

Kjartan Furset

# NORDIC te ch TOUR

## *nRF51 Series Intro*



nRF 51 Series Intro

## What is the nRF51 Series?

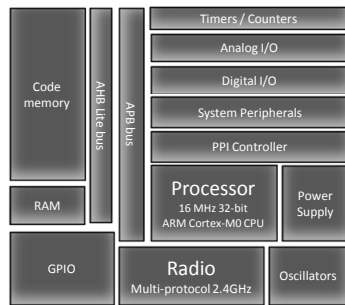
*Flexibility, consistency and ultra low power*

- Series of SoCs and Software Stacks
- Common hardware architecture
- Common software architecture
- Powerful range of features
- Optimized for Ultra Low Power operation
- Code and pin compatibility
- Designed for easy migration across devices and protocols

### nRF51 IC Family



## IC Architecture



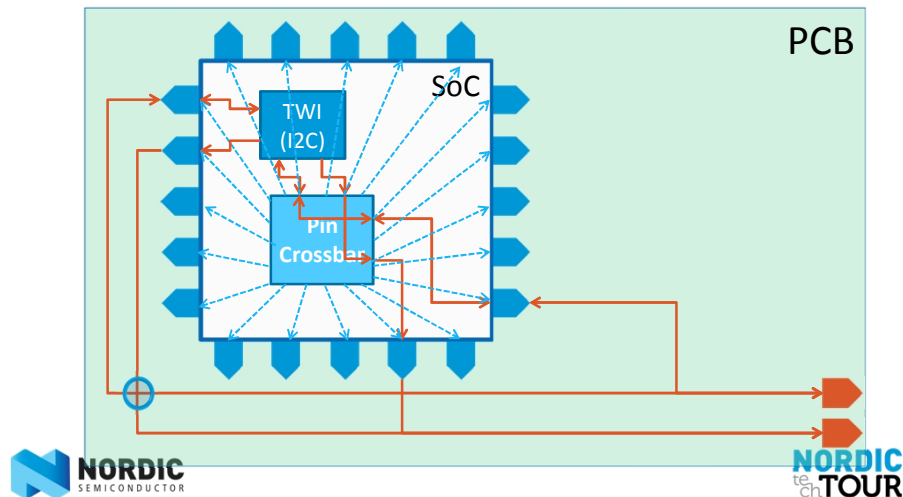
- 2.4GHz Multiprotocol radio
- 32-bit Cortex-M0 CPU
- All-flash memory
- Fast and flexible radio/processor interface
  - RAM mapped FIFOs
  - 'On-the-fly' configuration
- Fine grained power management
- Programmable Peripheral Interconnect (PPI)
- Flexible GPIO pin-mapping

## nRF51 main HW features



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## Flexible GPIO



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## 2.4GHz Multiprotocol Radio

### Problem: The device you use does not support the protocol you want

- Multiple devices for multiple protocols
- Develop new code for your application

### nRF51 Solution: New multi-protocol 2.4GHz Radio

- The same device can be used in all your wireless designs

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## 2.4GHz Multiprotocol Radio

|                                      |   |
|--------------------------------------|---|
| Multi-protocol<br>2.4GHz Transceiver | <ul style="list-style-type: none"> <li>▪ Programmable modulation, deviation and packet format</li> <li>▪ <i>Bluetooth®</i> SMART</li> <li>▪ ANT™</li> <li>▪ 2.4GHz RF 250kbps, 1Mbps, 2Mbps compatible (nRF24L)</li> </ul>  |
| Baseband logic                       | <ul style="list-style-type: none"> <li>▪ “On the fly” packet packet assembly/disassembly</li> <li>▪ AES / CCM payload encryption</li> <li>▪ Dynamic payload length – up to 256B</li> <li>▪ Data whitening using 7-bit LFSR</li> <li>▪ PPI support for protocol hardware acceleration</li> </ul> |
| Processor interface                  | <ul style="list-style-type: none"> <li>▪ RAM mapped FIFOs</li> <li>▪ EasyDMA for payload handling</li> </ul>  |



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## 32-Bit ARM Cortex-M0 CPU

### Problem: ‘old’ CPU not powerful enough and getting old

- 8051 not suitable to run big protocols like Bluetooth, hit on power consumption
- 8051 consumed unwanted power in startup and idle
- 8051 getting old, no longer industry standard

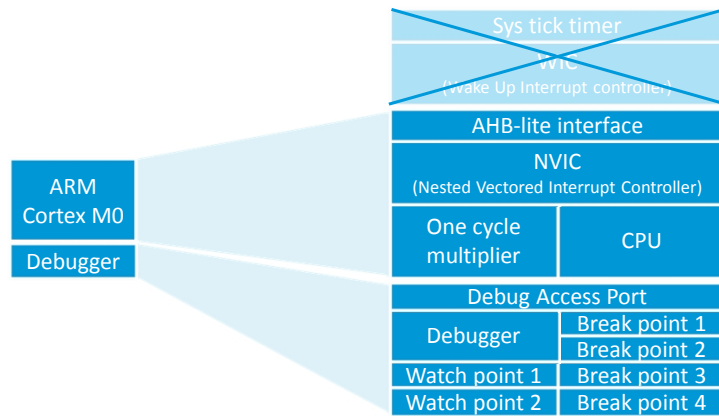
### nRF51 Solution: Cortex M0

- Modern and powerful CPU
- Vast ECO system of tools and user forums
- Fast startup and processing



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## 32-Bit ARM Cortex-M0 CPU



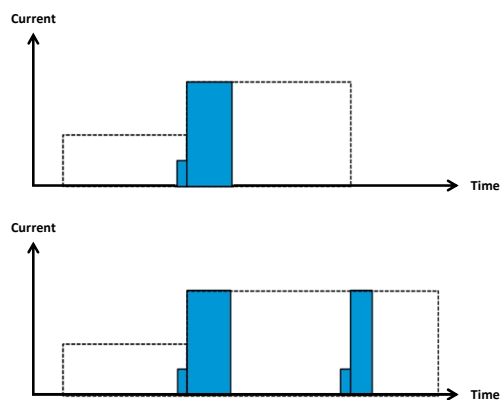
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## Cortex-M0 benefits

**Fast start-up: 2.5  $\mu$ S**  
Spend less current starting-up

**Up to 10X more powerful**  
Finish processing tasks faster  
(Reference: 8051)

**Improved 'duty cycling'**  
Spend more time sleeping between tasks



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## Programmable Peripheral Interconnect (PPI)

### Problem: CPU interrupt latency effects real time tasks

- Software stacks changes real time behavior
- Unnecessary CPU activity

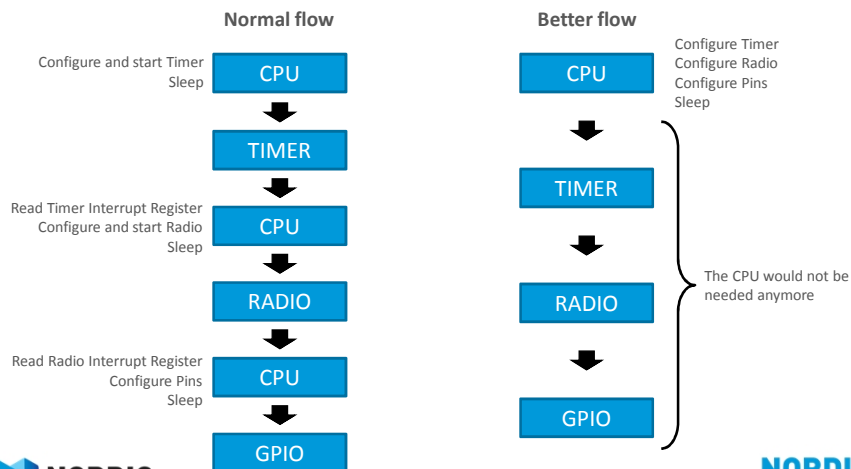
### nRF51 Solution: Programmable Peripheral Interconnect (PPI)

- Minimise CPU activity
- Maintain real time system



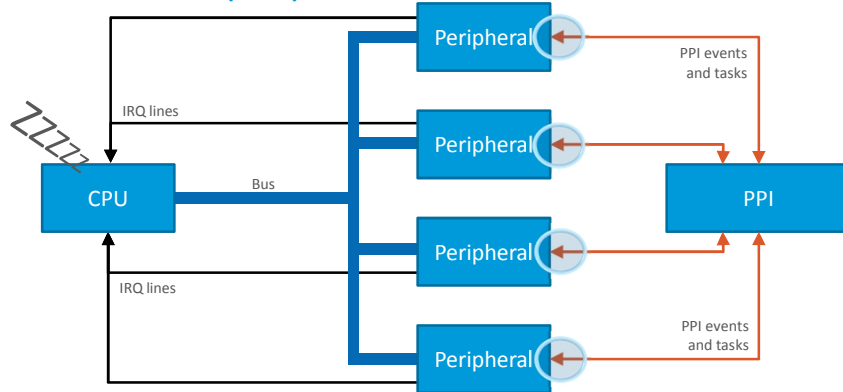
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## Signalling flow between peripherals



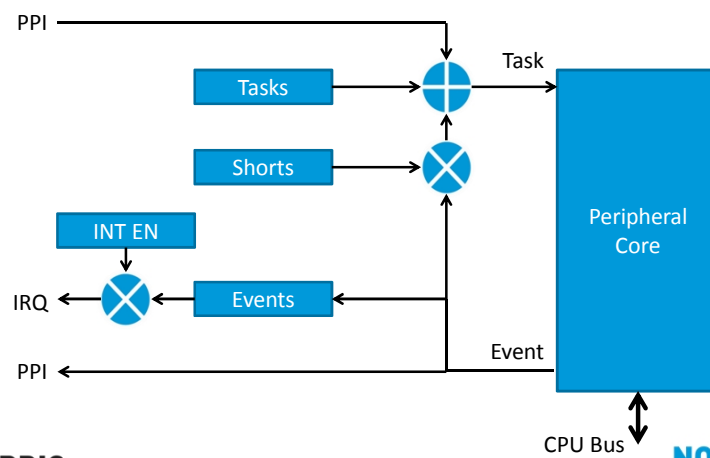
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## IRQ vs Programmable Peripheral Interconnect (PPI)

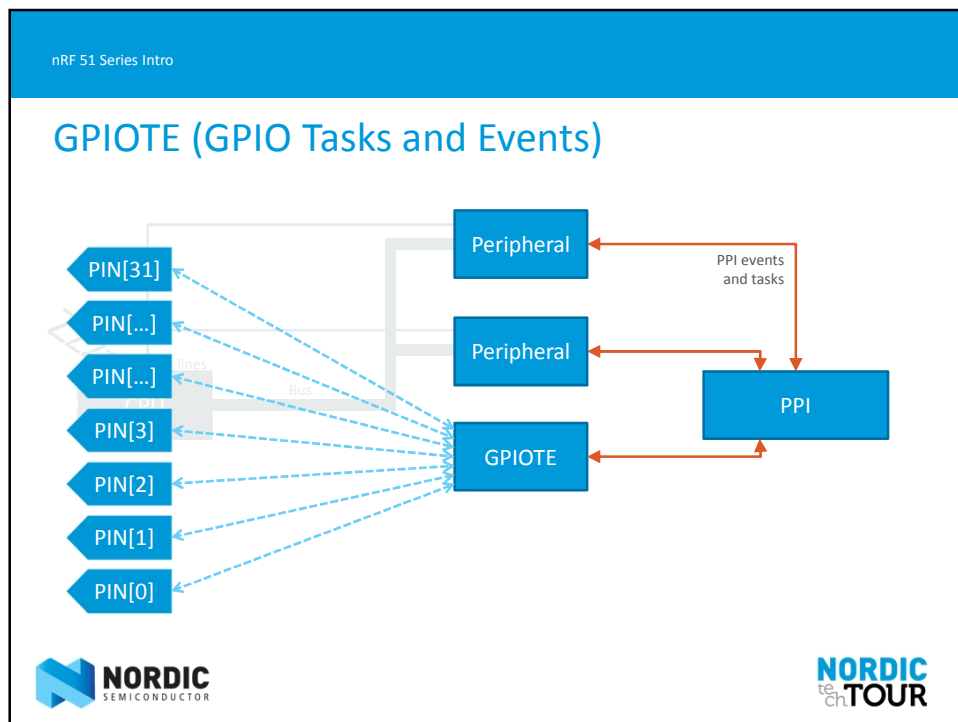
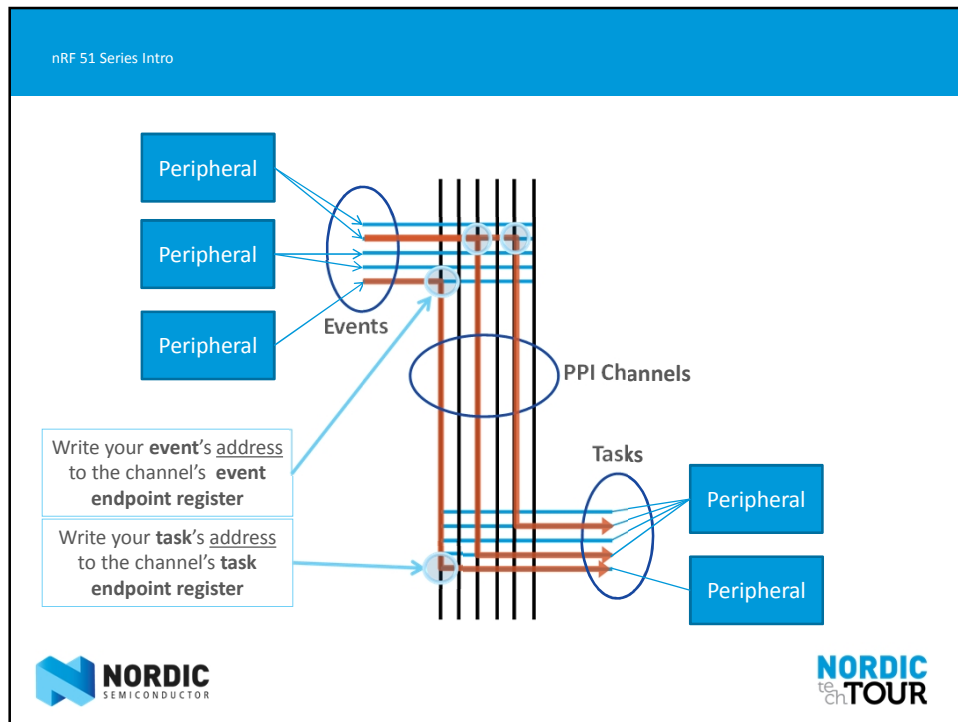


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## PPI - Block Diagram







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## CPU + PPI System Power usage benefits

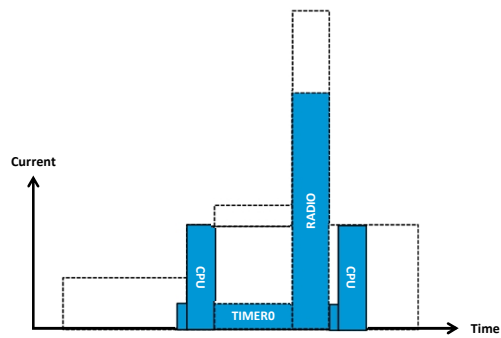
### Tight timing control

#### Minimizes CPU active time

CPU 'programs' a sequence of peripheral operations

Peripherals operates autonomously

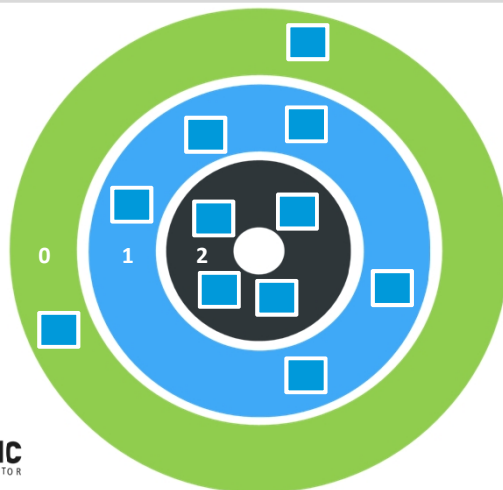
CPU sleeps while peripherals are active



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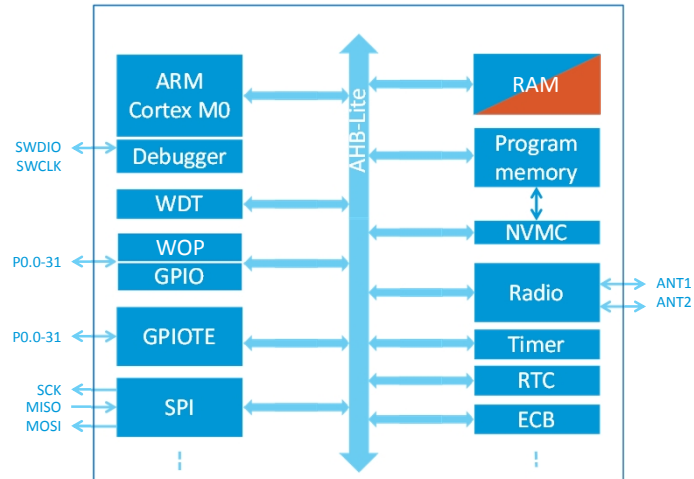
### Problem: Inflexible power management

- Modes manually controlled
- Need to turn on many peripherals to use only 1 of them



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## Power Management



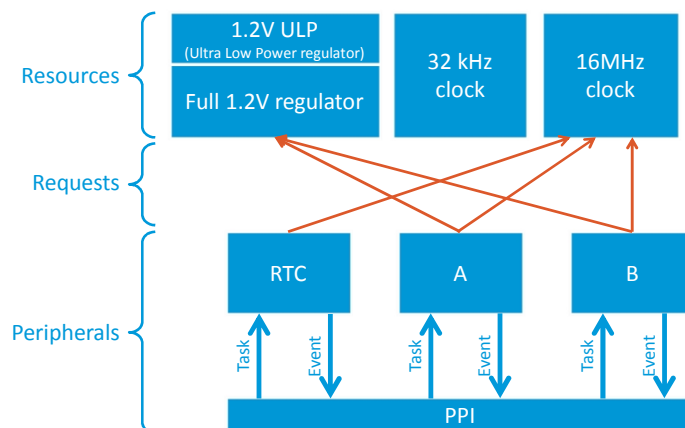
SYSTEM: OFF

SYSTEM: ON



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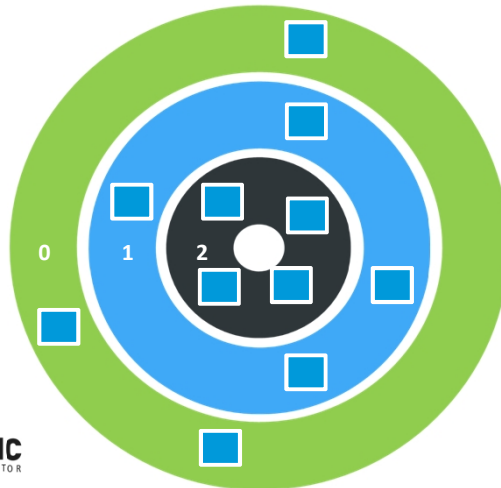
## Power and Clock – HW Perspective



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**nRF51 Solution: Automated power management**

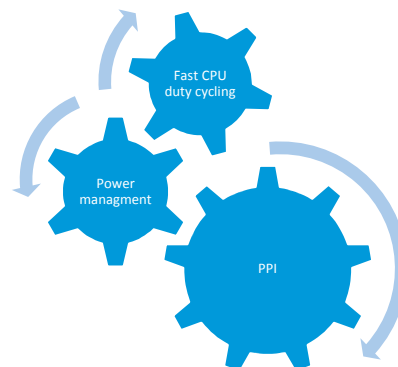
- 2 modes: ON and OFF
- Peripherals only use power when they need power



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**Working together**

- The three cogs:
  - Fast CPU cycling
  - nRF51 power management
  - PPI system
- Works like clockwork to give:
  - Minimize number active modules
  - Minimize peak current
  - Minimize average current
- Still handling:
  - Complex sequences of peripheral activity
  - Multiple real time tasks
    - Ex: Protocol + sensor input



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## Key device specs

*nRF51822 and nRF51422*

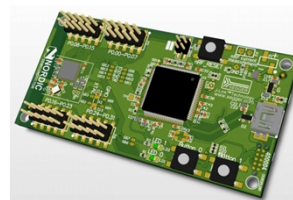
|                              | nRF51822   | nRF51422   |
|------------------------------|--|--|
| Memory                       | 256kB/128kB Flash, 16kB RAM  |  |
| Analog and digital I/O       | 2xMaster/Slave SPI, 2x 2-wire, UART, 10-bit ADC, Quadrature Demodulator  |  |
| System Peripherals           | 16-channel PPI, 128-bit AES ECB/CCM/AAR co-processor, RNG, Temp sensor, Watchdog   |  |
| Oscillators                  | 16 MHz XO, 32kHz XO,<br>16 MHz RC, 32kHz $\pm$ 250ppm RC   |  |
| Timers / Counters            | 2 $\times$ 16-bit Timers, 1 $\times$ 32-bit Timer, 2 $\times$ 24-bit RTC   |  |
| Power Supply (Supply range)  | LDO (1.8 to 3.6V), LDO bypass (1.75 to 1.95V), On-chip Buck DC/DC (2.1 to 3.6V)  |  |
| Software stacks              | S110 Bluetooth® low energy Peripheral Software Stack<br>S120 Bluetooth® low energy Central Software Stack<br>Gazell 2.4GHz RF Software Stack | S310 ANT/Bluetooth low energy Software Stack<br>S210 ANT™ 8-Channel Software Stack |
| Package options (GPIO count) | 6x6mm 48-pin QFN (31)<br>3.5x3.8mm 62 ball WLCSP (32)  |  |



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## nRF51x22 Evaluation Kit

- Flexible evaluation and development platform
- Stand-alone battery-powered system
- Portable system development
- In-situ evaluation and test
- USB dongle for easy PC interface and debug



Eval-board



USB dongle



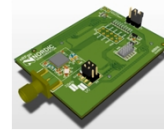
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## nRF51x22 Development Kit

- Interfaces to existing nRFgo platform
  - nRFgo available separately
- Fully featured for full system development
- Range of I/O options via nRFgo motherboard
- Stable development platform
- Enables detailed measurement & test
  - Current measurements
  - RF measurements using SMA connector
- USB dongle for easy PC interface and debug



Module: PCB antenna



Module: SMA connector



USB dongle



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