e^4meter

Power management for the people

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NICTA

Australian Government
Department of Broadband, Communications and the Digital Economy
Australian Research Council

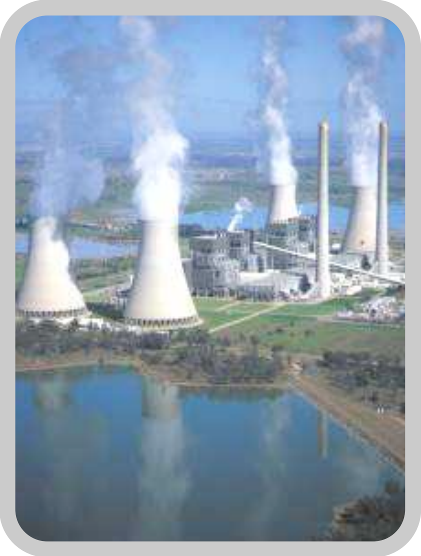
NICTA Funding and Supporting Members and Partners

Power is expensive!

Eraring

Liddell

Bayswater



Mt Piper

Munmorah

Vales Point

Obligatory photos of horrible power plants
At least they're in context. **These are all in NSW and are coal-powered. There are 8 in total!**

What can we do?

- Raise people’s awareness of their own power consumption:
  - use of smart grid metering and feedback through tools like Google PowerMeter,
  - provide incentives to use renewable energy sources, like solar and wind, and
  - give people tools to manage their own power consumption.

Power measurement in the home

Current Cost ENVI - $150

- LCD display
- current ‘clamp’ measurement
- multi-source via wireless data transmission

The Energy Detective - $200

- LCD display
- current ‘clamp’ design
- data transmitted over existing AC wiring

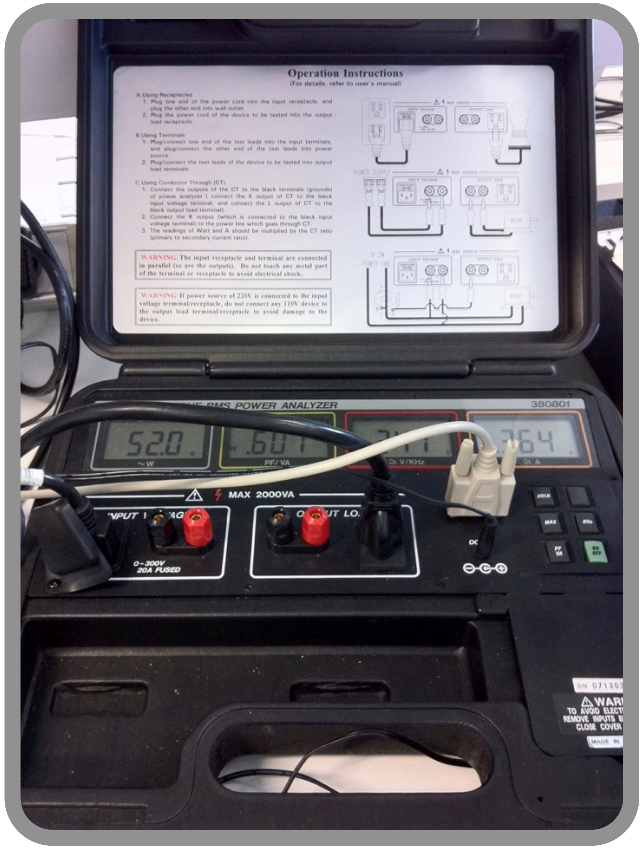
Power measurement in the datacenter

- APC Metered Rack PDU
  - lots of outlets
  - individually switched
  - aggregate metering
  - approx. US $600

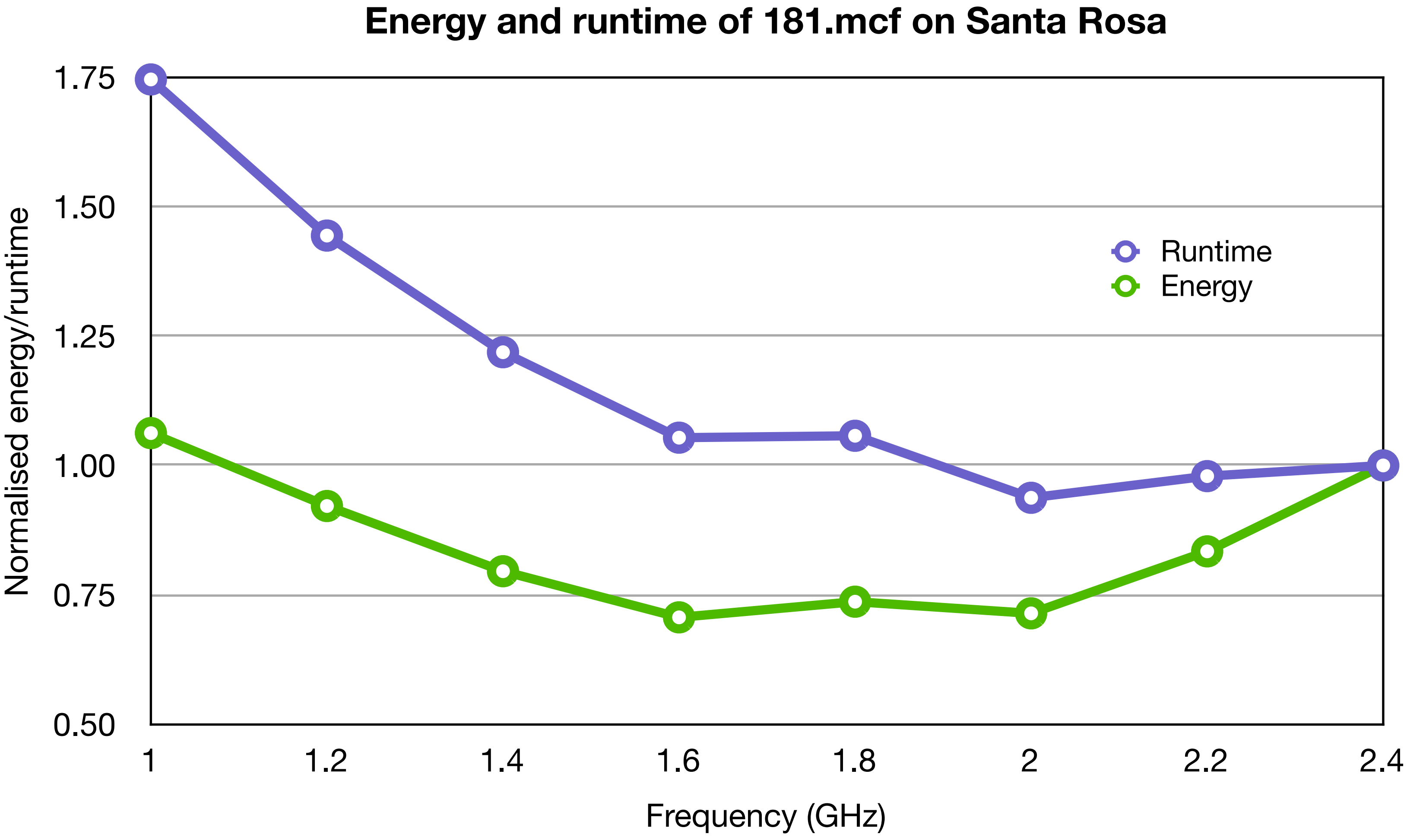
http://www.apc.com/products/family/index.cfm?id=136

Who are we?

- Power management research group at ERTOS/NICTA
  - Measuring power consumption of computers (big & small)
  - Existing high-accuracy devices cost ≥ US$700 and measure one device
  - Determine the effectiveness of power management techniques such as DVFS.

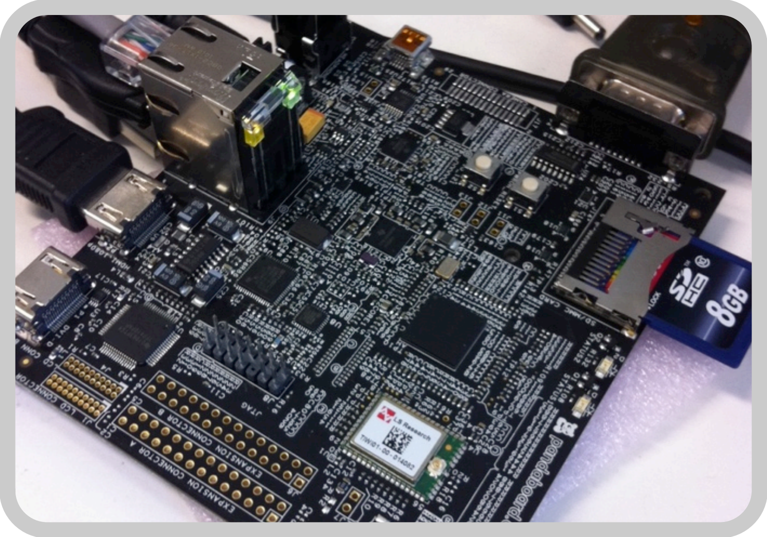


CPU power management

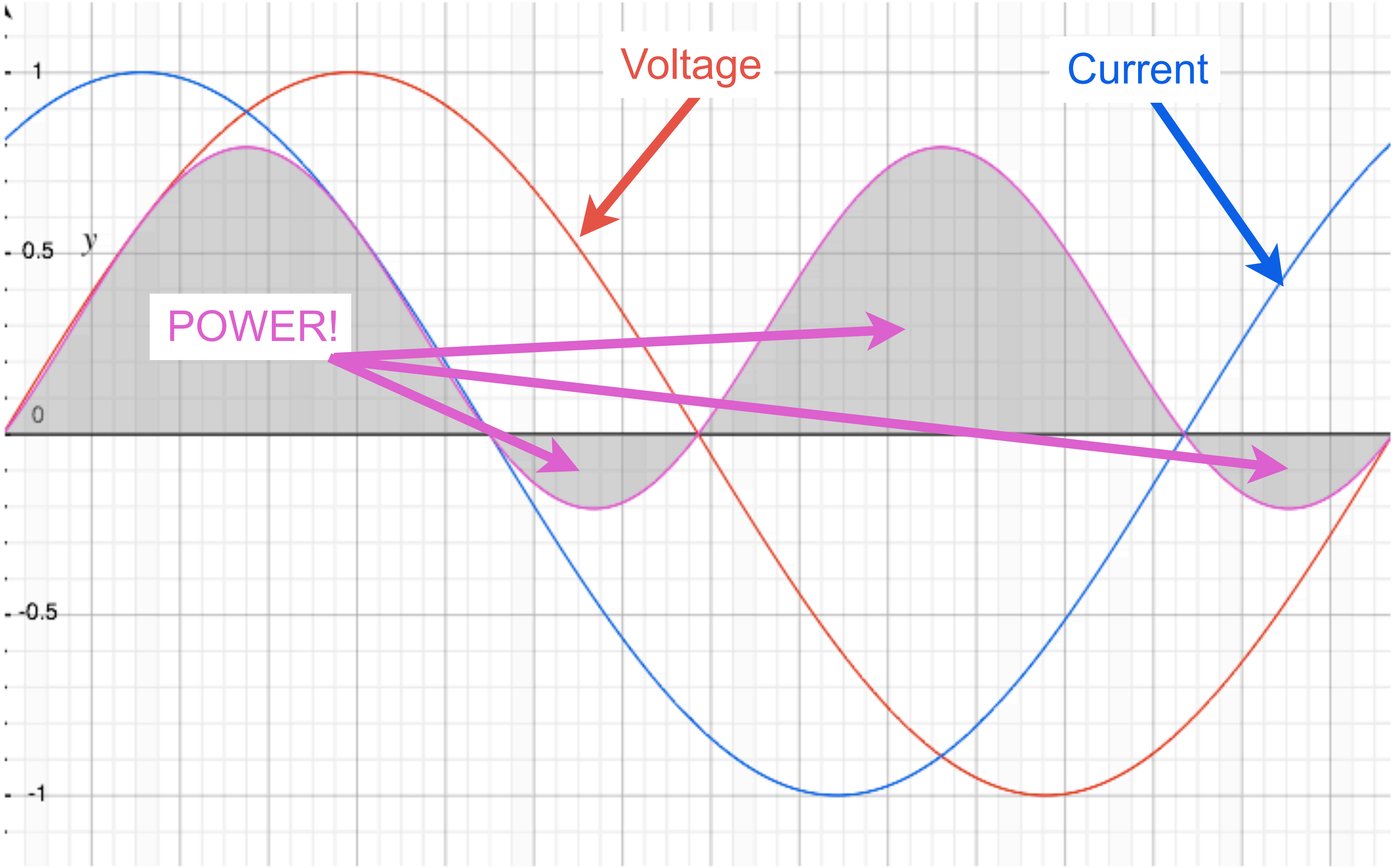


Motivation

- Measure more
- Spend less
- Maintain high-accuracy

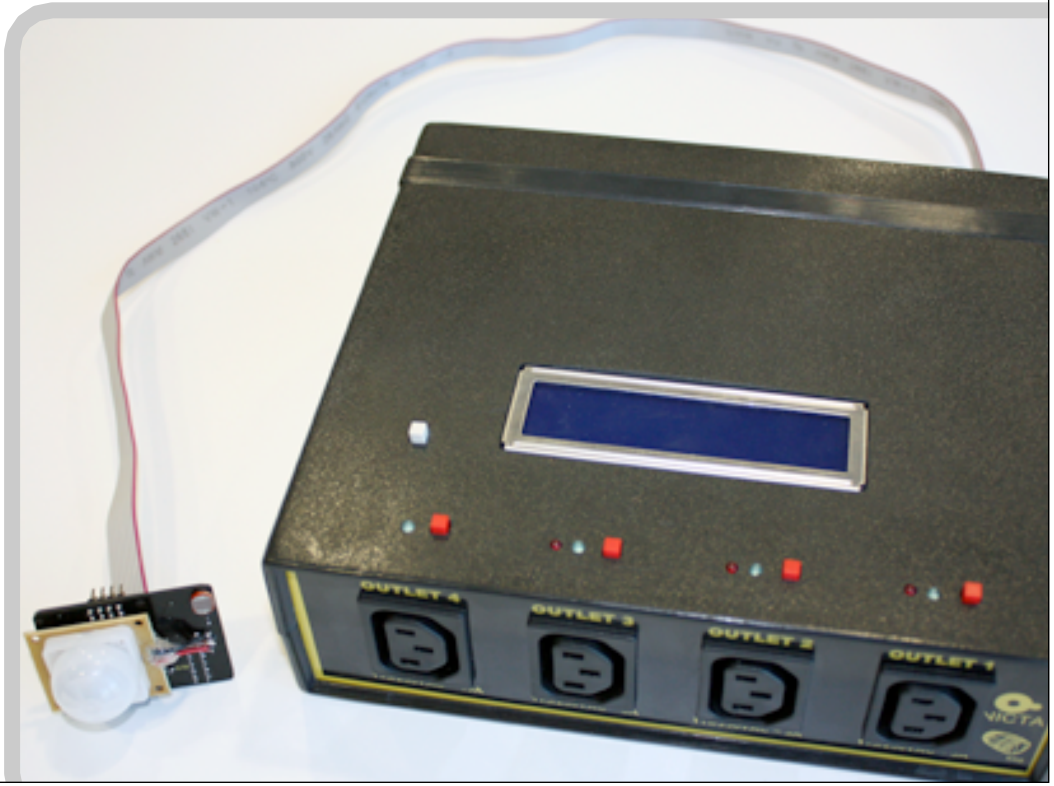


Measuring Power

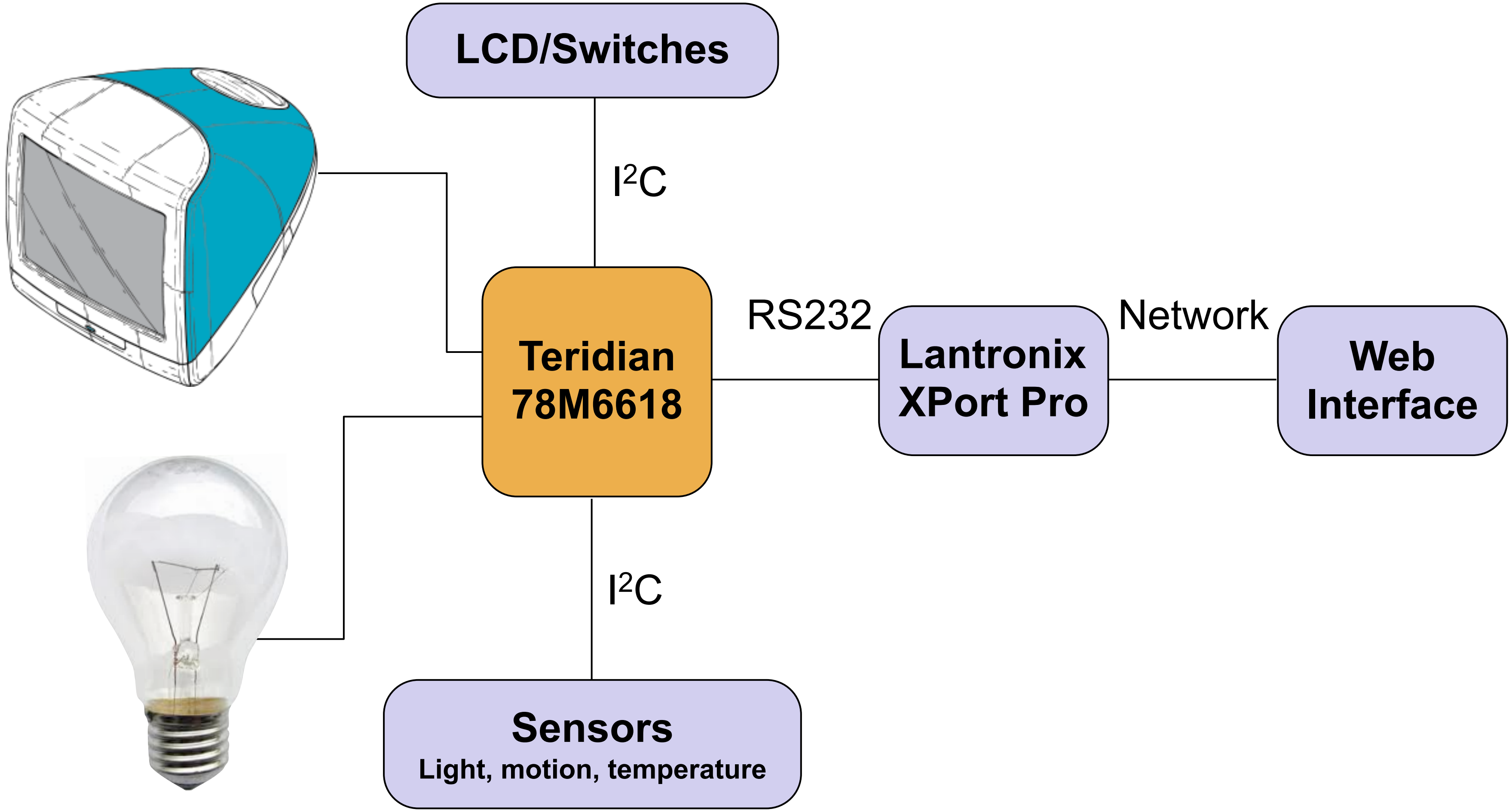


The e⁴meter

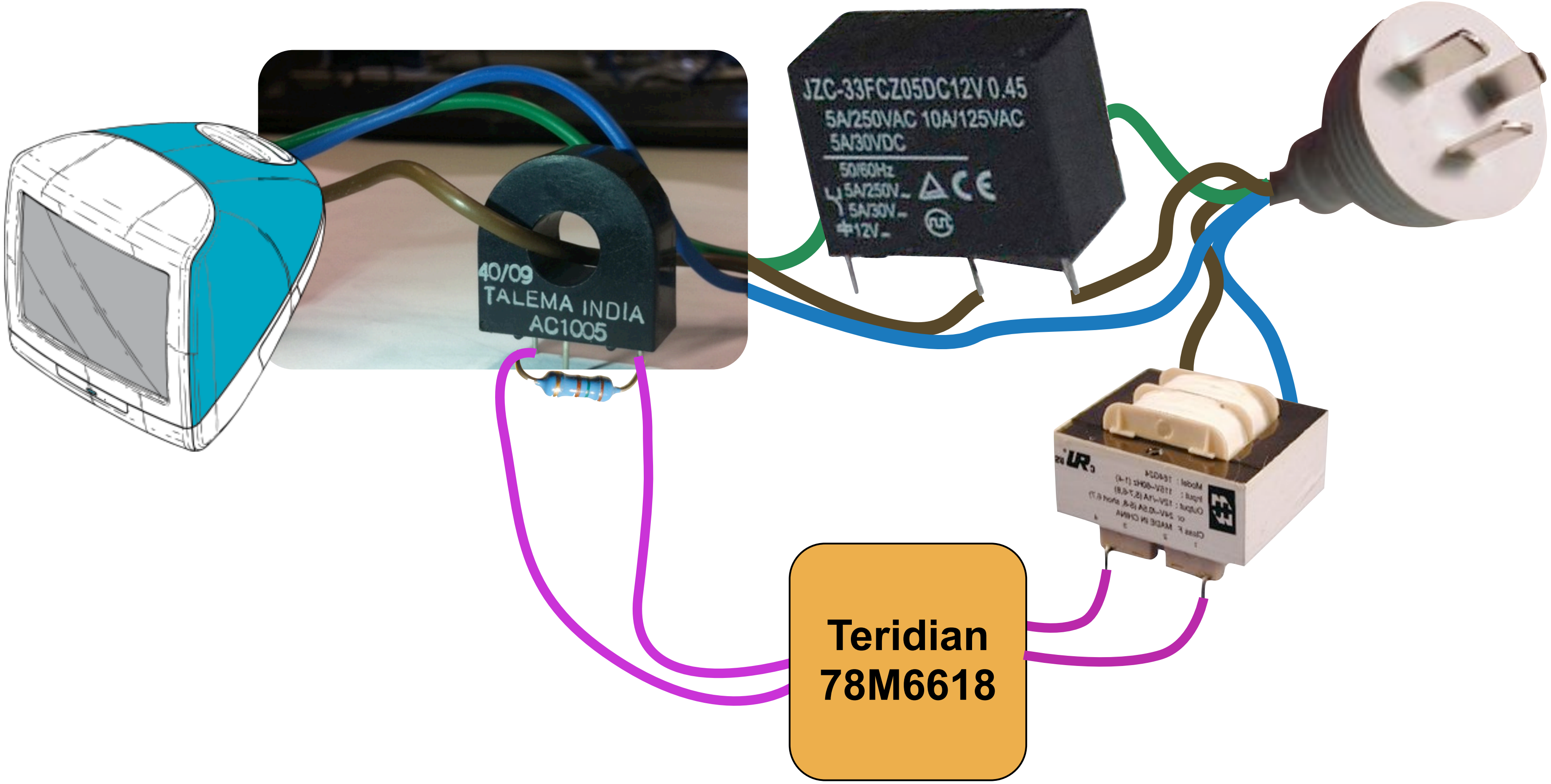
- Intelligent power metering and control
- Control and measure the power consumption of four devices (or four groups)
- Entered (and won!) the Lantronix XPort Pro design competition



High level overview

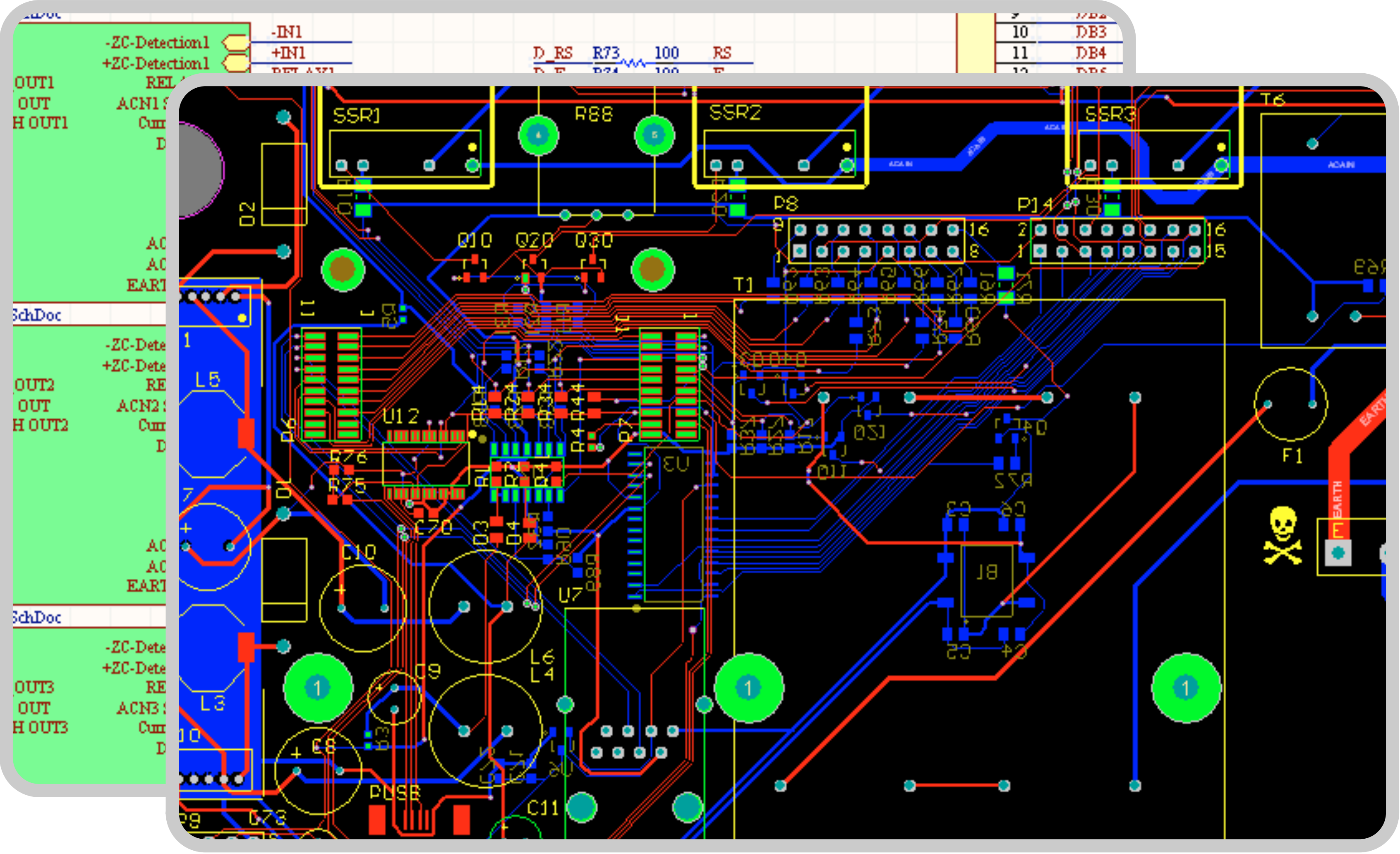


Measurement circuitry

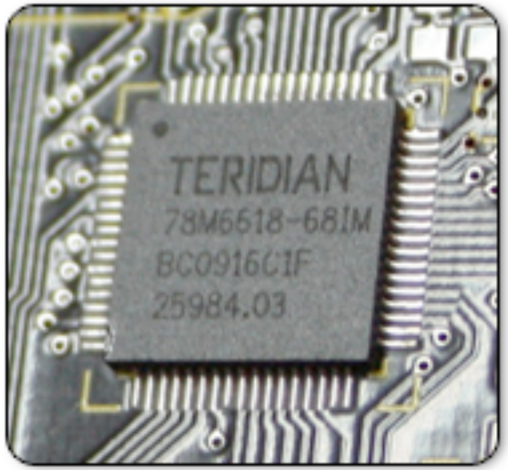


Teridian 78M6618

Gratuitous CAD pictures...



Measuring power



- 78M6618 is an 8052-based microcontroller (MCU) designed for power measurement.
- Energy measurement code is provided as a binary-only library.
- Requires the use of Keil 8051 development tools.

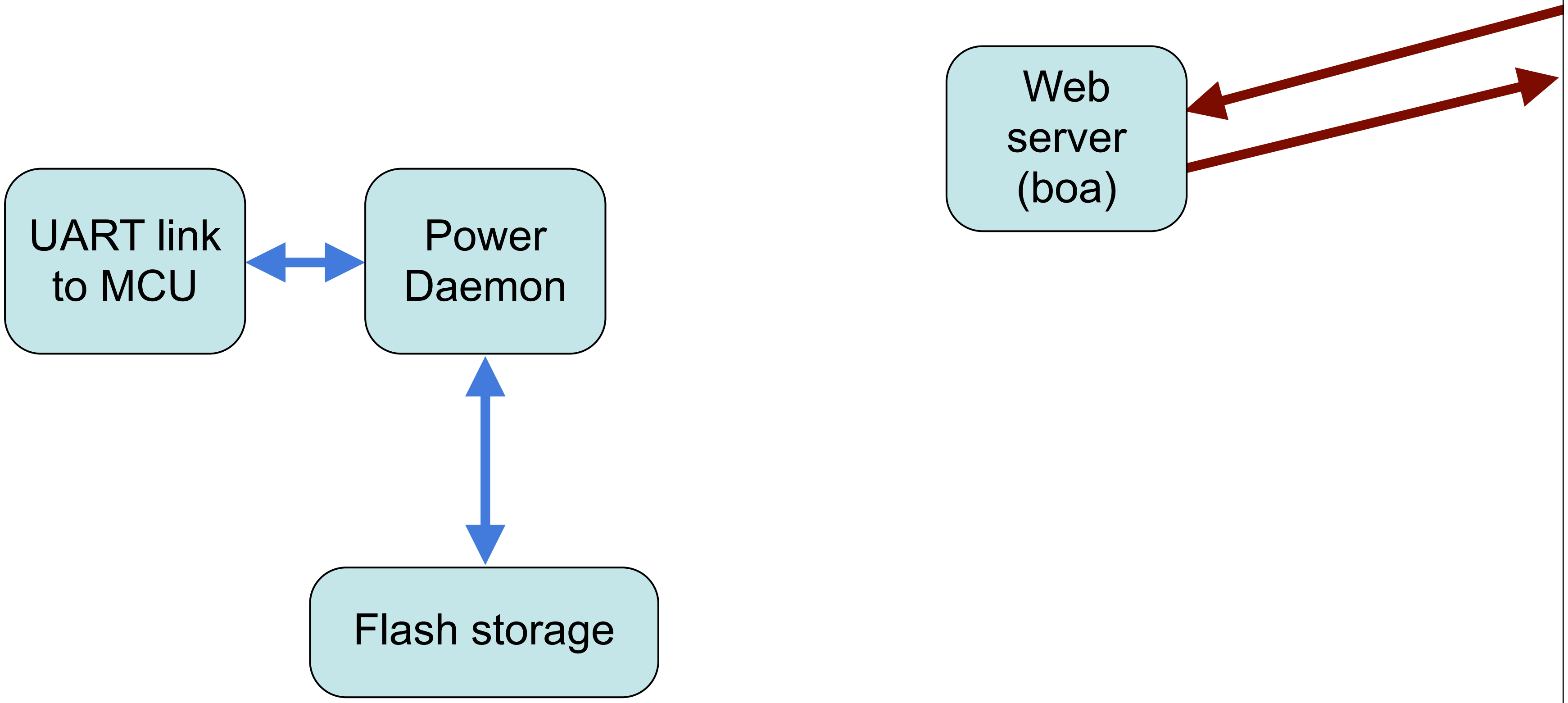
```
# apt-get install dis51
```

```
# apt-get install sdcc
```

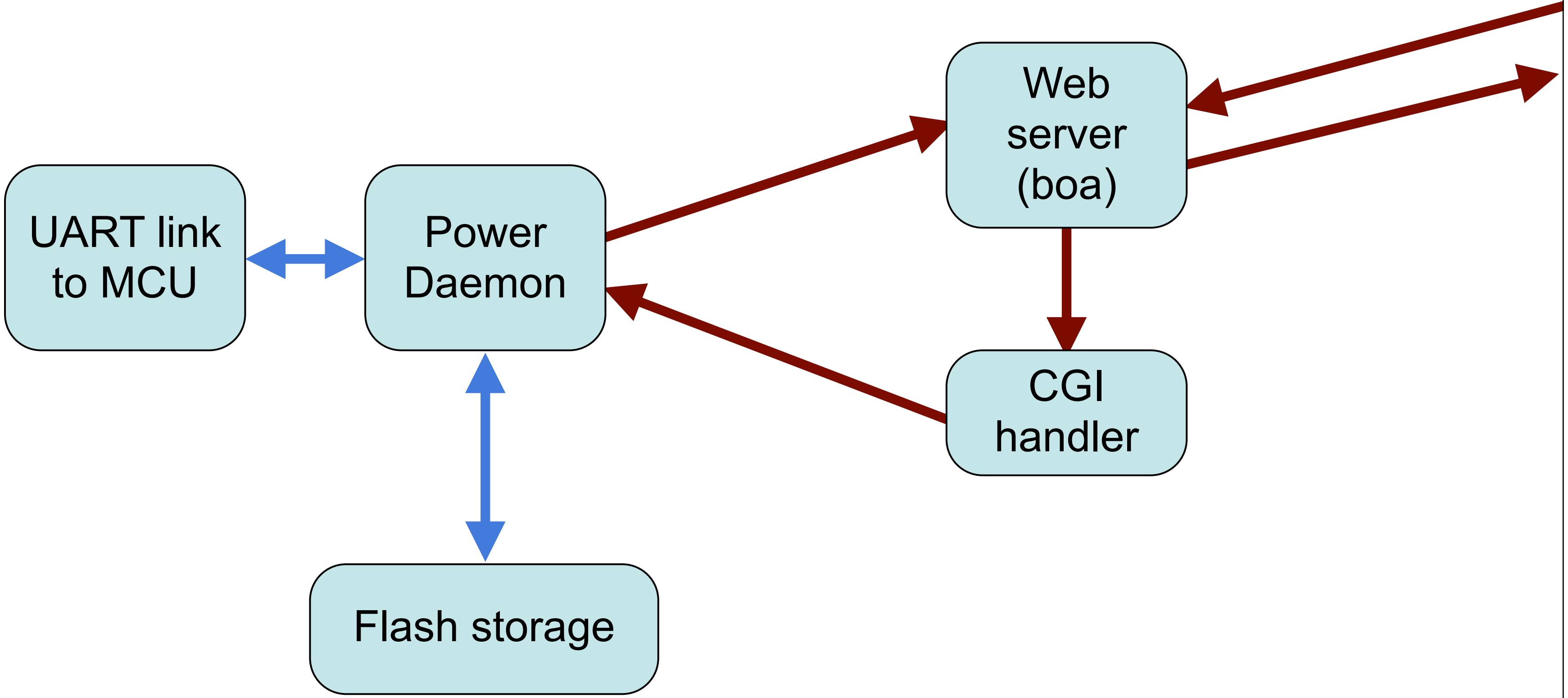
Interfacing to the world

- Lantronix XPort Pro runs uClinux on a Coldfire m68k
- Power daemon logs data and responds to events.
- Web server (boa)
  - serves static HTML + JS
  - dynamic content is passed off to power daemon

A web request – static HTML

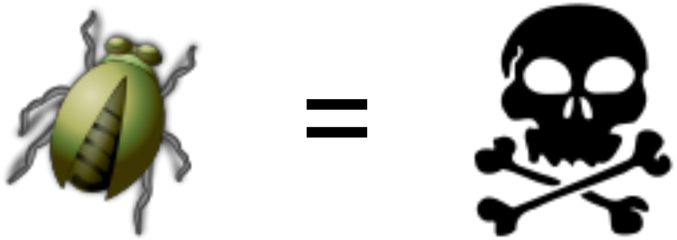


A web request – dynamic content



Hurdles

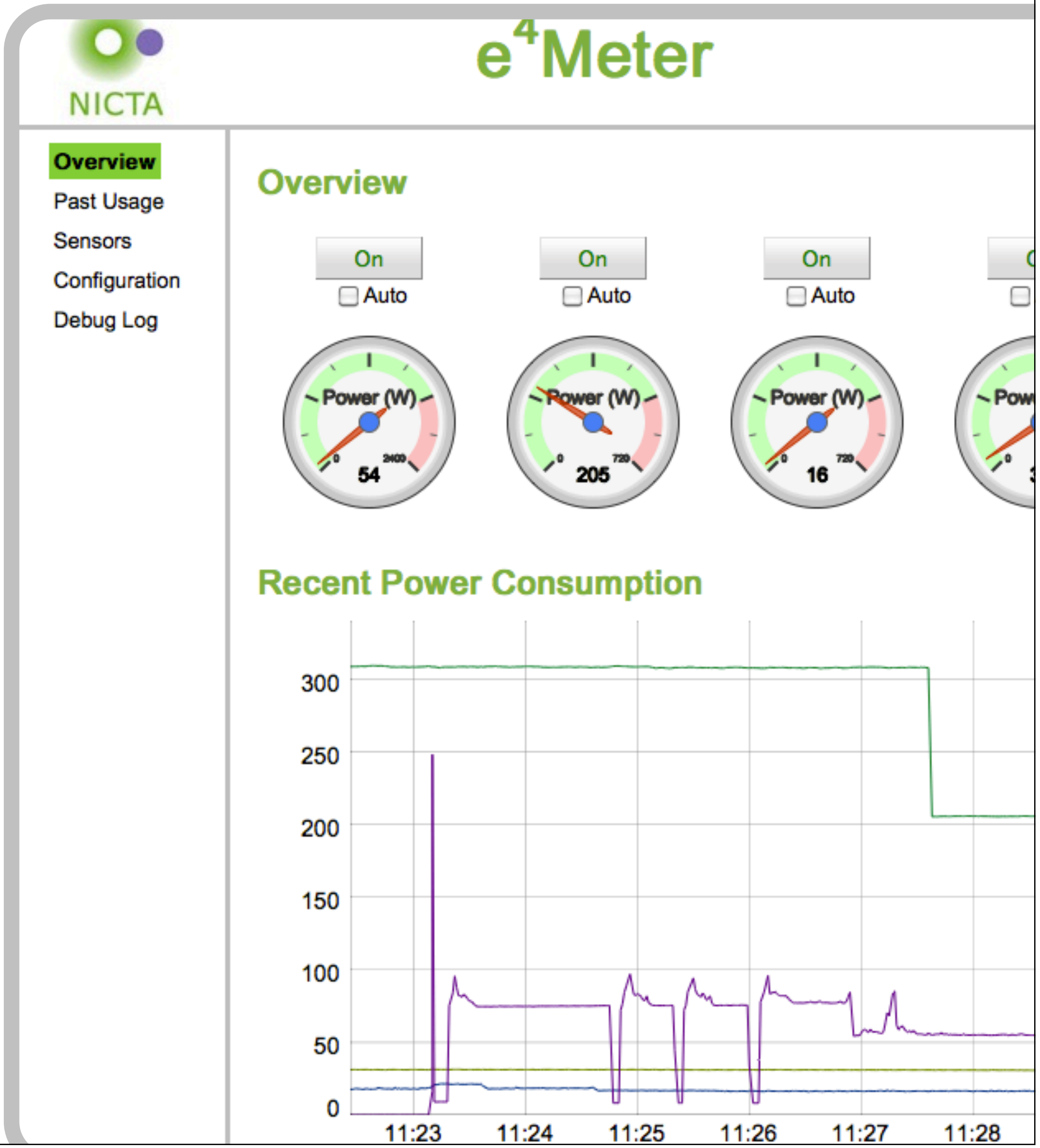
- The Coldfire m68k has no MMU



- But, code is fully portable to any Linux machine
  - We can build & debug on a desktop!

Web interface

- Control
- Current usage
- Past usage
- Configuration
- Sensors



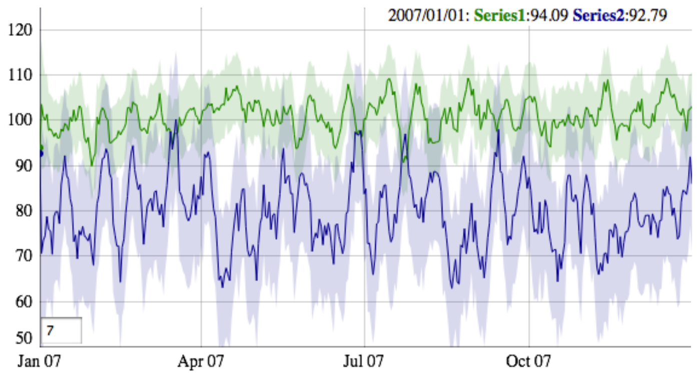
Web interface

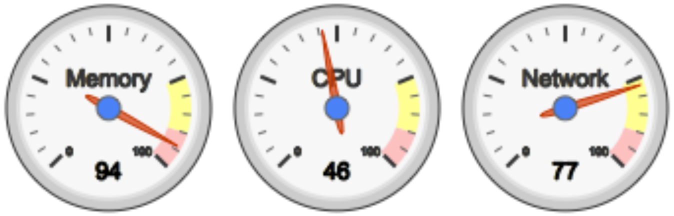
NICTA

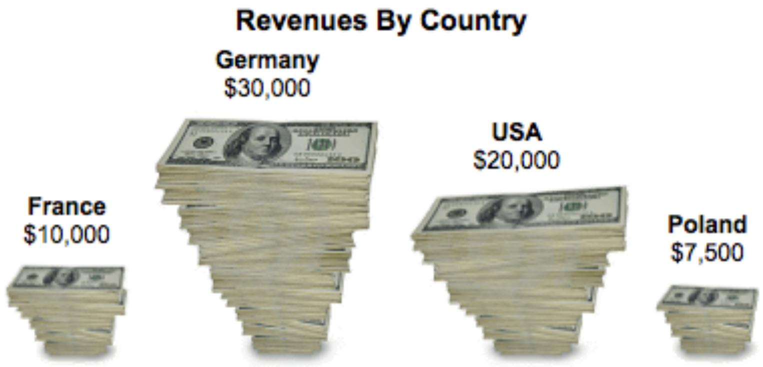
- Built with Google's Web Toolkit
  - entirely client-side UI
  - clean, clear and concise
  - written in Java
  - completely asynchronous using AJAX
  - instant compatibility with Firefox, IE, Chrome, Safari ...
  - responsive to user
  - graphs and dials update in real-time (once per second)

Web interface

- GWT offers awesome visualisation widgets

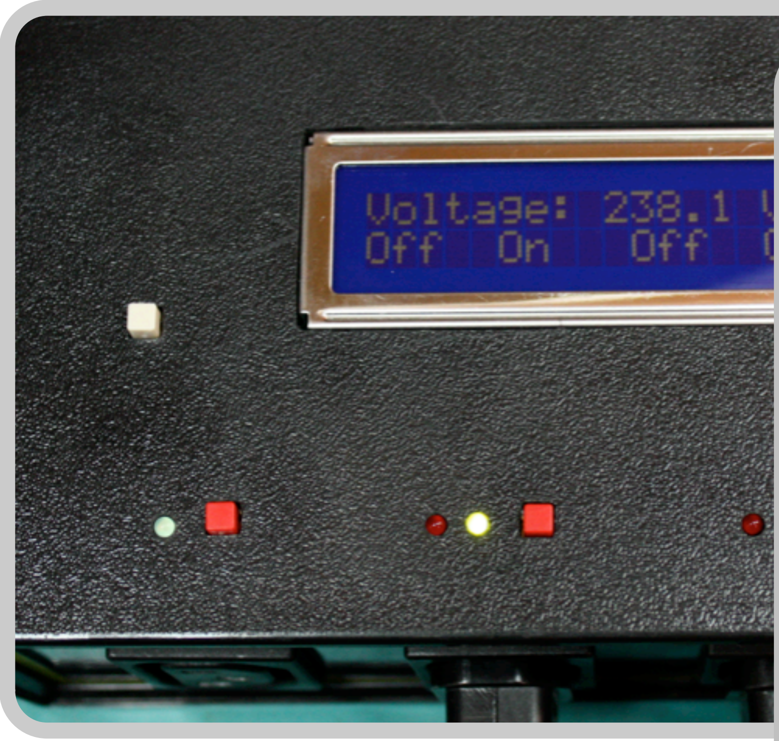


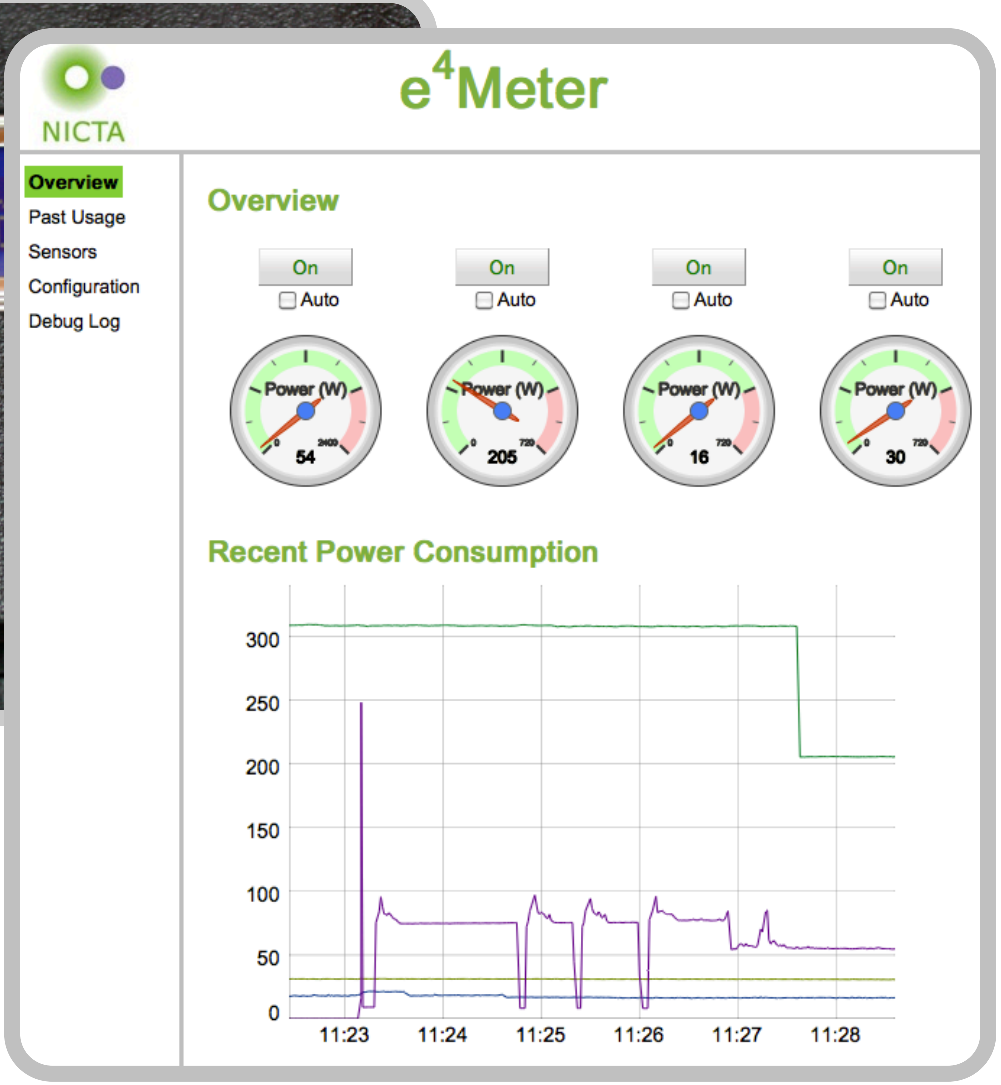




- These require the user to be online :(

More pictures…

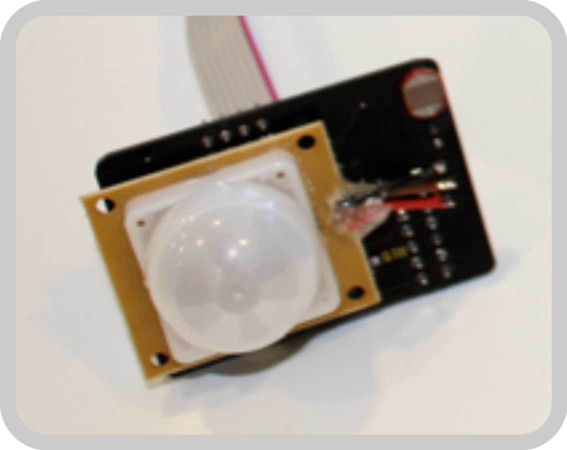




www.ertos.nicta.com.au/hardware/e4meter

Automation

- e^{4}meter connects to environmental sensors, allowing you to control devices automatically.

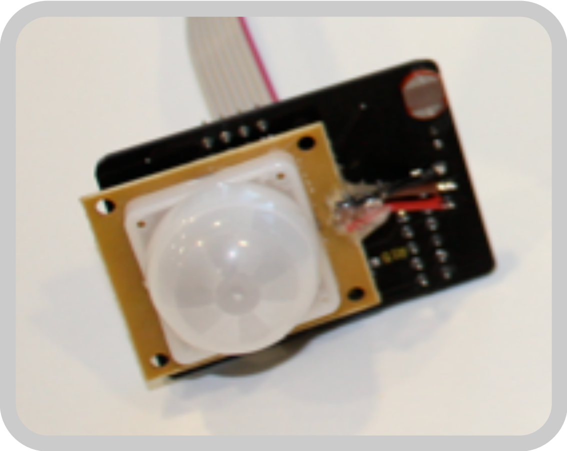


Q: How do you make easy things easy, and intricate things possible?

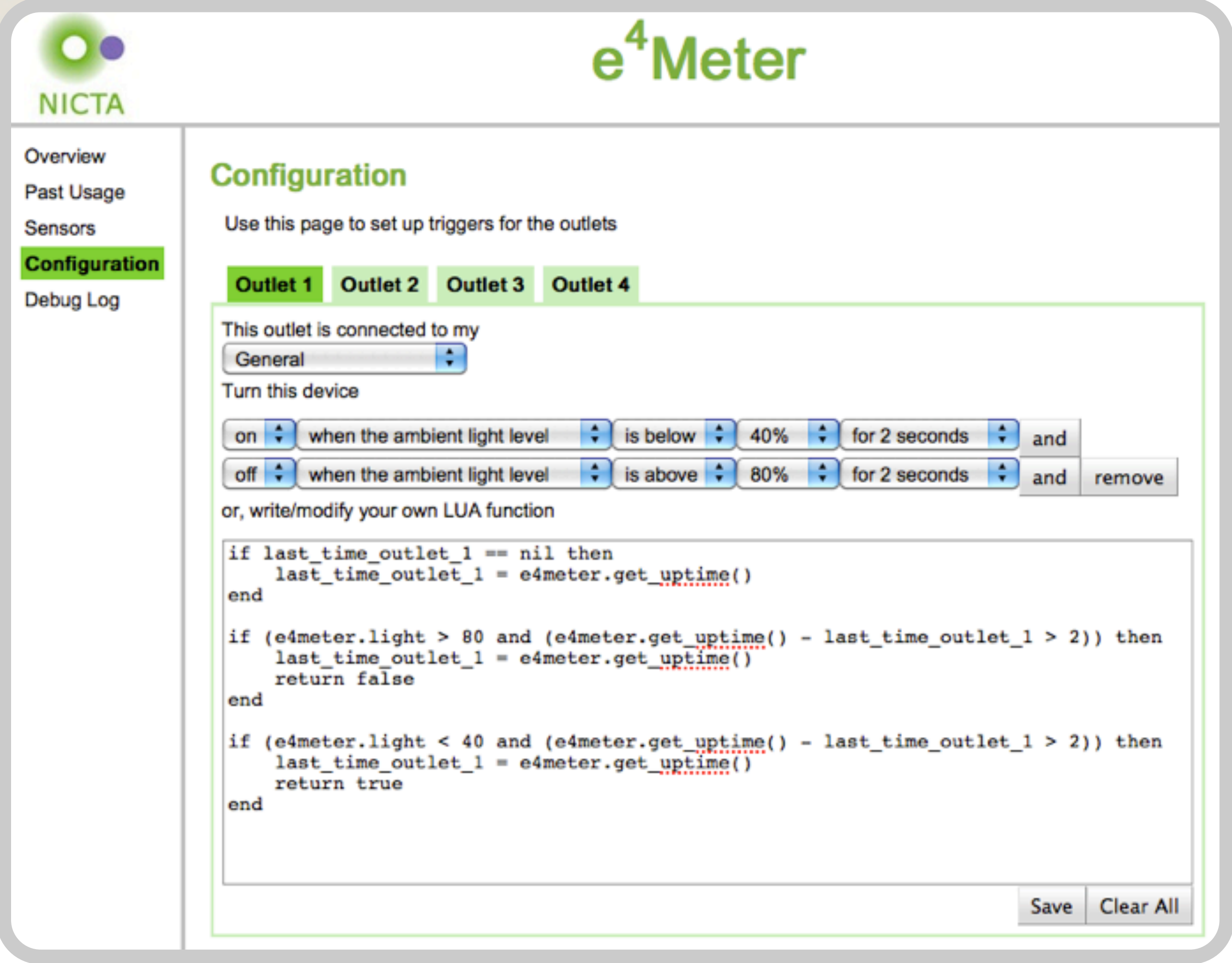
A: Support arbitrary code execution!

Automation

- Enter Lua
  - Small footprint
  - Embeddable!
  - Fast
  - Open source
  - Secure
  - Customisable!



Scripting for triggers – for smarty-pants



Configuration

Use this page to set up triggers for the outlets

This outlet is connected to my

General

Turn this device

on | when the ambient light level | is below | 40% | for 2 seconds | and

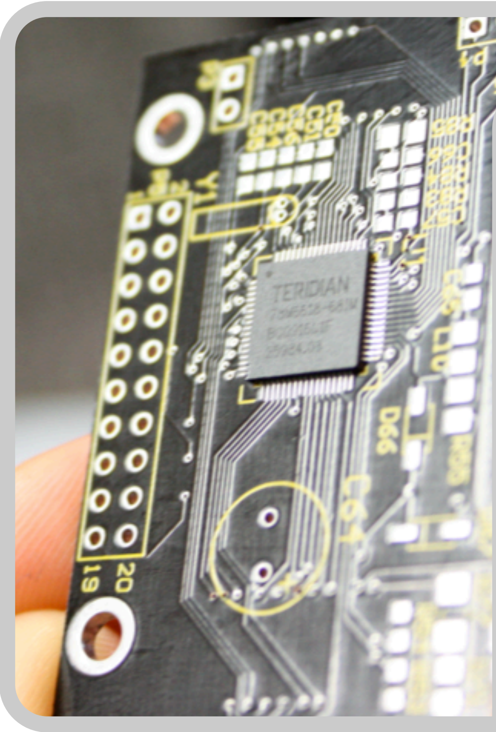
off | when the ambient light level | is above | 80% | for 2 seconds | and | remove

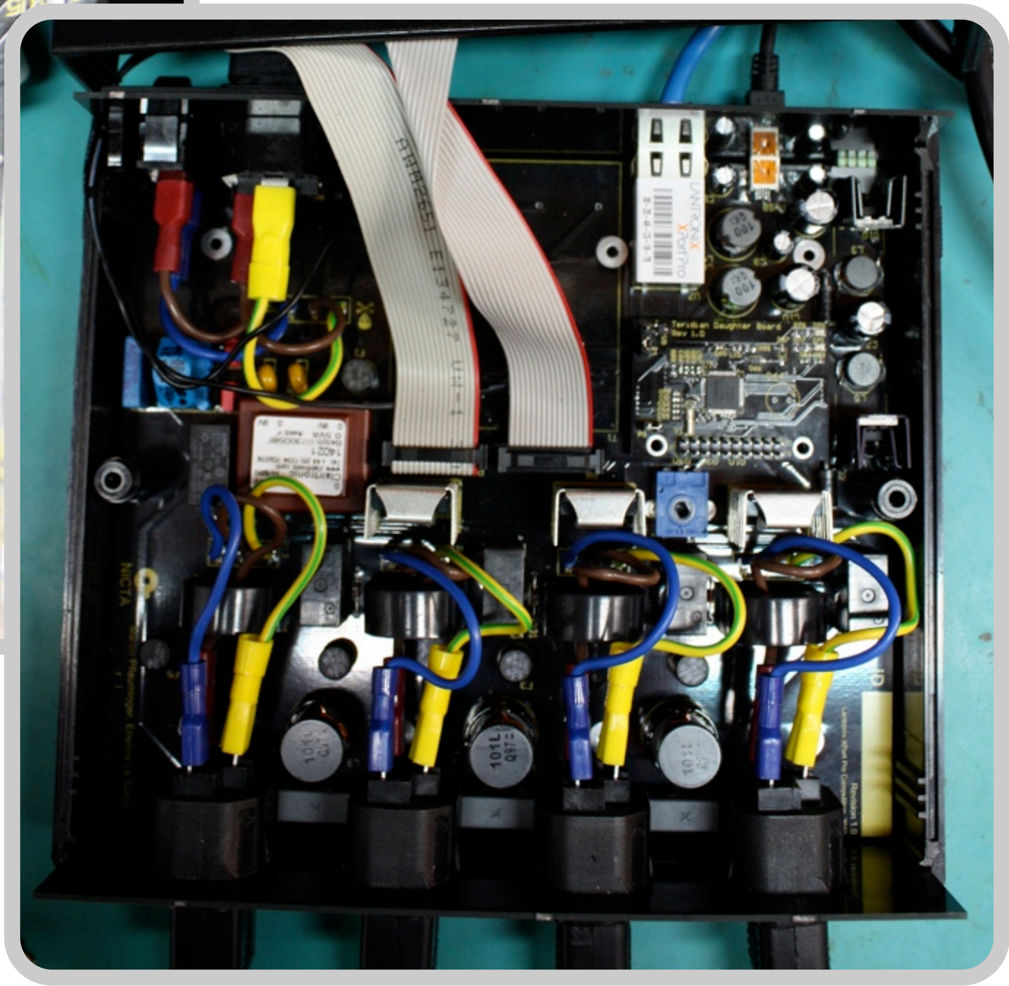
or, write/modify your own LUA function

```
if last_time_outlet_1 == nil then
    last_time_outlet_1 = e4meter.get_uptime()
end

if (e4meter.light > 80 and (e4meter.get_uptime() - last_time_outlet_1 > 2)) then
    last_time_outlet_1 = e4meter.get_uptime()
    return false
end

if (e4meter.light < 40 and (e4meter.get_uptime() - last_time_outlet_1 > 2)) then
    last_time_outlet_1 = e4meter.get_uptime()
    return true
end
```

www.ertos.nicta.com.au/hardware/e4meter

More gratuitous pictures...





What did we learn?

- Closed source → reliance on external companies → bad for schedules!
  - Learn your software thoroughly before committing to hardware!
- MMU-less hardware is difficult to debug
- Pay attention to electrical noise
- Compiler bugs are difficult to debug, even with an open-source compiler

Questions?