lero THE IRISH SOFTWARE RESEARCH CENTRE

Science Foundation Ireland sfi For what's next

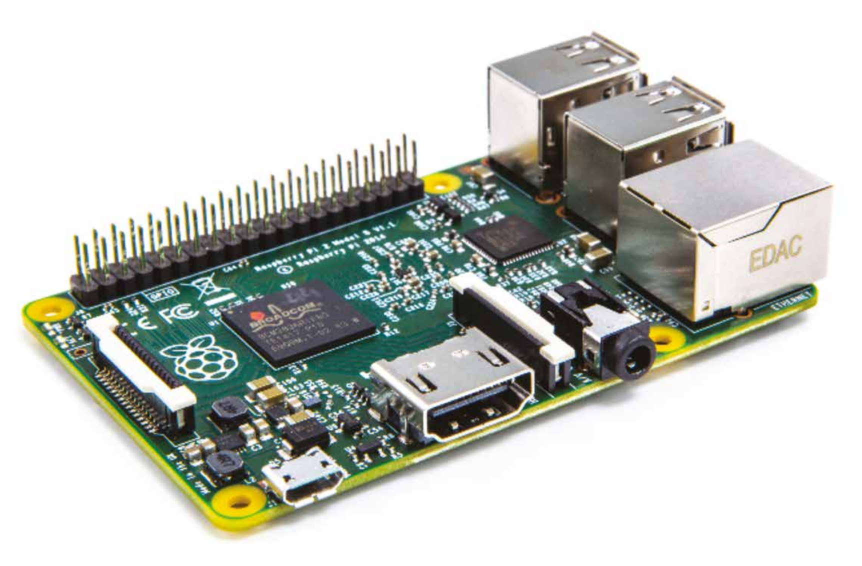
UCD DUBLIN

RCA, Testing Large Scale Systems and IRC Scholarship

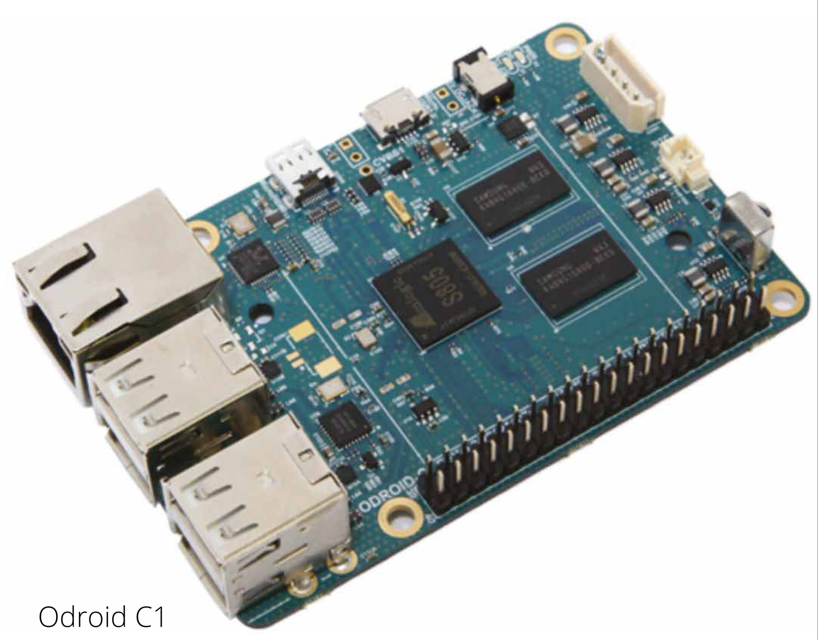
David Smith and Dr. Cristian Olariu, Supervised by: Prof Liam Murphy

1 Motivation

- The cost of Phasor Measurement Units (PMUs) is very high, ESB charge roughly €7000 to enable a residential prosumer to connect to the grid.
- A potential way to circumvent these costs would be to allow multiple prosumer neighbours to connect to one another with low cost PMUs i.e. Pi's, Odroids which cost less than $40, and then only one neighbour is required to have a connection to the Grid.
- Initial research involved testing the quality of NTP using Raspberry Pi's. These tests produced timing anomalies of >10ms, where the CPU stopped processing the NTP packets.
- Our goal is to use the Pi's along with some Odroid C1's as sensors in a micro grid. Therefore a high level of synchronization is required.



Raspberry Pi 2



Odroid C1

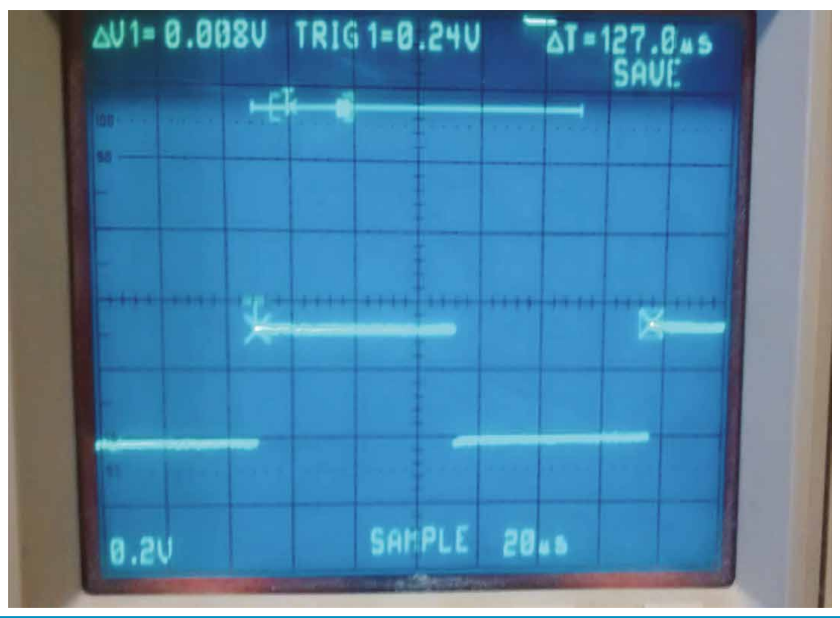
2 Progress to Date

- Our initial NTP tests led us to testing the impact of non deterministic software execution times in a SmartGrid scenario. We decided to investigate the cause of the timing anomalies and their reproducibility.
- From this we carried out a series of timing tests using a simple loop on the Pi's and an Oscilloscope.
- The experiments we carried out furthered our understanding of single vs. quad core systems and the results were published at ISSC 2015, in Carlow, June 2015.
- During February, we applied for the IRC postgraduate scholarship, we were successful in our application and have won a Scholarship due to run from Oct 2015 to Sept 2018.
- As part of this research we have been looking at various other works. Some people have produced low cost PMUs before, however they employed GPS in their system which keeps the price quite high $1000+.
- The overall direction of this work is to produce a testbed of sensors simulating a micro grid prosumer with several neighbours, and incorporate it with IBMs Node.js to gather data from and manage the sensors nodes.

3 Experiment Setup

- The experiment consisted of two Raspberry Pi's, the older B+ (Single CPU), and the newer Pi 2 (Quad Core). As well as an Oscilloscope to calculate precise time intervals.
- A simple while loop which changes the state of the GPIO pin every 125μs from high to low, this creates a square wave that is easy to measure on the scope:
  - while(true):
    - AssertPin(High)
    - wait(62μs)
    - AssertPin(Low)
    - wait(63μs)
- For each Pi, there were two scenarios, GUI on and off. This simulates using the Pi as a control node or just as a sensor or relay node. The GUI further stresses the CPU and increases execution time.
- The total time between rising edges of the square wave were recorded, and the process repeated 100 times for each scenario.

Capture shown has an Interval of 127μs.



4 Planning

- The results have shown that the OS running on the single core Pi B+ was unable to cope with extra tasks that stressed the system. This can be seen by the higher standard deviation in the table below (in μs).

	Min	Max	Median	Std Dev
Pi B+ NG	125.8	137.6	127.2	1.20
Pi B+ GUI	126	154.6	127.2	4.88
Pi 2 NG	124.8	127.4	126	0.57
Pi 2 GUI	124.2	127.6	126	0.61

- Furthermore, the quad core Pi performed very well with the three other cores able to manage the load of the OS or any other housekeeping i.e. SSH, WiFi.
- We plan to use only quad core nodes in our testbed from now on. We have adopted Odroids and Pi 2s to build a simulated micro grid.
- By utilizing the GPIO pins of the Pi we generate a 50Hz signal after passing through a RC and LC filter. This 50Hz signal is then read in by the Odroids ADC pin. This simulates the 50Hz signal of the national grid, and a PMU attached to some prosumer residence.
- Our plan is to use three or more Odroids to poll the 50Hz signal from the Pi and run synchronization tests. Starting with NTP and following that a packet train frequency sync idea proposed by us.

Ireland's European Structural and Investment Funds Programmes 2014-2020
Co-funded by the Irish Government and the European Union

European Union
European Regional Development Fund

SOUTHERN Regional Assembly
Promoting our Region