Embedded systems engineering
Distributed real-time systems

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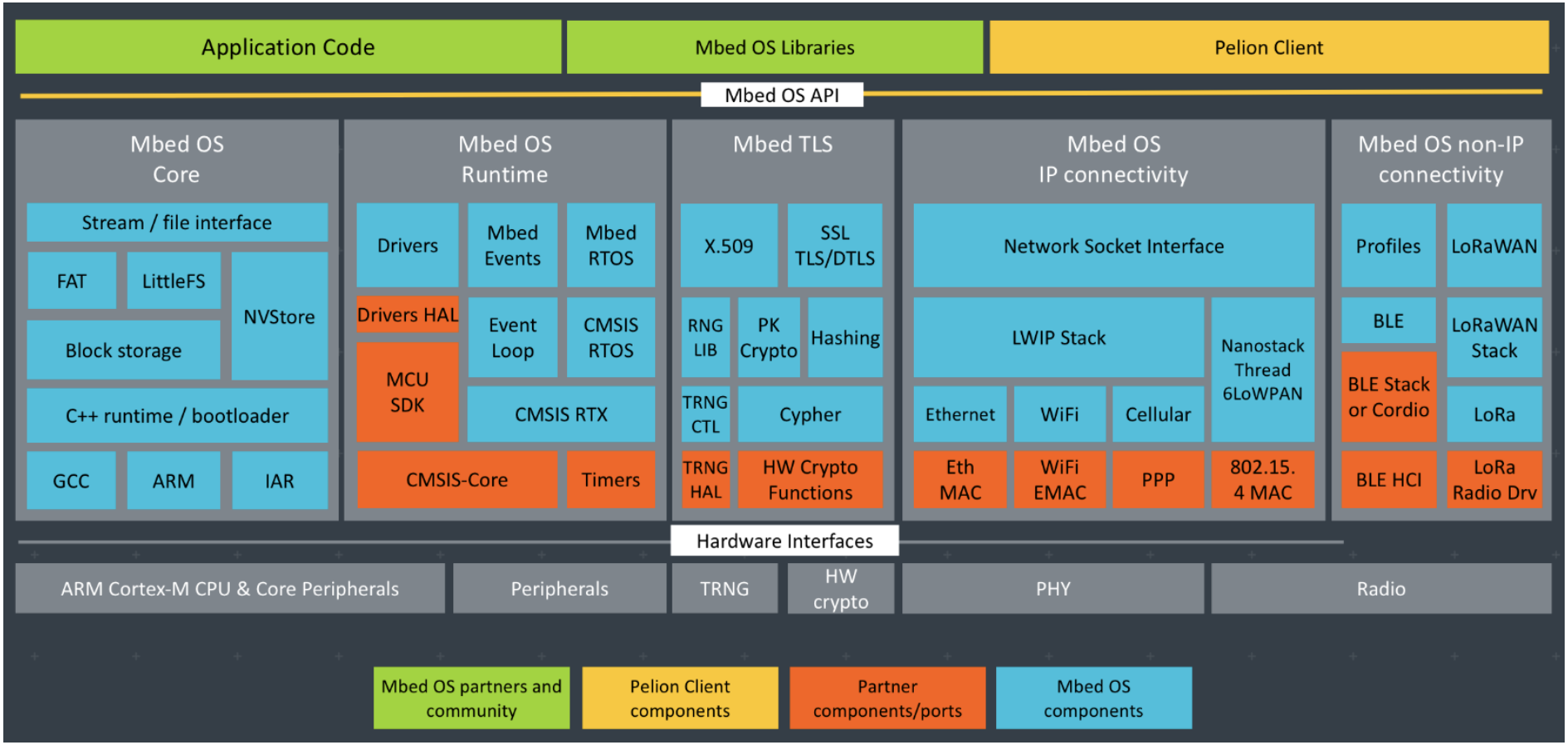
MBED OS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Documentation

MBED has a fairly full set of documentation.

```
https://os.mbed.com/docs/v5.10/apis/index.html
```

Each class has the documentation for the functions it provides, and some examples. (Some need a little interpretation/translation to our setup)

The RTOS has an overview at

```
https://os.mbed.com/docs/v5.10/apis/rtos.html
```

MBED RTOS

Characteristics

- deterministic
- multithreaded
- real-time
- pre-emptive

The RTOS primitives are always available

- threads
- semaphores
- mutexes
- events and eventqueue

Threads

Threads can be created and started in much the same way as in other OSs

```
Thread thread;
thread.start(taskfn);
```

where the parameter to `start` is the thread task function

thread task

```
void taskfn(void)
{
    while(true) {
        /* ... do something ...*/
    }
}
```

Threads

Priorities

Threads can be created with a given priority

```
Thread thread( osPriority );
```

The values that can be used for priorities range over 48 values

lowest	`osPriorityLow`, `osPriorityLow1`...`osPriority7`
	`osPriorityBelowNormal`
	`osPriorityNormal`
	`osPriorityAboveNormal`
	`osPriorityHigh`
Highest	`osPriorityRealtime`, `osPriorityRealtime1`...`osPriorityRealtime7`

Semaphores

Semaphores are provided for synchronisation and resource access.

creation

```
Semaphore sync;
```

wait, pend,

```
sync.wait();
```

release, post,

```
sync.release();
```

Semaphores

initial state

Semaphores can be created with an initial state,

```
Semaphore resource(2);
```

Recall the behaviour of wait and release

wait depends on semaphore state s

- $s > 0$ decrement state by 1
- $s = 0$ wait until state is $\neq 0$

release increment state by 1

Semaphores

uses

The LCD takes a long time to update. The Thread handling the display can be made to wait until data is available for it.

Semaphore

```
Semaphore available;
```

LCD thread

```
while(true) {
    available.wait();
    lcd.printf("etc"... );
}
```

Data acquisition

```
available.release();
```

Events

Events are provided to trigger and handle actions in the code.

EventQueue is provided to manage and dispatch events

The EventQueue needs to run in a thread, I've found the simplest way is to put it in `main`

```
EventQueue queue;
int main(void)
{

    queue.dispatch();
}
```

the `dispatch` function does not return if called with no parameters.

Events

simple events

Event handlers are usually functions that take no parameters and return no values, similar to ISRs.

simple events

```
// immediate
queue.call(red_on);

// after delay in ms
queue.call_in(500, green_on);

// repeats every period in ms
queue.call_every(1000, blink);
```

Events

Event objects and ISR

The event queue can create an event object that is suitable for use as an ISR handler to trigger the event.

falling edge ISR

```
sw2.fall(  queue.event(display) );
```

- The ISR triggers the event.
- The event handler runs in the context of the `EventQueue` thread.
- The event handler can be a long process or one not allowed in an ISR.
- Be aware of effects on the event-queue if using a *very long* or *blocking* handler.

Examples and exercises

1. https://github.com/dr-alun-moon/blinky-mbed-rtos
2. https://github.com/dr-alun-moon/blinky-mbed-semaphore
3. https://github.com/dr-alun-moon/blinky-mbed-semaphore-alt
4. https://github.com/dr-alun-moon/blinky-mbed-events