Technische Hochschule Rosenheim
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Modul
- Internet of Things (IoT) -

02-Vorlesung

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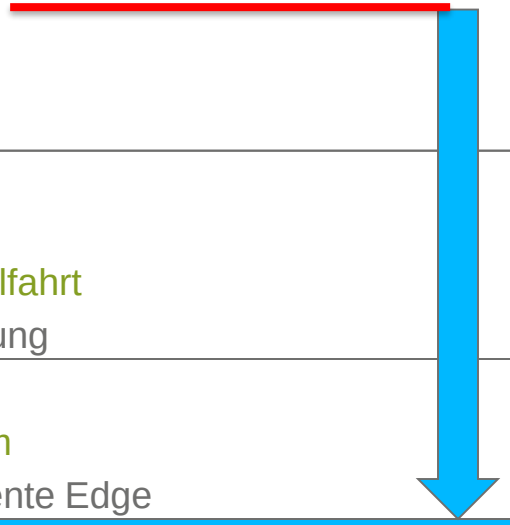
Fakultät Informatik, Cloud Computing

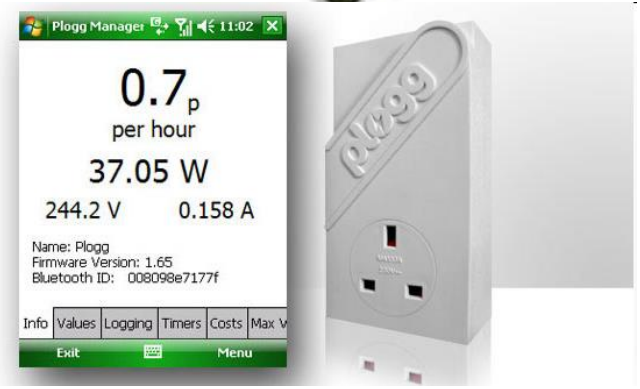
Überblick

21. März	Einführung in das Internet der Dinge
28. März	IoT Architekturen
4. April	Things und Sensoren
11. April	From Device to Cloud
18. April	Vorlesungsfrei – Ostern
25. April	IoT Analytics
02. Mai	Big Data in IoT
9. Mai	Data Exploration
16. Mai	IoT Platformen
23. Mai	Entwicklung einer IoT Lösung
30. Mai	Vorlesungsfrei; Christi Himmelfahrt
05. Juni	opt. Gastvortrag – Digitalisierung
13. Juni	Data Science in IoT
20. Juni	Vorlesungsfrei – Fronleichnam
27. Juni	Intelligente Cloud und intelligente Edge
04. Juli	PStA Abschlusspraesentationen



Sensor devices are becoming widely available

- Programmable devices
- Off-the-shelf gadgets/tools



More Things

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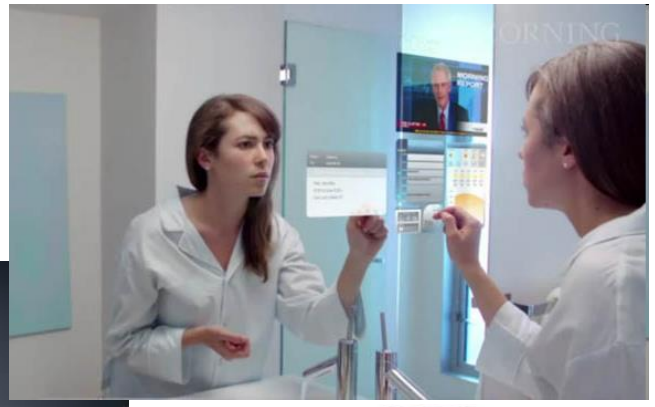
Home/daily-life devices
Business and
Public infrastructure
Health-care
…



Things

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Challenges

Memory
Processor
Energy (Battery) , lifetime
Security
Various generations (old vs new)
Heterogeneous platforms
Provisioning
Variety of device categories (sensor, gateways)
Variety of device types
Programming languages
Physical size
Inputs
Connectivity

Technology

Microcontroller vs OS powered
C, Java, Python, JavaScript, C++, C#, ….







Initial thoughts about ‘Things’

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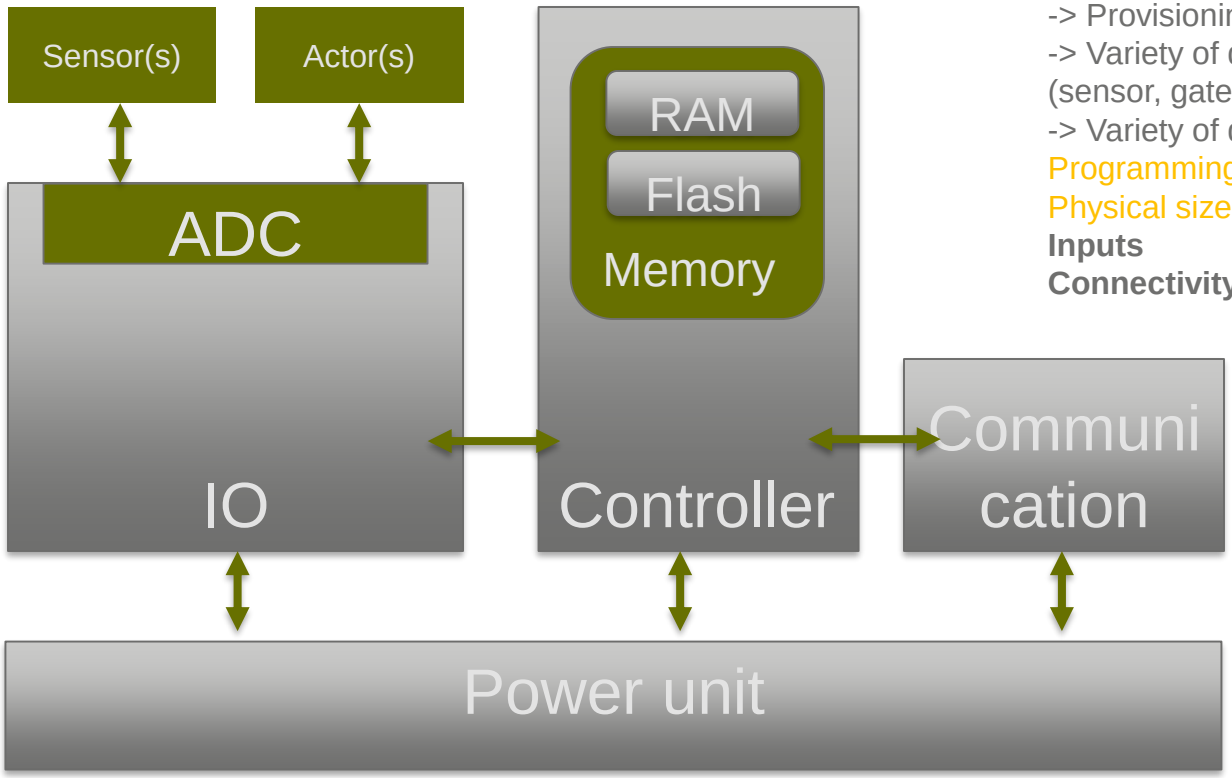
- We can turn almost every object into a “thing”.
- A “thing” still looks much like an embedded system currently.
- A “thing” generally consists of four main parts:
  - Sensors & actuators
  - (Micro) - Controller
  - Communication unit
  - Power supply

To be discussed:

- A “thing” has the following properties:
  - It’s generally powered by battery: This implies limited source of energy.
  - It’s generally small in size and low in cost: This limits their computing capability.
  - It doesn’t usually perform complicated tasks.
- Power consumption is the main design issue.

‚Thing‘ Setup



Memory
Processor
Energy (Battery) , lifetime
Security
-> Various generations (old vs new)
Heterogeneous platforms
-> Provisioning
-> Variety of device categories (sensor, gateways)
-> Variety of device types
Programming languages
Physical size
Inputs
Connectivity

ADC = Analog-to-digital converter

‚Thing‘ Setup

- A ‘thing’ consists of several components
  - Controller: Central processing unit (CPU)
  - Memory for application and data
    - Usually different memory types are used for application and data
  - Communication interface
    - Wireless radio interface with antenna
    - Wired
  - Sensors/Actors
    - Interface to the real world
    - Monitoring, changing of real world phenomena
  - Power unit
    - Power supply for all the components

Controller

- Four important factors for the controller
  - Number of transistors -> size, cost, power
  - Number of clock cycles -> power
  - Time to develop -> cost, acceptance
  - Nonrecurring engineering cost (NRE) -> cost, acceptance

Ideal: Minimize all factors at the same time!

Controller Types

The controller is the Central Processing Unit (CPU) of the device
Different architectures possible

- Microcontroller (MCU)
  - Resource constrained compared to desktop processors
  - Software controlled, general purpose
- Digital Signal Processor (DSP)
  - Processing of large data streams, parallelizing
  - Hard-wire basic functions
- Field-Programmable Gate Arrays (FPGA)
  - Special hardware, expensive
  - Limit coding to configuration
- Application-Specific Integrated Circuits (ASIC)
  - Special hardware designed only for one application
  - Possibly embedding several MCU or DSP cores
- General purpose CPU
  - Resource consuming but flexible
  - Software controlled

Controller

	Time to Market	Perfor-mance	Price	Develop-ment Ease	Power	Features Flexibility
MCU	Excellent	Fair	Excellent	Good	Fair	Excellent
DSP	Excellent	Excellent	Good	Excellent	Excellent	Excellent
FPGA	Good	Excellent	Poor	Excellent	Poor	Good
ASIC	Poor	Excellent	Excellent	Fair	Good	Poor
CPU	Excellent	Excellent	Good	Excellent	Poor	Excellent

Overview of some MCUs

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	Atmega1281	TI MSP430	PIC 18F6720	ARM7TDMI-S	ARM926EJ-S
	8 bit RISC	16 bit RISC	16 bit RISC	32 bit RISC	32 bit RISC
RAM	8 kB	10 kB	4 kB	98 kB	1 MB
Flash	128 kB Program 512 kB Data (Serial Flash) 4 kB EEPROM	48 kB	128 kB Program 512 kB File system 1 kB EEPROM	512 kB	8 MB
Max. Freq.	8 MHz	8 MHz	20 MHz	Up to 72 MHz	400 MHz
Power-consumption	Active: 8 mA Sleep: < 8 µA	Active: 1.8 mA Sleep: 5.1 µA	Active: 8 mA		20-144 mA Sleep: 65 µA
Platform	IRIS	TelosB MSB-H30	Particle	MSB-A2	Sun SPOT (Rev 8.0)
Price	~12 €	~5 €	~5 €		

Memory

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Properties
- Often different program and data memory
- No memory management unit (MMU) available
- Size of memory varies
  - May depend on the application

Types of memory
- Random Access Memory (RAM)
  - Store temporarily sensor data and messages
- Electrically Erasable Programmable Read-Only Memory (EEPROM)
  - Stores the program code
  - Operates on bytes
- FLASH Memory
  - Non-volatile memory
  - Stores the program code
  - Stores data if RAM too small or protection against power loss required
  - Operates on blocks (read, write)
  - High delay and energy consumption

Communication interface

Communication interface is required to exchange data with other devices

Typical communication media

- Radio
  - Bluetooth, ZigBee, WiFi, LORA, …
- Infrared (IR)
  - Directed / undirected
- Ultrasonic
  - More in military applications
- Sound
  - Underwater communication

Communication interface has high energy consumption

- Radio interface consumes the most energy usually

Platforms Overview

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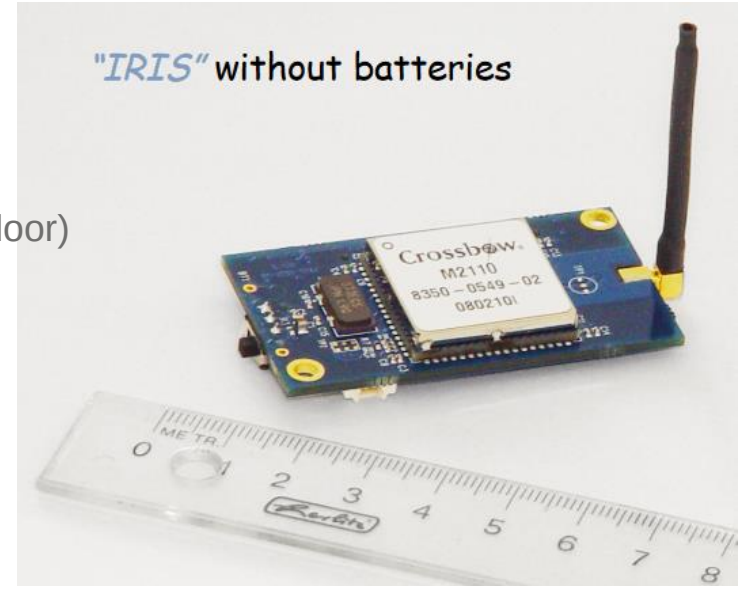
Platform	Microcontroller	Radio chip
AVRraven	ATMEGA1284p, ATMEGA3290p	AT86RF230
BTnode	ATMEGA128L	CC1000
EyesIFX v1 / v2	MSP430F149, MSP430F1611	TDA5250
iMote, iMote2	ARM core, ARM 7TDMI, ARM 11	Bluetooth, CC2420
Lotus	ARM7 Cortex M3	AT86RF231
MICA, MICA2/MICAz, Cricket, MICA2Dot, IRIS	ATMEGA103, ATMEGA 128, ATMEGA128L, ATMEGA1281	TR1000, CC2420, AT86RF230
Particle, DINAM	PIC18F720, PIC18F14K22	TR1001
ScatterWeb MSB	MSP430F1612IPM	CC1020
Shimmer	MSP430F1611	CC2420
SunSPOT	ARM926EJ-S	CC2420
Telos, TelosB, T-Mote Sky	MSP430	CC2420
Tinynode	MSP430	SX1211

Platforms: IRIS Motes

- Processor
  - XM2110CA based on Atmel ATmega1281
  - 8 bit Microcontroller
  - 8 MHz
  - Compute power similar to 8088 CPU from the original IBM PC (~1982), but reduced energy consumption
- Radio chip
  - AT86RF230
  - IEEE 802.15.4
  - ZigBee compatible
  - 2.4 GHz, 250 kbps, up to 300 m (outdoor), up to 50 m (indoor)
- Memory
  - 4 kB EEPROM
  - 8 kB RAM
  - 128 kB program Flash Memory
  - 512 kB measurement Flash Memory



Plattform: Freedom Development Boards

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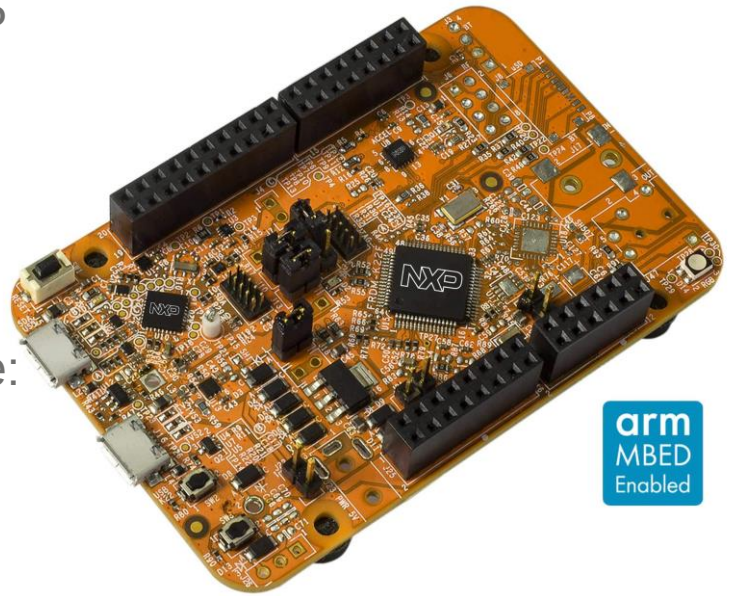
- Processor
  - MK22FN512VLH12 MCU
  - 120 MHz
  - 512 KB flash memory
  - 128 KB RAM
  - low-power, and crystal-less USB in 64 LQFP package

- Radio
  - Optional header for add-on RF module: nRF24L01+ Nordic 2.4 GHz radio
  - Optional header for add-on Bluetooth module: JY-MCU BT board V1.05 BT



Plattform: Arduino Uno

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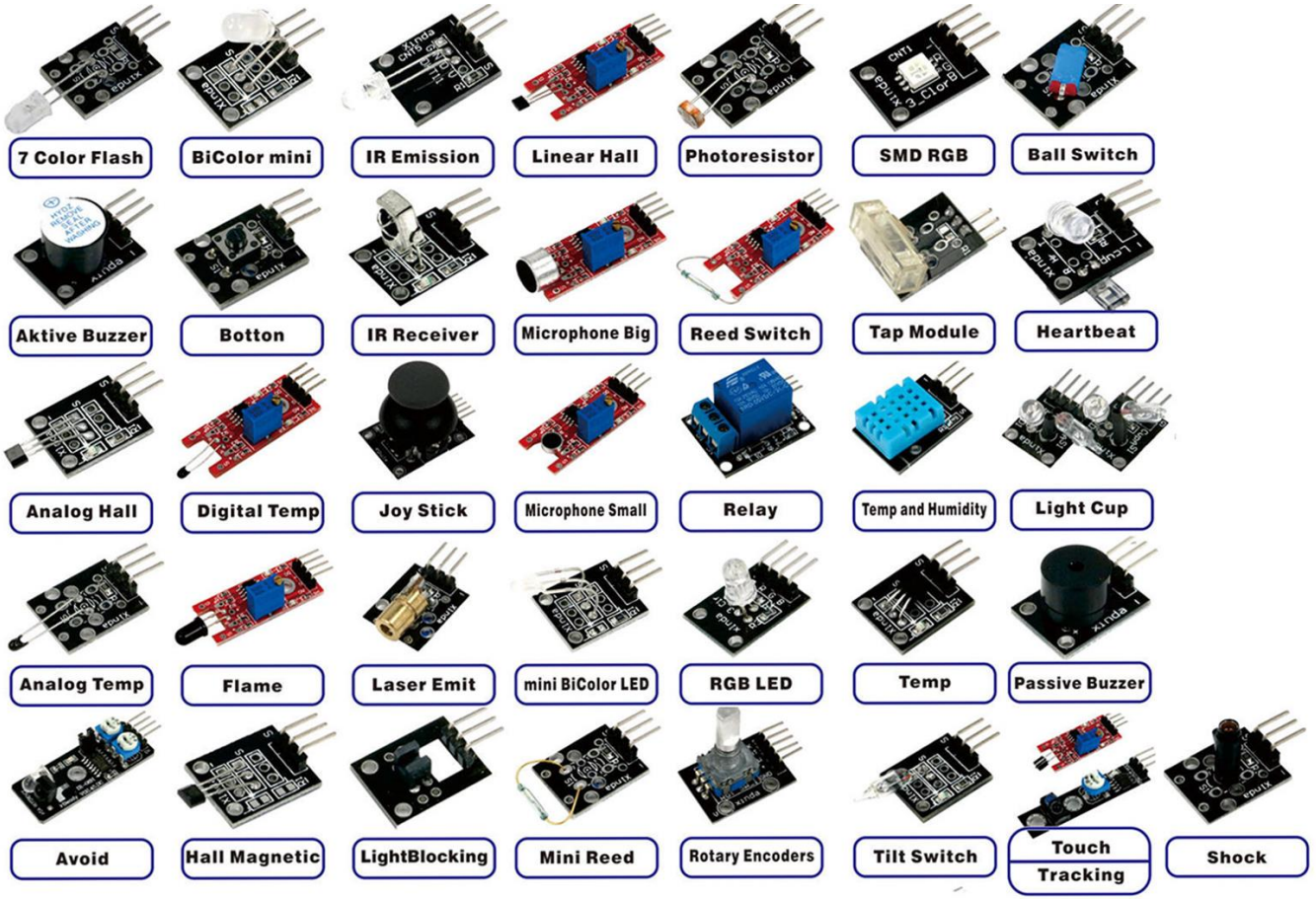
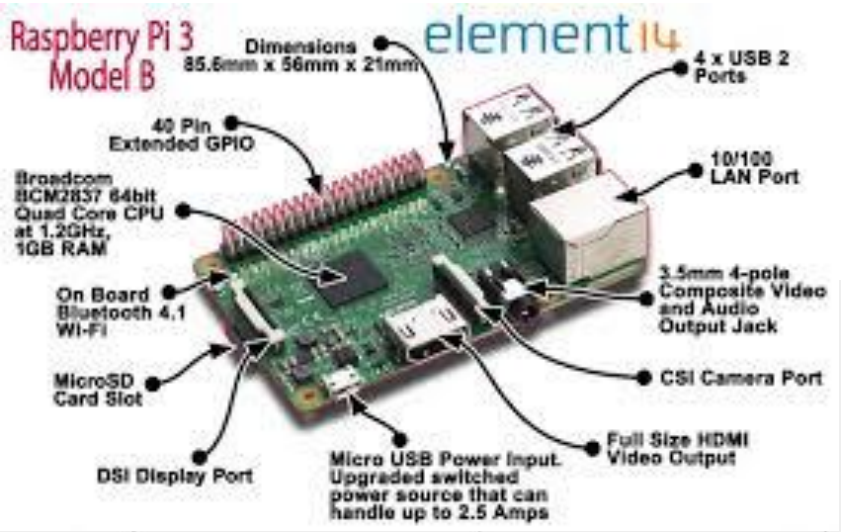
- Processor
  - Microchip ATmega328P
  - SRAM: 2 KB
  - EEPROM: 1 KB
  - Clock Speed: 16 MHz
  - Flash Memory: 32 KB of which 0.5 KB used by bootloader
- Radio
  - No Radio default but everything is available as breakouts

Sensors available in Market



Plattform: Raspberry Pi



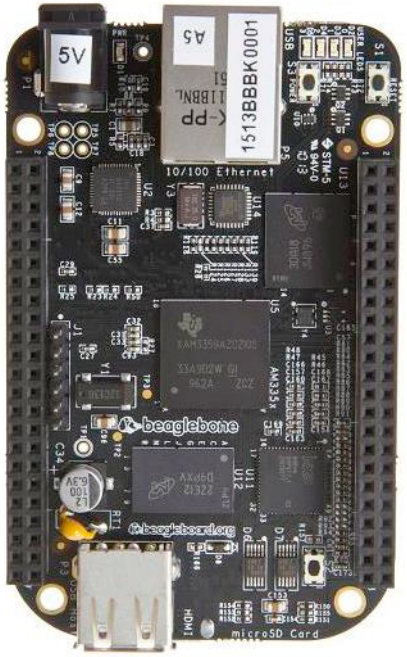
	Raspberry Pi 3 Model B	Raspberry Pi Zero	Raspberry Pi 2 Model B	Raspberry Pi Model B+
Introduction Date	2/29/2016	11/25/2015	2/2/2015	7/14/2014
SoC	BCM2837	BCM2835	BCM2836	BCM2835
CPU	Quad Cortex A53 @ 1.2GHz	ARM11 @ 1GHz	Quad Cortex A7 @ 900MHz	ARM11 @ 700MHz
Instruction set	ARMv8-A	ARMv6	ARMv7-A	ARMv6
GPU	400MHz VideoCore IV	250MHz VideoCore IV	250MHz VideoCore IV	250MHz VideoCore IV
RAM	1GB SDRAM	512 MB SDRAM	1GB SDRAM	512MB SDRAM
Storage	micro-SD	micro-SD	micro-SD	micro-SD
Ethernet	10/100	none	10/100	10/100
Wireless	802.11n / Bluetooth 4.0	none	none	none
Video Output	HDMI / Composite	HDMI / Composite	HDMI / Composite	HDMI / Composite
Audio Output	HDMI / Headphone	HDMI	HDMI / Headphone	HDMI / Headphone
GPIO	40	40	40	40
Price	$35	$5	$35	$35

Plattform: Beagle Bone

- Processor
  - AM335x 1GHz ARM® Cortex-A8
  - 512MB DDR3 RAM
  - 4GB 8-bit eMMC on-board flash storage
  - 3D graphics accelerator
  - NEON floating-point accelerator
  - 2x PRU 32-bit microcontrollers

- Connectivity
  - USB client for power & communications
  - USB host
  - Ethernet
  - HDMI
  - 2x 46 pin headers

- Software
  - Debian
  - Android
  - Ubuntu



Plattform: Intel Galileo

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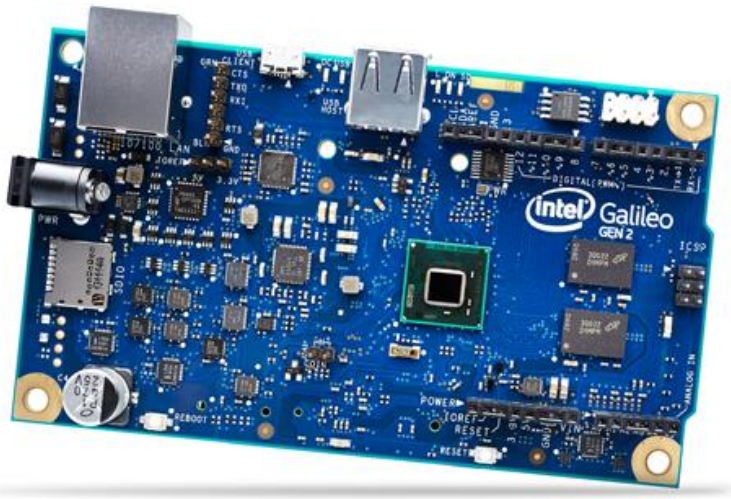
•Processor
- 1 Core 32-bit Intel Pentium processor-compatible ISA Intel Quark SoC X1000
- 400 MHz
- 16 KB L1 Cache
- 512 KB SRAM
- Integrated real-time clock (RTC)

•Storage
- 8 MB NOR Flash for firmware and bootloader
- 256 MB DDR3; 800 MT/s
- SD card, up to 32 GB
- 8 KB EEPROM

- Connectivity
  - USB 2.0
  - RJ45 Ethernet
  - 10-pin JTAG for debugging
  - 6-pin UART
  - 6-pin ICSP
  - 1 mini-PCI Express slot
  - 1 SDI



Plattform: Tessel

- Procesor
  - 580MHz Mediatek MT7620n
  - 48MHz Atmel SAMD21 coprocessor
  - 64 MB DDR2 RAM & 32 MB Flash
  - Plenty of space for your code
- Connectivity
  - 802.11 b/g/n Wi-Fi
  - Ethernet
- Programming Language
  - JavaScript

Some Project Ideas

Smart Egg Tray

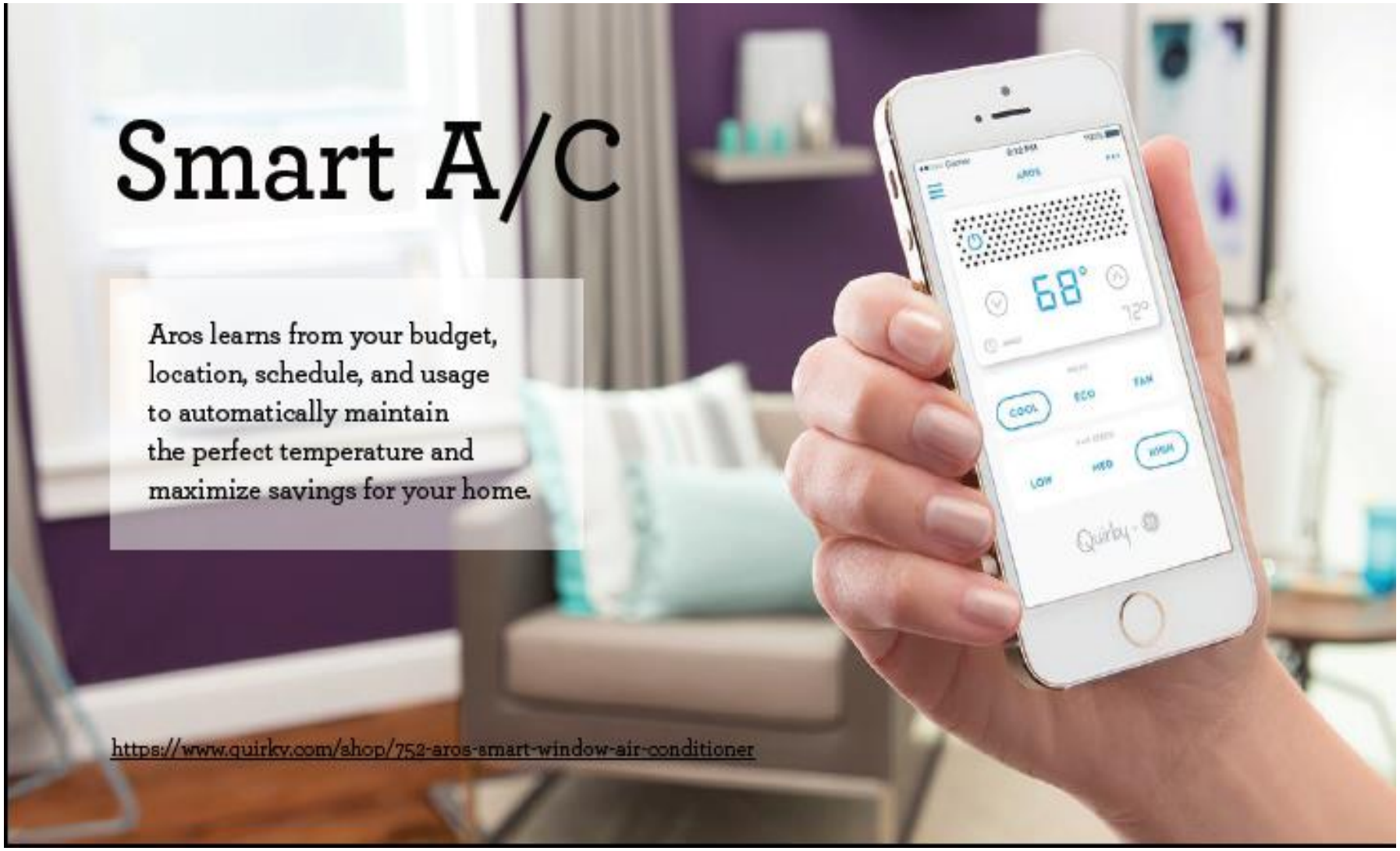
Egg Minder syncs with your smartphone to tell you how many eggs you've got at home (up to 14 eggs) and when they're going bad.

http://www.quirky.com/shop/619

Smart Washing Machine

Smart Aqualtis is the first Indesit Company washing machine designed to be integrated in 'Smart' ecosystems, covering a wide range of use cases.

http://zigbee.org/Products/ByStandard/AllStandards.aspx



Smart Sleep System

Visualize your sleep cycles, understand what wakes you up, and compare nights. From the palm of your hand you can control your personalized wake-up, and fall-asleep programs.

http://www.withings.com/us/withings-aura.html

Smart Weather Station

The Netatmo Weather Station allows you to use indoor temperature, relative humidity and CO_2 readings to live in a healthier home.

http://www.netatmo.com/en-US/product/weather-station/