SMART W*ater* H*eater*

Mauro Cordoba, EE
Bryan Mitchell, EE
Vipol Sophonwatthanawichit, CpE

Group 36

MOTIVATION

"Water heaters account for nearly 17 percent of a home's energy use, consuming more energy than all other household appliances combined."

- To reduce energy consumption by modernizing a common appliance
- To provide more control

PROJECT goals

- Create an Internet of Things device
- Work with embedded linux devices
  - Try to avoid common platforms such as raspberry pi
- Develop Android application
- Get experience designing PCB

PROJECT requirements

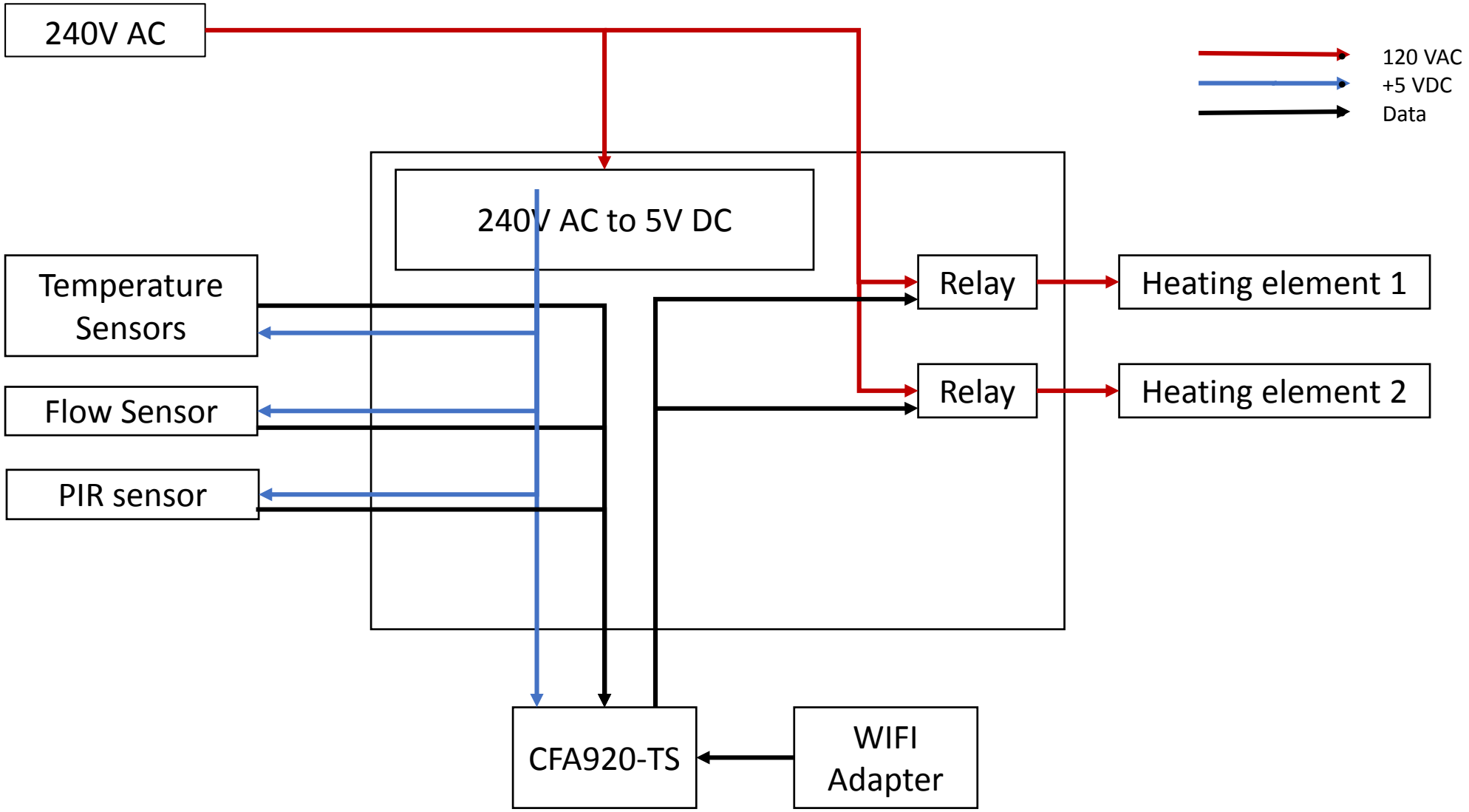
- Comparable in size to modern water heater thermostats
- Able to control a standard electric water heater element
- Able to regulate temperature to +/- 1° C of desired temperature
- It will run from 240V mains (120V for demo)
- It will be controlled directly though a touchscreen interface or remotely via network

PROJECT overview

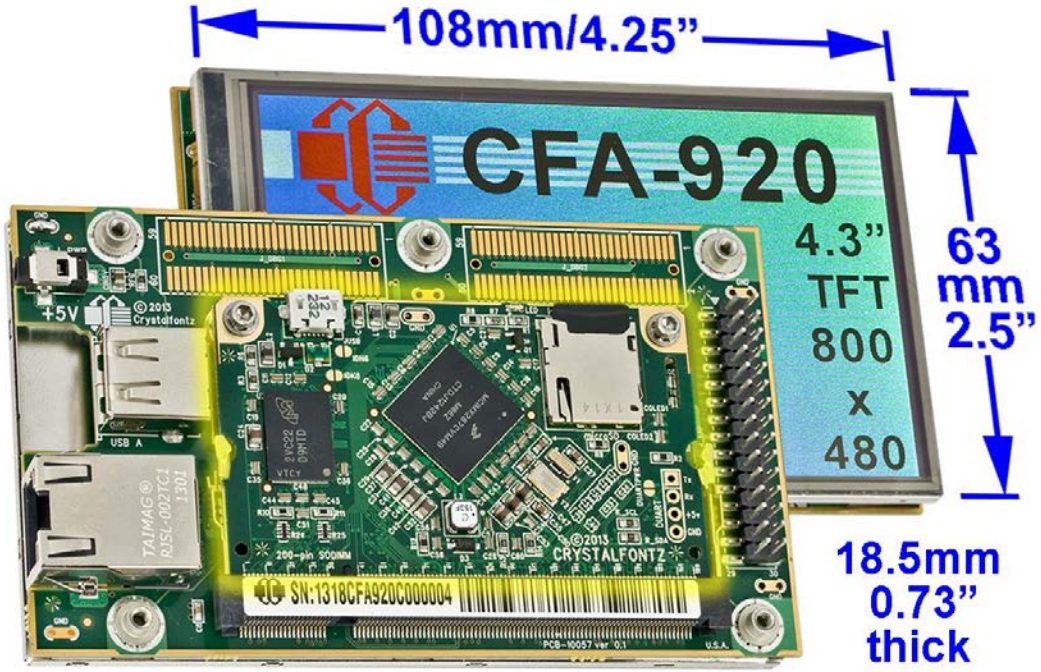
PROJECT overview

HARDWARE design

HARDWARE diagram



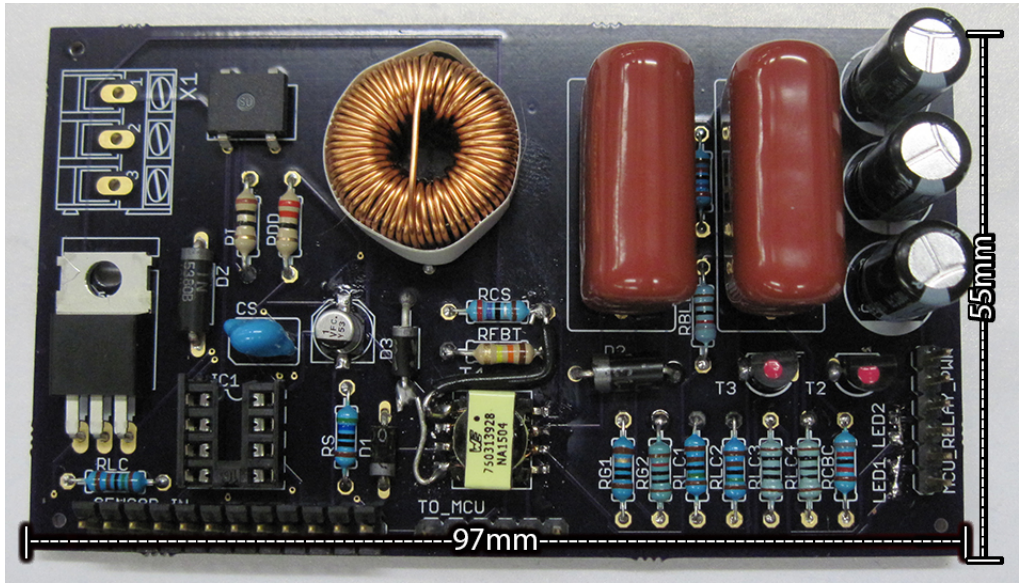
MAIN board



CFA920-TS

- 454MHz Freescale i.MX283 processor
- 4.3 inch 800*480 TFT touchscreen display
- 10/100 Ethernet port
- USB port
- 128MB DDR2 RAM
- µSD reader supports up to 64GB
- 24 GPIO pins

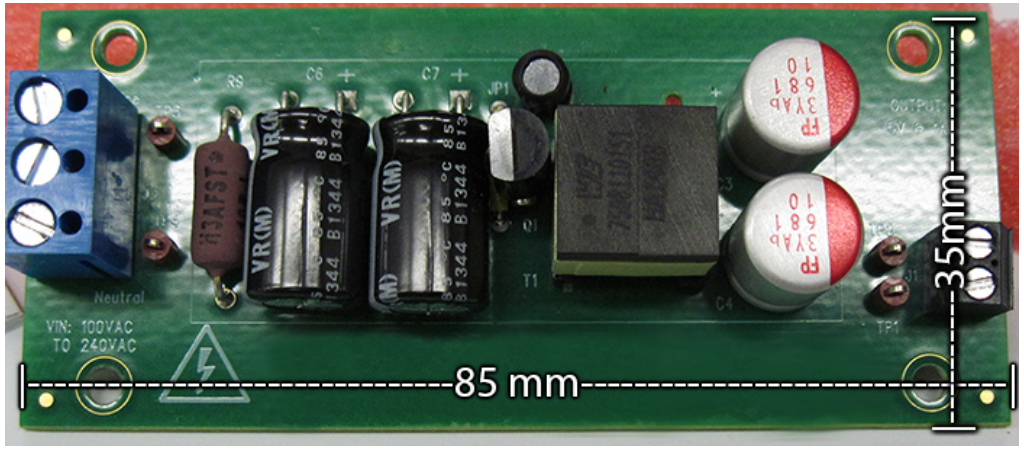
EXPANSION board(s)



The first iteration of the expansion board

- 240v AC - 5v DC power supply
- Interface with CFA920-TS
- 97mm x 55mm
- Sensor inputs
- Relay controlled heating element outputs

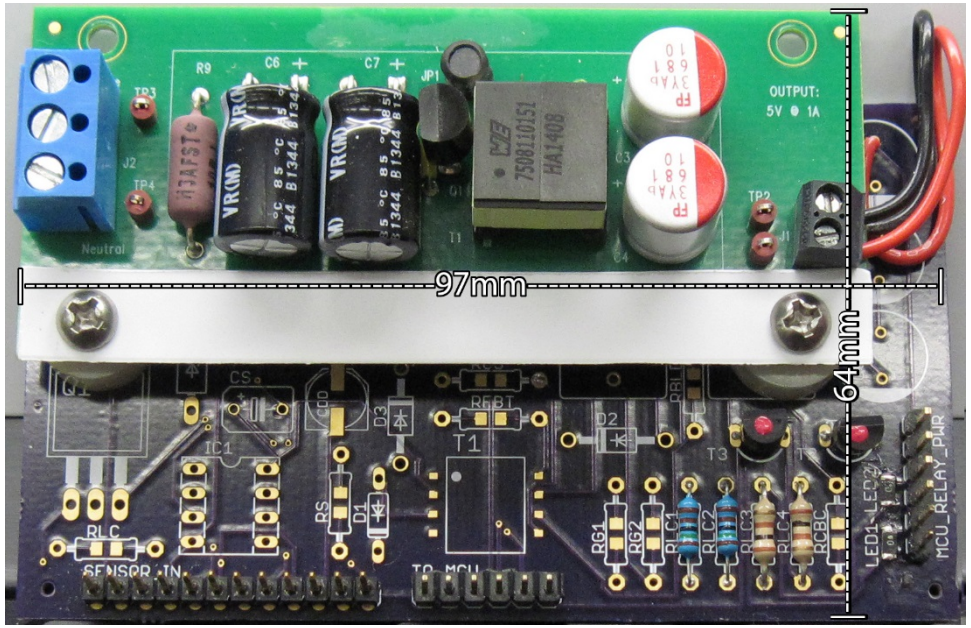
EXPANSION Power board



The replacement power board

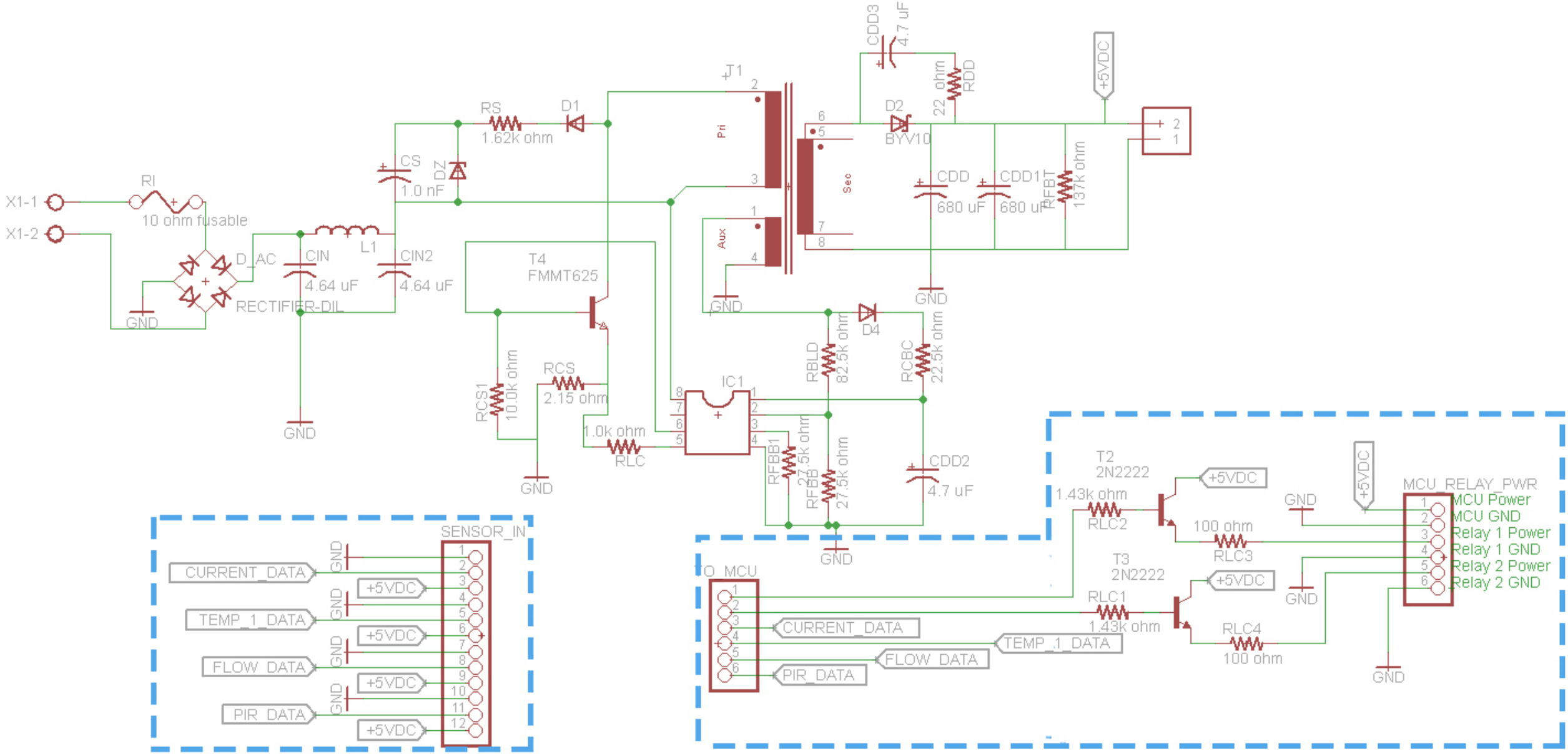
- Redesigned 120v AC - 5v DC power supply to replace former supply
- A rush order, tested and machine populated before delivery

EXPANSION board 2



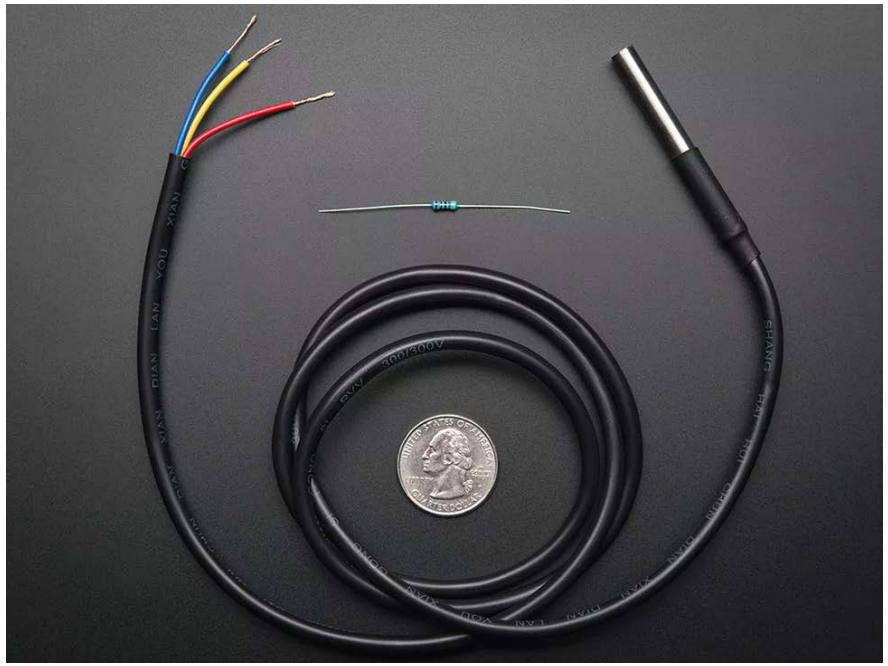
The replacement power board + expansion board

- Using portion of former expansion board, with new power supply board mounted in place of old power circuit
- Decision to reuse portion of old board
  - That portion of first expansion board worked
  - Additional machine mounted components would have increased new power supply board cost



Portions encircled with dashed lines indicate circuitry reused from first expansion board

TEMPERATURE sensor



DS18B20

- Usable temperature range: -55 to 125°C (-67°F to +257°F)
- Uses 1-Wire interface- requires only one digital pin for communication
- Unique 64 bit ID burned into chip
- Multiple sensors can share one pin
- ±0.5°C Accuracy from -10°C to +85°C
- Usable with 3.0V to 5.5V power/data
- Waterproof

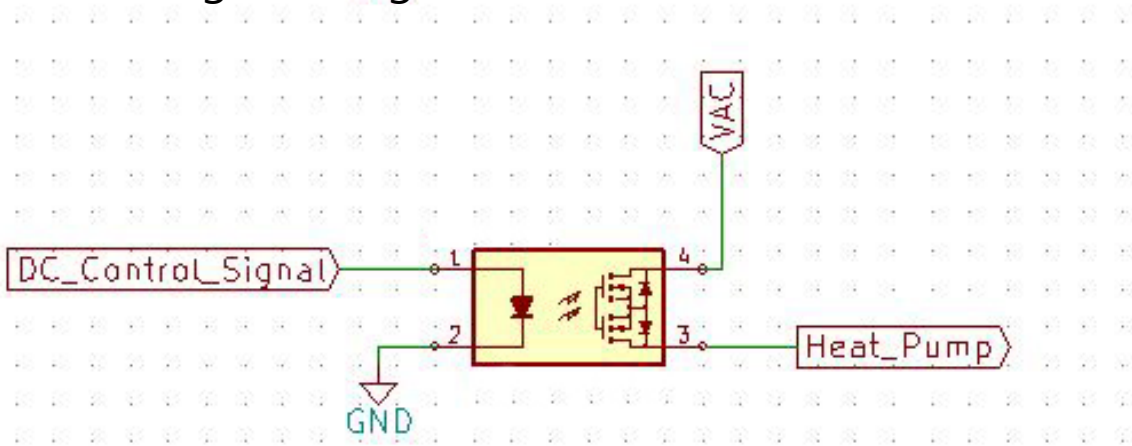
FLOW sensor

YF-S201

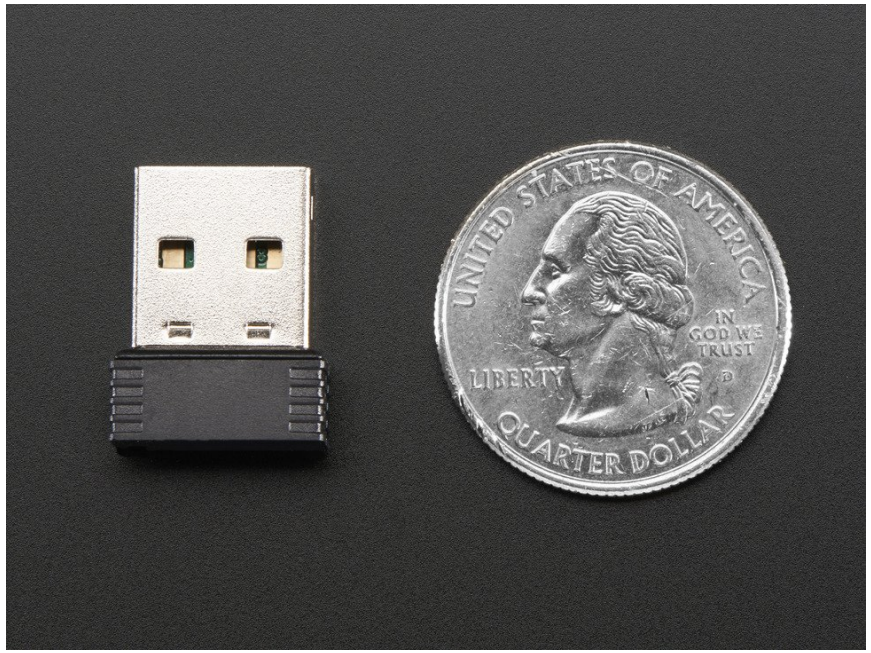
- Working Voltage: 5 to 18VDC
- Max current draw: 15mA @ 5V
- Working Flow Rate: 1 to 30 Liters/Minute
- Working Temperature range: -25 to 80°C
- Maximum water pressure: 2.0 MPa

RELAY

- Solid state relay for electrical isolation
- Input: DC 3~32V
- Output: AC 24~380V
- Current: 25A (with heatsink) 12A w/o
- Dimensions: 62mm x 45mm x 26mm
- Weight: 115 g



WIFI adapter

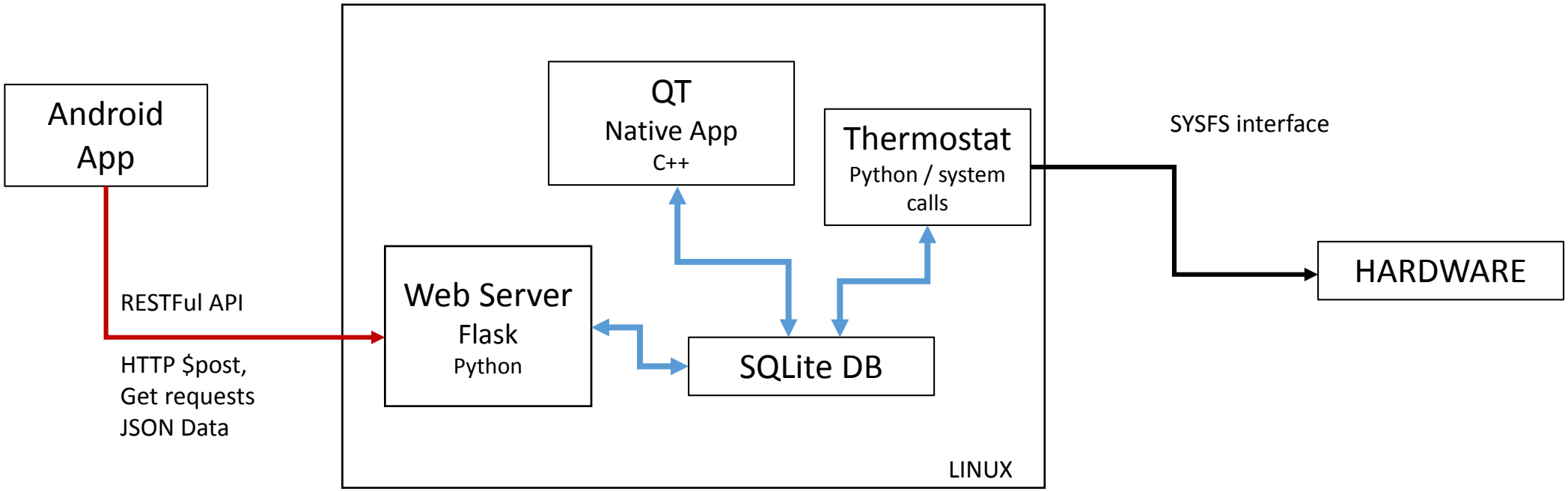


CFA-WIFI-01

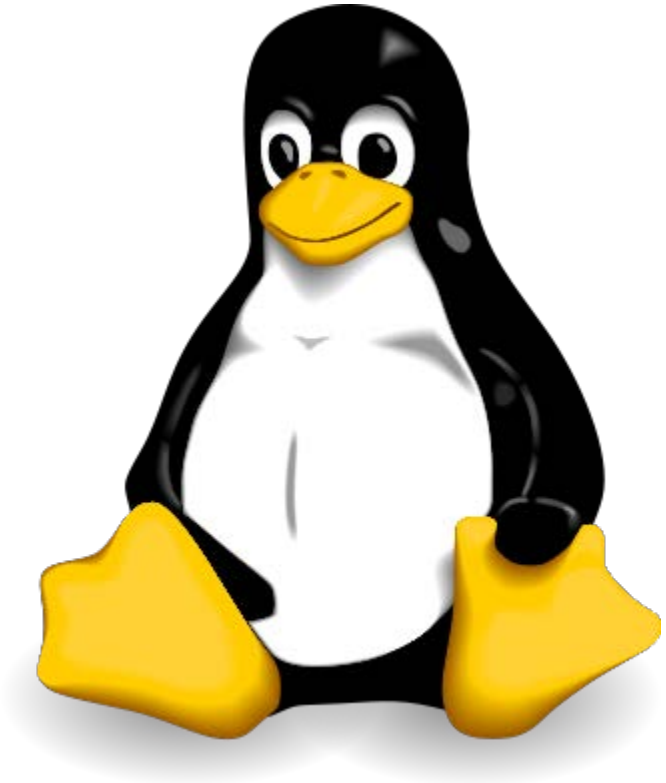
- Any USB dongle will work
- Can be 2.4 or 5 GHz
- Realtek chipset
  - Rcl8192cu driver

SOFTWARE design

SOFTWARE design



OPERATING system



- Custom Linux OS made with Yocto
- Based on kernel version 3.12.17.
- Will have the bare minimum we need
  - USB
  - GPIO
  - Networking/WPA supplicant
  - QT and python libraries

YOCTO development

- Yocto provides the tools to develop a custom linux distribution
- Organized into layers made up of recipes
  - Layer cover a theme
  - Recipes define how to build and install packages

BACKEND

- Flask as a webserver/application framework
  - Python-based
  - API to communicate with android app
- SQLite Database
  - Perfect for single applications and embedded systems
  - Can be created from directly within Flask

API

- ‘/temperature/get’, methods=[‘GET’, ‘POST’]
- ‘/element/get’, methods=[‘GET’, ‘POST’]
- ‘/status/get’, methods=[‘GET’]
- ‘/status/set_target, methods=[‘POST’]
- ‘/status/set_mode, methods=[‘POST’]

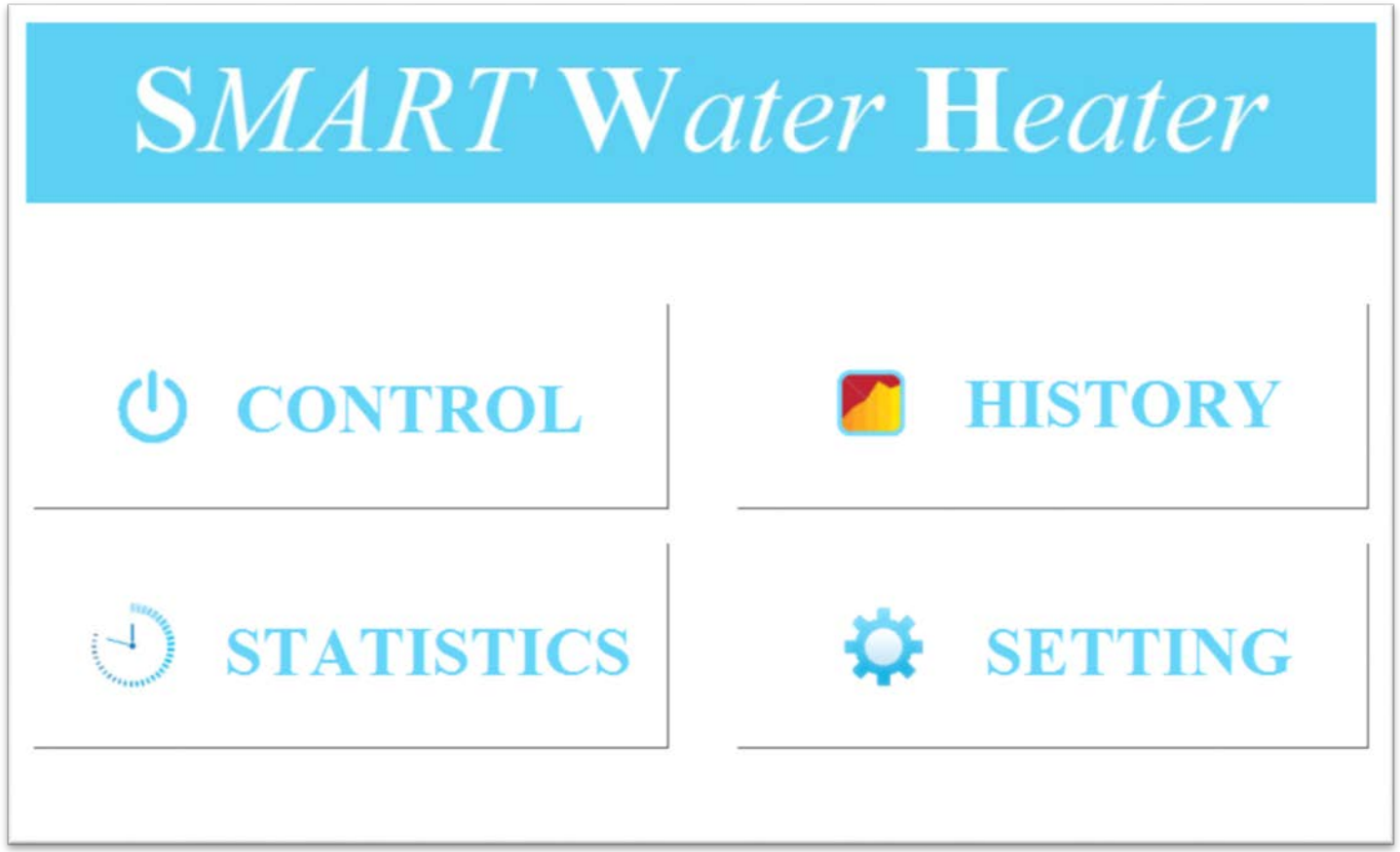
SQLite

- TEMPERATURE_TABLE
- ELEMENT_TABLE
- FLOWRATE_TABLE
- PREDICTION_TABLE
- STATUS_TABLE
  - Only one row that gets updated
  - Avoids making multiple calls for current information

FRONTEND

- QT application framework for UI development
  - Cross platform
  - It can output to our frame buffer without a window manager
  - It can interface with SQLite database

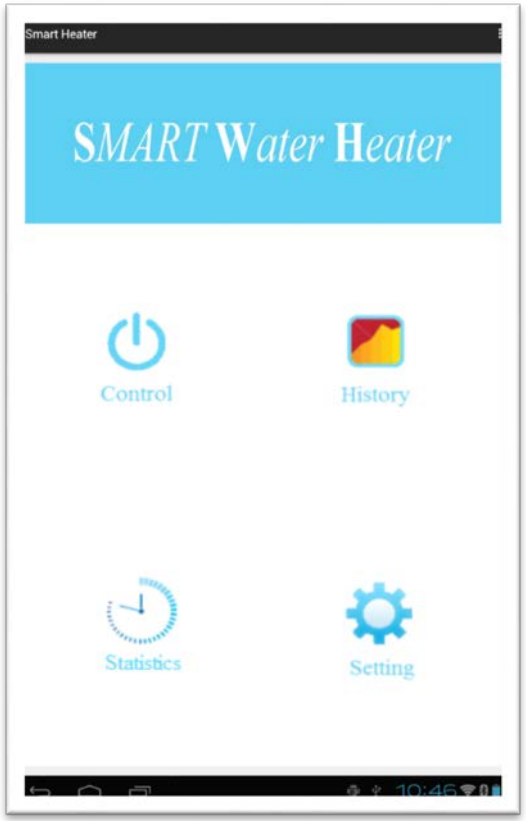
QT application



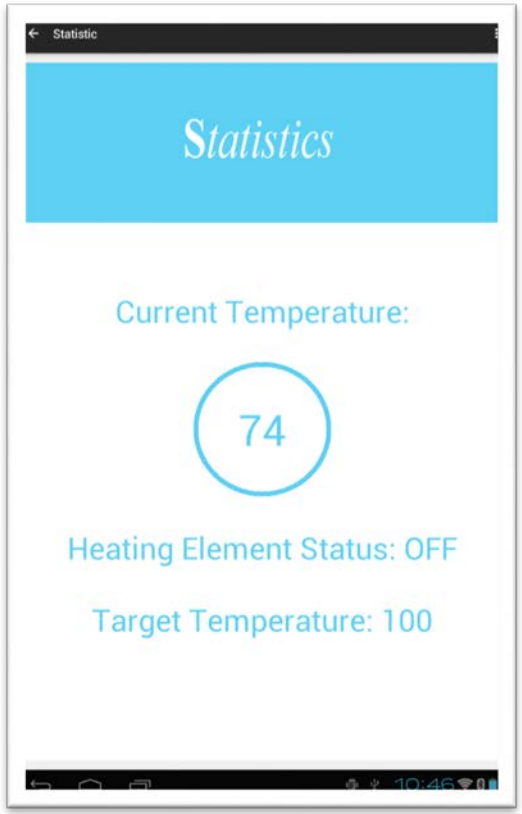
MOBILE application

- Android App to communicate with water heater remotely
- Uses RESTful API
  - HTTP requests
  - JSON

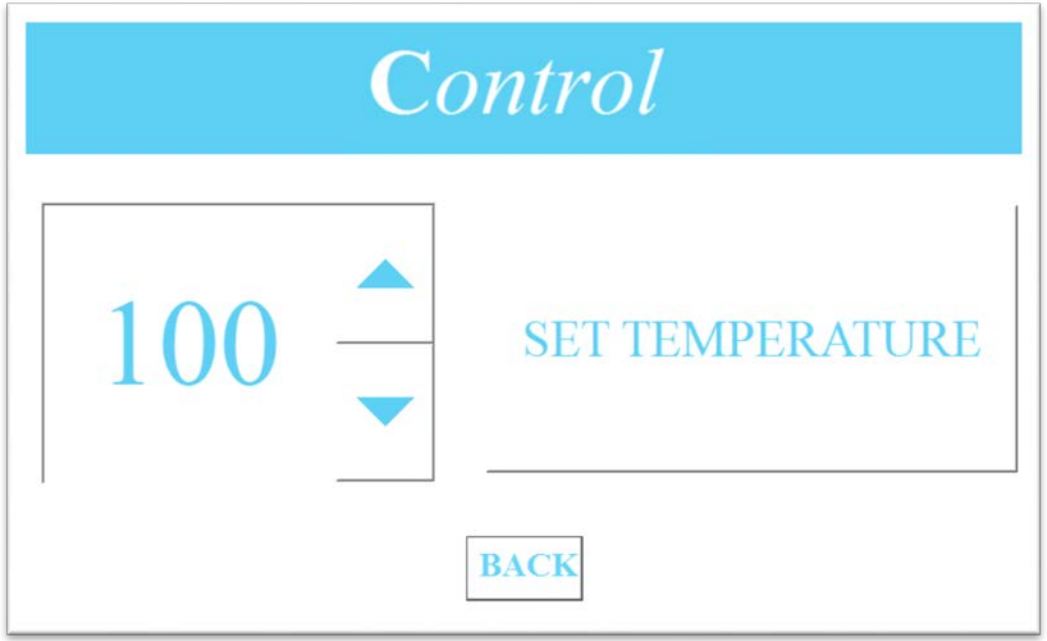
ANDROID application



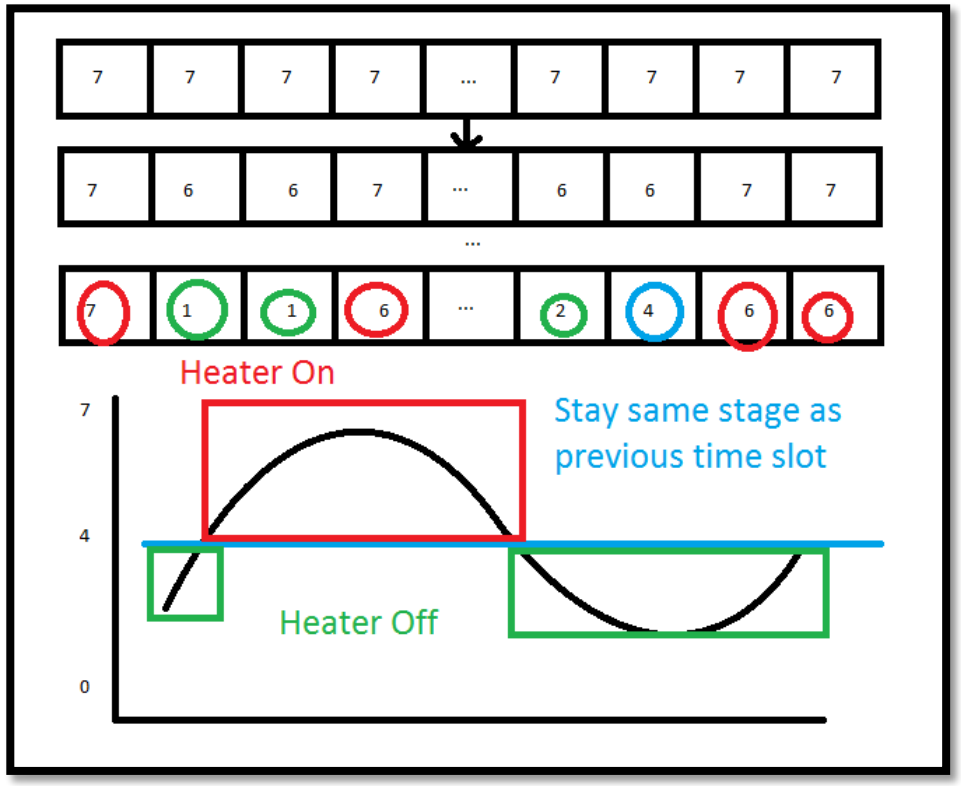
APPLICATION features



- Control
  - Set temperature
- Statistic
  - Current status
- History
  - Pull out past usage history
- Setting
  - Set mode



PREDICTION method



- Store flow rate data into array
- Update the array as the user data as the user uses the system
- Based on the past data, make a prediction
  - If the data passes certain threshold, turns on the heater
  - Else, turn off

ADMINISTRATIVE content

WORK distributions

	Hardware	Software backend	Software frontend
Mauro		X	
Bryan	X		
Vipol			X

BUDGET

	Quantity	Price	Extended	Cost
CFA920-TS	1	187	187	0
WiFi adapter	1	5	5	0
Temperature sensor	2	10	20	20
Flow meter	1	10	10	10
Misc Hardware (project box, etc)	Various	25	25	25
Relays	3	12	36	36
PCB	1	47	47	47
2nd Power PCB (populated)	1	110	110	110
Misc. Electrical Components	Various	40	40	40
		Total	480	288

QUESTIONS?