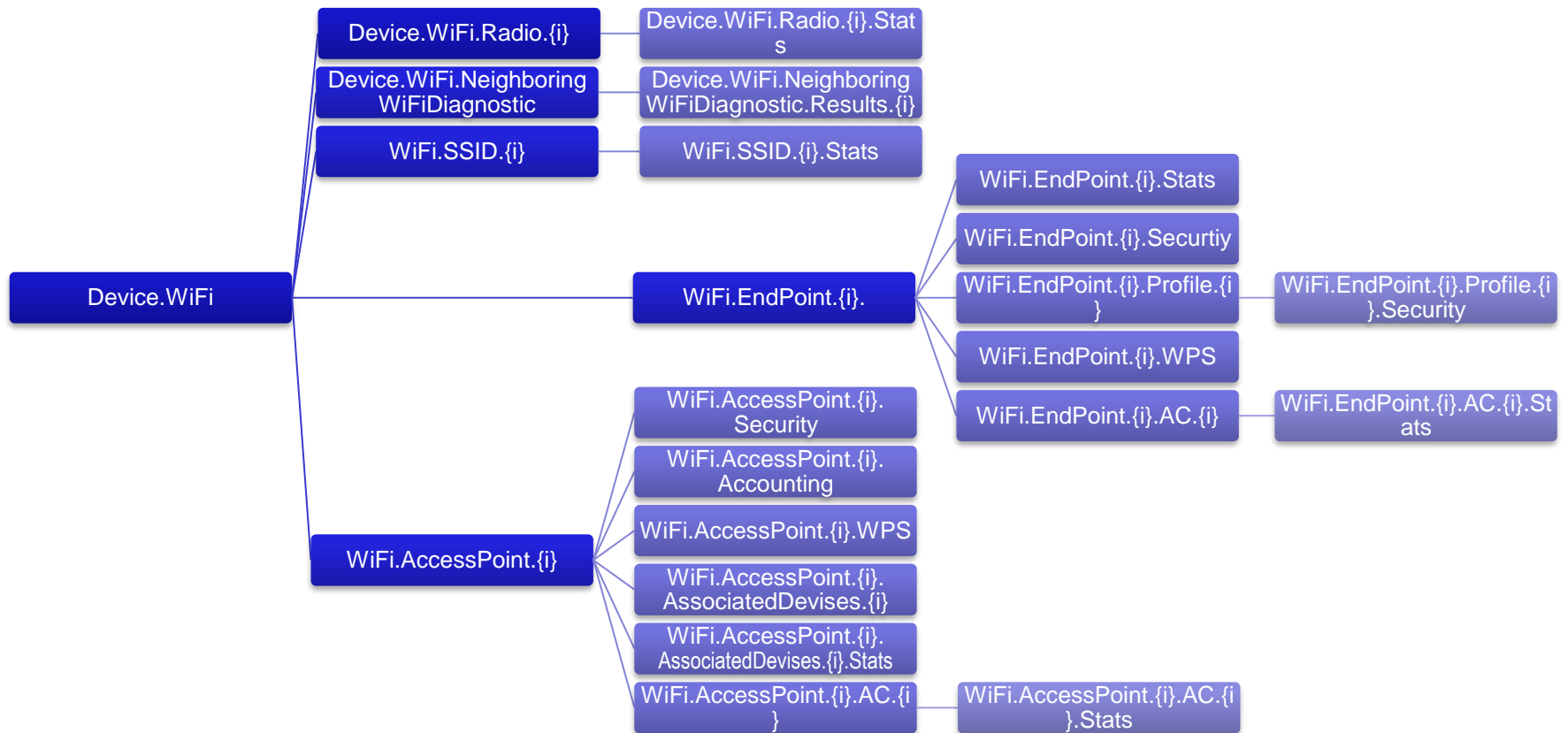
- **CWMP: CPE WAN Management Protocol aka TR-069**
 - <https://www.broadband-forum.org/cwmp.php>



Broadband Forum, MR230, TR-069 deployment scenarios

- TR-069 is an soap/HTTP based protocol for transmission of XMLbased descriptions of management models between CPE and ACS
- TR-069 Data Models are xml documents that are “schema-like”, that describe the management objects and parameters used for particular use cases.
- **The CWMP Data Model Schema is specified in TR-106.**
- **TR-181 defines version 2 of the TR-069 Device data model (Device:2) and is applicable to all types of TR-069-enabled devices. It obsoletes both Device:1 and InternetGatewayDevice:1 specifications**



TR-181 Wi-Fi Model







TR-181 Wi-Fi model summary

- **TR-181 supports two kinds of devices: APs and (nonAP) STAs (Endpoints)**
- **A Wi-Fi device consists out of 1..n radio interfaces, 1..n SSIDs and 1..n AccessPoints or EndPoints**
- **A compact set of IEEE 802.11 specific attributes are provided for configuration**
- **Each of the elements of the Wi-Fi model has a rich set of attributes for monitoring/accounting/statistics.**

CableLabs

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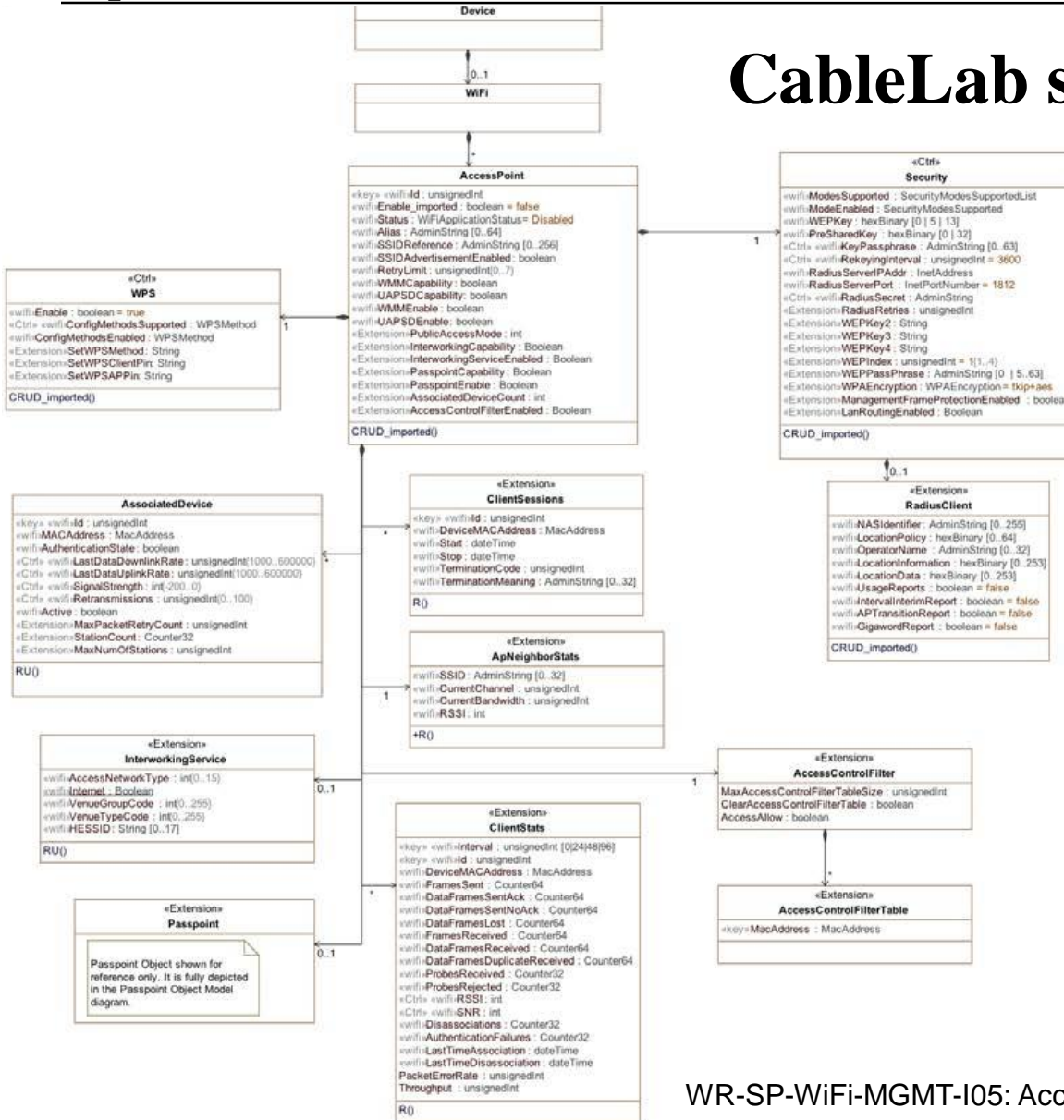
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CableLabs Wi-Fi MGMT overview

- **WR-SP-WiFi-MGMT-I05-141201.pdf is CableLabs' most relevant specification for OAM of Wi-Fi interfaces.**
- **CableLabs builds management of Wi-Fi on top of TR-069 approaches by**
 - adopting the TR-181 device model for Wi-Fi
 - amending the device model by vendor specific extensions for missing functions
 - defining a compatible SNMP MIB to enable backward-compatibility to the legacy provisioning and management systems in the cable environment
- **CableLabs has currently the most far-reaching Wi-Fi management model for 'residential' deployments**
 - Covering Passpoint™ and reaching out into SON for Wi-Fi

CableLab specific extensions:

- RadiusClient
- Interworking Service
- Passpoint
- ClientSessions
- ClientState
- ApNeighborStats
- AccessControlFilter

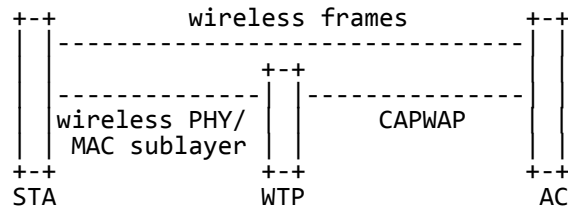


WR-SP-WiFi-MGMT-I05: Access Point Object Model Class Diagram

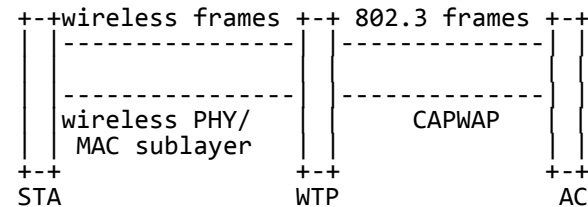
IETF CAPWAP

Control And Provisioning of Wireless Access Points

- **CAPWAP addresses the communication between a wireless termination point (WTP) and an access controller (AC)**
- **Supports different architectural models with various possibilities to locate functions either in WTB or AC**



Representative CAPWAP Architecture for Split MAC



Representative CAPWAP Architecture for Local MAC

- **RFC 5415 defines Control And Provisioning of Wireless Access Points (CAPWAP) Protocol**
- **RFC 5416 provides Binding of CAPWAP for IEEE 802.11**

Applicability

- **Market momentum of CAPWAP was never reached to diminishing benefits of split-MAC implementations**
 - High throughput is easier handled by local MAC solutions
- **Local MAC solutions not really require a complex protocol like CAPWAP**
 - Other protocols like TR-069 (or even ssh) are sufficient
- **802.11 binding in RFC5416 is too hard-coded.**
 - Even tiny extensions have to go through a complete IETF standardization cycle
 - Recent activities in IETF opsawg to amend RFC5416 for more recent 802.11 standards and deployment scenarios
 - RFC7494: IEEE 802.11 Medium Access Control (MAC) Profile for Control and Provisioning of Wireless Access Points (CAPWAP)

LINUX Wireless

The image displays two overlapping browser screenshots of the Linux Wireless website.

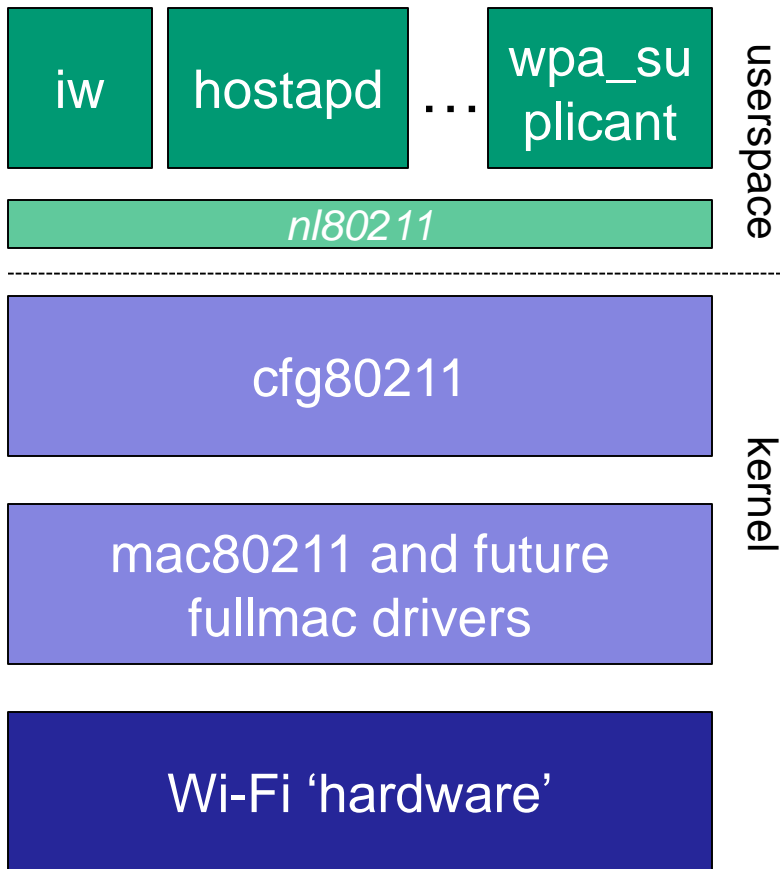
Left Screenshot (http://linuxwireless.org/welcome/):

- Header: Linux Wireless logo and a penguin icon.
- Text: "Welcome to", "This is the main source for Linux wireless features information", "This site covers all the new user space applications are also", "If you want to keep track of the latest news or get it through RSS", "News archive: view old news (News list)", "This is a static dump of the old wiki. The latest versions of this page: last, v58, v57, v56, v35, v34, v33, v32, v31, v30, v29, v8, v7, v6, v5, v4, v3, v2, v1".

Right Screenshot (https://wireless.wiki.kernel.org/en/users):

- Browser: Mozilla Firefox, address bar shows the URL.
- Page Title: Linux Wireless.
- Navigation: File, Edit, View, Favorites, Tools, Help.
- Trace: welcome · documentation · users.
- Users:
 - main page
 - Support
 - Drivers
 - Devices
 - Download
 - Documentation
- Vendors:
 - Vendor Support
 - Driver Development
- Developers:
 - Documentation
 - mailing lists
 - todo list
- Main Content:
 - wireless.kernel.org – Users**: "There has been a lot of recent development and advances on Linux wireless. We intend on documenting this progress for users here."
 - User sections**:
 - Support - Our various support channels
 - Documentation - General user documentation
 - Wireless hardware device list
 - Drivers - Linux wireless drivers for new wireless cards
 - Download - Download and compile the latest drivers available
 - Tips to stay on top of things**: "If you are interested in the latest advances in Linux wireless you are highly recommended to subscribe to the RSS feed for this site - make sure you take the global and not the per-namespace one (unless you care only about one namespace, of course)".
- Table of Contents:
 - wireless.kernel.org – Users
 - User sections
 - Tips to stay on top of things
- Footer: 100% zoom.

LINUX Wi-Fi driver architecture



- **nl80211 has become defacto standard for Wi-Fi configuration in LINUX**
 - Defines a comprehensive list of controls, commands and attributes for Wi-Fi
 - Communicates by netlink (RFC3549) with kernel
- **cfg80211 provides unified interface into kernel drivers**

Wi-Fi OAM specification ‘nl80211.h’

<http://git.kernel.org/cgit/linux/kernel/git/linville/wireless.git/tree/include/uapi/linux/nl80211.h?id=HEAD>

```
#ifndef __LINUX_NL80211_H
#define __LINUX_NL80211_H
/*
 * 802.11 netlink interface public header
 *
 * Copyright 2006-2010 Johannes Berg <johannes@sipsolutions.net>
 * Copyright 2008 Michael Wu <flamingice@sourmilk.net>
 * Copyright 2008 Luis Carlos Cobo <luisca@cozybit.com>
 * Copyright 2008 Michael Buesch <m@bues.ch>
 * Copyright 2008, 2009 Luis R. Rodriguez <lrodriguez@atheros.com>
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 * ANY SPECIAL, DIRECT, INDIRECT, OR CONSEQUENTIAL DAMAGES OR ANY DAMAGES
 * WHATSOEVER RESULTING FROM LOSS OF USE, DATA OR PROFITS, WHETHER IN AN
 * ACTION OF CONTRACT, NEGLIGENCE OR OTHER TORTIOUS ACTION, ARISING OUT OF
 * OR IN CONNECTION WITH THE USE OR PERFORMANCE OF THIS SOFTWARE.
 */
#include <linux/types.h>

#define NL80211_GENL_NAME "nl80211"

/**
 * DOC: Station handling
 *
 * Stations are added per interface, but a special case exists with VLAN
 * interfaces. When a station is bound to an AP interface, it may be moved
 * into a VLAN identified by a VLAN interface index (%NL80211_ATTR_STA_VLAN).
 * The station is still assumed to belong to the AP interface it was added
 * to.
 *
 * Station handling varies per interface type and depending on the driver's
 * capabilities.
 */
```

nl80211.h defines...

- 120 commands
- about 600 attributes and controls

Potentially nl80211.h is the most comprehensive open OAM interface for 802.11

- next to the 802.11 MIB

IETF RADIUS

Remote Authentication Dial-In User Service

- **RADIUS is commonly used for the communication between Access Point and AAA server for user authentication, user authorization and user accounting.**
- **Support of EAPoLAN (IEEE 802.1X), which was introduced to 802.11 by 802.11i, is specified in RFC3580 (IEEE 802.1X Remote Authentication Dial In User Service (RADIUS) Usage Guidelines).**
- **Further IEEE802 specific attributes are specified by RFC7268 (RADIUS Attributes for IEEE 802 Networks) to support interworking with external networks and enhanced security modes.**
- **RFC5580 (Carrying Location Objects in RADIUS and Diameter) allows also 802.11 to convey location information over the AAA infrastructure.**

Conclusion

- **There are several specifications for open OAM interfaces into an IEEE802.11 radio interface.**
 - Created in various places in the communication industry according to deployment needs
- **None of them seems to be sufficient to cover all current and future deployment cases.**
 - Ease of amending the OAM interface specification seems to be highly important to allow for timely deployment of new 802.11 features and functions.
 - Apparently some of the current specifications do better than others
- **Is there really need to start something new from scratch?**

Steps forward

- **Further work on the assessment of existing OAM specification for 802.11 would benefit from input from experts:**
- **Are there other specifications?**
- **Guidance for comparison of specifications?**
- **Is there a recommended structure for listing/grouping capabilities?**
 - e.g. CableLabs Access Point Management Object Model
- **Is there any prior art on comparative assessment of 802.11 management models?**