

Contactless Health Monitoring

David Rodriguez and Yaqoob Hanona

Group 2



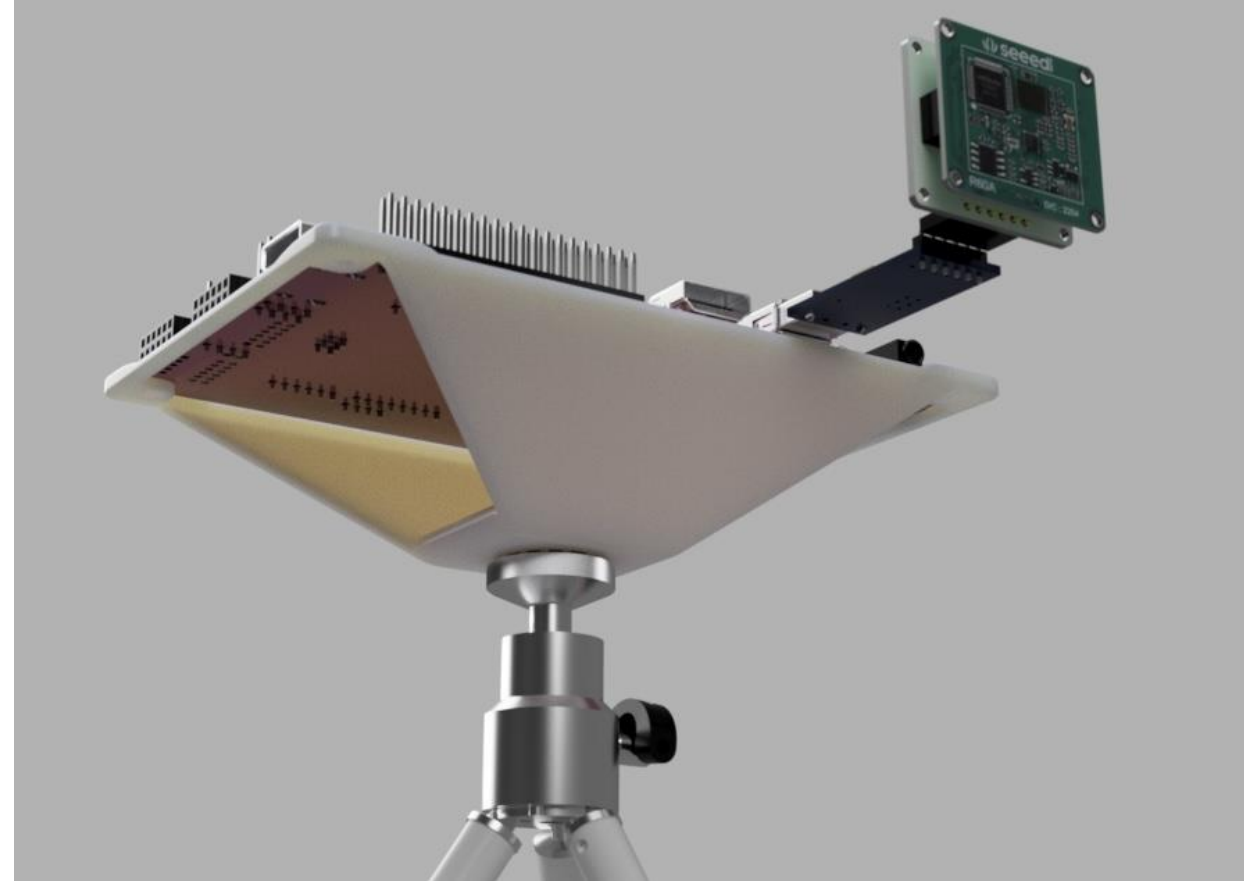
WES 237A Intro to Embedded Systems

Prof. Nadir Weibel
March 11, 2023

UC San Diego
JACOBS SCHOOL OF ENGINEERING

CONTACTLESS HEALTH MONITORING SYSTEM

- What does the system do?
 - Measures Patient Heart Rate
 - Measures Patient Respiratory Activity
 - Measures Patient Temperature
 - Detects Human Presence
 - Detects Movement of Patient
 - Detects Distance away from Patient
 - Streams data values to AWS Cloud Server



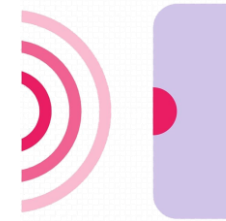
CONTACTLESS HEALTH MONITORING SYSTEM

- How does it work?

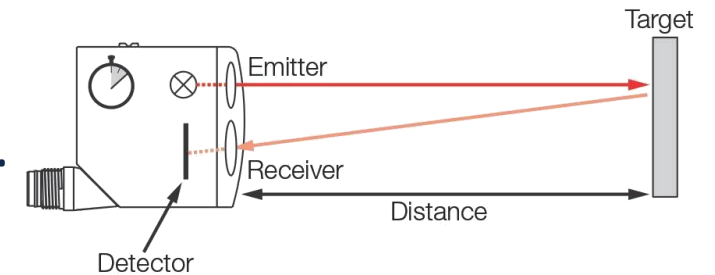
60GHz Radar module relies on CWFM Doppler Analysis to determine small displacements associated with heart beats and breathing.



Infrared Temperature Sensor measures light intensity for wavelengths associated with infrared heat signatures.



ToF Distance Sensor emits infrared light pulses, records the time taken to detect reflections, and correlates time to distance value.



PYNQ Z2 board joins sensor and networking functionality together to form a discrete health monitoring device

CONTACTLESS HEALTH MONITORING SYSTEM

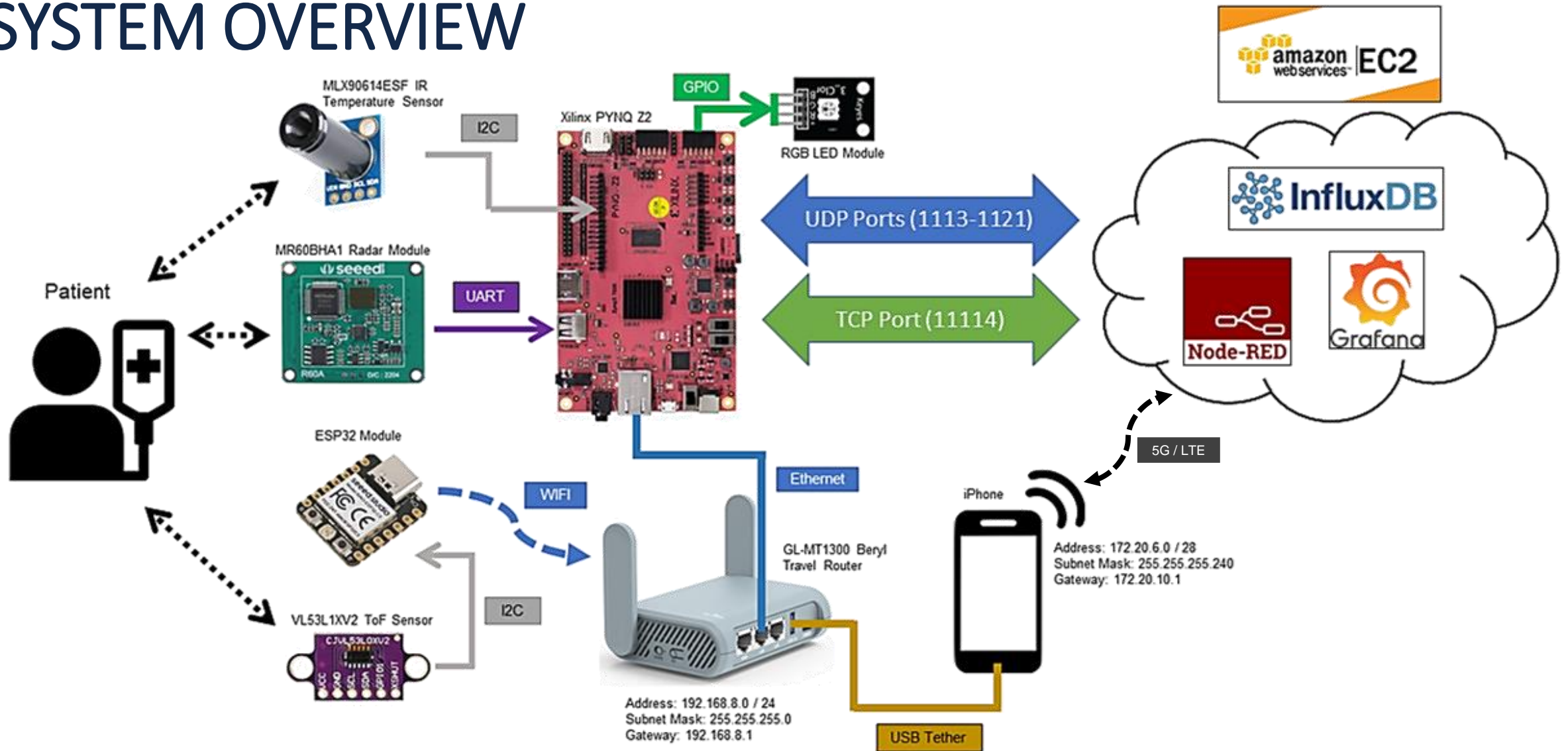
- Goals

- Create a functional contactless IoT health monitoring system using the Xilinx PYNQ Z2 board.
- Able to measure cardio, respiratory, and temperature data at a distance from a patient and produce health metrics visualizations in near real-time.
- Able to use concepts learned in WES 237A lab/lecture.

WES 237A TOPICS USED IN PROJECT

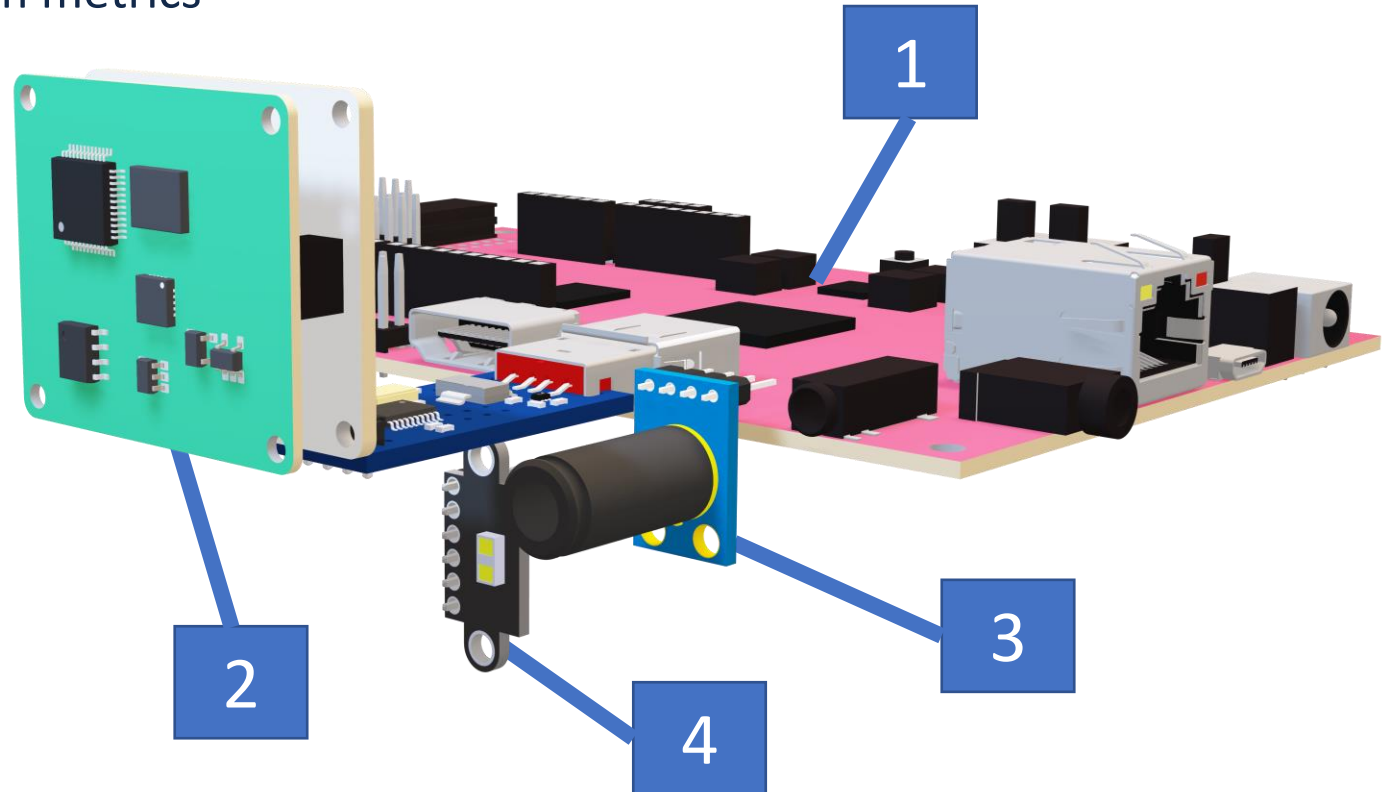
- **I/O:** Uses PYNQ Microblaze for GPIO Digital Write controls for RGB LED Module
- **Multi-Tasking:** Uses Python Multiprocessing library to run multiple concurrent data collection and socket connection routines for each sensor
- **Networking:** Uses multiple UDP connections and TCP connections to send data to Server
- **Sensors/Actuators/IoT:** Uses I2C communication protocol to obtain data from VL53L1XV2 ToF Distance and MLX90614ESF Temperature sensors

SYSTEM OVERVIEW



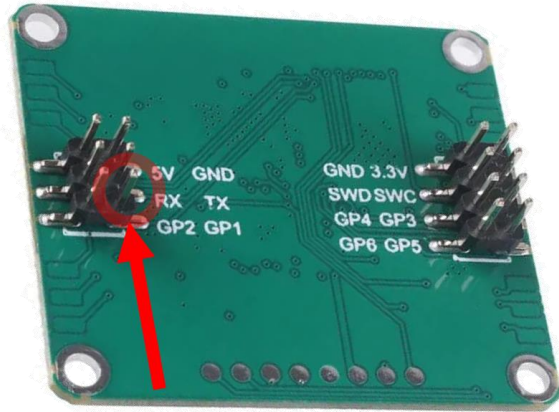
COMPONENTS USED

1. Xilinx PYNQ Z2 Board
2. Seeed Studio MR60BHA1 60 GHz mm Wave Sensor
 - Onboard MCU processes radar signals and outputs UART messages containing cardio/respiratory health metrics
3. MLX90614 IR Temperature Sensor
 - I2C and PWM compatible sensor
 - Supports measurements taken at distances of $\leq 12\text{cm}$
4. VL53L1X ToF Distance Sensor
 - I2C compatible sensor
 - Supports accurate distance measurements of up to 4 meters



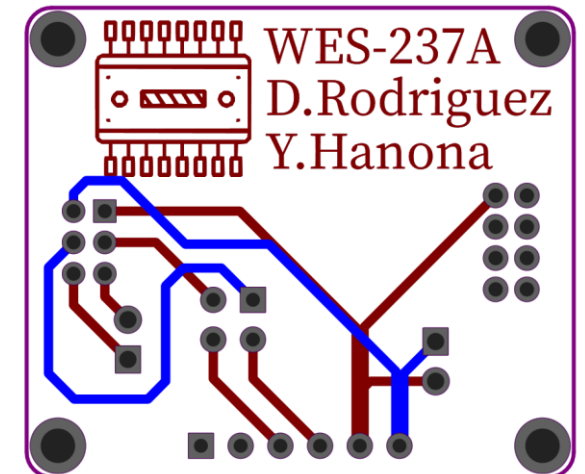
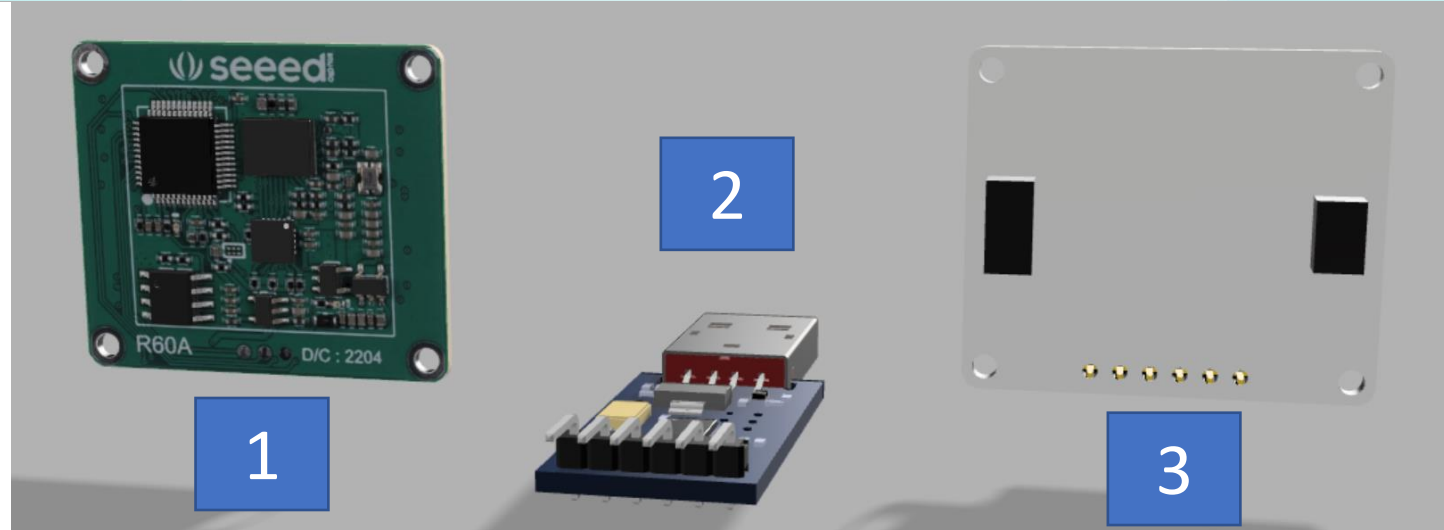
RADAR SENSOR ASSEMBLY

1. Seeed Studio MR60BHA1 60GHz mmWave Radar Sensor
2. USB to UART FTDI Adapter
3. Custom PCB - MR60BHA1-to-USB Adapter



MR60BHA1 GP1 Pin

- MR60BHA1 GP1 IO Pin reports human presence detection via digital signal output (3.3V = Presence Detected / 0V = No Presence Detected)



Custom PCB Design

AWS EC2 SERVER



- Ubuntu 22.04
- 2 Cores vCPU
- 16 GB EBS Storage

- Services Hosted:

- NodeRed
- InfluxDB
- Grafana

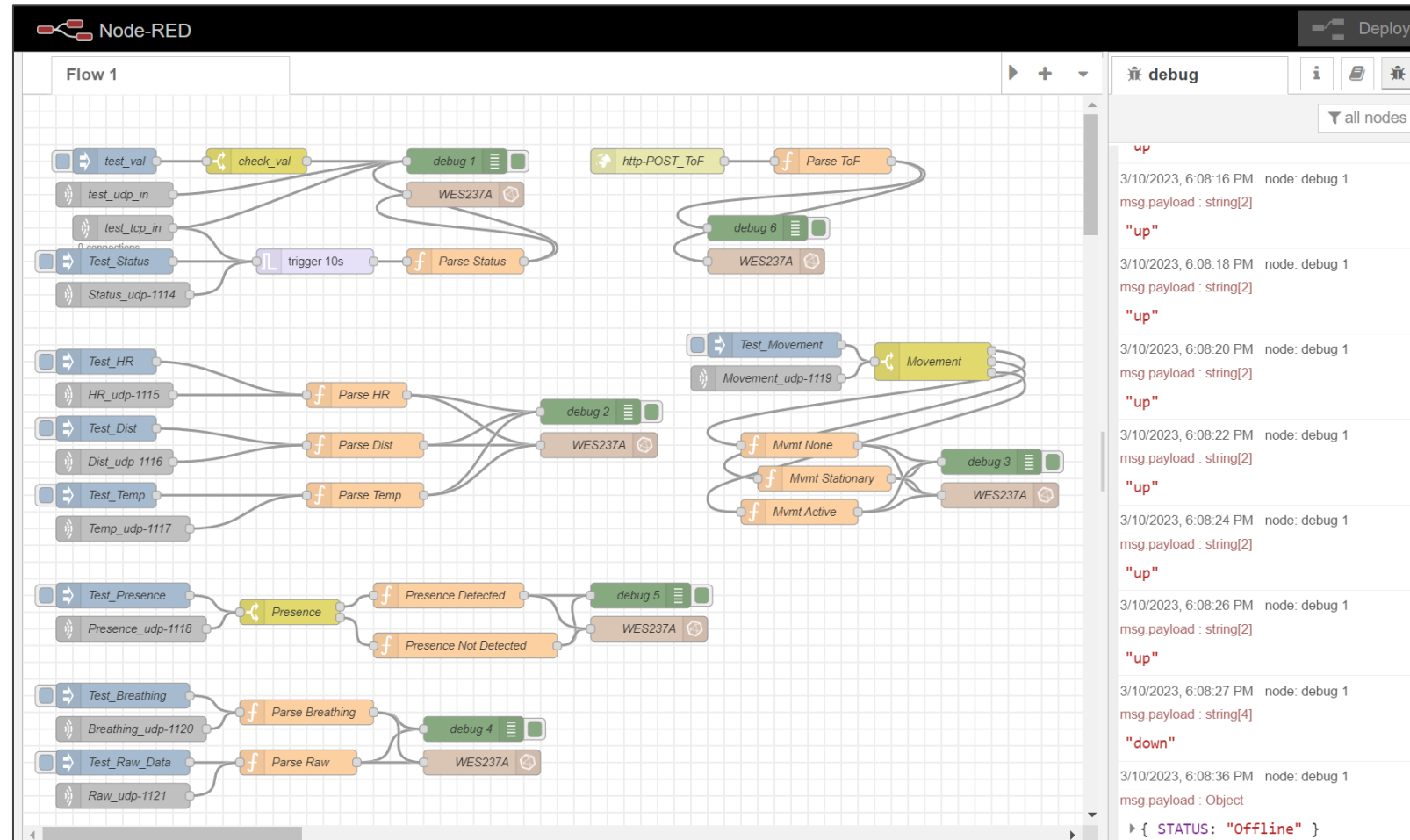
```
ubuntu@ip-172-31-45-123: ~  
  
0 [||| 1.3% 2299MHz] Tasks: 36, 123 thr; 1 running  
1 [||| 0.7% 2299MHz] Load average: 0.05 0.01 0.00  
Mem [||||| 654M/3.83G] Uptime: 1 day, 22:13:18  
Swp [ 0K/0K]  
  
PID USER PRI NI VIRT RES SHR S CPU% MEM% TIME+ Command  
491 mongodb 20 0 2548M 124M 59812 S 0.7 3.2 12:08.94 /usr/bin/mongod --config /etc/mongod.conf  
790 ubuntu 20 0 971M 140M 35288 S 0.7 3.6 6:21.88 node-red  
1 root 20 0 98M 11644 8268 S 0.0 0.3 0:08.37 /sbin/init  
171 root 19 -1 94192 50068 48844 S 0.0 1.2 0:02.61 /lib/systemd/systemd-journald  
215 root RT 0 282M 27360 9072 S 0.0 0.7 0:14.02 /sbin/multipathd -d -s  
218 root 20 0 282M 27360 9072 S 0.0 0.7 0:00.00 /sbin/multipathd -d -s  
219 root RT 0 282M 27360 9072 S 0.0 0.7 0:00.00 /sbin/multipathd -d -s  
220 root RT 0 282M 27360 9072 S 0.0 0.7 0:00.00 /sbin/multipathd -d -s  
221 root RT 0 282M 27360 9072 S 0.0 0.7 0:00.20 /sbin/multipathd -d -s  
222 root 20 0 23040 6616 4744 S 0.0 0.2 0:00.32 /lib/systemd/systemd-udevd  
223 root RT 0 282M 27360 9072 S 0.0 0.7 0:10.03 /sbin/multipathd -d -s  
224 root RT 0 282M 27360 9072 S 0.0 0.7 0:00.00 /sbin/multipathd -d -s  
425 systemd-n 20 0 16248 8024 6980 S 0.0 0.2 0:00.96 /lib/systemd/systemd-networkd  
427 systemd-r 20 0 25400 13512 9396 S 0.0 0.3 0:00.68 /lib/systemd/systemd-resolved  
460 root 20 0 2812 1148 1056 S 0.0 0.0 0:00.00 /usr/sbin/acpid  
463 chronogra 20 0 1207M 45776 29836 S 0.0 1.1 0:20.70 /usr/bin/chronograf  
466 root 20 0 7284 2728 2472 S 0.0 0.1 0:00.21 /usr/sbin/cron -f -P  
467 messagebu 20 0 8652 4840 4156 S 0.0 0.1 0:00.11 @dbus-daemon --system --address=systemd: --nof  
477 _chrony 20 0 18888 3388 2772 S 0.0 0.1 0:03.01 /usr/sbin/chronyd -F 1  
479 _chrony 20 0 10560 528 0 S 0.0 0.0 0:00.00 /usr/sbin/chronyd -F 1  
483 grafana 20 0 1656M 110M 63580 S 0.0 2.8 1:59.50 /usr/sbin/grafana-server --config=/etc/grafana  
490 root 20 0 82696 4044 3700 S 0.0 0.1 0:05.16 /usr/sbin/irqbalance --foreground  
492 root 20 0 33104 18760 10104 S 0.0 0.5 0:00.11 /usr/bin/python3 /usr/bin/networkd-dispatcher  
494 syslog 20 0 217M 5620 4276 S 0.0 0.1 0:00.55 /usr/sbin/rsyslogd -n -iNONE  
497 root 20 0 82696 4044 3700 S 0.0 0.1 0:00.00 /usr/sbin/irqbalance --foreground  
498 root 20 0 1346M 14768 9800 S 0.0 0.4 0:07.98 /snap/amazon-ssm-agent/6312/amazon-ssm-agent  
509 root 20 0 854M 47632 20300 S 0.0 1.2 0:08.47 /usr/lib/snapd/snapd  
519 root 20 0 15332 7500 6492 S 0.0 0.2 0:00.28 /lib/systemd/systemd-logind  
536 syslog 20 0 217M 5620 4276 S 0.0 0.1 0:00.30 /usr/sbin/rsyslogd -n -iNONE  
  
F1Help F2Setup F3Search F4Filter F5Tree F6SortBy F7Nice -F8Nice +F9Kill F10Quit
```

AWS EC2 SERVER: NODERED



NodeJS based Flow Process Manager
Application that facilitates data flow and
network communications using an
assortment of node modules:

- **Debug Nodes** - output data payloads to debug console
- **UDP and TCP Port Nodes** - host port communications
- **HTTP Endpoint Node** - supports HTTP-POST requests
- **JS Function Nodes** - Parse Received Data
- **Influxdb Nodes** - Forward Data into Database



AWS EC2 SERVER: INFLUXDB



Open-source Timeseries Database optimized for IoT applications

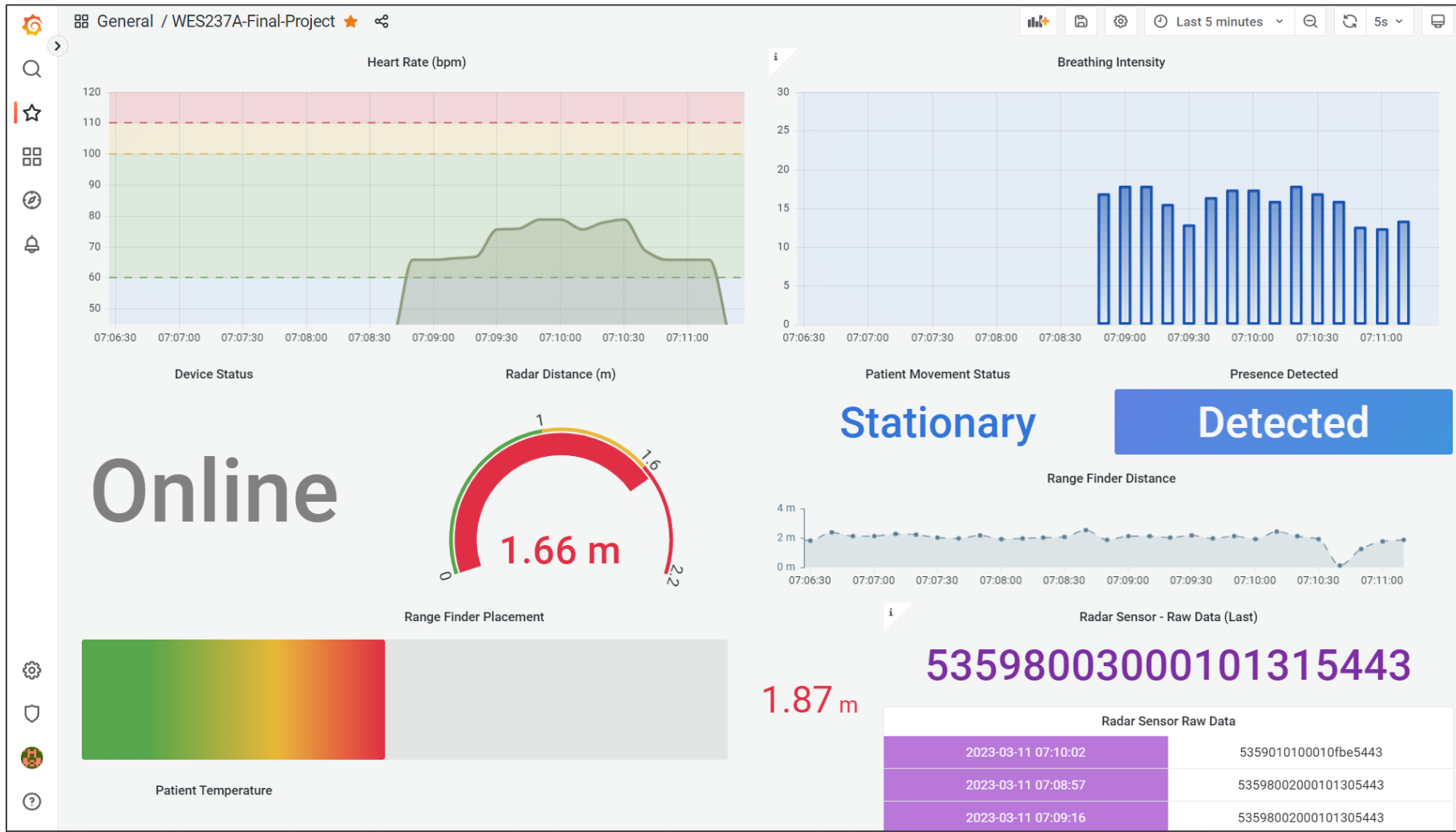
- Manages Storage of data entries
- Hosts Retention Policy to maintain long-term data accumulation
- Incorporates Timestamp for each data entry
- Accessed by Grafana Service to support dashboard visualization

```
>
> show databases
name: databases
name
----
_internal
WES237A
> show measurements
name: measurements
name
----
HEALTH
> SELECT last(*) from HEALTH
name: HEALTH
time last_BREATHE last_DIST last_HR last_MOVEMENT last_PRESENCE last_STATUS last_TEMP last_breathing last_raw
----
0      8           0.59      73      Active      Detected      Offline      99.5      11           5359070700
0100bb5443
```

AWS EC2 SERVER: GRAFANA



- Data Visualization GUI and Dashboard Application
- Reads and displays sensor data from Influxdb Database



ISSUES

MLX90614 Temperature Sensor

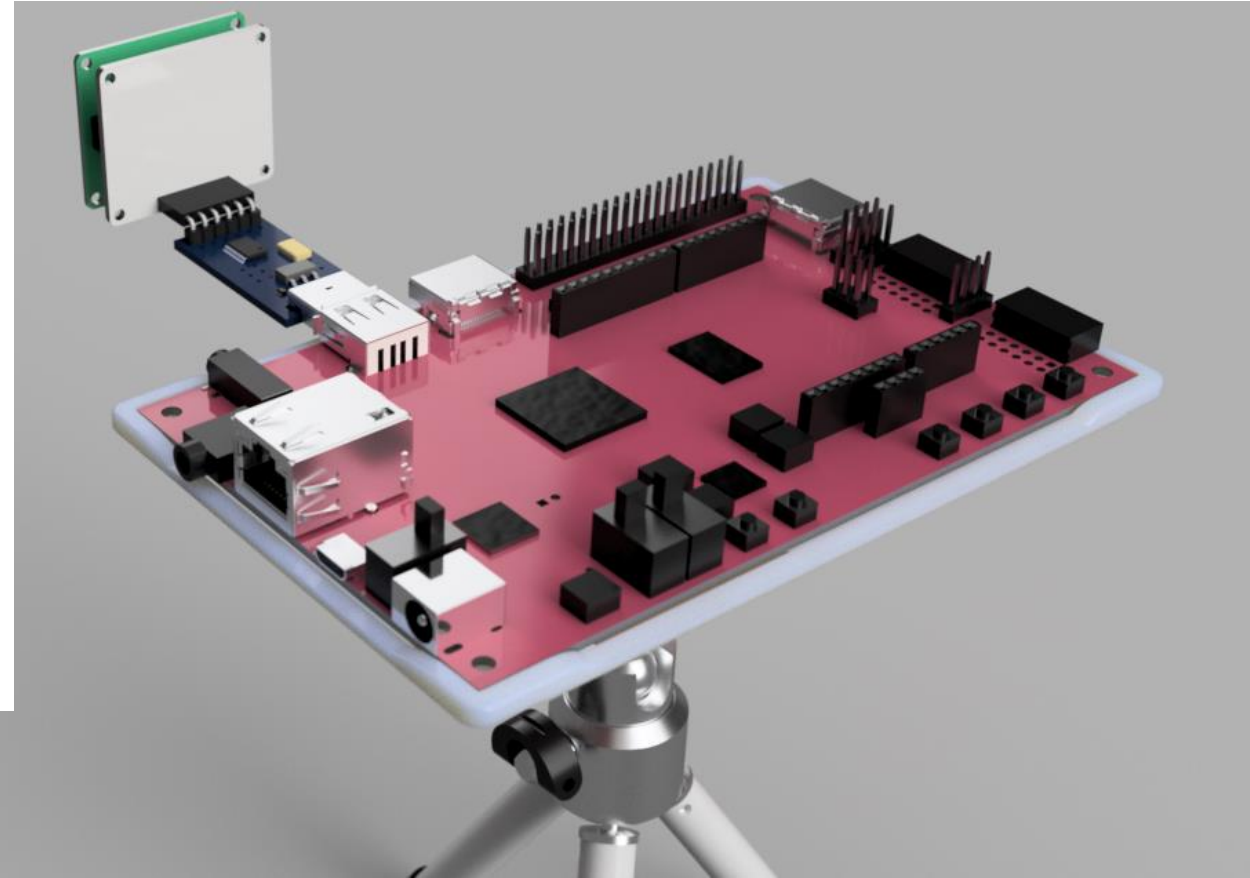
- I2C Reading Errors
- 'Errno 9 Socket Error Bad File Descriptor' with multiprocess

VL53L1X ToF Distance Sensor Integration

- I2C Device Detection Problems

MR60BHA1 60GHz Radar Sensor

- Intermittent performance of presence detection pin
- Serial message querying problems



NEXT STEPS

1. Spend more time troubleshooting I2C write/read steps on MLX90614 Temperature Sensor
2. Integrate bidirectional communications between AWS Server and PYNQ Board
3. Introduce improvements in data filtering to improve accuracy
4. Have PYNQ board facilitate Push Notifications/Alerts based on health anomaly detection
5. Integrate IP Camera stream into Health Monitoring System





www.wes237a.site:3000

1. Login with credentials:

Username: test

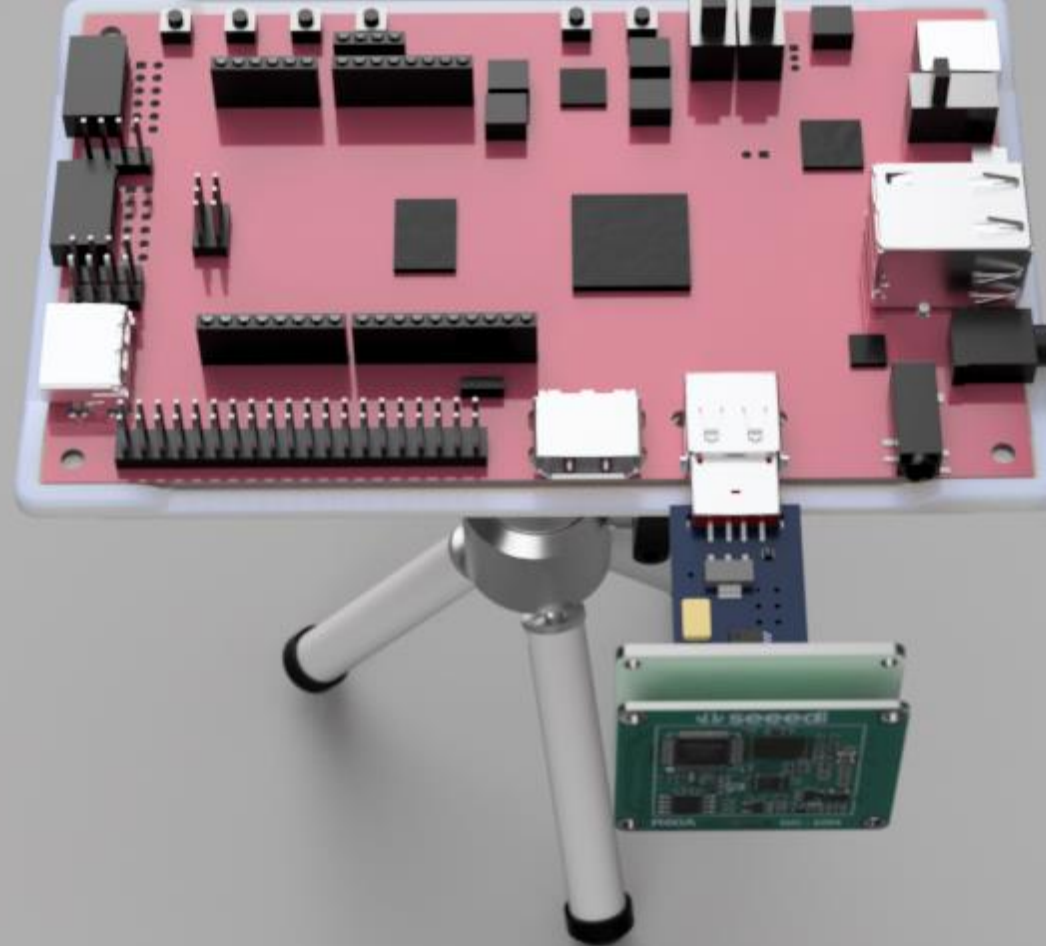
Password: test

2. Under *Dashboards*, click on:

WES237A-Final-Project

March 11, 2023

UC San Diego
JACOBS SCHOOL OF ENGINEERING



QUESTIONS / CLOSING