Designing for Wearables

James Bruce, Director Mobile Solutions
Challenges in Wearables Market

**Behavioural Challenges**
- Price
- Personal Connection
- Evolving use cases
- User habits
- Social acceptance

**Technical Challenges**
- Fashion drives form factor
- Diverse Requirements
- Battery life
- Evolving Software ecosystem
- Thermal constraints

Use cases still evolving for wearable devices
Wearables: Rapidly Evolving Based on Experience

- **Deeply Embedded**
  - Embedded OS
  - Peripheral
  - Always aware, lowest-power

- **Tethered Embedded**
  - Companion Devices
  - Autonomous Compute
  - High-efficiency performance, constrained power budget

- **Companion Devices**
  - Rich OS

- **Standalone Devices**
Building the wearables reality

Battery Life
Life on Single Charge

- Battery size and small form factor
- What is using the battery?
  - WiFi
  - Bluetooth
  - GPS
  - Sensors
  - Screen
  - Applications
- Markets are still developing
- Use cases are still emerging

Battery life on wearables already ranges from 1 day to 1 year
Smaller Devices Demand Even More Efficiency

- Pushing the boundaries of possibility
  - Choice of technology crafted for efficiency
  - Enabling products previously unimagined

3000 mAh  300 mAh  150 mAh

Battery bulk dominates many connected devices
(Smart watch teardown shown)

Source - www.ifixit.com
Integration Addressing the Packaging Challenge
Building the wearables reality

Battery Life

Software design matters
Wearables Optimized for Micro-interactions

High time and interaction cost for “a moment of information”

Reduced overhead per interaction – more present in the real world
Modes of Operation in Android Wear Devices

- **Ambient Mode**
  - Sensing
  - Notification
  - Time
  - Date
  - Calendar

- **Interactive Mode**
  - Search
  - Message, Audio
  - Video
  - Calling

- **Sleep Mode**
Wearable Devices........ Always-on, Always Sensing

- Software must run on the “right” core

ARM Cortex-A
Application Processor
Rich OS & Apps

Sensor Hub API

ARM Cortex-M
Sensor Hub

Sensor Fusion, Averaging, filtering, calibration, long term trends, event alarms, use case learning etc.
Building the wearables reality

- Battery Life
- Software design matters
- Connectivity Matters
Wearables Must Minimize Radio Interactions

- Each time the radio is woken up, power is consumed
- “Incessant chatter” is the enemy of battery life

Maximize period between data interactions
Group data transactions together
Tethering Limits Openness ....

Tethered Wearable Device

Locally installed Apps

No direct IP connectivity

Encrypted BT Link

Locally installed App traditionally manages wearable connectivity and cloud connect

App is the gatekeeper to services

Smartphone / Tablet ‘My Personal Hub’

Authenticated Link

Encrypted Cellular/WiFi/LAN Link

Cloud Services

Cloud Apps

Cloud encryption

‘Cloud’ encrypted storage

Authentication Server

Locally installed Apps

Private

ARM®
IP to the edge to enable openness ……

Tethered Wearable Device

Smartphone / Tablet ‘My Personal Hub’

Remove the need for gatekeeper App

IP to the edge, seamless connectivity

IP to the edge, wearable device tunnels through any paired Bluetooth 4.1 enabled device as it comes into range

Wearable becomes discoverable and autonomous
Whilst maintaining low power

Locally installed Apps

Cloud Services

Cloud Apps

Authentication Server

‘Cloud’ encrypted storage

Private

Encrypted BT Link

Encrypted Cellular/WiFi/LAN Link
Building the wearables reality

- Battery Life
- Software design matters
- Connectivity Matters
- Solutions Matter
Wearable Systems Architecture

Basic Architecture

- Always On
- Interconnect
- FLASH
- ROM
- SRAM

Mid Architecture

- Apps. CPU
- Always On
- GPU
- Display Processor
- Video Processor
- FLASH
- ROM
- SRAM

High-end Architecture

- Apps. CPU
- Always On
- GPU
- Display Processor
- Video Processor
- ROM
- SRAM
- DMC

RTOS

Rich OS

Higher Performance
High-efficiency ARM® Cortex® A Processors for Wearables

**ARM® Cortex®-A5**
- 8 stage in-order
- Single issue
- ARMv7-A
- AMBA® 3

**ARM® Cortex®-A7**
- 8 stage in-order
- Partial dual issue
- ARMv7-A Extensions
- AMBA 4 ACE

**ARM® Cortex®-A53**
- 8 stage in-order
- Full dual issue
- ARMv8-A
- AMBA 4 or AMBA 5
ARM® Cortex®-A53: Energy-efficient CPU for Next Gen Wearables

Provides Lower Power, Latest Architecture for Existing Cortex-A9 Based Wearables

Cortex-A53 @ 1.6 GHz, 28 nm

- 50% higher performance
- 40% less power
- 60% less area

~2.5x More energy efficient
~4x More area efficient

Advanced power saving features
aggressive power savings

Cortex-A9 (ARMv7-A) → Cortex-A53 (ARMv8-A)
High-efficiency ARM® Mali™ GPUs for Wearables

- Leading OpenGL® ES 2.0 Performance Density
- Utgard Graphics Architecture
- Integrated Memory Management
- AMBA® 3

Mali-T720 GPU

- Optimized for Android
- OpenGL® ES 3.1
- Renderscript Compute
- Midgard Graphics Architecture
- Transaction Elimination
- AMBA 4 ACE-Lite
Always-aware ARM Cortex-M CPUs For Wearables

- Cortex-M0: Lowest Area
- Cortex-M0+: Highest Energy Efficiency
- Cortex-M3: Energy-Performance Balance
- Cortex-M4: Blended MCU and DSP
- Cortex-M7: Highest Performance

Scalable & Compatible ISA
Accelerated Device Development
Professional prototyping for a broad spectrum of developers

- Rapid, make-able professional device development
  - An open source platform
  - Libraries for Cortex-M microcontrollers
  - Web-based tools

- Mix & match essential components for your product design
  - Microcontrollers, radios, sensors, software stacks
  - Bluetooth, 802.15.4/6LoWPAN, WiFi, cellular

- Simplify integration with Internet cloud services
  - Embedded agents and APIs for cloud services
ARM Cordio: Bluetooth Smart Radio IP

- Cordio BT Profiles
- Cordio BT Stack
- Cordio BT Link
- Cordio Radio
- Bluetooth SoC

60% more battery life

Battery curve

1.2V only to here

1V takes us to here
Wearables are about Merging Expertise
Leading the Wearables Revolution on ARM

Silicon & Sensors

Software

Leading OEMs