Emerging Technologies in Embedded System Design

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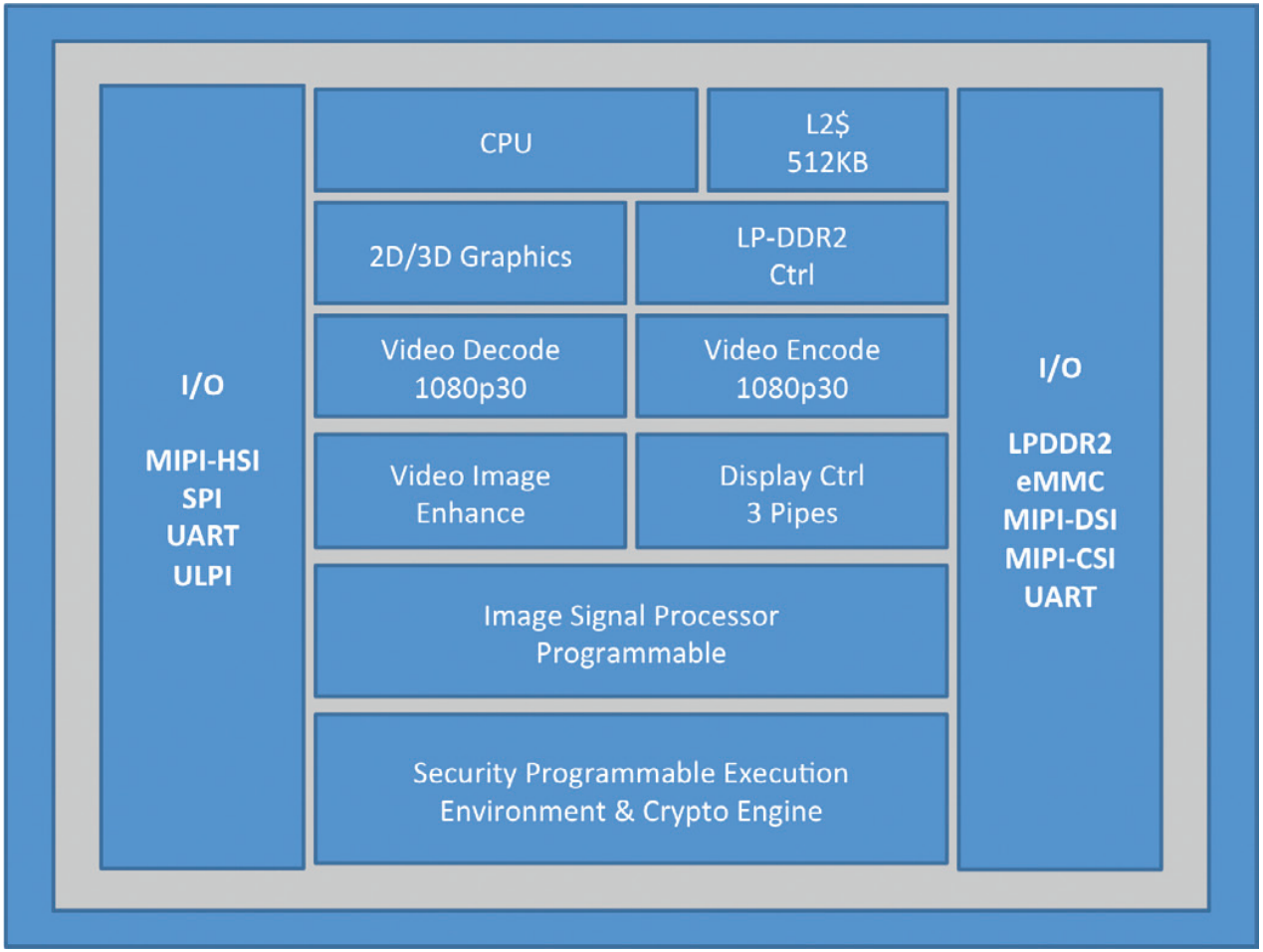
Overview

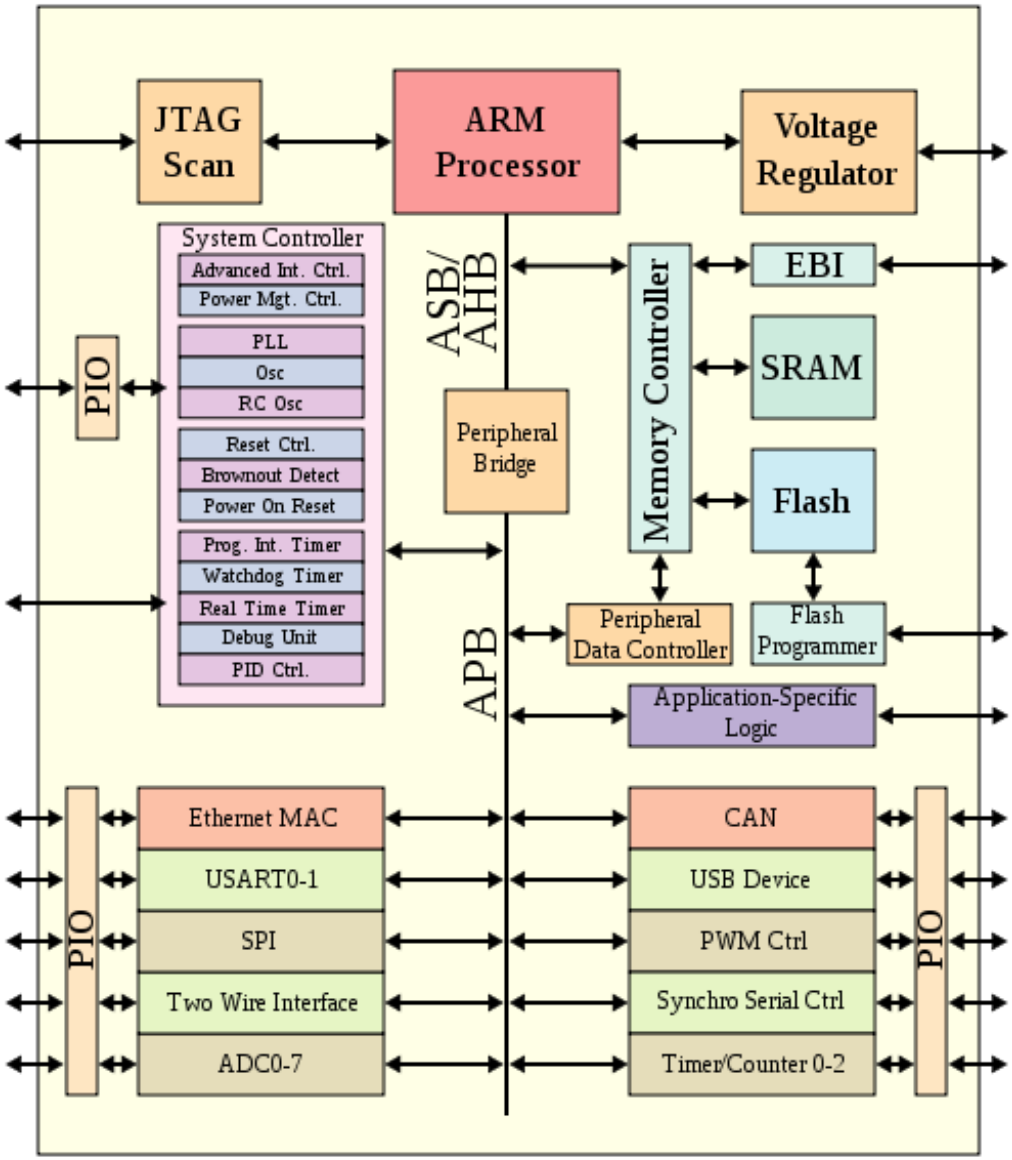
- Hardware
  - System on Chip (SoC)
  - Open Hardware (Beagleboard, Edison, Galileo, etc.)
- Software
  - Embedded OS (Android etc.)
  - Applications (health care, e-commerce, etc.)
  - Internet of Things and Intelligent System
  - Open Embedded Projects (Yocto)
- Design Methodology
  - Full System Simulation (Simics)

System on a Chip

- Integrate (all) components of a computer into a single chip
  - ARM, MIPS, or x86 cores
  - digital, analog, mixed-signal, RF, DSP
  - much more powerful than conventional simple microcontrollers
- connects to
  - external Flash or RAM
  - USB, Ethernet, SPI, I2C, etc.
- Runs embedded OS and many applications
  - Linux or embedded Windows
  - network stack, database, etc.

Intel Atom Z2580

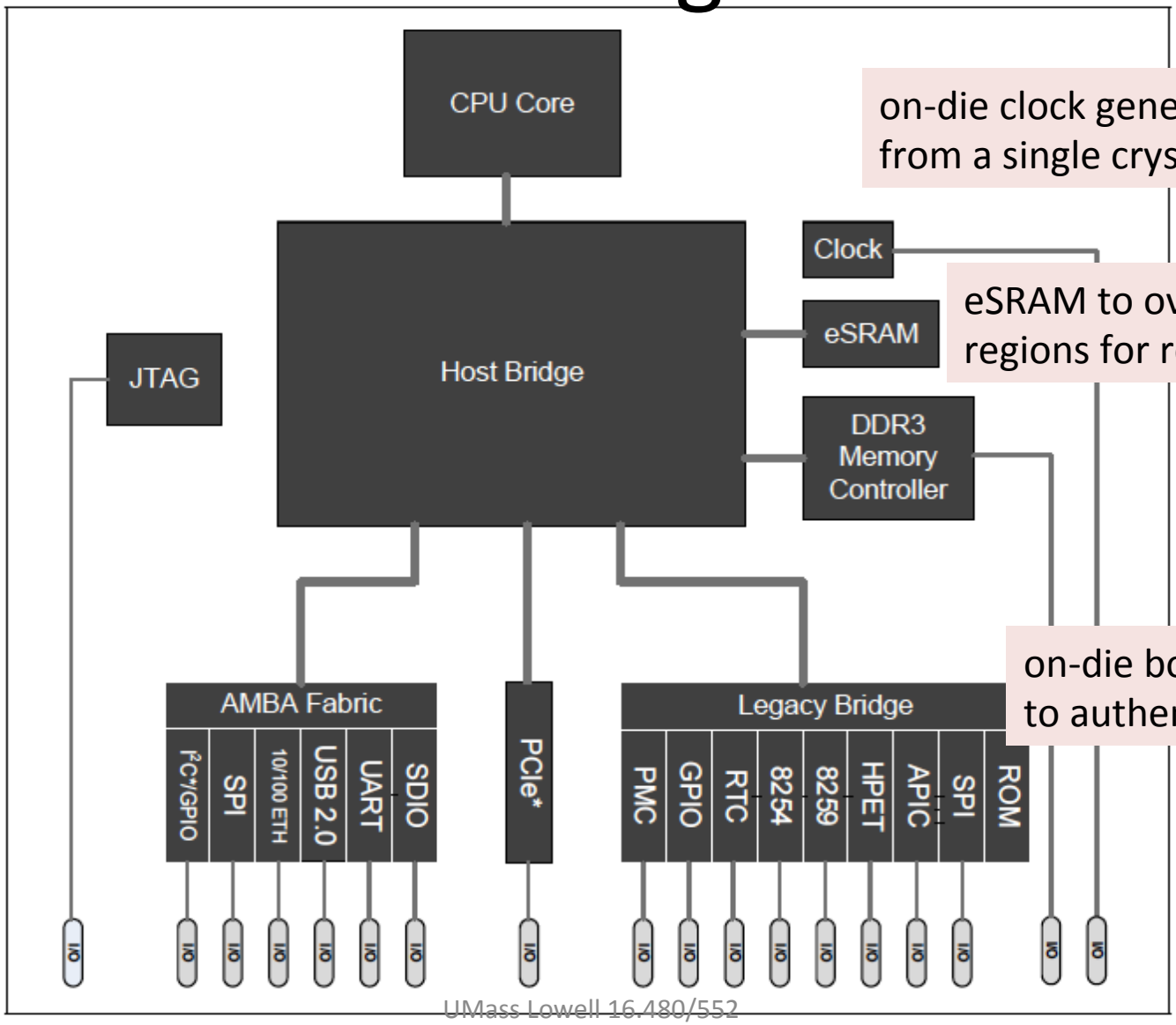



JTAG Scan
ARM Processor
Voltage Regulator
System Controller
Advanced Int. Ctrl.
Power Mgt. Ctrl.
PLL
Osc
RC Osc
Reset Ctrl.
Brownout Detect
Power On Reset
Prog. Int. Timer
Watchdog Timer
Real Time Timer
Debug Unit
PID Ctrl.
PIO
ASB/ AHB
Peripheral Bridge
Memory Controller
EBI
SRAM
Flash
Peripheral Data Controller
Flash Programmer
APB
Application-Specific Logic
Ethernet MAC
USART0-1
SPI
Two Wire Interface
ADC0-7
CAN
USB Device
PWM Ctrl
Synchro Serial Ctrl
Timer/Counter 0-2
PIO
PIO

Intel Quark SoC

- low power secure System-on-Chip (SoC) designed for bring intelligence to network edge for securely managed Internet of Things (IOT)
- Single 32-bit core, single thread
- Integration of I/O interfaces:
  - on-chip Ethernet* interfaces, PCI Express*, USB 2.0, SD/ SDIO/eMMC, SPI, UART, and I2C/GPIO.
- Supports Intel Pentium instruction set

Block Diagram



on-die clock generation
from a single crystal

eSRAM to overlay DRAM
regions for reduced latency

on-die boot rom
to authenticate firmwar

Apple A8

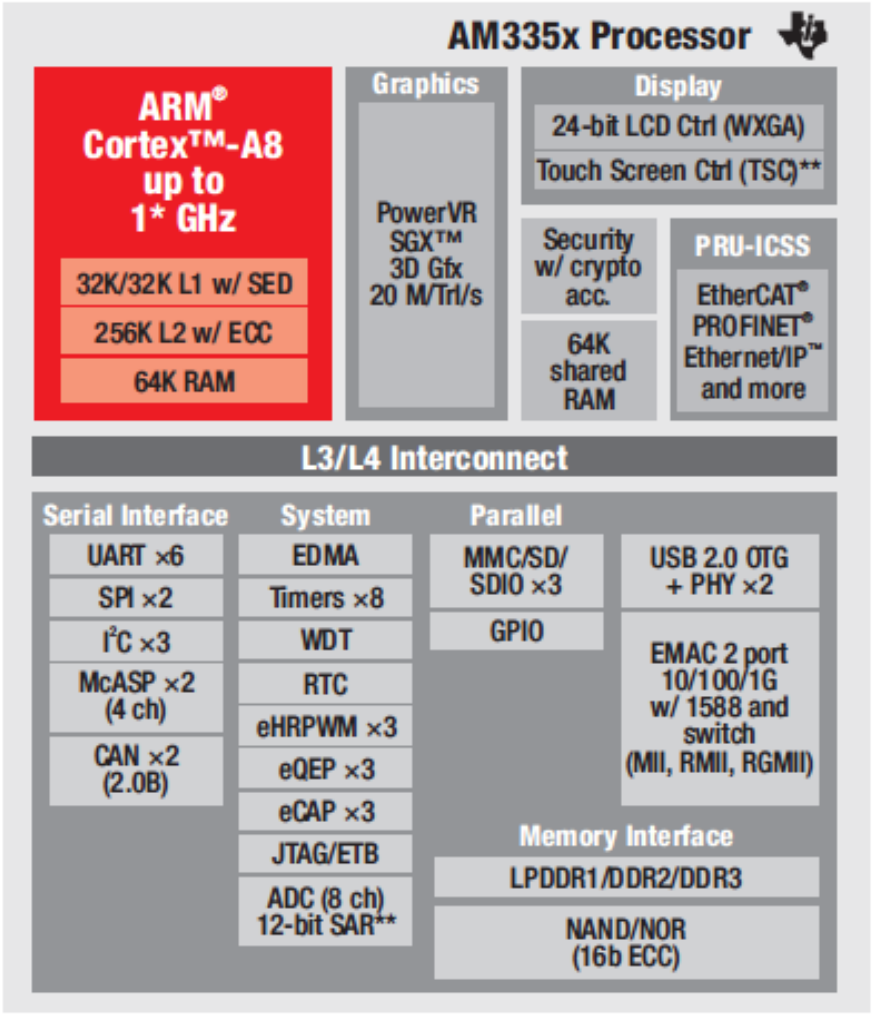
- 64-bit SoC used in iPhone 6 and iPhone 6 Plus
- 25% more CPU performance and 50% more GPU performance, 50% less power than A7
- ARMv8 instruction set
- 20nm technology with 2 billion transistors
- Dual-core @ 1.38GHz

Qualcomm Snapdragon

- SoC (CPU+DSP+GPU)
- Hexagon DSP
  - maximize work per clock cycle (e.g. FFT in one cycle)
  - high performance at lower clock freq, thus low power
  - could be used for “camera/vision/ video/sensor” tasks
- Heterogeneous system to share processing intensive tasks among CPU,DSP,GPU

TI Sitara AM335x

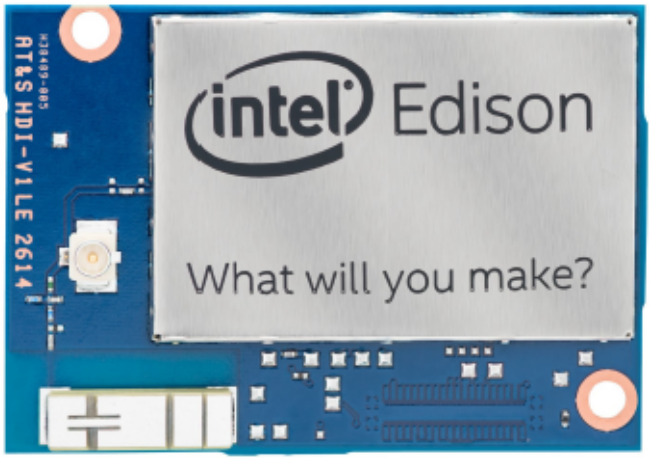
- ARM cortex-A9 core
- 3D graphics processing power
- on-chip quad-core PRU for real-time processing
- vector floating-point
- two parallel camera ports, dual-port 1Gb Ethernet



** 1 GHz only available on 15×15 package. 13×13 is planned for 600 MHz.*
*** Use of TSC will limit available ADC channels.*
SED: Single error detection/parity.

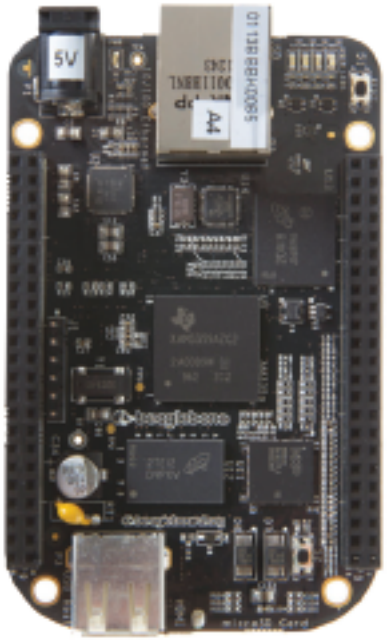
Intel Edison

- Intel Atom (2-core) @ 500MHz + Quark SoC @ 100MHz, 1G memory, 4G flash
- Small form factor (SD size)
- support Arduino sketch, Linux, wifi, bluetooth
- digital/analog I/Os, UART, I2C, SPI, etc.
- Yocto Linux, Arduino IDE



BeagleBone Black

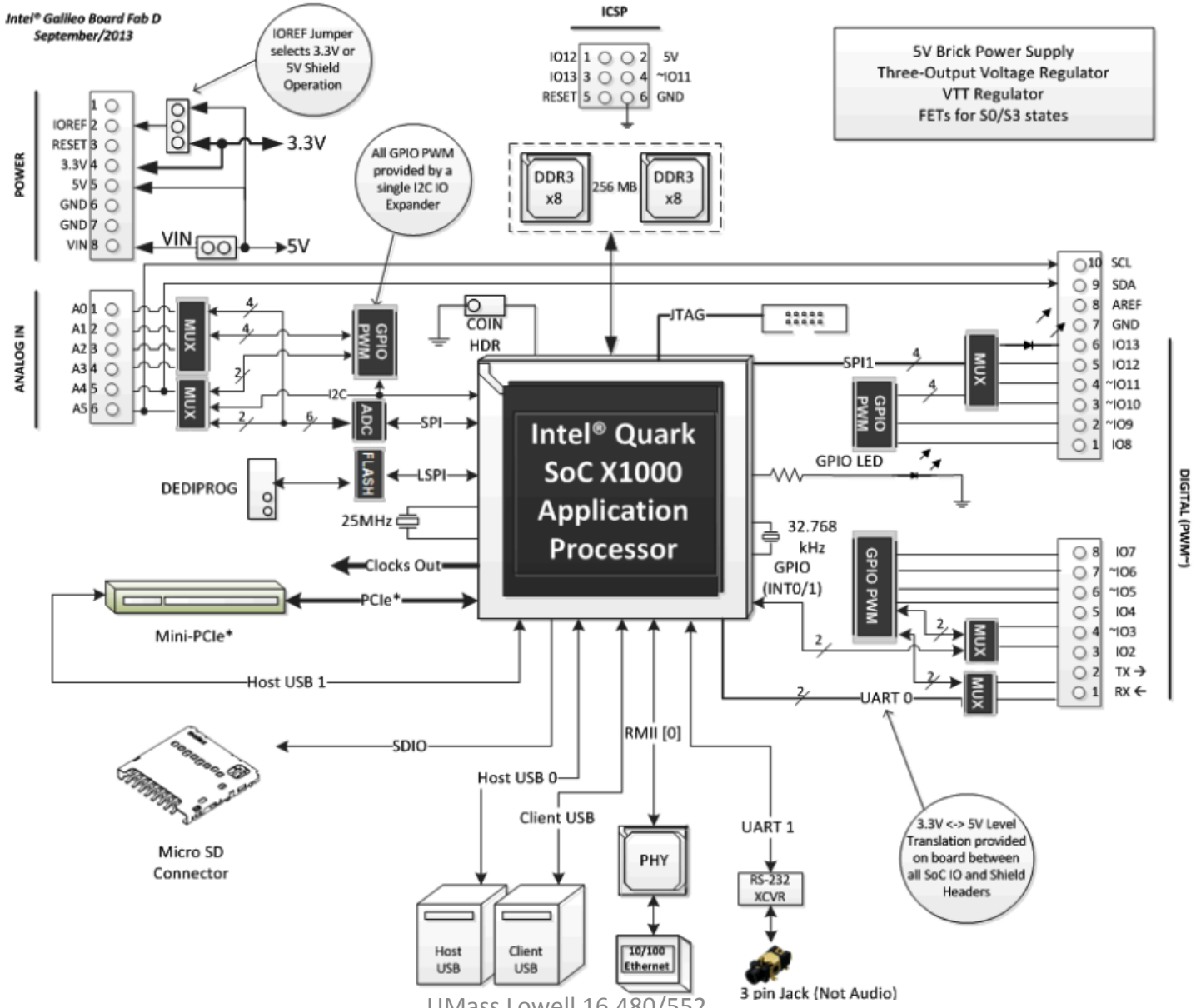
- www.beagleboard.org
- credit-card size, open hardware
- 1GHz CPU, 512MB DDR3, eMMC flash
- HDMI, USB, Ethernet, UART
- Runs Android, Linux, Windows CE, RT OS
- Yocto compatible



Intel Galileo

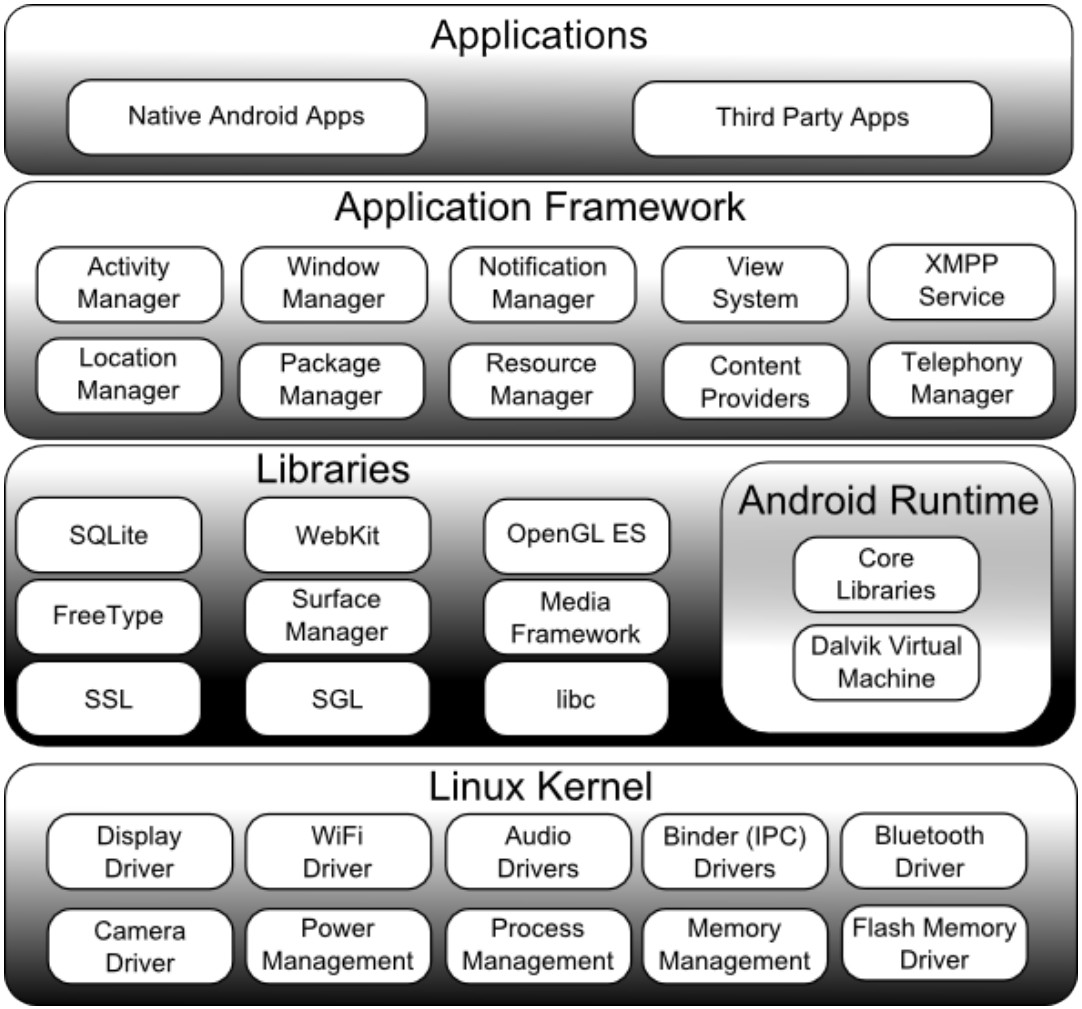
- Intel's Embedded Development Board based on Quark processor
- Open Source Hardware and Software
- Arduino Compatible
- With a variety of ports
  - USB, GPIO, Ethernet, mini PCIe, serial, etc.

Overview of Galileo Hardware



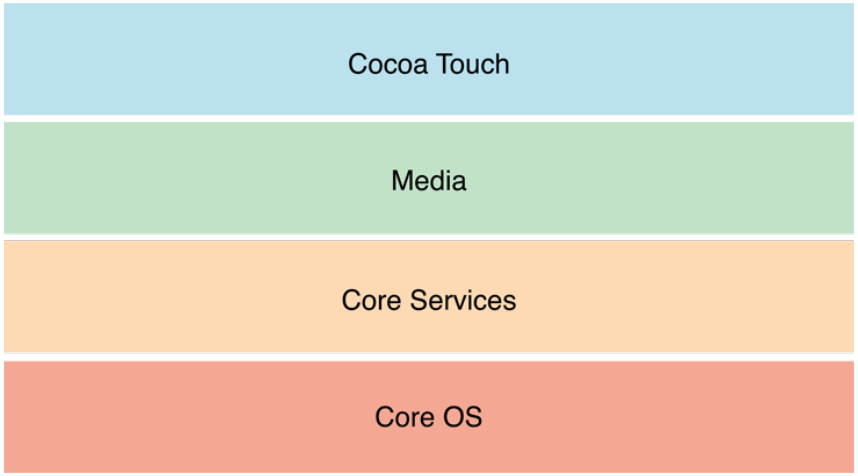
Android

- mobile OS / platform released in 2009
- Google backed, contributed by community and vendors
- Android SDK for App development



iOS

- Mobile OS / Platform
- By Apple and for Apple Only
- iOS SDK /Xcode, App development with Objective-C and/or Swift



- Appearance of the App
- graphics, video, audio
- location, social media, networking
- security, authentication, bluetooth

Other Embedded OSes

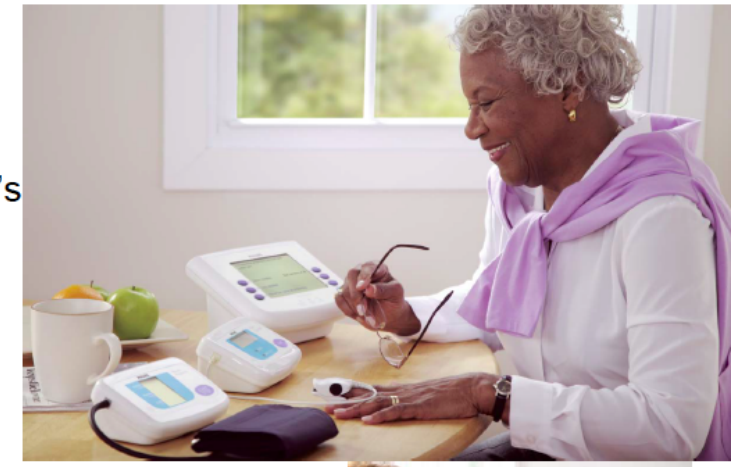
- Windows CE
  - Different kernel from desktop Windows
  - Supports x86 and ARM
  - Base of Windows Phone
- Wind River Linux
  - Commercial Linux, good support
  - Supports many processor architectures, and Yocto
- Wind River VxWorks
  - Real-time OS for critical applications (power, teleco, aerospace, etc.) -- Curiosity on Mars!
  - Modular: Microkernel (20KB) + common kernel
  - Broad connectivity: USB, CAN, Bluetooth, etc.

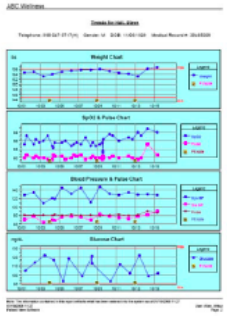
Remote Patient Monitoring

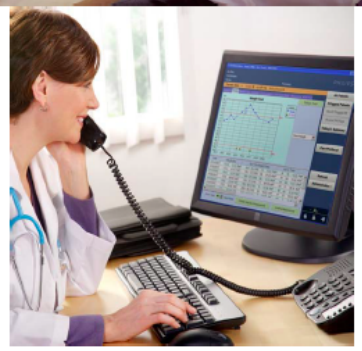
PHILIPS

Remote Patient Monitoring

- Measuring devices at patient's home (or even mobile)
- Network connection to service center
- Web-based clinical software to monitor a large number of patients efficiently







Philips Research Eindhoven, Pierre America, November 12, 2008

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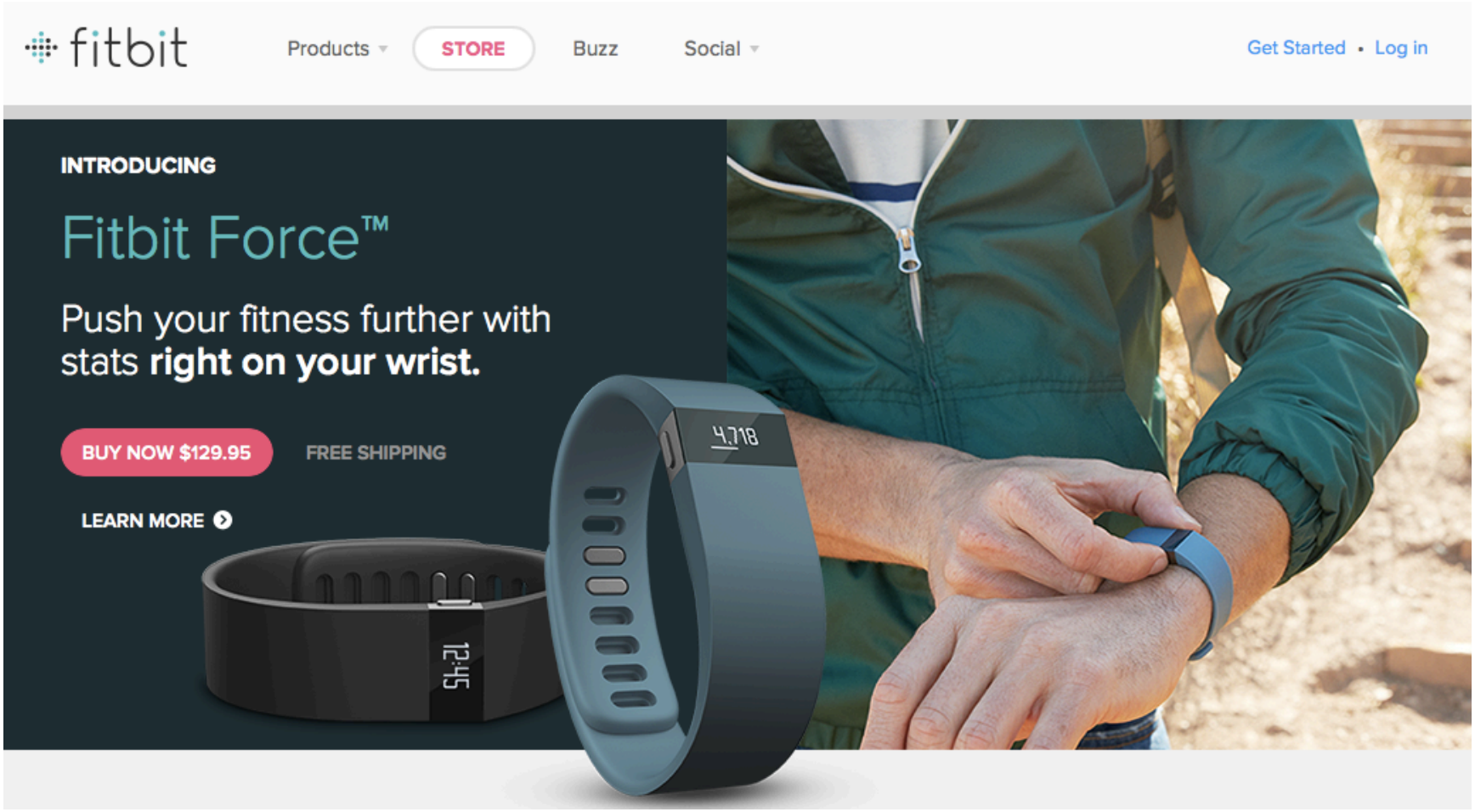
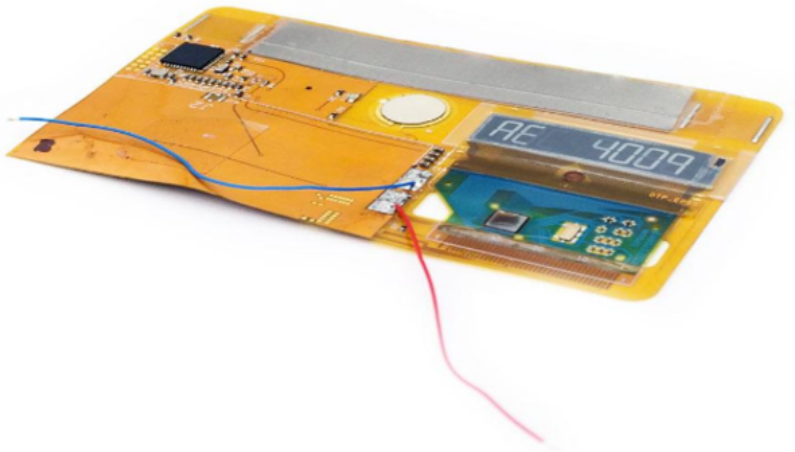
Fitness Tracking



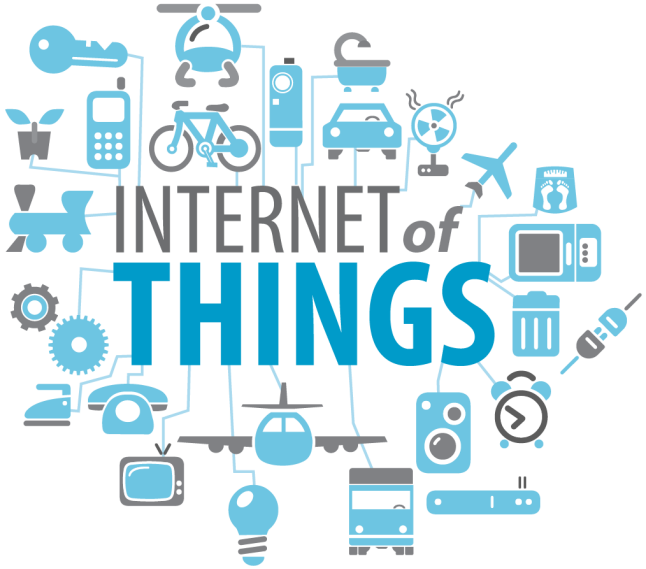
The “Coin” Credit Card(s)



https://onlycoin.com

Internet of Things (IoT)

- Ubiquitous interconnection of embedded devices (sensors, actuators, systems, services, …)
- 26 billions of smart connected objects in 2020
- Example of "Things"
  - Heart monitoring implant
  - Smart grid
  - Cars with sensors
  - Thermostat
  - Toys and diapers
  - …



Picture source: http://blog.surveyanalytics.com/2014/09/top-5-infographics-of-week-internet-of.html

Yocto Project

- Yocto is not a new Linux
- Yocto is a collection of tools to
  - Help you build a (Embedded) Linux distribution
  - Help you customize your distribution/package
  - Help you pull sources and compile packages for a specific hardware platform
- Supports many processor ISA
- Backs from a large group of companies

Simics

- See separate slides.