# Enabling IoT OSs for Intel Quark MCU Platforms: the fast way

OpenIoT Summit Europe

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# Agenda

- Intel Quark MCU Platforms
- Intel Quark Microcontroller Software Interface (QMSI)
- Zephyr/QMSI Integration
- Contiki/QMSI Integration
- Final Considerations

# Intel Quark Microcontrollers

# Intel Quark MCU D2000

Processor core

- 32 MHz clock frequency
- Pentium 586 ISA compatible without x87 Float Point Unit

Memory system

- 32 KB Flash
- 8 KB OTP Code
- 4 KB OTP Data
- 8 KB SRAM

# Intel Quark MCU D2000

I/O Peripheral

- UART, I2C, SPI, GPIO, PWM, ADC, Analog Comparator, and DMA

Timer

- RTC, Watchdog, Always-On Counters

# Intel Quark MCU Developer Kit D2000

- Small form-factor
- Flash storage
- 6-axis compass/accelerometer
- Temperature sensor
- Arduino-Uno compatible shield interfa

# Intel Quark SE MCU C1000

Processor core

- 32 MHz clock frequency
- Pentium 586 ISA compatible without x87 Float Point Unit

Memory system

- 384 KB Flash
- 8 KB OTP
- 80 KB SRAM

# Intel Quark SE MCU C1000

I/O Peripheral

- UART, I2C, SPI, GPIO, PWM, Analog Comparator, DMA, USB, I2S, Mailbox

Timer

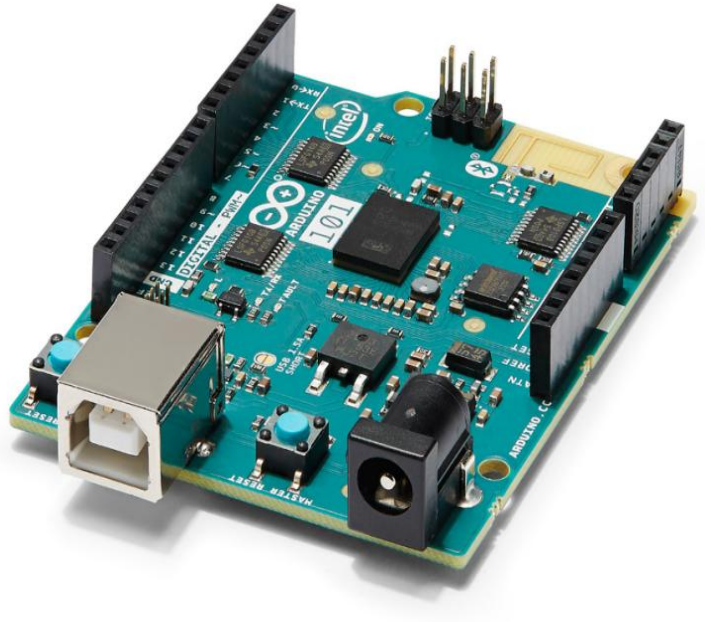
- RTC, Watchdog, Always-on Counters

Sensor subsystem

- ARC EM4 DSP with floating point extension
- I2C, SPI, GPIO, ADC, Timers

# Intel Curie Module

- Intel Quark SE MCU C1000
- BLE radio
- Pattern Matching Engine
- 6-axis accelerometer/gyroscope
- Used in Arduino/Genuino 101



# Intel Quark Microcontroller Software Interface (QMSI)

# QMSI

- Hardware Abstraction Layer for Intel Quark MCUs
- Specifies APIs for all peripherals present in Quark MCUs
- Provides a common API for different MCUs
- Reduces learning curve for new MCUs
- Currently supports Quark D2000 and Quark SE C1000
- Current version: 1.2

# QMSI BSP

- Open source implementation of QMSI specification
- Bootloader
- Device drivers for almost all peripherals
  - Missing I2S, SPI and I2C slave mode
  - Static library libqmsi
- Linker scripts and crt0
- Newlib system calls
  - fstat(), write(), and sbrk()
  - pico_printf()
- Bare-metal example applications

# QMSI BSP

- BSD 3-clause License
- Drivers available on github.com/quark-mcu/qmsi
- Bootloader available on github.com/quark-mcu/qm-bootloader

# QMSI Structure Overview

```
$ tree -d -L 1
.
|-- board       <-  Board level drivers
|-- doc         <-  Project documentation and guidelines
|-- drivers     <-  QMSI drivers
|-- examples    <-  Example applications using QMSI APIs
|-- include     <-  Top level headers
|-- soc         <-  SoC-specific support
|-- sys         <-  crt0 and newlib syscalls
|-- tools       <-  Helper tools
`-- usb         <-  USB device stack
```

# Zephyr/QMSI Integration

# Zephyr Overview

- Open source small-footprint RTOS
- Multiple architecture support
  - x86, ARC, ARM, and Nios2
- Networking support
  - Bluetooth Low Energy, IEEE 802.15.4, Ethernet
- IoT communication protocols
  - 6LoWPAN, RPL, CoAP, MQTT
- Supports Quark D2000 and Quark SE C1000
- Apache License version 2.0
- Available in zephyrproject.org

# Zephyr/QMSI Integration

Reused components

- Bootloader
- Device drivers*

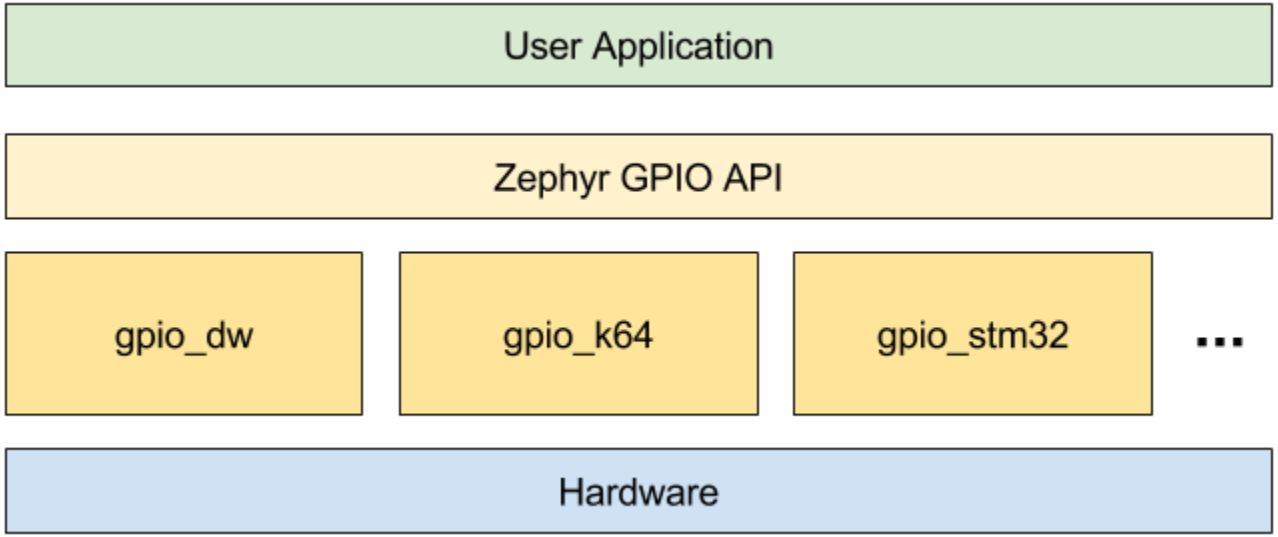
Not reused components

- Newlib system calls
- Linker script and crt0
- Device drivers
  - Interrupt controller
  - Local APIC Timer
  - Mailbox

# Zephyr Device Driver Model Overview

- Unified peripheral API
- Applications access peripherals devices via Zephyr peripheral APIs
  - Top-level include/ directory
- Device drivers implement Zephyr peripheral APIs
  - Top-level drivers/ directory
- Device driver is selected during kernel configuration

# Driver Model Architecture



# Device Driver Integration

- QMSI shim drivers
  - Shim layer between Zephyr and QMSI
  - Implements Zephyr driver APIs using QMSI APIs
  - Eventually translates Zephyr APIs parameters into QMSI APIs parameters
  - Located in drivers/ directory
- Zephyr has a copy from the latest QMSI release
  - ext/hal/qmsi/ directory
- QMSI drivers are built by Zephyr build system when the corresponding shim driver is selected during kernel configuration
- Optional: link against libqmsi (see CONFIG_QMSI_LIBRARY option)

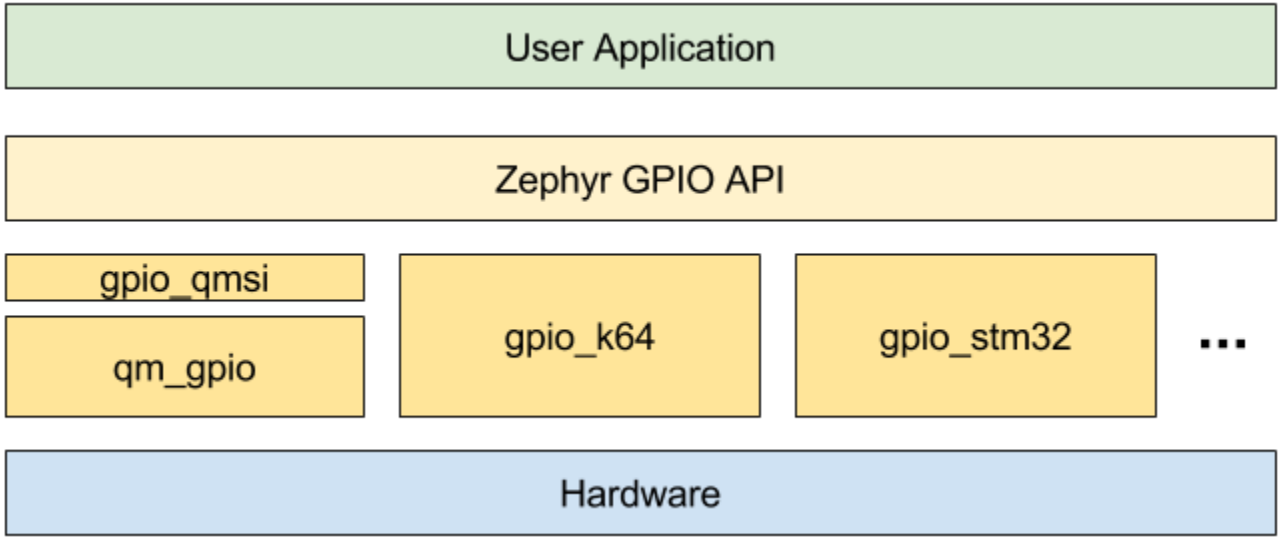
# Device Driver Integration Example

```
static int rtc_qmsi_set_config(struct device *dev, struct rtc_config *cfg)
{
        qm_rtc_config_t qm_cfg;

        qm_cfg.init_val = cfg->init_val;
        qm_cfg.alarm_en = cfg->alarm_enable;
        qm_cfg.alarm_val = cfg->alarm_val;
        qm_cfg.callback = (void *) cfg->cb_fn;
        qm_cfg.callback_data = dev;

        return qm_rtc_set_config(QM_RTC_0, &qm_cfg);
}
```

# QMSI Shim Driver Architecture



# Integration Highlights

- QMSI shim drivers are used by all Quark MCU based boards
  - D2000 CRB, SE C1000 devboard, and Arduino 101
- Shim drivers approach enabled us to rapidly support Intel Quark MCUs peripherals
- Minimum overhead

# Contiki/QMSI Integration

# Contiki Overview

- Open source OS for the Internet of Things
- Multiple architecture support
  - x86, ARM, 8051, AVR, MSP430
- IoT communication protocols support
- BSD 3-clause License
- Available in contiki-os.org
- Quark D2000 and Quark SE C1000 ports available in github.com/otcshare/contiki-x86
- Pull-request for Contiki upstream (Quark D2000 devkit)

# Contiki/QMSI Integration

- Helper script to download and build libqmsi and bootloader
- All BSP components are reused out-of-the-box
  - Bootloader
  - Linker scripts and crt0
  - Newlib syscalls implementation
  - Device drivers
- Contiki links against libqmsi

# Contiki Port

## Timers Support

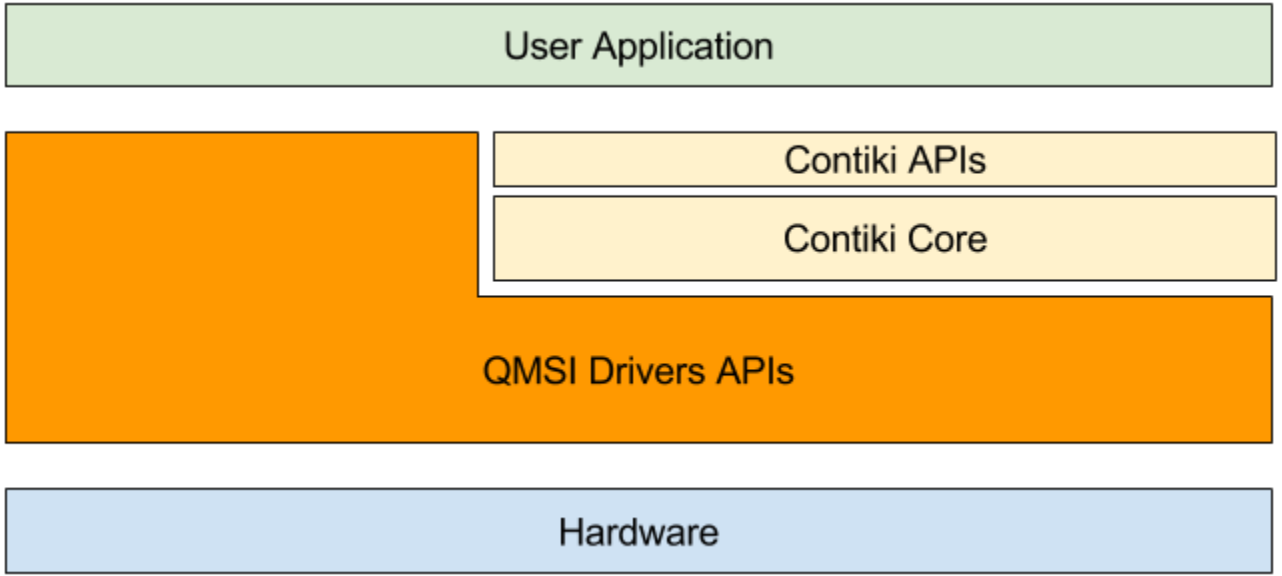
- Clock module support
  - Enables Timer, Stimer, Etimer, and Ctimer libraries
  - Located in platform/qmsi-common/core/sys/clock.c
  - Implemented using qm_pic_timer driver
- Rtimer library support
  - Located in platform/qmsi-common/core/sys/rtimer-arch.c
  - Implemented using qm_rtc driver
- Watchdog support
  - Located in platform/qmsi-common/core/dev/watchdog.c
  - Implemented using qm_wdt driver

# Contiki Port

## I/O Support

- No unified API
  - I/O APIs are platform dependent
- Serial
  - C library API for output
  - core/dev/serial-line.h for input

# Contiki Port Architecture



# Integration Highlights

- Initial Quark D2000 port done in 4 small patches
- Initial Quark SE C1000 port done in 2 patches
- Quark SE C1000 port was very straightforward once another QMSI-based port was already in place
  - Clock, rtimer, watchdog, stdout support is shared between both ports
- Initial ports are pretty decent
  - Support for main Contiki subsystems
  - Support for all I/O devices via QMSI APIs

# Final Considerations

# Final Considerations

- QMSI is the way to go with Intel Quark MCU platforms
  - Abstracts away peripheral device complexities
  - No need to jump into datasheet at first
  - APIs are very simple
  - Good documentation
  - Example applications are very useful
- Reusing QMSI BSP components can accelerate your porting work
- Zephyr and Contiki showcase two different approaches on how to integrate with QMSI
- They can provide guidelines on porting other IoT OSs to Intel Quark MCU platforms

# Q & A

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