Case Study: Rapid implementation of an IoT device – OR – three engineers and three months

Tim Whitfield
Director of Engineering, Taiwan / ARM

TechCon 2015
IoT characteristics of end-point devices

- **Data**
  - Sense
  - Communicate
  - Security, authentication, trust

- **Battery**
  - Long battery life (days → years)
  - Long standby (hours → days)
  - Minimize energy
  - Device mostly asleep

- **SW / deployment**
  - Easy access & control
  - Maintain SW when devices are deployed
  - Scalability / updates

**Cost**
Cents not $s
Pence not £s
The Challenge

- Rapid prototyping of low-cost IoT endpoint
  - **Goal:** from RTL to GDS – 3 engineers, less than 3 months
  - Integration of ARM, TSMC and Cadence IP on a single die

- Build a silicon demonstrator platform
  - Fully compliant with ARM mbed OS
  - Simulate real end-point device characteristics
  - Expansion ports for third party development

- Enhance knowledge base
  - Understand challenges
  - Knowledge transfer to enhance IP quality
The Building Blocks

- IoT Subsystem
- Cordio Bluetooth LE Radio
- Artisan Physical IP
- Security Hardware
- TSMC Process Technology
- mbedOS
- **Cadence IP blocks**
  - External interfaces
Cordio Radio Integration - Logical

- **Hard macro**
  - Complex mixed-signal & RF
  - Real-time embedded firmware
  - Integrated Power Management Unit
  - Verilog model for loop-back testing

- **Synthesizable host interface**
  - AMBA-3 32-bit AHB component
  - Interrupt driven slave & master
  - Fully asynchronous Tx to Rx transfers
  - Side band signals – clocks, power management & DFT controls
ARM Cordio Radio – Physical Integration

- No mixed signal/RF knowledge required
- EDA agnostic complete physical design kit
  - Timing models for multiple PVT & extraction corners
  - Physical abstract for APR tools
  - Power intent description
  - DRC/LVS support
  - CDL and GDS
- Built in pad ring for radio I/O
- Layout guidelines for noise isolation
- Minimal external component BOM
  - 7 caps, 2 inductors, 2 crystals, antenna
Radio Integration for Digital Designers

- Avoiding supply coupling in bond wires
  - Requires ~100pF decoupling per supply
  - Fill capacitance in I/O is inefficient
  - Use MoM cap macros built by radio design team

- Avoid ground coupling through substrate
  - Requires guard-ring with well-ties to ground
  - Spacing between radio and digital chip depends on proximity of noisy sources
  - Guidance given by radio design team including well-tie macro with ground pin
Embedded Flash Integration

- eFlash requires 1.2V/2.5V supply
  - Data/control interface requires level shifting from 0.9V standard cell domain
  - Power isolation/sleep mode enable & low voltage read enable are 2.5V signals
  - Thick gate oxide level shifters required
- eFlash DFT mux/test code provided by TSMC
  - Simple RTL integration and example test bench
- High voltage prog pin for wafer testing
  - Pad (not bonded) provided by TSMC
- Analog pins (not bonded) for wafer testing
Rapid Implementation of IoT Endpoint

- ARM & TSMC have collaborated to provide the building blocks for the rapid implementation of low power and low cost IoT endpoints
  - Logical IP: IoT subsystem for Cortex-M, security
  - Physical IP: Optimized IP for compact, highly power managed implementations
  - Radio IP: Cordio pre-qualified and designed for integration in classic digital design flows
  - Software: From protocol stack to mbed OS for rapid proto-typing and software development
  - Process: Ultra low power process with embedded flash

- More than marketing!
  - Physical implementation completed by 3 engineers in 3 months
  - Taped out August 2015, silicon on boards now
Further Work

- **Short term**
  - Silicon bring up and demonstrator by end 2015
  - Reference flows, whitepapers and knowledge transfer
  - Improvements to power management and performance

- **Medium term**
  - Radio enhancements supporting new standards
  - Road map of IoT reference platforms
  - Security enhancements, CPU enhancements
  - Process enhancements – 40ULP and beyond
  - Physical IP to support near threshold operation
The trademarks featured in this presentation are registered and/or unregistered trademarks of ARM Limited (or its subsidiaries) in the EU and/or elsewhere. All rights reserved. All other marks featured may be trademarks of their respective owners.

Copyright © 2015 ARM Limited