27th AMEU Technical Convention 2019

The 4th Industrial Revolution ("4IR") | *Building the Power Utility of the Future, Today*

Open Source remote monitoring in the municipal landscape

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Hosted by

CITY OF CAPE TOWN
ISIXEKO SASEKAPA
STAD KAAPSTAD

Introduction

Africa's Technical sovereignty

Industry 4.0

Prosperity and modernisation

Technology participation

4.7 : 1 [1]

Import Export (GDP)

Open source

Enel Energy's Open Meter

Business case

Asset	Description	Count	Monitoring opportunities	Cost to monitor	Total cost
Distributor substations	Incomers from major substations and feeders to local transformers and other DSSs.	731	Per Bay Digitals (6): Breaker status; breaker position; cable earth; overcurrent; earth fault; relay fail Analogue (1): Phase current Control (2): Open and close General substation: a.c. fail; d.c. fail; charger fail.	~ R 50 000 (2014)	~ R 36 550 000
Mini-substations	Typically residential 11 kV to 400V transformers.	5849	1 x EFI 3 x LV fuse fail (per circuit) x (1-6) circuits 1 x door open 3 x CTs (LV busbar)	~ R 28 000 (2015)	~ R 163 772 000
Kiosks	Industrial, commercial and residential 11 kV to 400 V transformer with switchpillar and LV panel.	2835	1 x EFI 3 x LV fuse fail (per circuit) x (1-6) circuits 1 x door open 3 x CTs (LV busbar)	~ R 28 000 (2015)	~ R 79 380 000
Pole top transformers	Residential (typically rural). Similar concept to MSSs.	6090	3 x 11 kV drop-off fuse 3 x LV fail (per circuit) x (1-3) circuits 3 x CTs (LV)	~ R 28 000 (2015)	~ R 170 520 000

Monitoring Opportunities

a) The deployment of monitoring equipment only at strategic points on the network

b) Leveraging Internet of Things (IoT) devices over Low Power Wide Area Networks

c) The use of open source technologies.

Research Objectives

a) Can open source technologies offer a technically viable remote monitoring solution?

b) What are the non-technical challenges that exist with open source technologies?

c) What are the cost advantages associated with the use of open source technologies?

Technical requirements

Crestmore substation 3532

Technical requirements

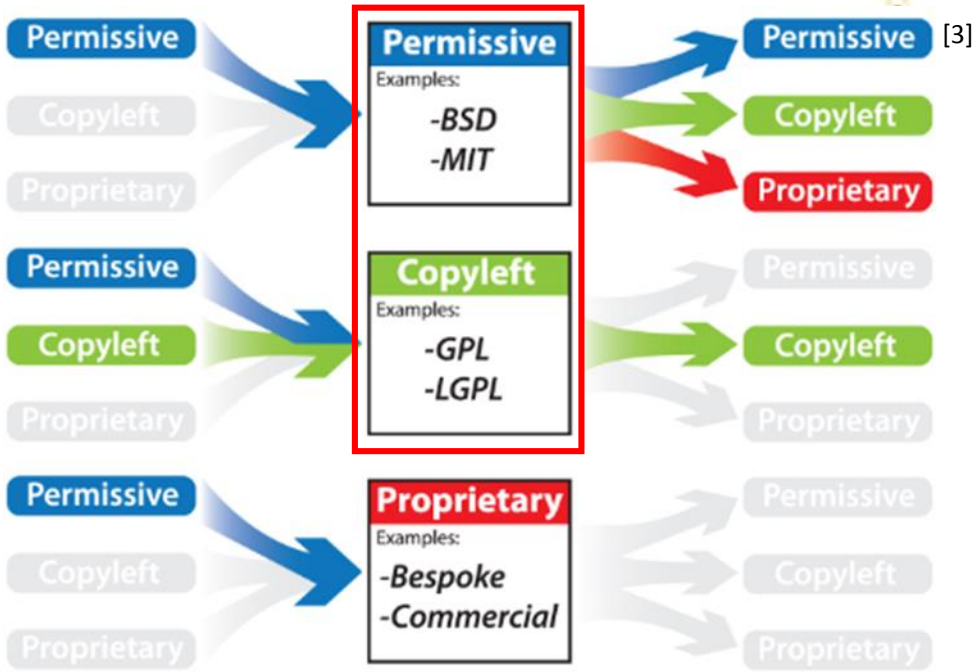
Characteristic	Requirement
1. Provisioning of digital inputs	Minimum 8 expandable
2. Provisioning of digital outputs	Minimum 2 expandable
3. Provisioning of analogue inputs	Minimum 4 expandable
4. Standard communications protocol over Ethernet	DNP3 (slave), Modbus (master)
5. Provisioning of Human Machine Interface	Web browser
6. Should be easily configurable through a web interface	Web browser
7. Compliance with temperature and EMI regulations	IEC61850-3 CX3; IEC 61000
8. Compliance with cyber security requirements	IEC62351 (Open VPN)
9. Compliance to availability/uptime requirements	Five nines principle

Open Source technologies

What is it?
Concept that is created and owned by the public

Open Source tenets	
1. No fee for distribution	4. No discrimination against fields for endeavour
2. Un-compiled and compiled source code must be made available	5. The license must be technology neutral
3. Must allow for modifications of source code	6. The license must not restrict other software, etc.

[2]



[3]

Hardware platforms

[4a]

[4a]

Board	Arduino Uno [4c]	RPI [4d123]	BeagleBone [4b123]	Requirement
Model	R3	Model 3B	Black	Open Source eco-system
Flash	32 kB	SD Card	4Gb Onboard	External/on-board
GPIO	14	40	69	At least 8 and expandable
Analog Input	6	External	7	At least 4 and expandable
IDE	OS - Arduino	OS - Linux	OS - Linux	Open Source (OS)
Ethernet	None	Yes	Yes	Yes
Temperature performance	85 °C (1)	85 °C (2)	90°C (processor)	70 °C (overall)
Project	Arduino LLC	RPi Foundation	BeagleBone.org	-
Cost	USD 30	USD 35	~USD 50-100 (variable; various sources on google)	-

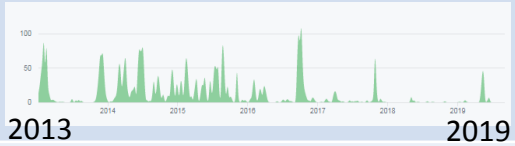
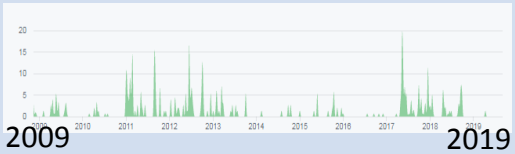
(1) ATMEGA chip

(2) Broadcom Application processor runs the hottest and can withstand temperatures of up to 85 °C. COMPULAB offers RPI unit with maximum operating temperature of 80 °C.

Objective 1: Technical feasibility

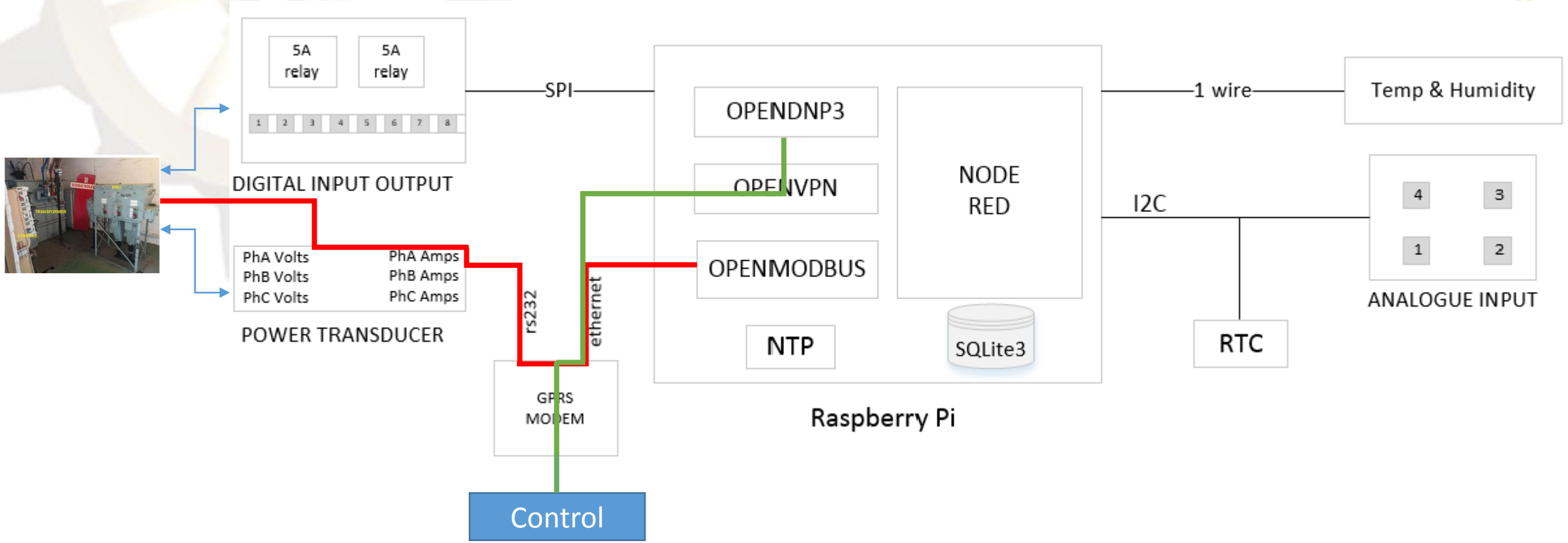
Are there open source applications in the market that meet our requirements; and
How mature are these applications?

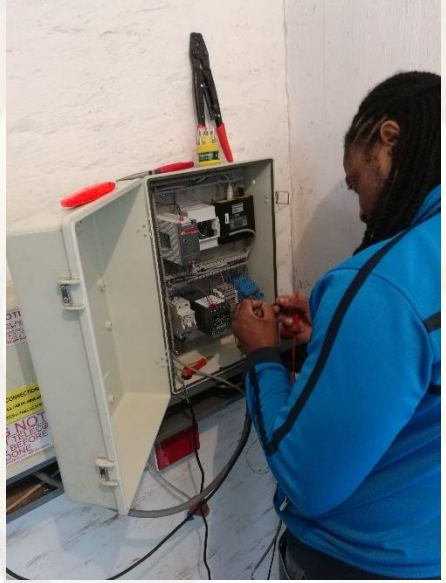
[5]

Software	Stars	Contributors	User group	Activity
OpenDNP3 [5a]	158	22	386 (674)	 2013 2019
OpenVPN [5b1] [5b2]	4024	102	34713 (19123)	 2010 2019
PyModbus [5c]	866	40	334 (263)	 2009 2019
Node-red [5d]	8317	106	5100 (6000)	 2013 2019

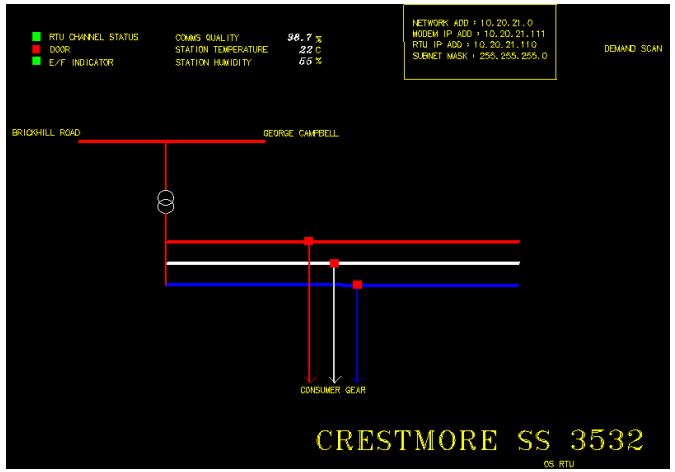
Objective 1: Technical feasibility

Architecture



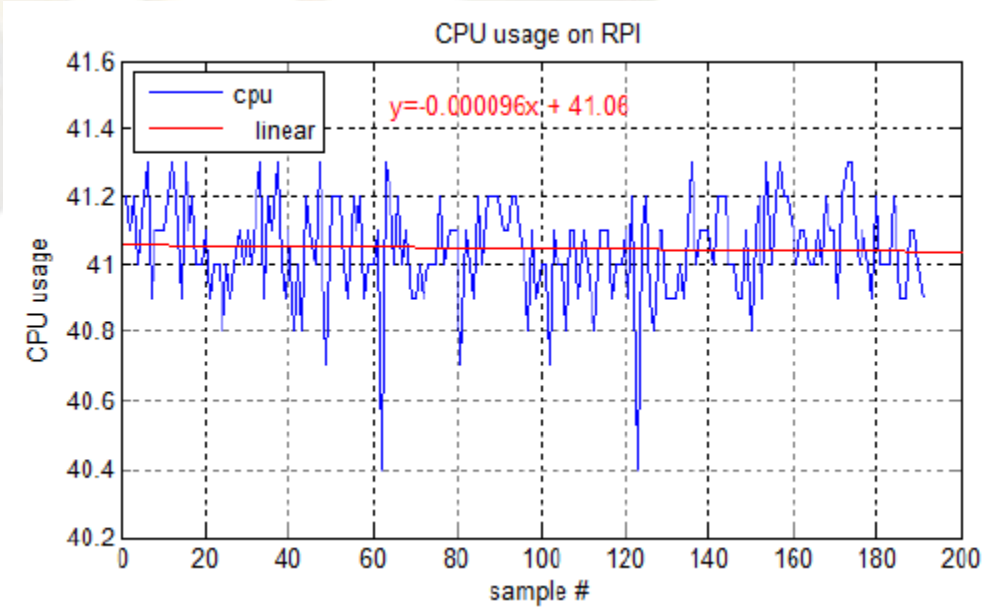


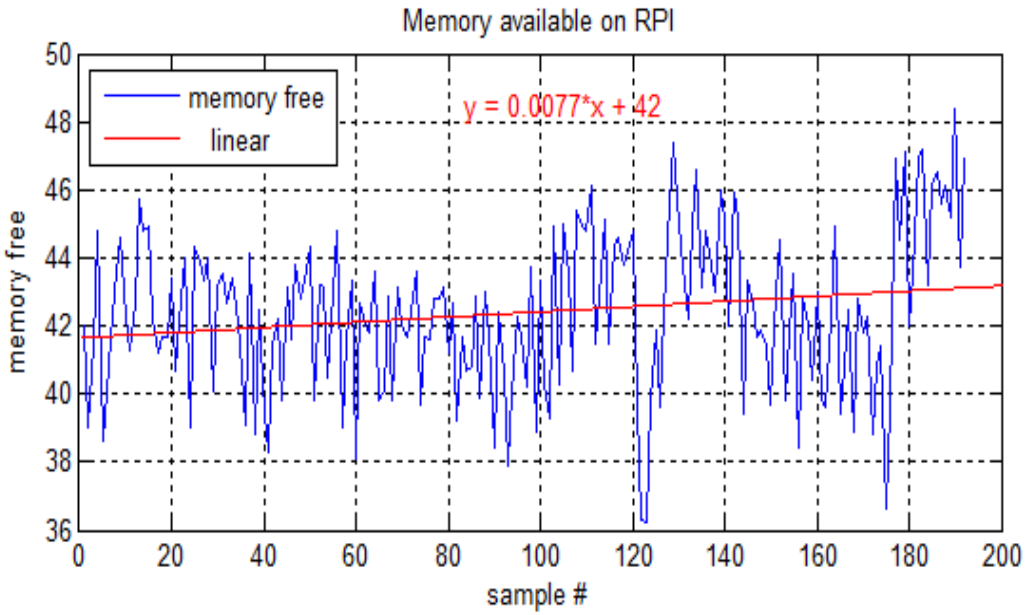

11 000 VOLTS


RTU CHANNEL STATUS
DOOR
E/F INDICATOR
COMMS QUALITY 98.7 %
STATION TEMPERATURE 22 C
STATION HUMIDITY 65 %
NETWORK ADD : 10.20.21.0
MODEM IP ADD : 10.20.21.111
RTU IP ADD : 10.20.21.110
SUBNET MASK : 255.255.255.0
DEMAND SCAN
BRICKHILL ROAD
GEORGE CAMPBELL
CONSUMER GEAR
CRESTMORE SS 3532
OS RTU

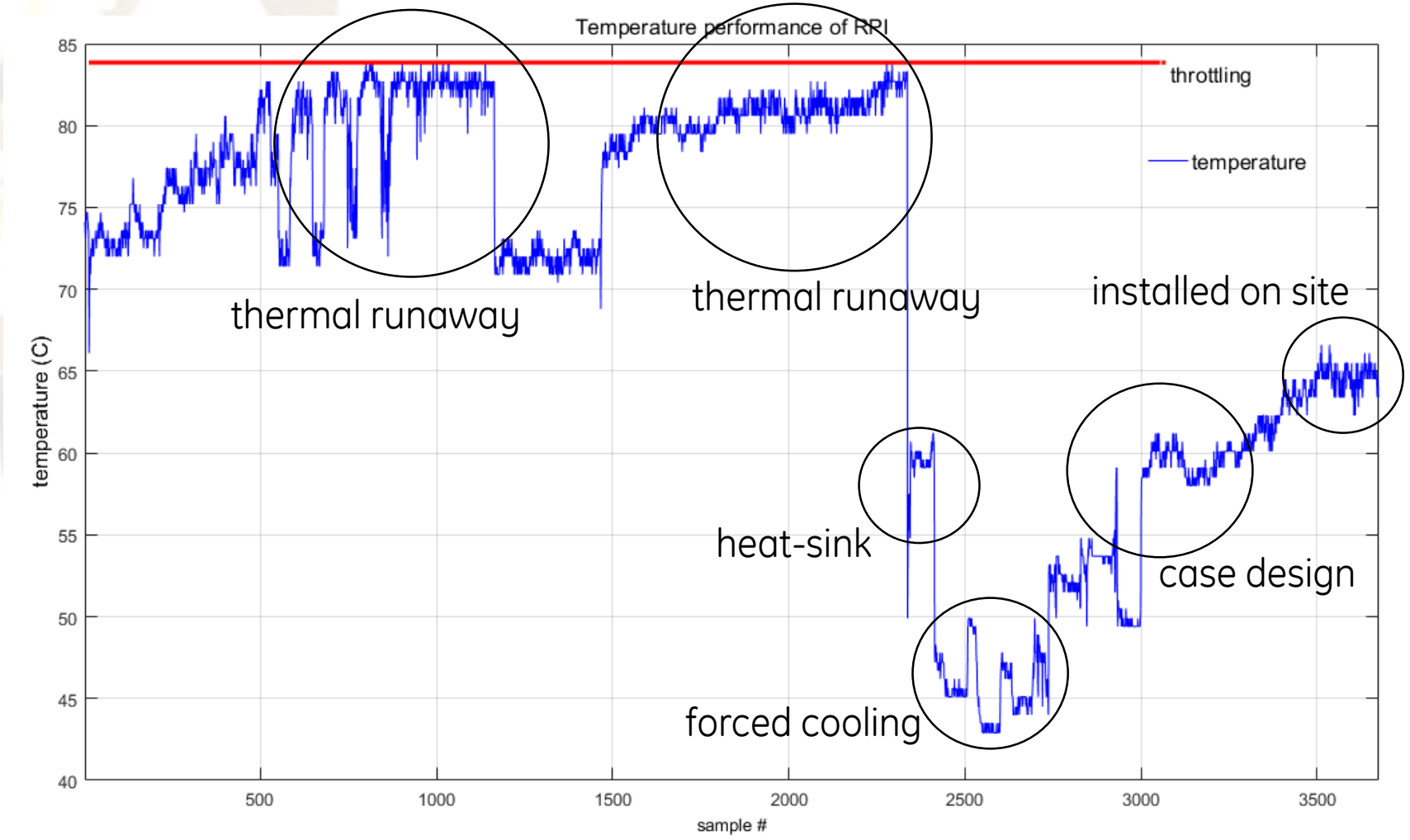
Objective 1: Technical feasibility

Processor and memory performance





Objective 1: Temperature performance



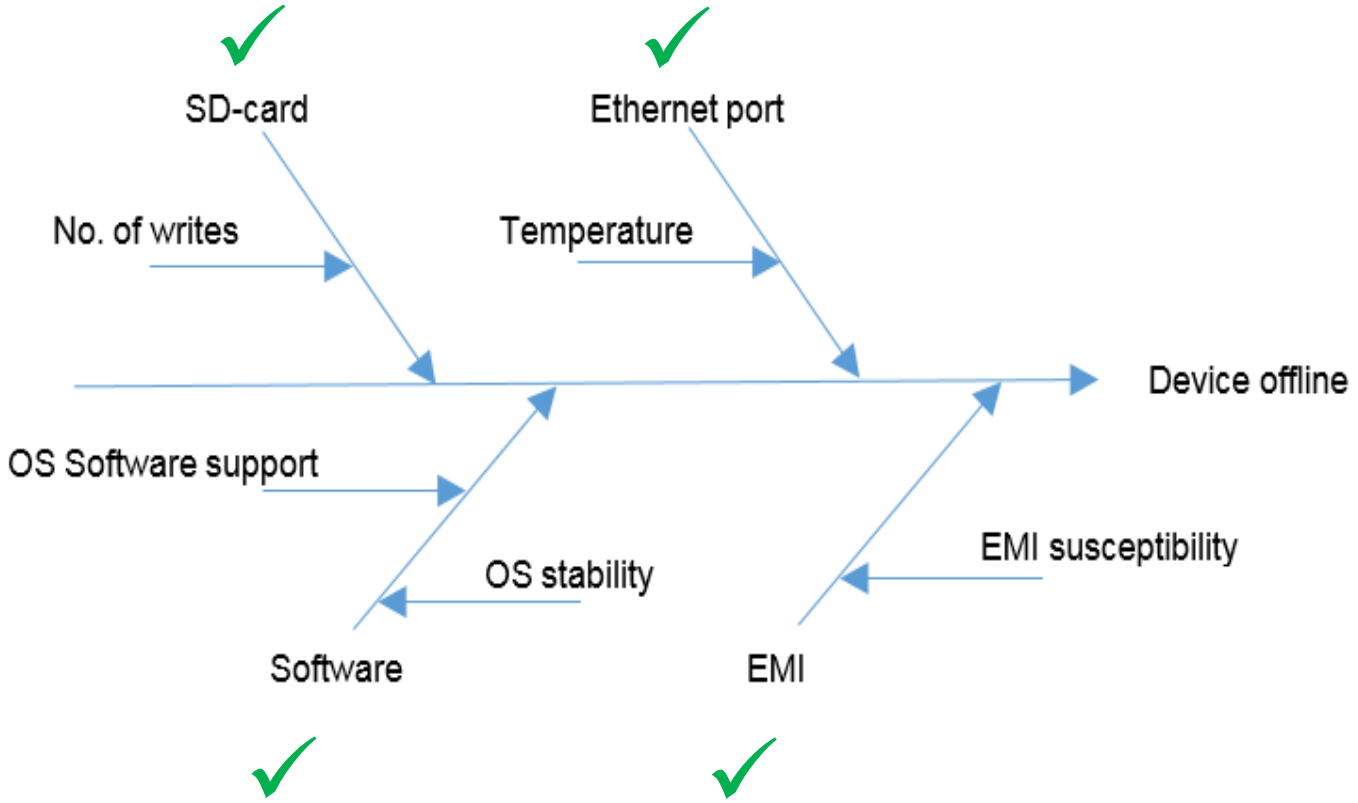
Objective 1: Technical feasibility

Availability performance

```
Last login: Mon Apr 10 22:27:49 2017 from 10.12.210.90
pi@raspberrypi:~ $ ps -ef | grep outs
www-data  1734     1 99  2017 ?        47721-20:24:18 ./outstation-demo
pi        7077  7066  0 13:48 pts/1    00:00:00 grep --color=auto outs
pi@raspberrypi:~ $ uptime
 13:53:13 up 499 days, 22:52,  2 users,  load average: 1.49, 1.45, 1.40
pi@raspberrypi:~ $ ps -o etime= -p 1734
499-22:52:32
pi@raspberrypi:~ $
```

Objective 1: Technical feasibility

Failure modes



Objective 2: Non-technical challenges

Human resources

Spares

Support

Objective 3: Cost advantages

Capex

Item	RPI	Vendor specific
Microprocessor with DNP3 protocol	R 3 000	R 22 000
Inputs (Digital and analogue)	R 800	R 6 000
Temperature and humidity sensor	R 150	R 200
Cabinet and accessories	R 1 100	Incl
Total	R 5 050 →	~R 23 000 ← R 28 200

eThekwini's 15 000 units	R 75 750 000 →	~R 345m ←	R 423 000 000

Opex

Virtual ecosystem for support

Discussion and conclusion

A. Technically viable OS remote monitoring for Smart Grid
   - Well supported Open Source software applications exist
   - Open Source proposal indicates stability

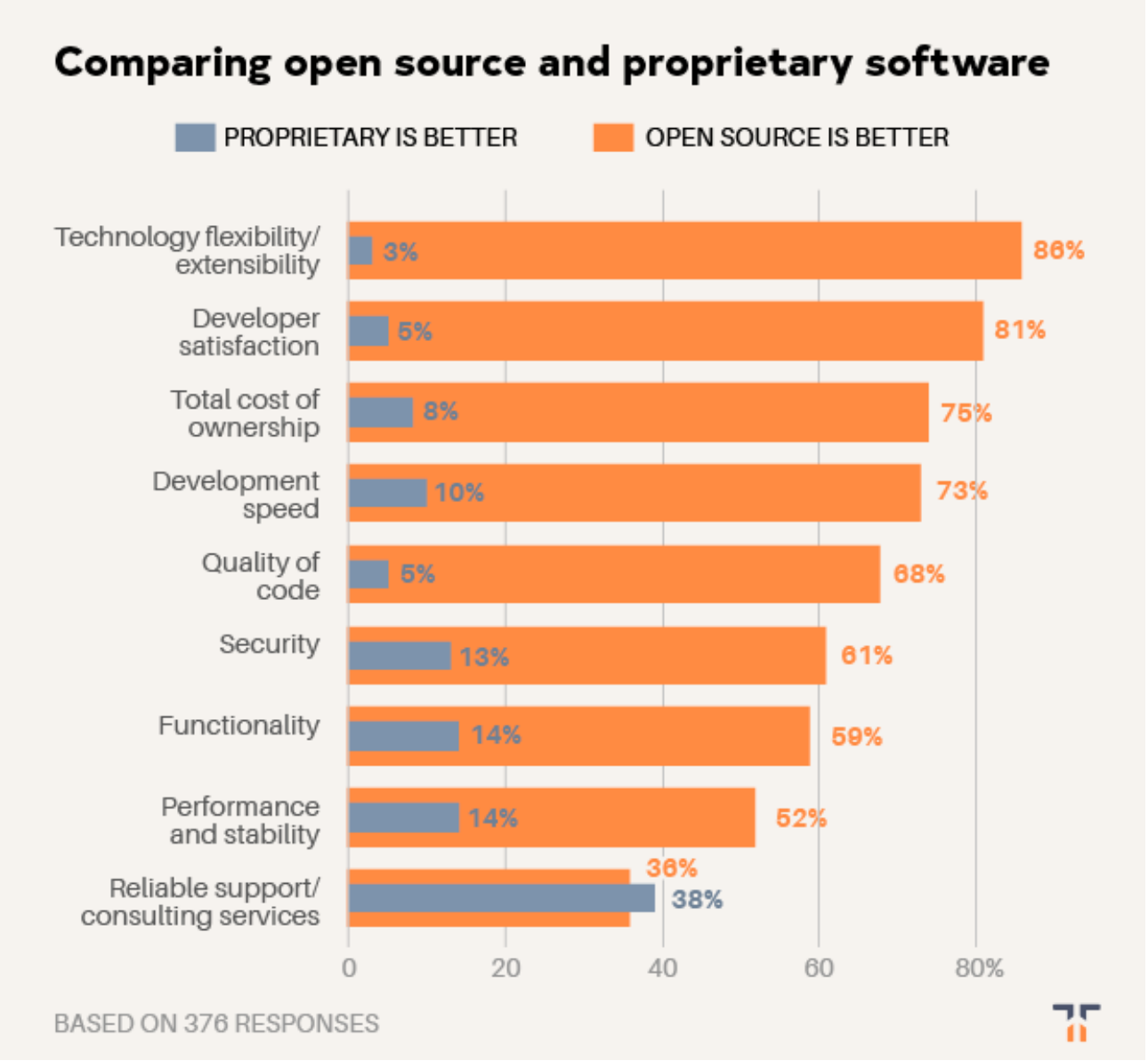
B. Non-technical challenges
   - More collaboration by Utility Engineers on Open Source concepts

C. Costing
   - Significant upfront and operating cost benefits

OS proposal offers a compelling low cost remote monitoring solution

Flexibility and technology agility to organisation

[6]


Comparing open source and proprietary software
PROPRIETARY IS BETTER
OPEN SOURCE IS BETTER
Technology flexibility/ extensibility
3%
86%
Developer satisfaction
5%
81%
Total cost of ownership
8%
75%
Development speed
10%
73%
Quality of code
5%
68%
Security
13%
61%
Functionality
14%
59%
Performance and stability
14%
52%
Reliable support/ consulting services
36%
38%
0
20
40
60
80%
BASED ON 376 RESPONSES

Questions

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b[2] OPENVPN 2019, Forum statistics, accessed 6 Jan 2020 < https://forums.openvpn.net/>

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d Node-red 2019, accessed 6 Jan 2020 <http://nodered.org>

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Thank you

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