Smartwatch Architecture

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Overview

- What is it and Why is it Becoming Popular
- Timeline
- Common Smartwatch Specifications
- Basic to High-End Smartwatch Architectures
- Performance and Power Consumption Challenges
- Future Goals
What is it and Why is it Becoming Popular?

● Definitions
  ○ General: A wristwatch with a screen that does more than just tell you the time.
  ○ Modern: A wristwatch that indicates time and connects to the internet wirelessly.

● Purpose: less distraction
Smartwatch Timeline

- **1927**: Plus Four Wristlet Route Indicator
  - First and only use of a scroll map cartridge
- **1972**: Pulsar
  - First all-electric digital watch with LEDs
- **1982**: Seiko TV Watch
  - With an adapter and a receiver box, you could watch TV on it
- **1983**: Seiko Data-2000
  - Memos, calendar, and calculator
- **1985**: Sinclair FM Wristwatch Radio
  - Radio with a speaker
- **1995**: Seiko MessageWatch
  - Caller IDs, sport scores, stock prices, and weather forecasts
Smartwatch Timeline (continued)

- **1995**: Breitling Emergency Watch
  - Produces distress signals when in an emergency
- **1998**: Linux Wristwatch
  - First Linux Powered watch
  - Communicated wirelessly with PXs, cell phones and other wireless enabled devices
- **2002**: Fossil Palm Pilot
  - Address book, memo pad, to-do list, and a calculator with a stylus
- **2003**: Microsoft SPOT
  - FM radio, charged wirelessly
- **2003**: Garmin Forerunner
  - GPS sports watch, measured speed, distance, pace and calories burned
- **2012**: Nike+ Fuelband
  - Tracked your steps
Modern Smartwatches (2012–present)

- **2012**: Sony SmartWatch
- **2013**: Pebble
- **2013**: Samsung Galaxy Gear
- **2014**: Samsung Gear Fit
- **2014**: Moto 360
- **2014**: Samsung Gear S
- **2015**: Apple Watch

**Features**
- Rich operating systems (OS)
- Touchscreen
- Paired with your smartphone via Bluetooth (BLE)
- Receive notifications
  - Emails, text messages, missed calls, etc
- Control your smartphone remotely
  - Play a specific song, take a picture, etc
Common Smartwatch Specifications

- **Operating System (OS)**
  - Common: Android Wear, Watch OS, Microsoft Band, Pebble OS
  - Others: Tizen, WebOS, Tencent OS (TOS+)
- **CPU**
  - Single or dual core
  - 80 MHz - 1.2 GHz
- **RAM**
  - 64 KB - 1 GB
- **Display Type**
  - LCD, OLED, AMOLED, White and Black/Color e-Ink
- **Battery**
  - Capacity: 130 - 420 mAh
  - Life per Charge: 18 Hours - 10 days
- **Charging Type**
  - Micro USB, Wireless, Magnetic
- **Connectivity**
  - Wi-Fi, Bluetooth 4.0+ (BLE), NFC, GPS
- **Sensors**
  - Heart Rate, Accelerometer, Gyroscope, Barometer, Ambient Light, Pedometer, etc
From Basic to High-End Smartwatch Architecture
Basic Device Architecture

- On-chip memories
  - Flash, ROM, SRAM
- Simple Design
  - Activity/sports band
  - Simple watch
- Ultra-low power processor core
  - Cortex-M Series: industry standard
  - Always on sensor-fusion CPU
- Simple real-time operating system (RTOS)
  - Longer battery life
Cortex-M Series Power Consumption and Area

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<td>(9-track, typical 0.9v, 25°C)</td>
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<td>Dynamic power (μW/MHz)</td>
<td>Area mm²</td>
<td>Dynamic power (μW/MHz)</td>
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<tr>
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<td>Cortex-M0+</td>
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<td>Cortex-M4</td>
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<td>0.17</td>
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# Cortex-M Series Performance Benchmarks

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<tr>
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<th>Dhrystone (max options) DMIPS/MHz</th>
<th>CoreMark/MHz</th>
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<td>Cortex-M0+</td>
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<tr>
<td>Cortex-M4</td>
<td>1.25</td>
<td>1.95</td>
<td>3.40</td>
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Mid-Range Device Architecture

- Either an RTOS or a full OS
  - i.e., Linux
- Suitable for a smartwatch with advanced OS and a color display
- Dynamic memory controller (DMC)
  - Provides an interface to off-chip memories
- Single-core application processor
  - Cortex-A Series (A5 and A7)
  - Typically in sleep mode when not being used
- Mali Processors
  - Graphics, video, and display
Cortex-A5 vs. Cortex-A7

- **Cortex-A5**
  - Smallest and lowest power applications processor in the series
  - 8 stage in-order pipeline
  - Longer battery life
  - Less heat dissipation

- **Cortex-A7**
  - Built on Cortex-A5’s 8 stage pipeline
  - Integrated L2 cache
    - Low power
    - Lower transaction latencies
  - Improved branch predictions and memory system performance
High-End Device Architecture

- Designed for high-end products
  - i.e., a smartwatch using Android Wear
- Dual-core multiprocessing application processor
  - Cortex-A7
    - Scalable performance
  - Energy-efficient L2 cache subsystem
- Low-power DDR memory
Performance and Power Consumption Challenges

- Power consumption: not optimized
- Memory caches: too large
  - Use more area and power
- Higher performance = more power consumed
  - 1-2 days of battery life
- Current approaches
  - Reduce standby power
    - Low-power modes
  - Reduce cache memory depending on the size of workloads
    - 32K L1 cache to 16K = less than 10% impact on performance
- Always a tradeoff between performance and power consumption
The Future of Smartwatches

● Fully integrated mobile phone technology
● Improved architecture
  ○ Smaller cache memory
  ○ Slower clock speeds
    ■ Lower frequency
  ○ Longer battery life
    ■ Slowly achieving 6-10 days
● More applications
  ○ Personal assistance
  ○ Medical/Health
  ○ Personal safety
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