AnyCloud WiFi Design Flow

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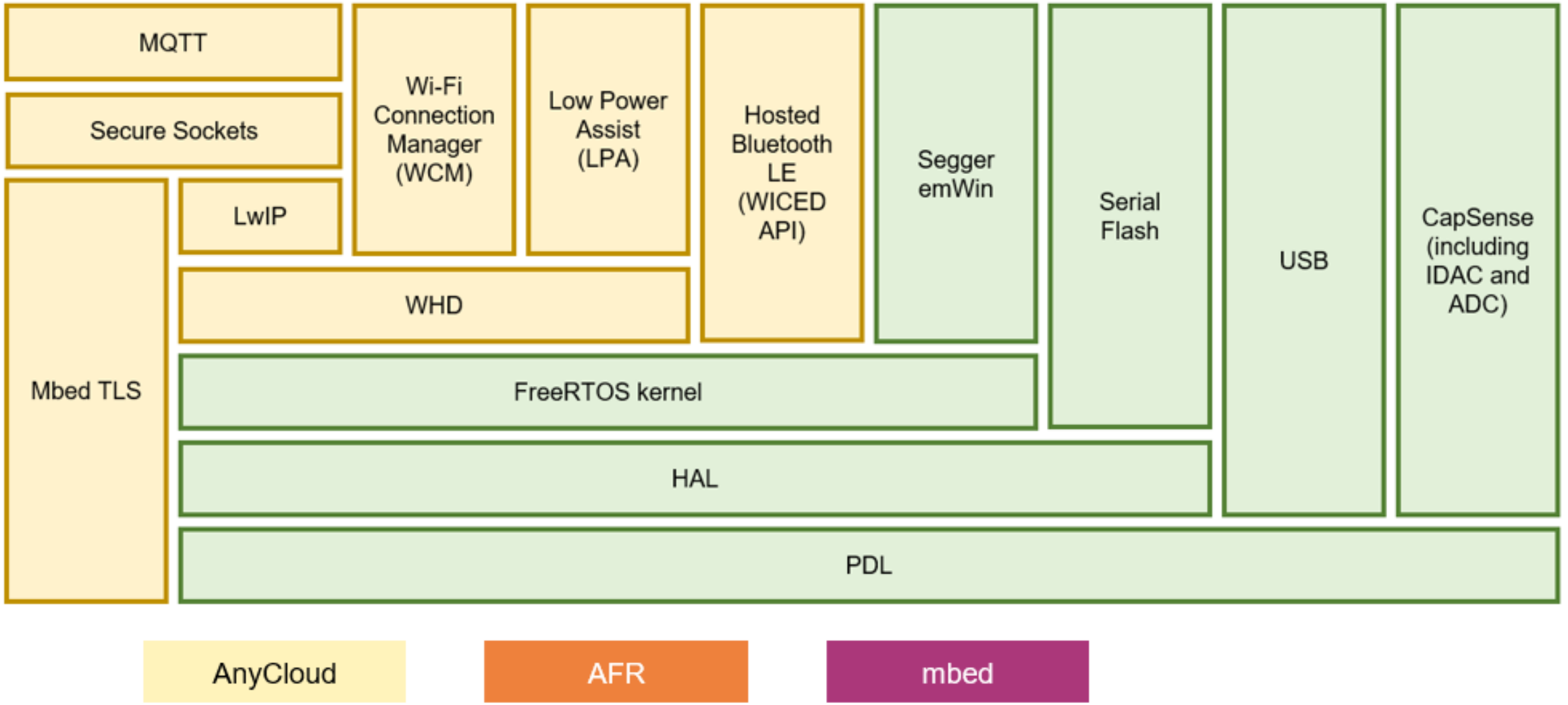
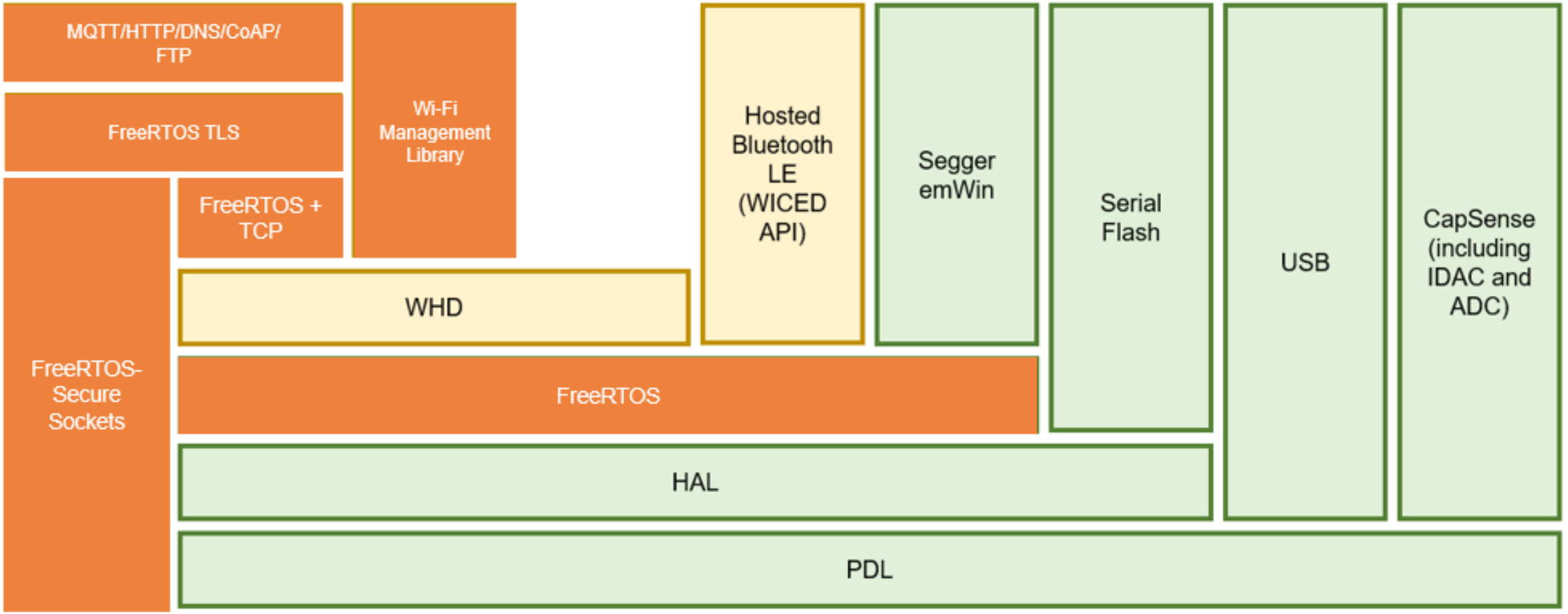
Agenda

- Software Architecture – AnyCloud / AFR / Mbed
- AnyCloud Stack
- AnyCloud WiFi Libraries
  - Using Library manager to add Wi-Fi to a PSoC 6 project in AnyCloud
  - Middleware Core Libraries
  - Wi-Fi Connection Manager (WCM)
  - Secure Sockets
- WICED Wi-Fi Driver
- WHD WiFi Host Driver
- Demo – TCP Client
- Q&A – Feel free to ask questions in the chat window even during the presentation.

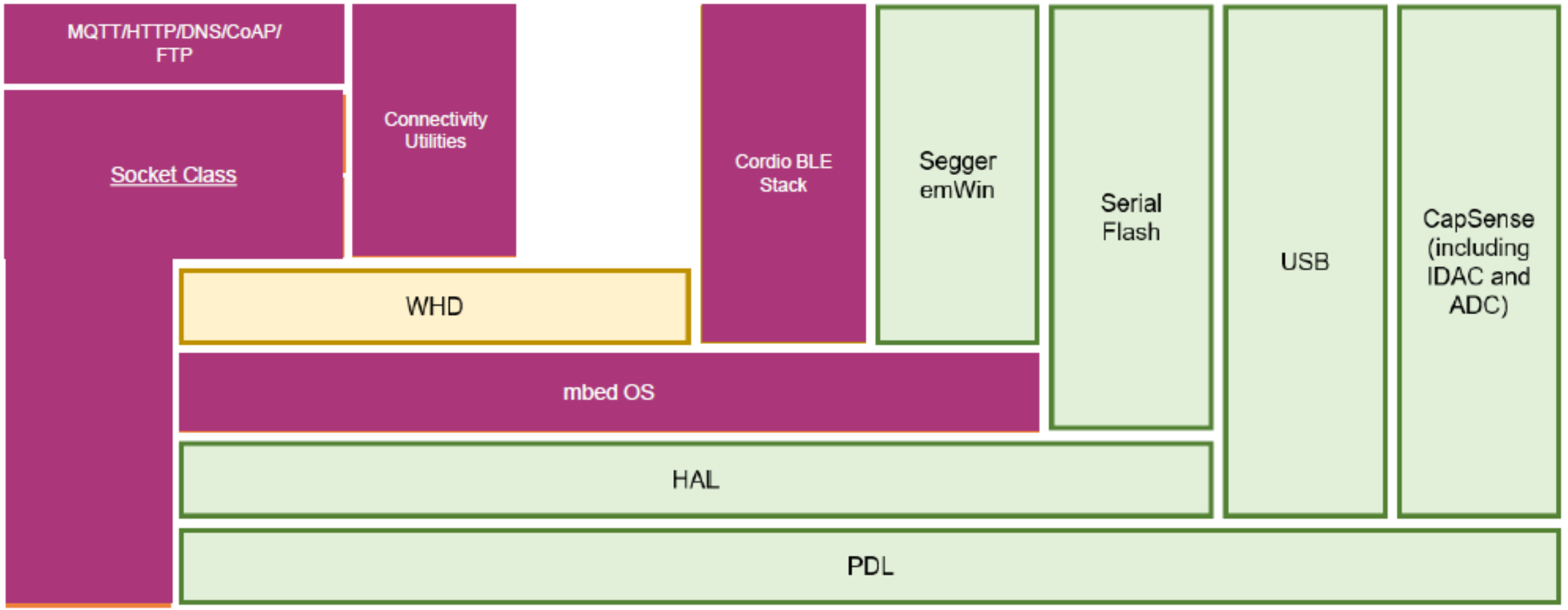
Software Architecture – AnyCloud / AFR / Mbed



Software Architecture – AnyCloud / AFR / Mbed

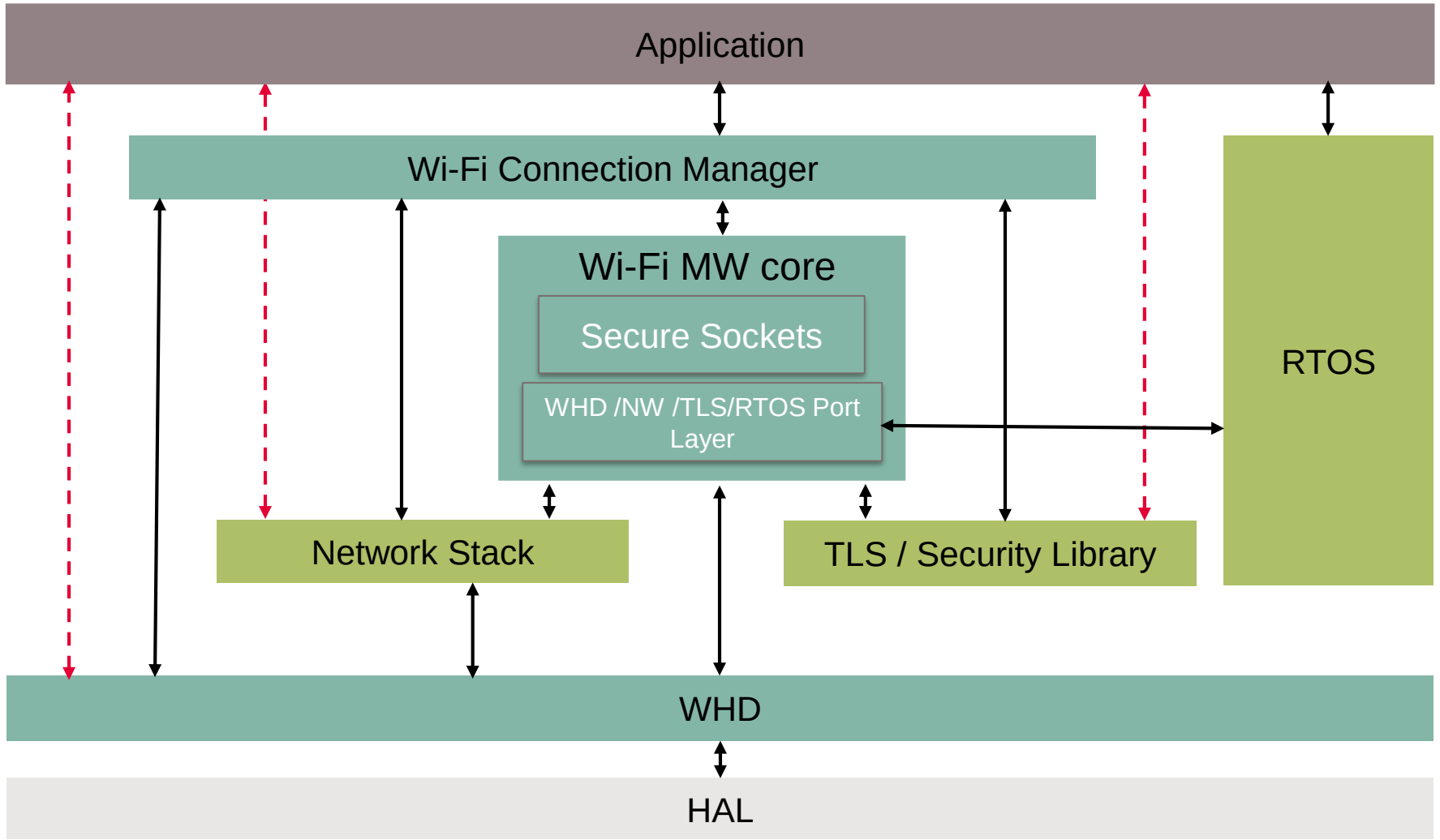


Software Architecture – AnyCloud / AFR / Mbed



AnyCloud Stack

- LwIP, mbedTLS & FreeRTOS are all pulled from their respective GIT Repos.
- RTOS, N/W Stack & Security (TLS) libraries can be substituted with alternatives in any combination.



Legend

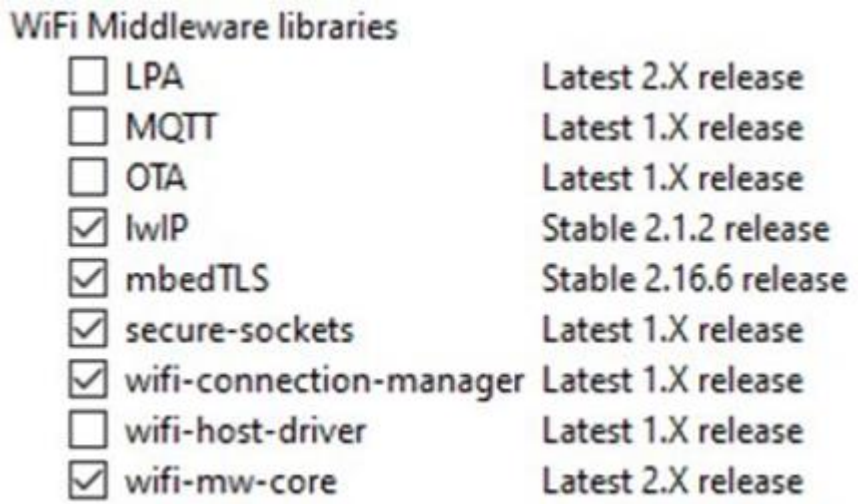
3rd Party Libraries

Infineon - AnyCloud Lib & Wi-Fi Driver

Host MCU HAL

WiFi Middleware Libraries

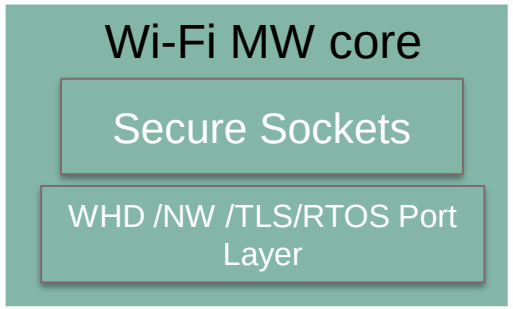
- Adding WiFi to an existing PSoC 6 project
  - Ensure the project is using FreeRTOS.
  - Add WCM from the library manager.
  - This will add / download all necessary libraries.
  - Make changes to the Makefile as below
  - Code should now compile



- Makefile Changes
  - `COMPONENTS=FREERTOS LWIP MBEDTLS`
  - `MBEDTLSFLAGS = MBEDTLS_USER_CONFIG_FILE='"mbedtls_user_config.h"'`
  - `DEFINES=$(MBEDTLSFLAGS) CYBSP_WIFI_CAPABLE CY_RTOS_AWARE`

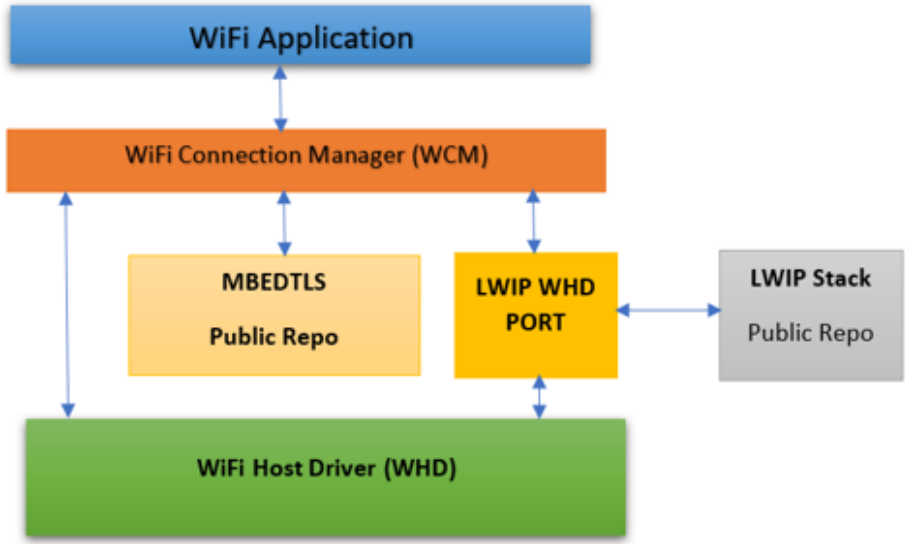
Wi-Fi Middleware Core Library

- Bundles all the core components required for Wi-Fi development.
- Adds LwIP, mbedTLS, FreeRTOS, WHD, and Secure Sockets as dependencies (.lib files)
- Adds the glue between LwIP and WHD



WiFi Connection Manager

- Provides API for Wi-Fi scan and connection management
- Application can register for disconnection and reconnection notifications
- Re-authenticates the connection with the AP on intermittent connection loss
- Implements Wi-Fi Protected Setup (WPS) Enrollee role
- Reduces code and no. of API calls in case of App level protocol. (For ex: MQTT).



- E.g.

```
cy_rslt_t cy_wcm_init(cy_wcm_config_t *config)
cy_rslt_t cy_wcm_register_event_callback(cy_wcm_event_callback_t event_callback)
```

Secure Sockets

- Abstraction API for the underlying network (LwIP) and security (mbedTLS) stacks
- Socket like API for secure (TLS) and non-secure socket communications
- Supports both client and server modes
- Ex: TLS handshake/secure connection.

mbedTLS APIs for the TLS handshake

```
mbedtls_platform_set_time
mbedtls_ssl_init
mbedtls_ssl_config_init
mbedtls_x509_crt_init
mbedtls_ctr_drbg_init
mbedtls_entropy_init
mbedtls_ctr_drbg_seed
mbedtls_ssl_config_defaults
mbedtls_ssl_conf_authmode
mbedtls_x509_crt_parse
mbedtls_ssl_conf_ca_chain
mbedtls_ssl_conf_rng
mbedtls_ssl_setup
mbedtls_ssl_set_hostname
mbedtls_ssl_set_bio
mbedtls_ssl_handshake
mbedtls_ssl_get_verify_result
```

Secure Sockets Library

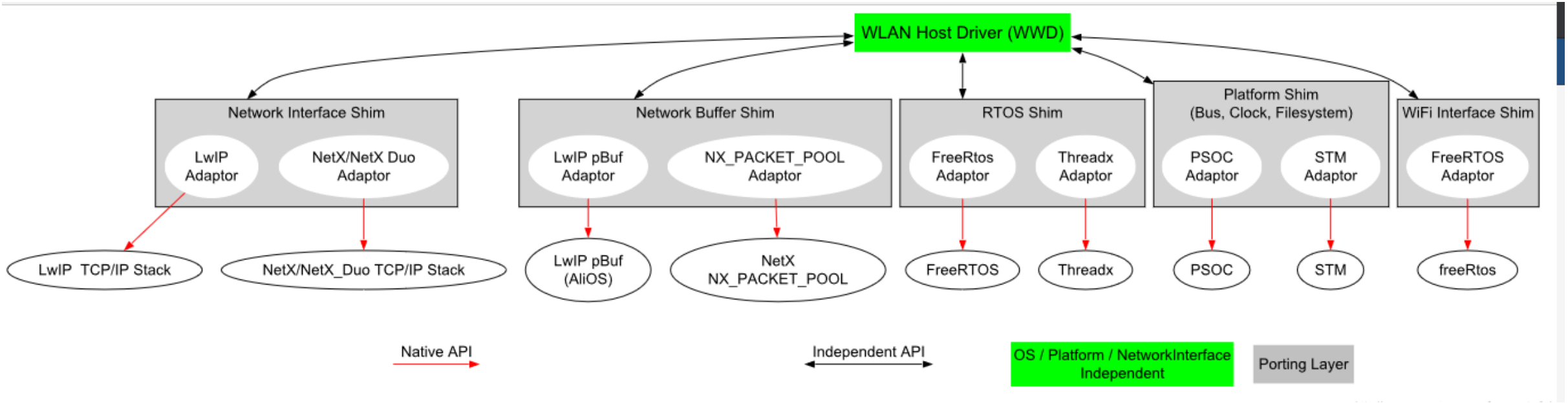
```
/**
 * Performs a TLS handshake and connects to the server.
 *
 * @param[in]  context Context handle for the TLS Layer created using \ref cy_tls_create_context.
 * @param[in] endpoint Endpoint type for the TLS handshake.
 * @return CY_RSLT_SUCCESS on success; an error code on failure.
 *         Important error code related to this API function is: \n
 *         CY_RSLT_MODULE_TLS_ERROR
 */
cy_rslt_t cy_tls_connect( cy_tls_context_t context, cy_tls_endpoint_type_t endpoint );
```

WiFi Driver

WiFi Driver

- Hardware needs underlying software which help them to interact known as device drivers
- Can be an audio driver, keyboard, Bluetooth, WiFi …
- Software allowing the CPU to interact with the WiFi/Network Card
- More specifically, software between the host and the WLAN chip
- In case of Cypress/Infineon → WWD, WHD

WICED WiFi Driver



- WICED WiFi Driver
- Intertwined with WICED
- Difficult to port
- WHD is used

WiFi Host Driver

- Used to interact with CY WLAN chips
- Modular with AnyCloud
- Portable

WHD Folder Structure

WHD Design

FW Download and WLAN Chip Logging Module

- Uses the HAL Resource API
- Doesn't use the services of control or data path module. It directly access the "WHD Bus Interface" to write the resources
- Once download is complete, allows the Chip to run
- Responsible for collecting WLAN chip logs

Control Module

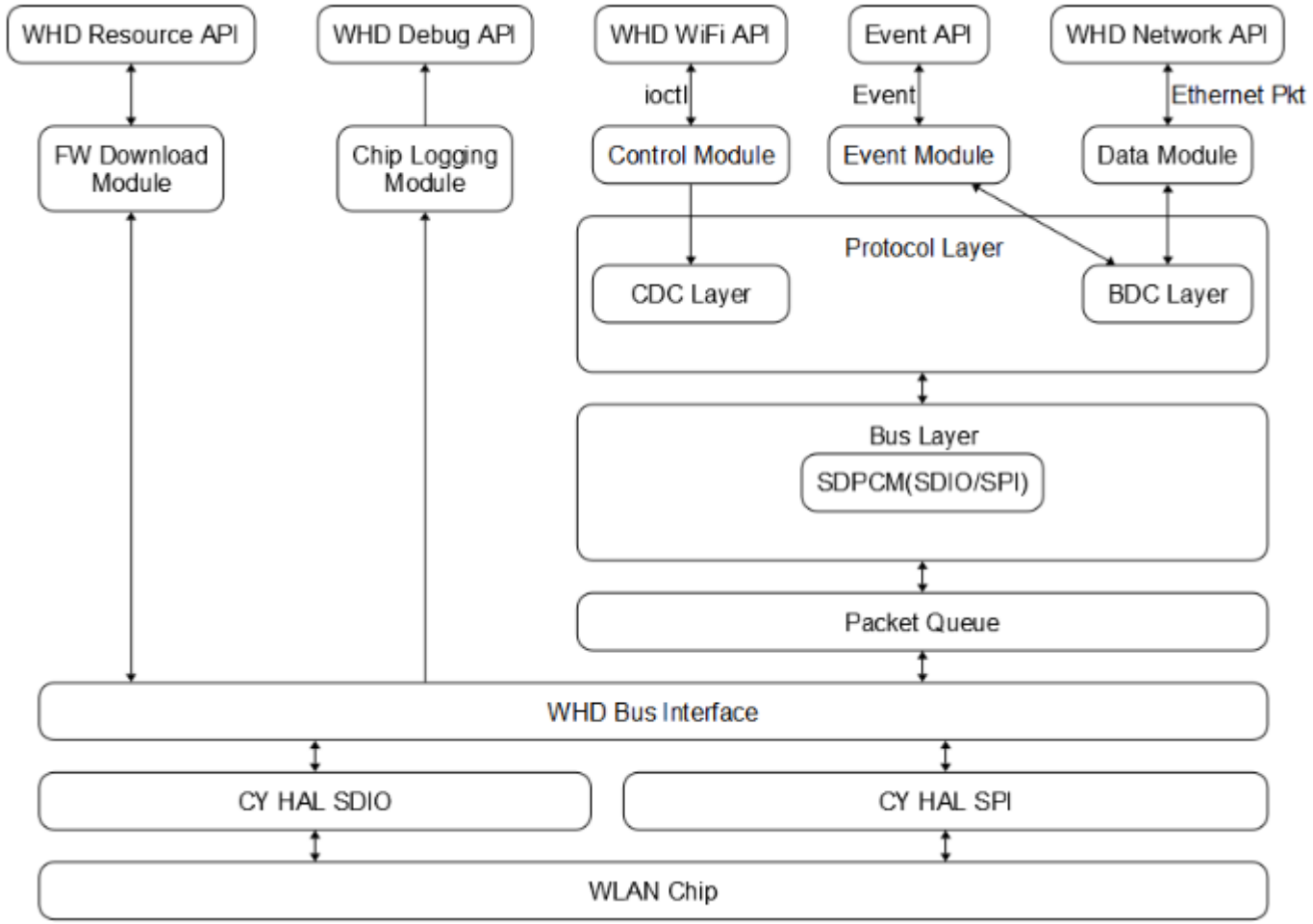
- Control access to WLAN Chip is done using IOCTLs

Data Module

- Responsible for handling User data received/sent in TCP/IP interface

Event Module

- Responsible for events generated from WLAN chip



WHD Design

Protocol layer

› Protocol layer is bus independent and is required for either SDIO/SPI.

› Packets sent to WLAN chip needs this header

CDC layer

› Control module sends messages

› Adds 16 byte header

CDC Header 16 bytes	IOCTL Message Variable size..

```
typedef struct
{
uint32_t cmd;    /* ioctl command value */
uint32_t len;/* lower 16: output buflen; upper 16: input buflen (excludes header)*/
uint32_t flags;  /* flag defns given in bcmcdc.h */
uint32_t status; /* status code returned from the device */
} cdc_header_t;
```

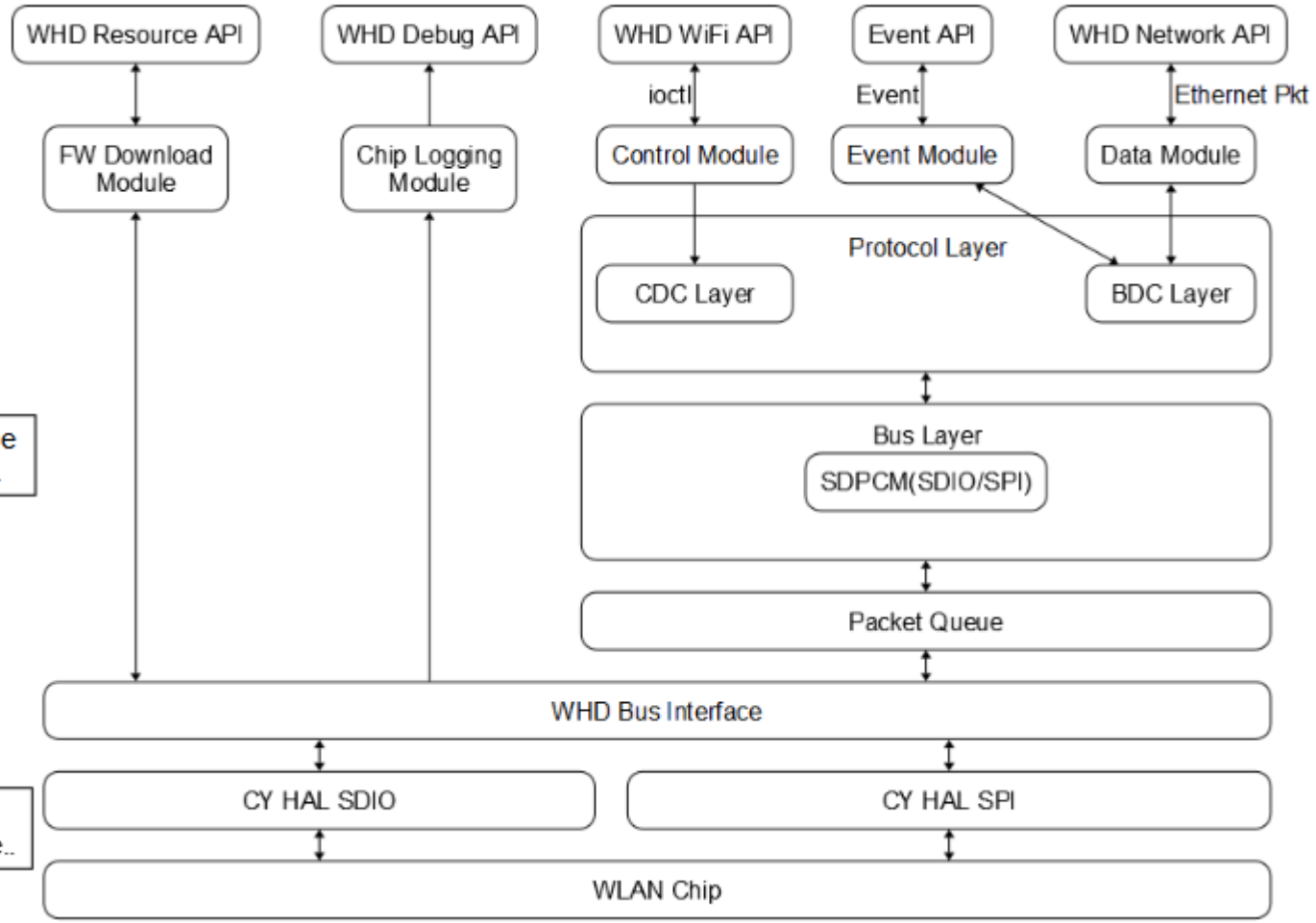
BDC layer

› Data module sends messages

› Adds a 4 byte header

BDC Header 4 bytes	User Data Variable size..

```
typedef struct
{
uint8_t flags;      /* Flags */
uint8_t priority;   /* 802.1d Priority (low 3 bits) */
uint8_t flags2;
uint8_t data_offset; /* Offset from end of BDC header to packet data, in 4-uint8_t
words.  Leaves room for optional headers.*/
} bdc_header_t;
```



WHD Design

BUS layer

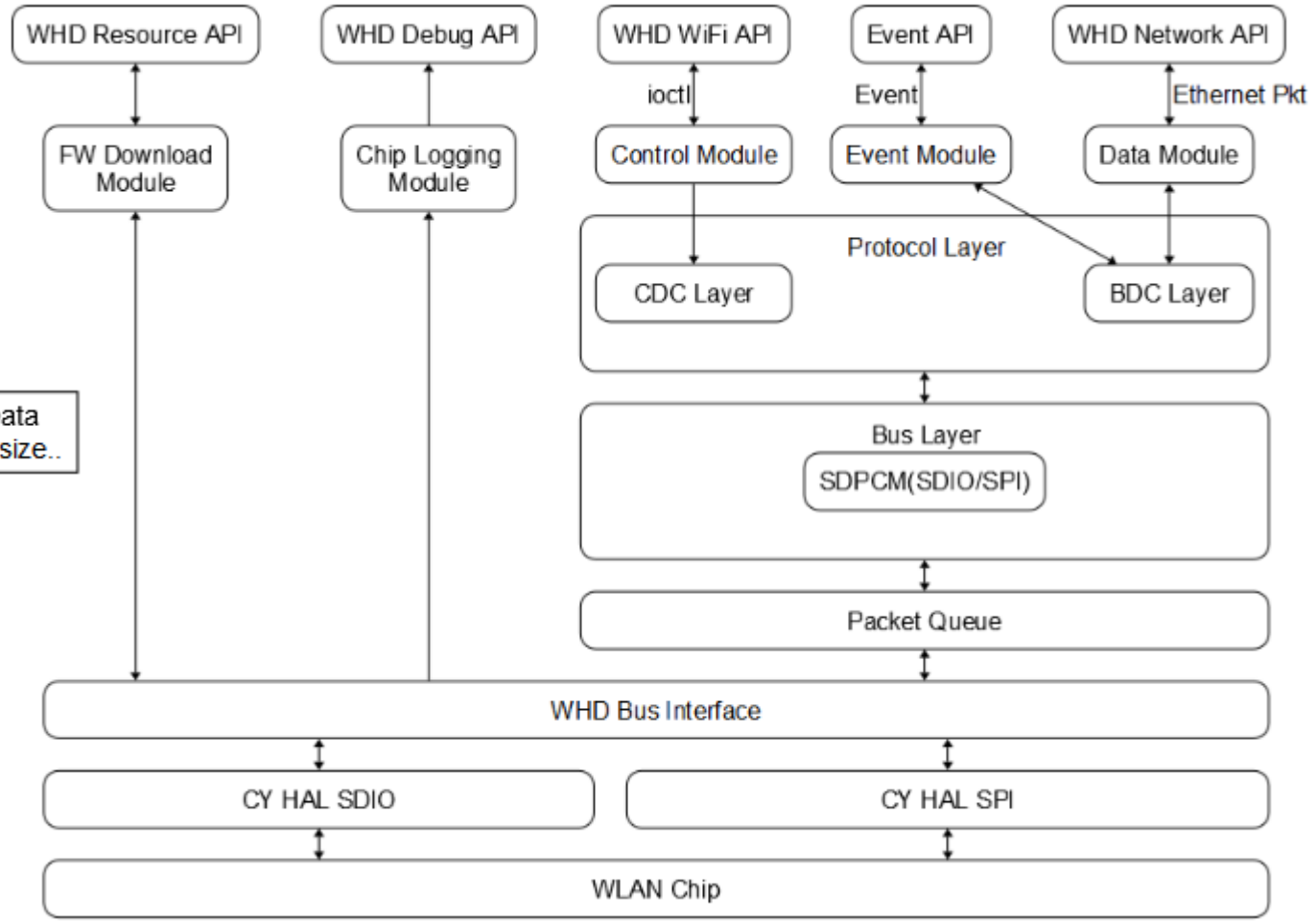
- Responsible for handling bus level protocol handling
- For SDIO, SDPCM is used

SDPCM - SDIO/SPI Bus Layer

- Adds sequence number to packet sent to WLAN Chip
- Flow control between WHD and WLAN Chip
- Adds 10 byte header

SDPCM Header 10 byte	CDC/BDC Header	User Data Variable size..

```
typedef struct
{
uint16_t  frametag[2]; /* SDPCM packet size */
uint8_t sequence; /* Sequence number of pkt */
uint8_t channel_and_flags; /* IOCTL/IOVAR or User Data or Event */
uint8_t next_length;
uint8_t header_length; /* Offset to BDC or CDC header */
uint8_t wireless_flow_control;
uint8_t bus_data_credit; /* Credit from WLAN Chip */
uint8_t _reserved[2];
} sdpcm_header_t;
```



WHD Design

Packet Queue

- Control/User data is queued in a link list in this layer
- Once Credit is available, sends data to WLAN chip

WHD Bus Interface

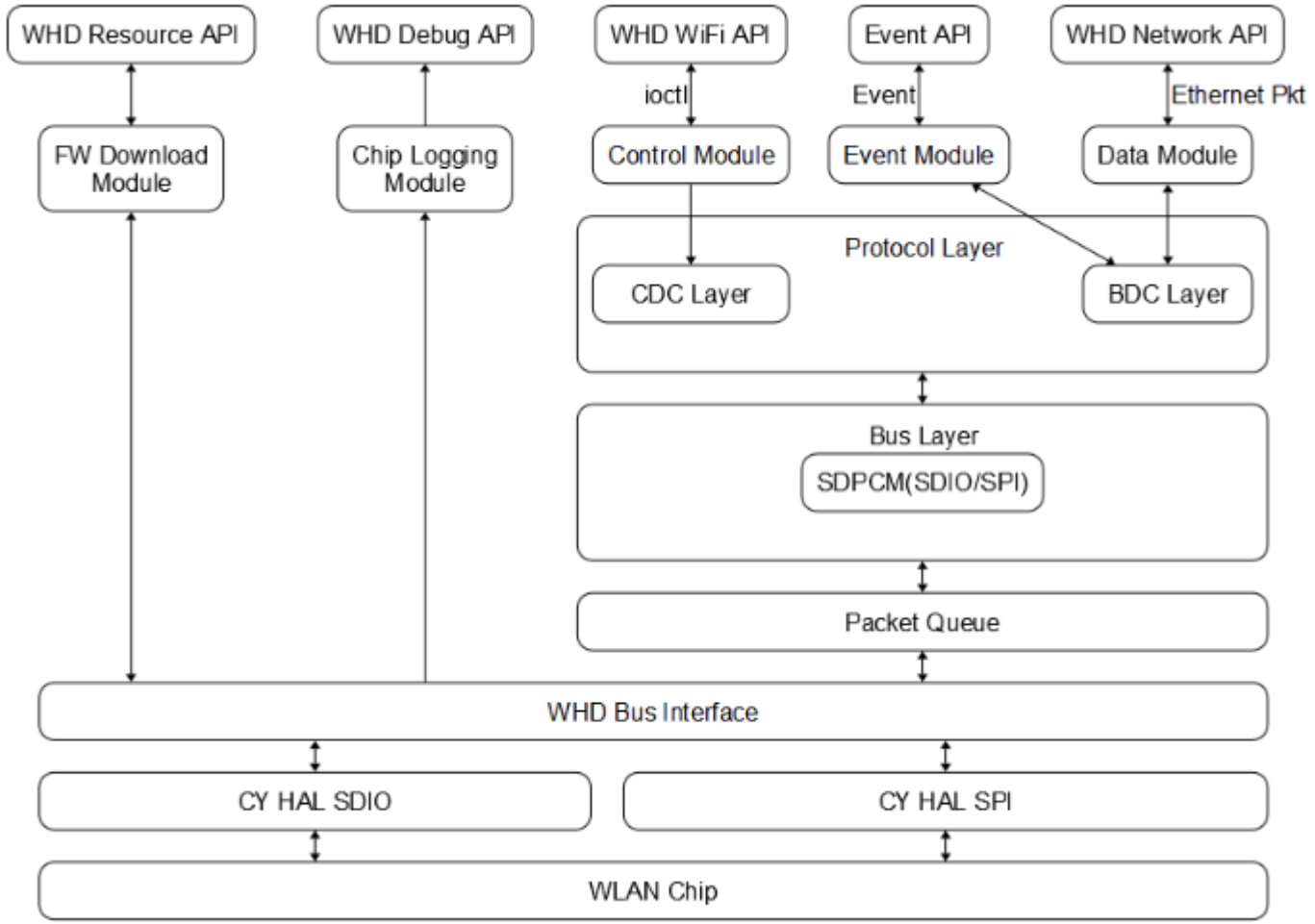
- Gives bus independent access functions to packet engine/sdpcm layer
- Primarily used to keep the access functions common between SDIO/SPI

SDIO HAL interface

- CY HAL interface to access the SDIO Host controller Hardware.
- External to WHD driver

SPI HAL Interface

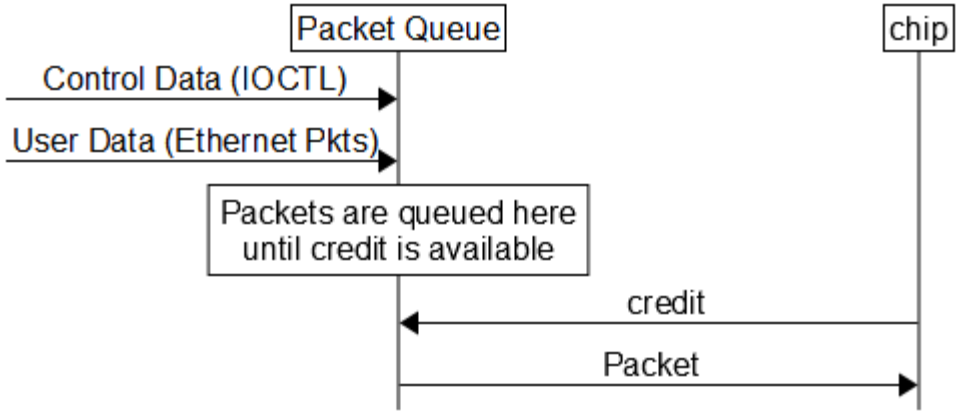
- CY HAL interface to access the SPI Host Controller Hardware.
- External to WHD driver

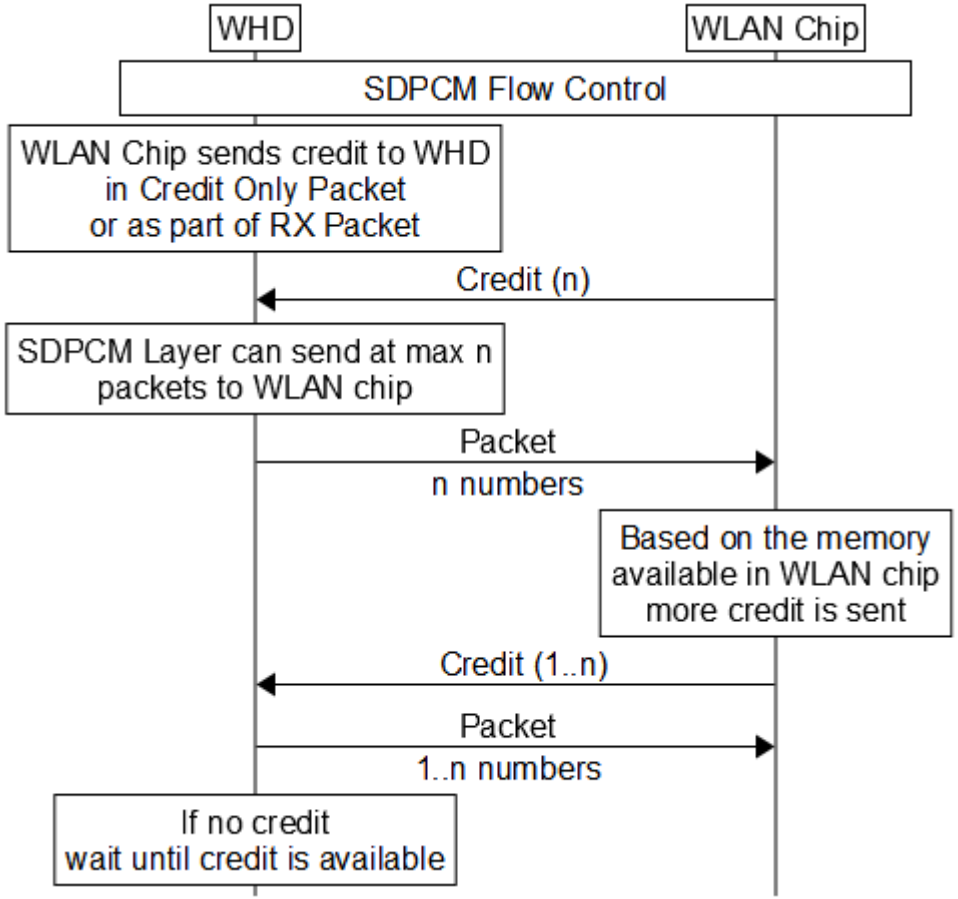


Flow Control Using SDPCM/ Packet Queue

Packet Queue

- Control/User data is queued in a link list in this layer
- Once Credit is available, sends data to WLAN chip





WHD Port

CY RTOS API

› Provides prototypes for functions that allow the WHD to use RTOS functionality

CY HAL Resource API

› Wi-Fi firmware, NVRAM, and CLM BLOB information are treated as resources to be downloaded onto the Wi-Fi chip

Buffer Interface API

› WHD requires packet buffers to exchange information between the host and Wi-Fi firmware

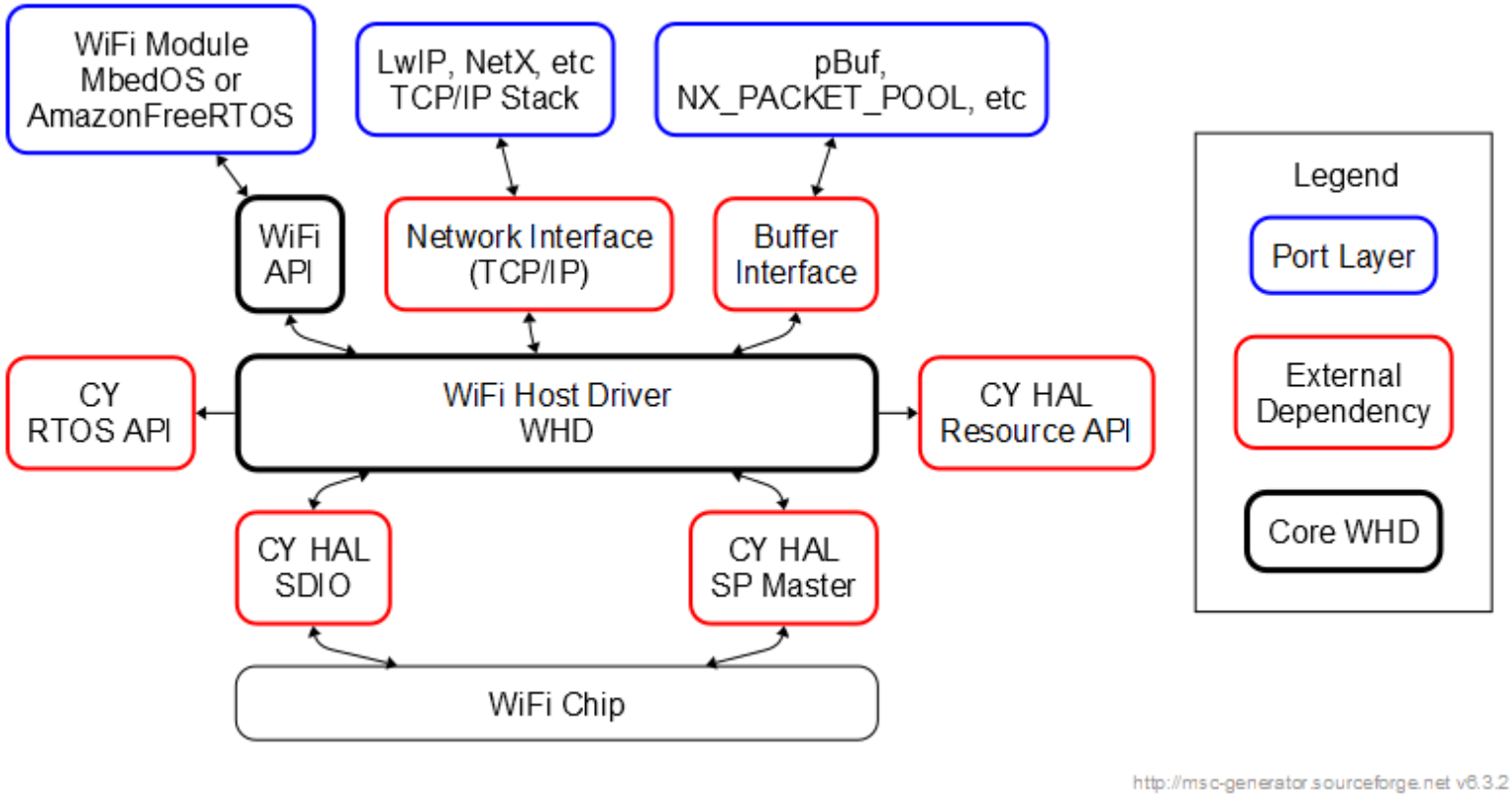
Network Interface API

› WHD calls this function pointer to pass the received TCP/IP data packet from WLAN

CY HAL SPI/SDIO Bus API

› WHD uses the following functions to access the host bus controller for SDIO or SPI buses

› Replace and use these functions appropriately to ensure bus operations



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Abbreviations

- AFR – Amazon FreeRTOS
- PSoC – Programmable system on chip
- WCM – Wi-Fi Connection Manager
- WWD – Wiced Wi-Fi Driver
- WHD – Wi-Fi Host Driver
- TCP – Transmission Control Protocol
- TLS – Transport Layer Security
- HAL – Hardware Abstraction Layer
- LwIP – Lightweight Internet Protocol
- LPA – Low Power Assistant
- OTA – Over the Air (Programming)
- MQTT – Message Queuing Telemetry Transport
- WPS – Wi-Fi Protected Setup
- HTTP – Hyper Text Transfer Protocol
- DNS - Domain Name System
- CoAP – Constrained Application Protocol
- FTP – File Transfer Protocol

References

- https://os.mbed.com/docs/mbed-os/v6.0/apis/socket.html
- https://docs.aws.amazon.com/freertos/latest/userguide/secure-sockets.html
- https://docs.aws.amazon.com/freertos/latest/userguide/freertos-wifi.html
- https://github.com/cypresssemiconductorco/secure-sockets
- https://github.com/cypresssemiconductorco/wifi-connection-manager
- https://github.com/cypresssemiconductorco/connectivity-utilities
- https://github.com/cypresssemiconductorco/wifi-host-driver
- https://community.cypress.com/community/software-forums/anycloud

AFR, Mbed and Modus

TCP/IP Model	AFR	Mbed	Any
Application	HTTP/DNS/MQTT/CoAP/FTP....		
Transport	FreeRTOS: Secure Sockets	Socket Class	Secure Sockets Library
Network	FreeRTOS: Wi-Fi Management Library	Connectivity Utilities	Wifi-Connection Manager Library
Physical	WWD/WHD	WHD	WHD