



Erlang Embedded

Concurrent Blinkenlights and More!

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Agenda

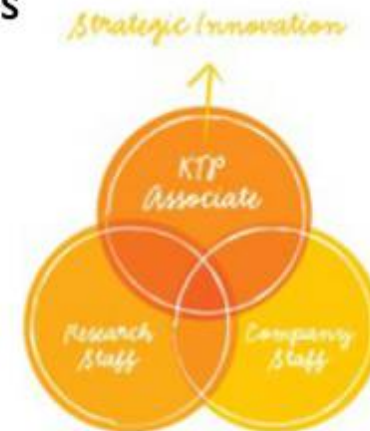
- Overview of the KTP Project
- Challenges in Modern Embedded Systems
- Current State of Erlang in Embedded Domain
- Our Plans for Erlang Embedded
- Questions

Knowledge Transfer Partnership

“Erlang for a New Era of Embedded Computing”, Ulf Wiger, EUC 2011

Knowledge Transfer Partnership

- UK Govt funded, 2 years, 1 person full-time
 - Erlang Solutions
 - University of Kent
- Erlang on embedded ARM devices
- Build relations with device HW manufacturers
- Try to make Erlang one of the standard environments on new hardware



Erlang

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Thursday, 3 November 2011

Knowledge Transfer Partnership

“The aim of this KTP project is to bring the benefits of concurrent systems development using Erlang to the field of embedded systems; through investigation, analysis, software development and evaluation.”

Challenges in Embedded Systems (I)

- Larger, more complex systems than ever before
- Multi-core processing
 - Harder to develop for using the standard embedded development flow
 - Harder to utilise the full processing potential
 - Much harder to debug (and fix!)

Challenges in Embedded Systems (II)

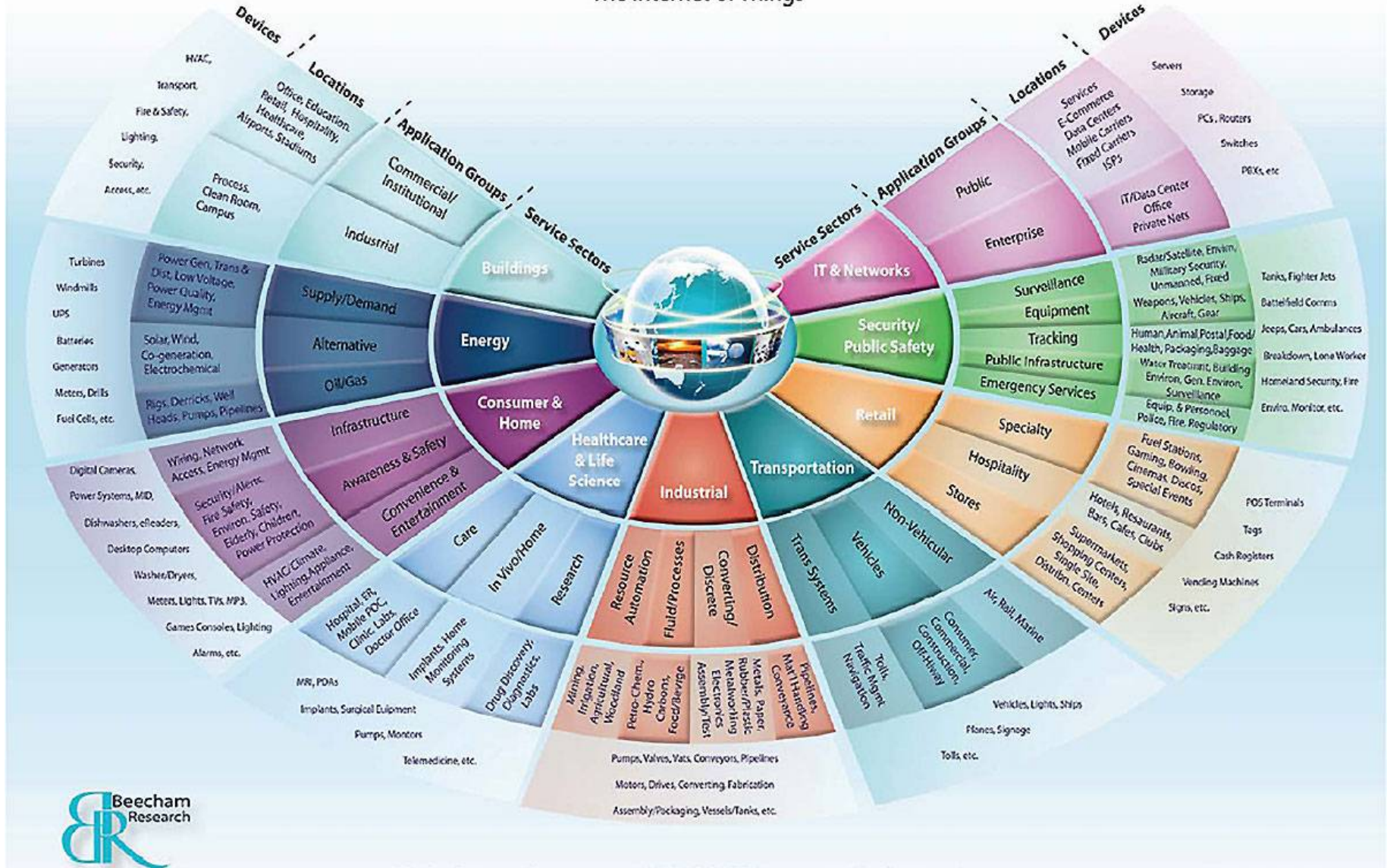
- Increasingly higher degrees of heterogeneity in terms of:
 - Cores
 - Hardware acceleration (GPU, co-processor etc)
 - Interconnect
 - Memory hierarchies

Challenges in Embedded Systems (III)

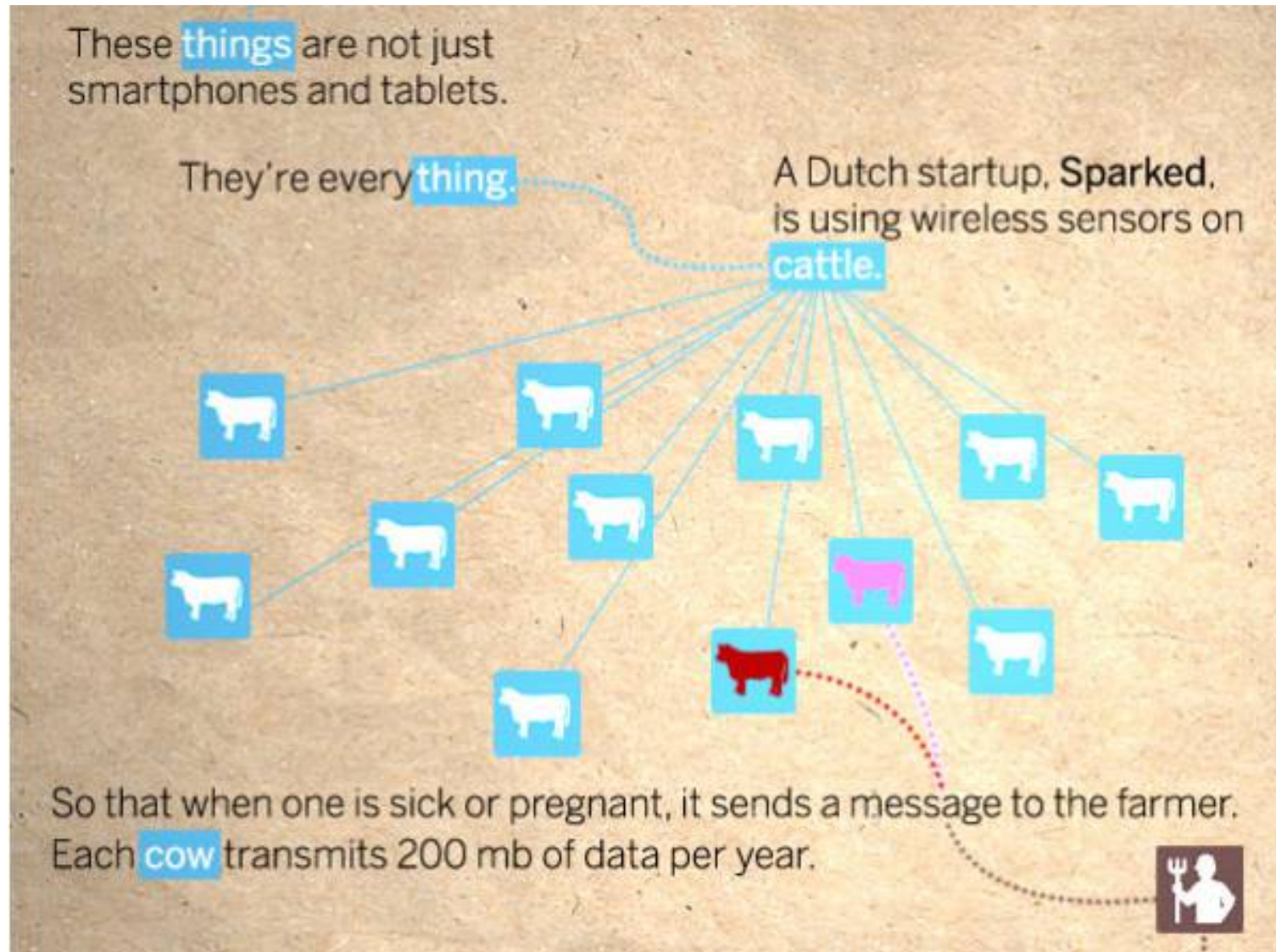
- Low power
 - Efficient use of batteries
- “Always connected”

Internet of Things (I)

The Internet of Things



Internet of Things (II)



<http://blogs.cisco.com/news/the-internet-of-things-infographic/>

Erlang Advantage (I)

- Declarative
 - Functional programming language, high abstraction level, concise readable programs.
- Concurrent and Parallel
 - Highly scalable, transparent or explicit concurrency, lightweight processes. Takes full advantage of multicore architectures.

Erlang Advantage (II)

- Robust
 - Simple and consistent error recovery and supervision hierarchies.
- Portable, Distributed
 - Runs on a variety of platforms, network-aware runtime, supports heterogeneous networks.

Erlang Advantage (III)

- External Interfaces
 - NIFs and ports used to interface external world to the Erlang runtime.
- Soft Real-Time
 - Response time (can be) in the order of milliseconds, per-process garbage collection.
- Hot-code loading
 - Dynamic reconfiguration.

Limitations

- No hard real-time guarantees
- Underlying OS dependency
 - Not “bare-metal”
- Lack of unified hardware/peripheral abstraction

Erlang, the Maestro



(flickr/dereckesanches)

Erlang, Embedded?

- Using standard tools/runtime/modules
 - Cross-compiled for specific architecture
 - Specific features disabled
- Bare metal
 - Here be dragons.

Current State

FEUERLABS



github

nerves-project / **bbone-erlang-buildroot**
forked from fhunketh/buildroot-beaglebone

Code

Network

Ready-to-go Erlang on the BeagleBone — [Read more](#)

ZIP

HTTP

Git Read-Only

<https://github.com/nerves-project/>



Mark Wolfe @wolfeidau

22 May

Submitted update to the [#erlang](#) package on [#OpenWRT](#) patchwork.openwrt.org/patch/2196/ if anyone wants to test it please ping me /cc [@ErlangEmbedded](#)



Niclas Axelsson @Burbass

22 May

I can now control my Mindstorm Lego car with Erlang. [#erlang](#) [#mindstorm pic.twitter.com/Jn78yViH](http://pic.twitter.com/Jn78yViH)

et al.

Erlang
SOLUTIONS

Hardware is cheap and plentiful



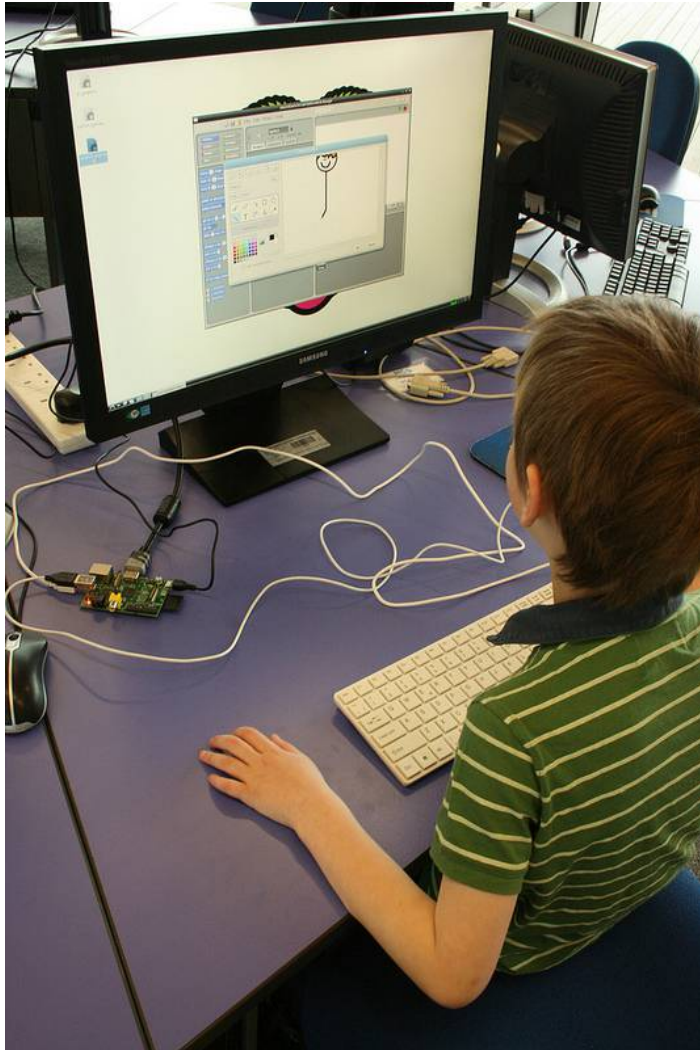
Special Mention: Raspberry Pi

- 700 MHz ARM11
- 256 MB DDR2 RAM
- 10/100Mb Ethernet
- 2x USB 2.0
- (HDMI, Composite Video, 3.5mm Stereo Jack, DSI, CSI-2)



\$35

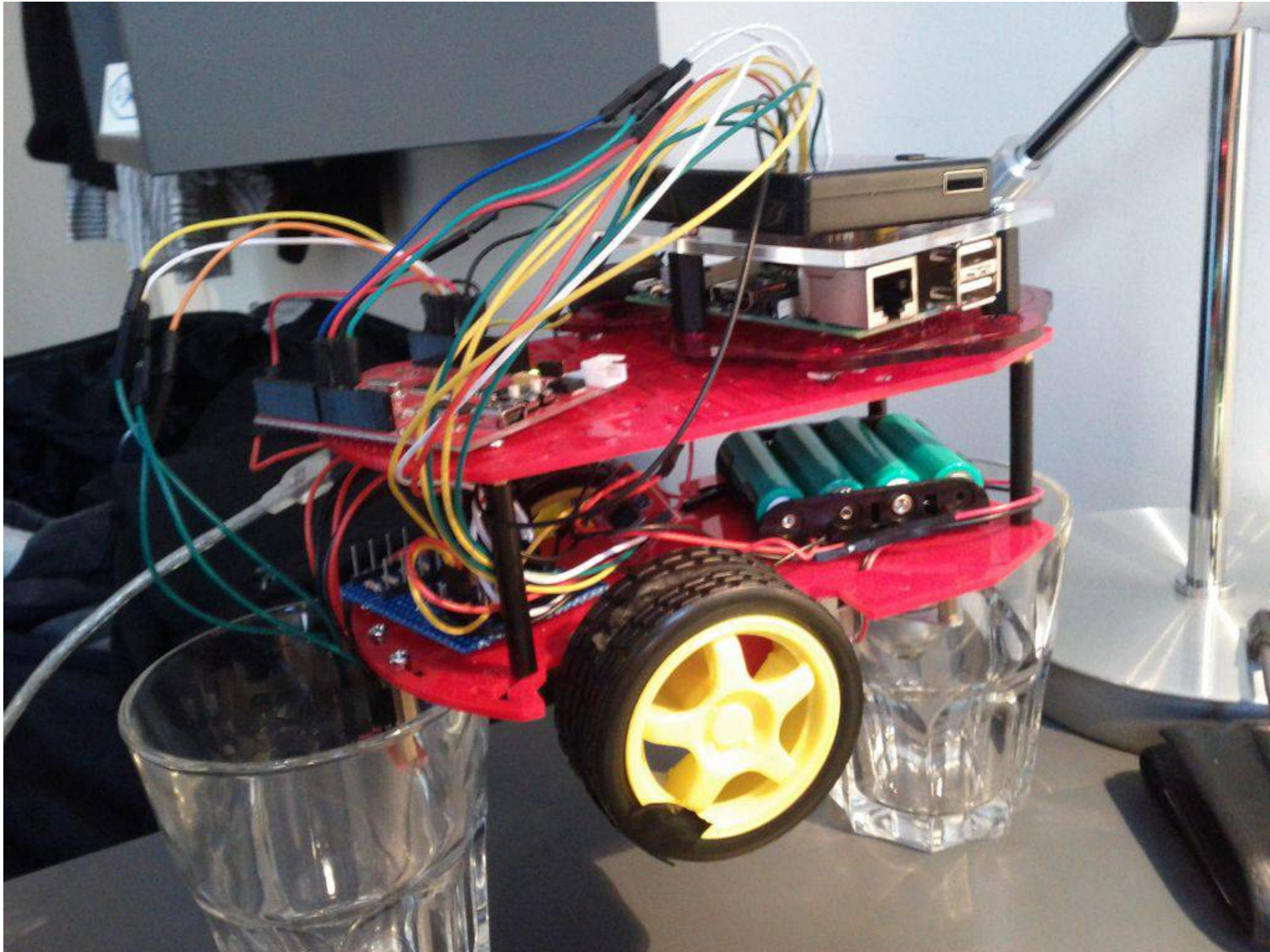
Special Mention: Raspberry Pi



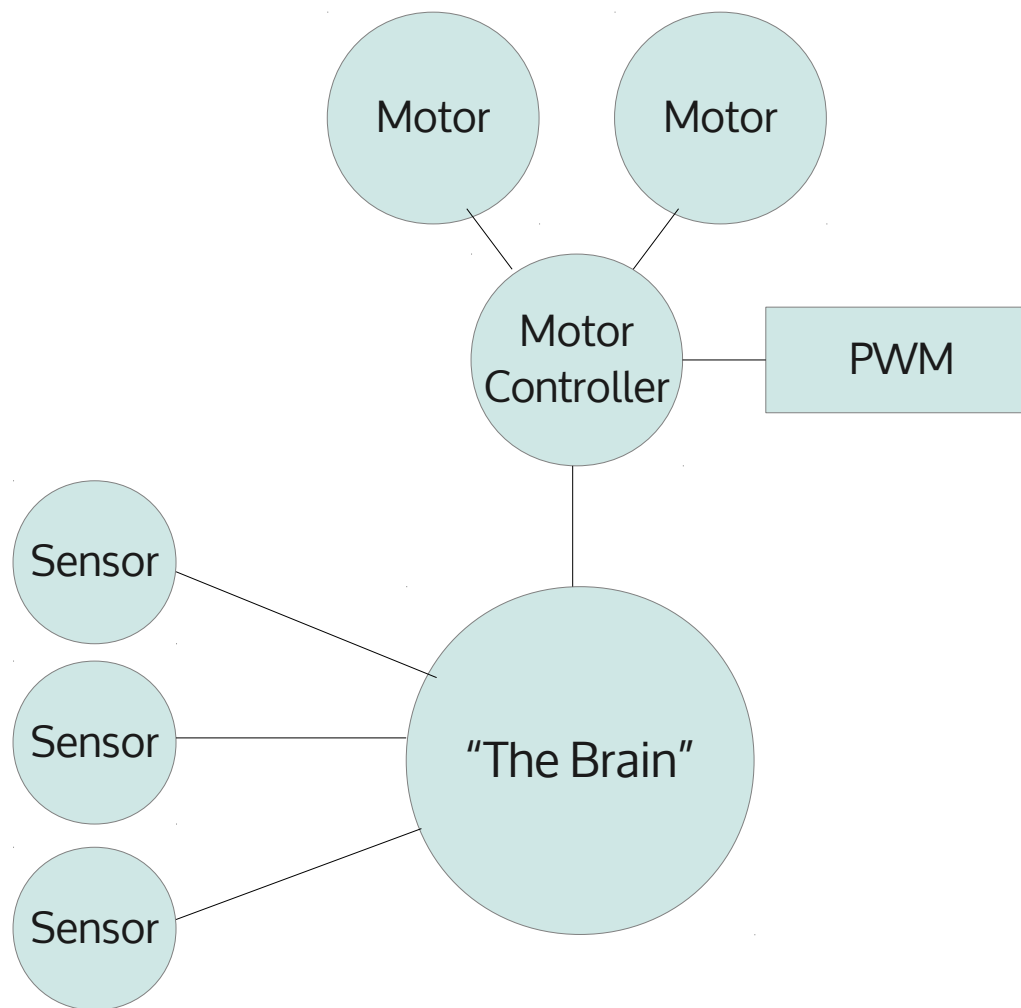
(flickr/lebeus)

- The Raspberry Pi Foundation is a UK registered charity.
- Mission statement: "*...to promote the study of computer science and related topics, especially at school level, and to put the fun back into learning computing.*"
- **Future Erlang hackers?**

The ErlBuggy!



The ErlBuggy!



Controlling a motor

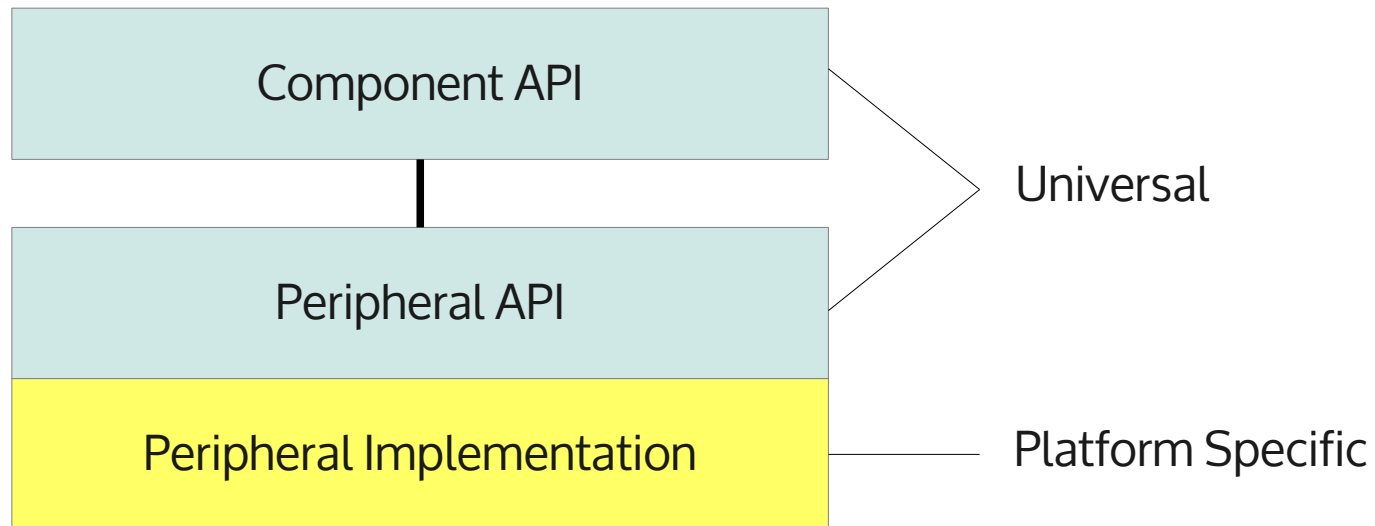
```
MotorL = motor:start({21, 22}).
```

```
MotorL ! cw.
```

```
MotorL ! ccw.
```

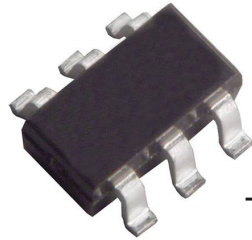
```
MotorL ! halt.
```

Universal Peripheral/Component Modules

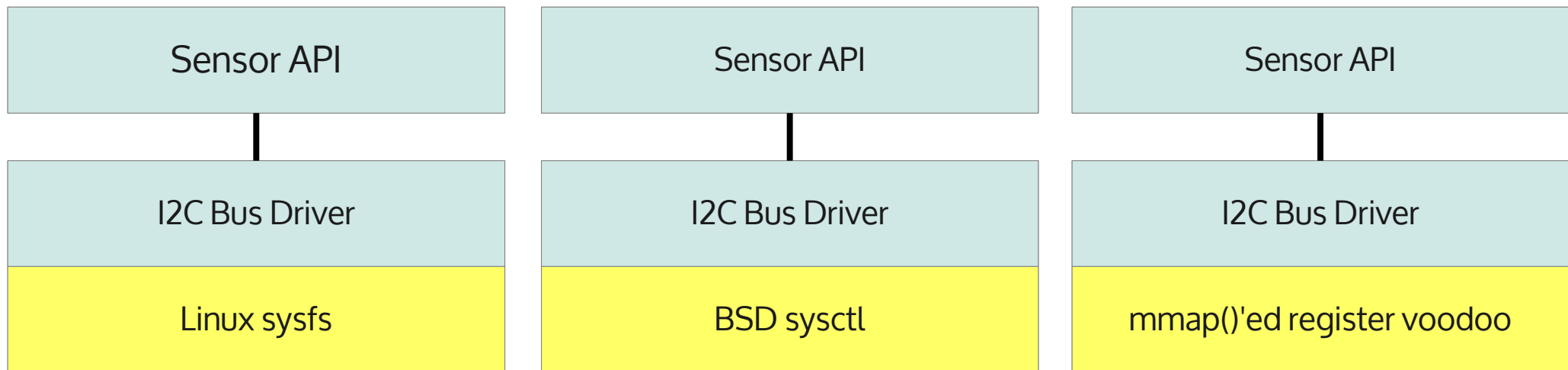


Universal Peripheral/Component Modules

An Example:



Temperature Sensor with I2C Interface



Our Plans

- Establish a user community, following existing successful models
- Design a generic software framework that will allow Erlang programs to interface with a range of embedded devices
- Develop software tools and libraries for quick and easy evaluation and adoption of embedded systems development using Erlang

The Arduino Approach



Hardware
Platform

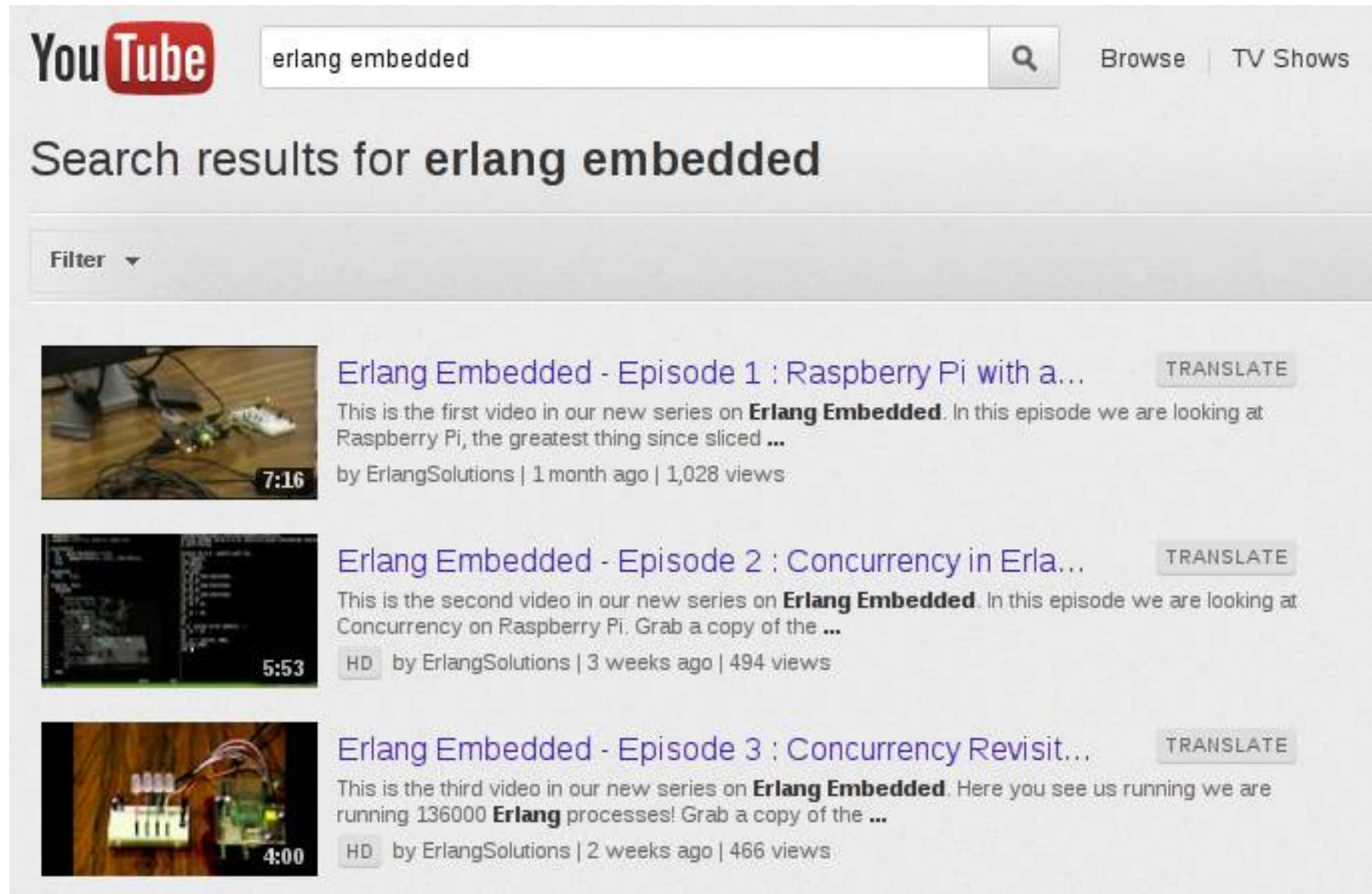


IDE with software libraries
programming/debug tools



Community

Video Series





The screenshot shows a YouTube search results page for the query "erlang embedded". The page features the YouTube logo, a search bar with the query, and navigation links for "Browse" and "TV Shows". Below the search bar, the text "Search results for erlang embedded" is displayed. A "Filter" dropdown menu is visible. Three video results are listed, each with a thumbnail, title, description, and metadata.


YouTube erlang embedded Browse | TV Shows

Search results for **erlang embedded**

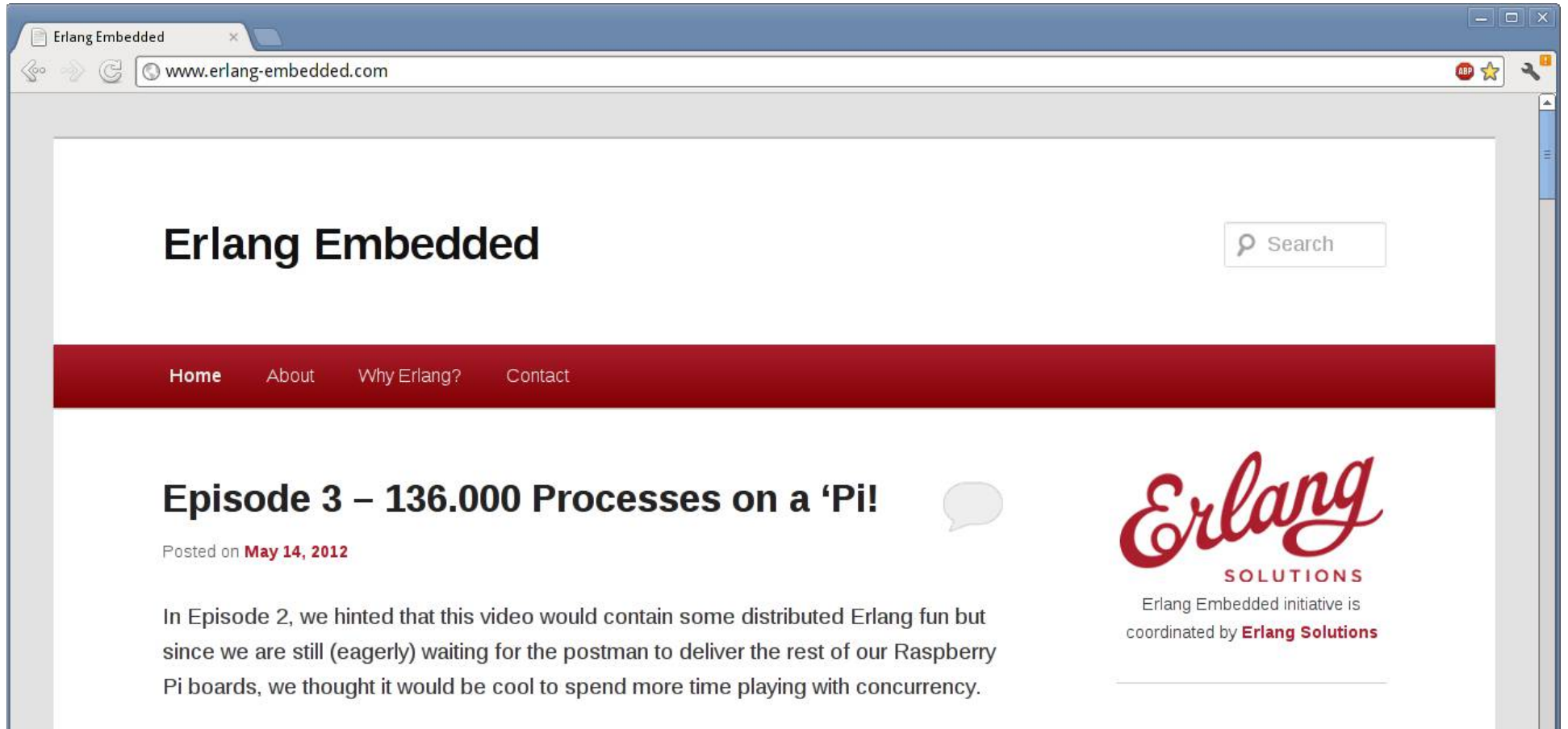
Filter ▾

 **Erlang Embedded - Episode 1 : Raspberry Pi with a...**
This is the first video in our new series on **Erlang Embedded**. In this episode we are looking at Raspberry Pi, the greatest thing since sliced ...
by ErlangSolutions | 1 month ago | 1,028 views

 **Erlang Embedded - Episode 2 : Concurrency in Erla...**
This is the second video in our new series on **Erlang Embedded**. In this episode we are looking at Concurrency on Raspberry Pi. Grab a copy of the ...
HD by ErlangSolutions | 3 weeks ago | 494 views

 **Erlang Embedded - Episode 3 : Concurrency Revisit...**
This is the third video in our new series on **Erlang Embedded**. Here you see us running we are running 136000 **Erlang** processes! Grab a copy of the ...
HD by ErlangSolutions | 2 weeks ago | 466 views

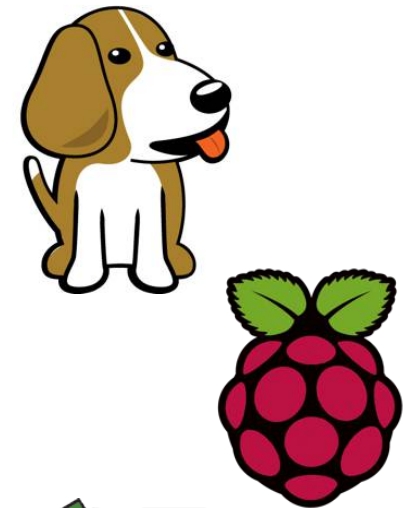
erlang-embedded.com



Standing on the shoulders of giants

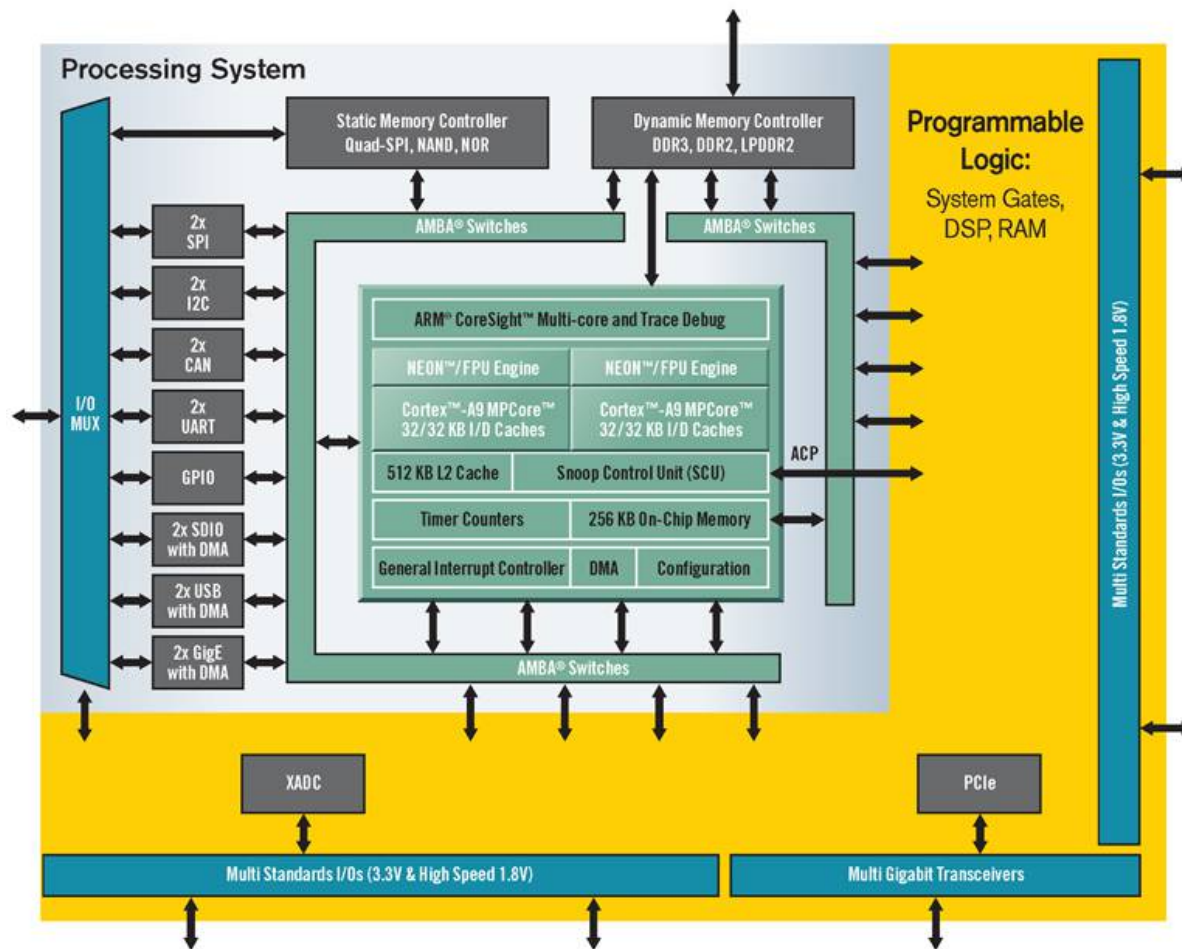


Ångström



Future Explorations

Xilinx Zynq Extensible Processing Platform



- Dual ARM Cortex™-A9 MPCore
 - Up to 800MHz
 - Enhanced with NEON Extension and Single & Double Precision Floating point unit
 - 32kB Instruction & 32kB Data L1 Cache
- Unified 512kB L2 Cache
- 256kB on-chip Memory
- DDR3, DDR2 and LPDDR2 Dynamic Memory Controller
- 2x QSPI, NAND Flash and NOR Flash Memory Controller
- 2x USB2.0 (OTG), 2x GbE, 2x CAN2,0B 2x SD/SDIO, 2x UART, 2x SPI, 2x I2C, 4x 32b GPIO
- AES & SHA 256b encryption engine for secure boot and secure configuration
- Dual 12bit 1Msps Analog-to-Digital converter
 - Up to 17 Differential Inputs
- Advanced Low Power 28nm Programmable Logic:
 - 28k to 350k Logic Cells (approximately 430k to 5.2M of equivalent ASIC Gates)
 - 240KB to 2180KB of Extensible Block RAM
 - 80 to 900 18x25 DSP Slices (58 to 1080 GMACS peak DSP performance)
- PCI Express® Gen2x8 (in largest devices)
- 154 to 404 User IOs (Multiplexed + SelectIO™)
- 4 to 16 12.5Gbps Transceivers (in largest devices)

Get involved!



Thank you

- www.erlang-embedded.com
- embedded@erlang-solutions.com
- [@ErlangEmbedded](https://twitter.com/ErlangEmbedded)