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Wireless Embedded Roadway Health Monitoring Network

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Project Scope

What are we doing?

Why are we doing it?

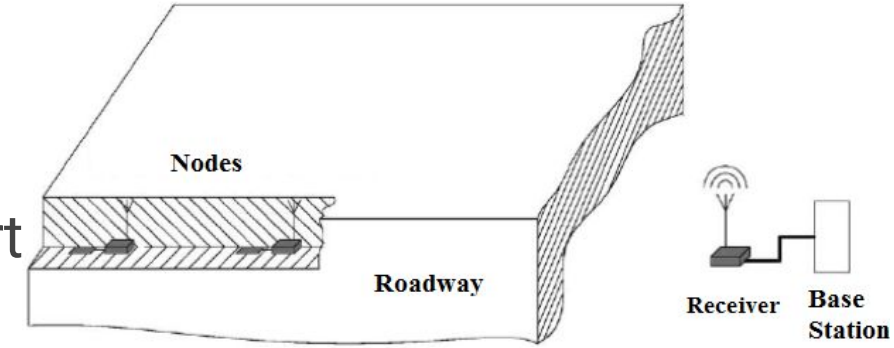
Past efforts

Project Scope - What are we doing?

We're starting Phase II of a network of nodes which measure humidity and temperature within roadways

Requirements of this network are:

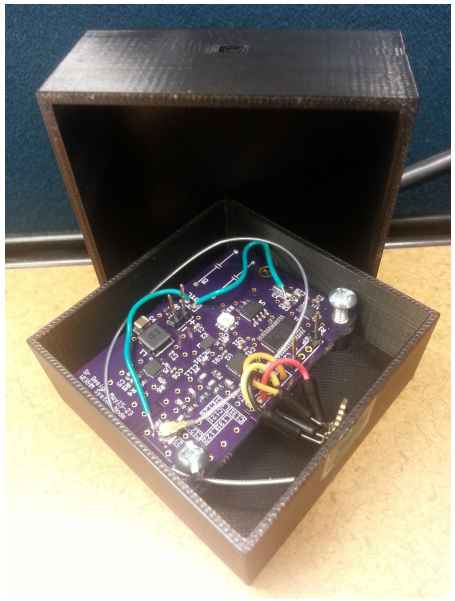
- ➔ Wireless communication between "smart pebbles" and a base station that stores data to transmit to smartphone
- ➔ Low power consumption for extended life
- ➔ Able to withstand harsh environment- temperature, chemicals, stress, etc.
- ➔ Node size must be small enough to minimize impact on road integrity



Project Scope - Why are we doing it?

- ➔ Provides a feasible method of monitoring the status of roadways and other structures throughout their lives
- ➔ Directly observes the condition of the roadway at different parts as often as desired
- ➔ Determines more accurately when a roadway needs to be replaced

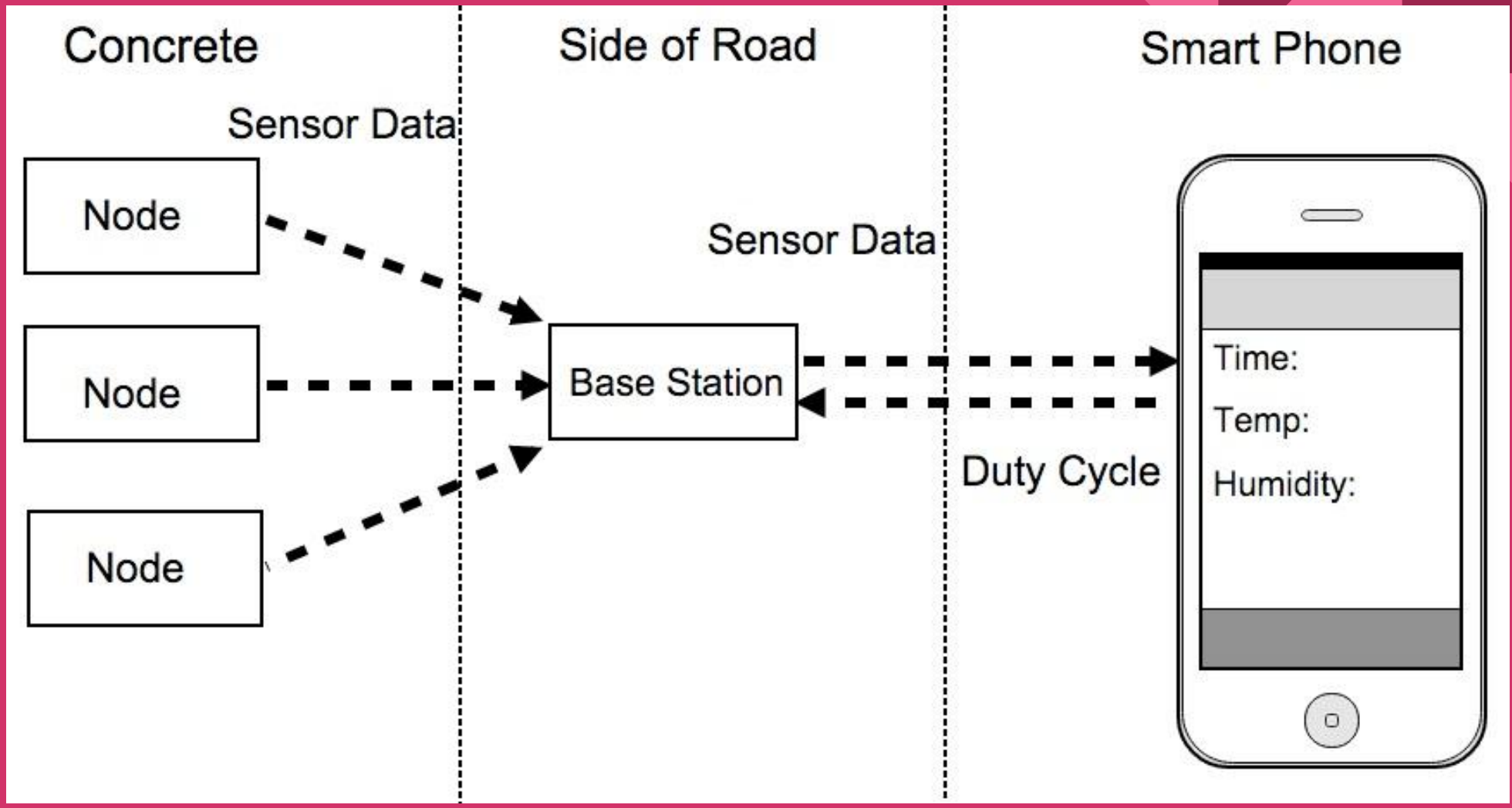
Project Scope - Past Efforts



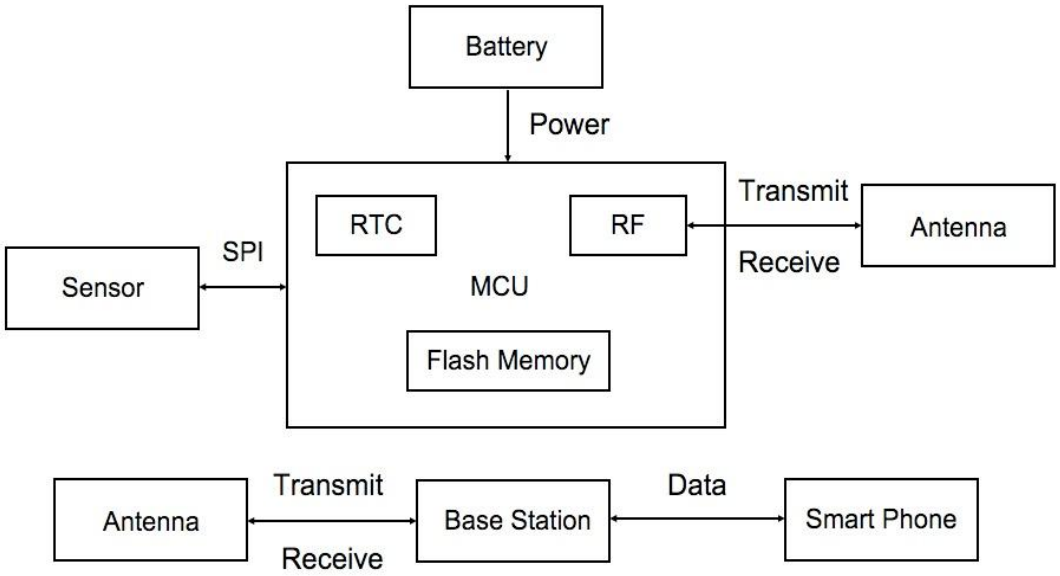
Phase I:

- ➔ **Wired Communication:** Delicate - connections destroyed during pouring and curing process of concrete
- ➔ **Wireless Communication using Zigbee operating at 2.4GHz:** Frequency too high to penetrate concrete
- ➔ Charging circuitry prohibitively large and expensive
- ➔ Enclosure too large and unwieldy to feasibly be poured with concrete

Conceptual Sketch in Phase II



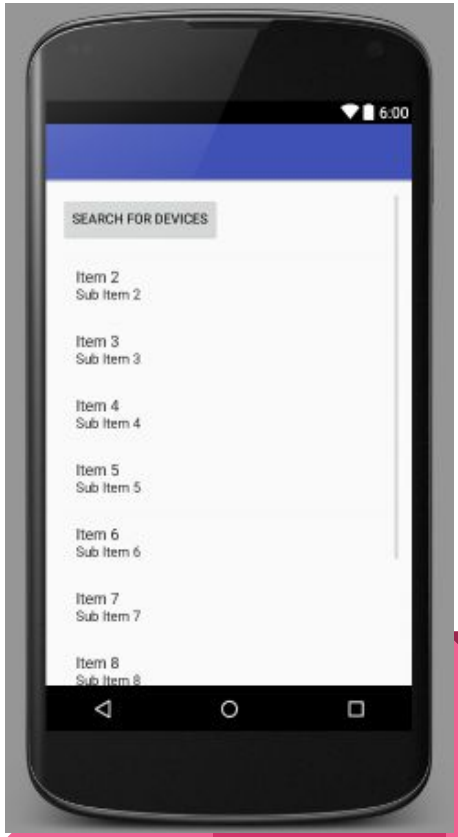
Current Design



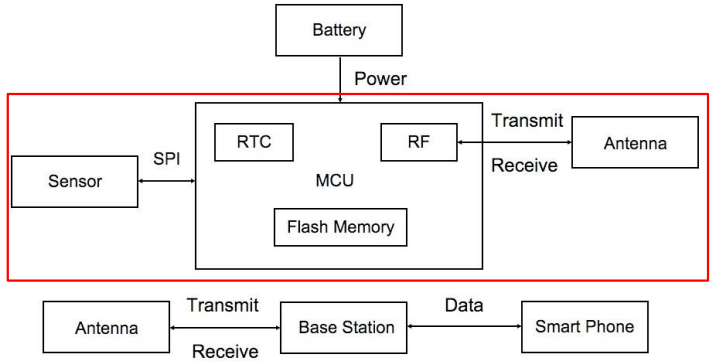
- ➔ Software / Networking
- ➔ Hardware
- ➔ Digital Circuit Layout
- ➔ Battery
- ➔ Enclosure
- ➔ Base Station
- ➔ Data extraction

Current Design - Software / Networking

- ➔ Wireless sensor network utilizes directed flooding technique
- ➔ Embedded code will be optimized for low power consumption, very short ‘awake’ time
- ➔ Android applications for smartphone and base station communicate via Bluetooth

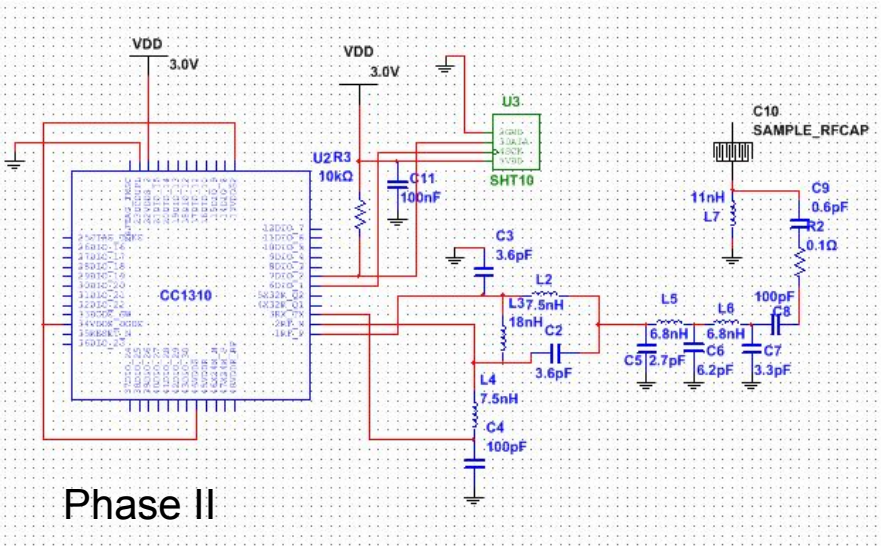


Current Design - Hardware

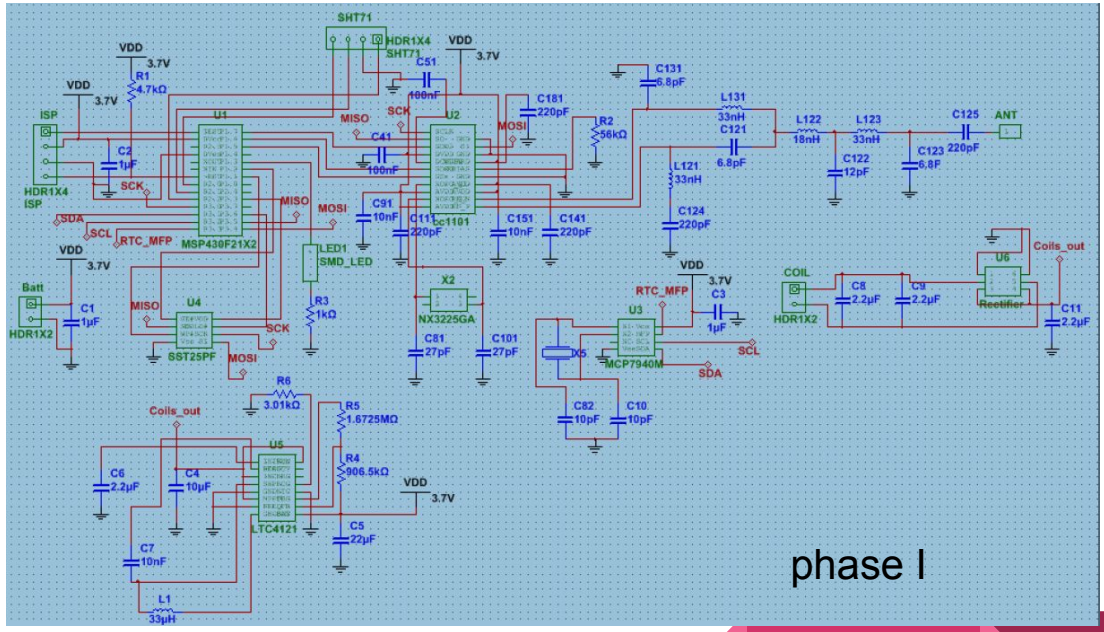


- Powered by TI CC1310 Microcontroller
  - Real-time clock (RTC) for accurate timekeeping
  - Low-power radio frequency (RF) transceiver
  - 128KB programmable flash memory
- Sensirion SHT10 temperature and humidity sensor
- Vishay VJ 6040 ceramic chip antenna
- Overall size ~1” x ~1”

Current Design - Digital Circuit Layout

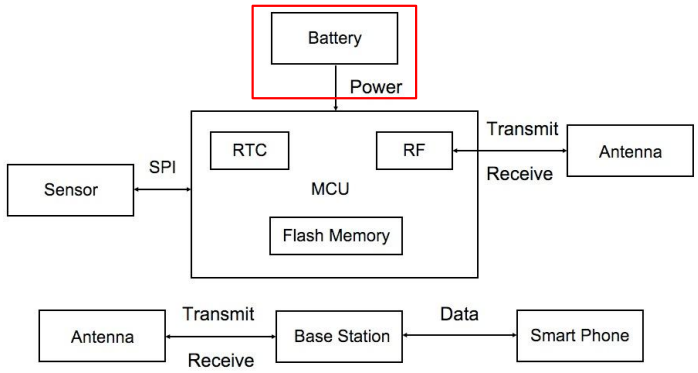


Phase II



phase I

Current Design - Battery



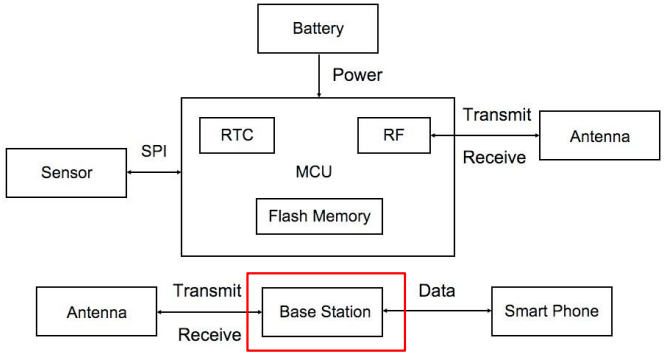
- ➔ 1000 mAh capacity
- ➔ Assuming 30 min duty cycle:
  - ◆ Consumption per hour: 18.4mA
  - ◆ Battery life in hours: 1000/.0184 = 54,347 h
  - ◆ Battery life in days: 54,347/24 = 1151 d
  - ◆ Battery life in years: 3.15 y
- ➔ This fulfills the lifetime requirement

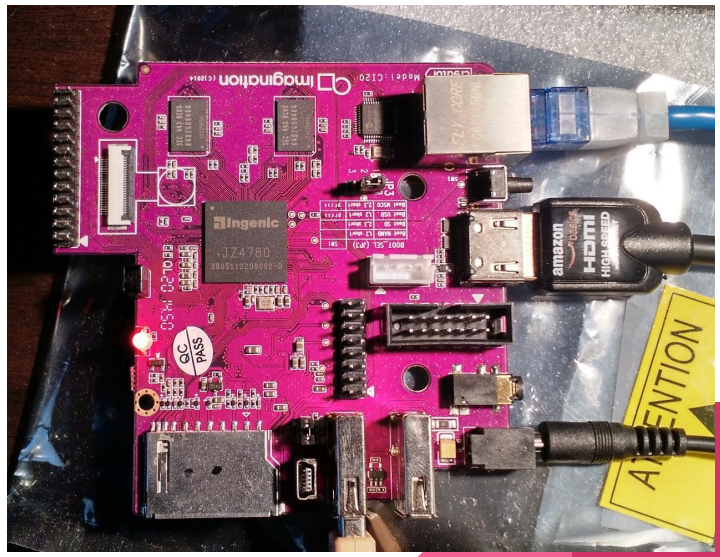
Current Design - Enclosure

- ➔ Will 3D print enclosure to be roughly 1.1”x1.1” or smaller
- ➔ Needs to withstand the heat, pressure, and acidity of curing concrete
  - ◆ While allowing the sensor to accurately take measurements

Current Design - Base Station

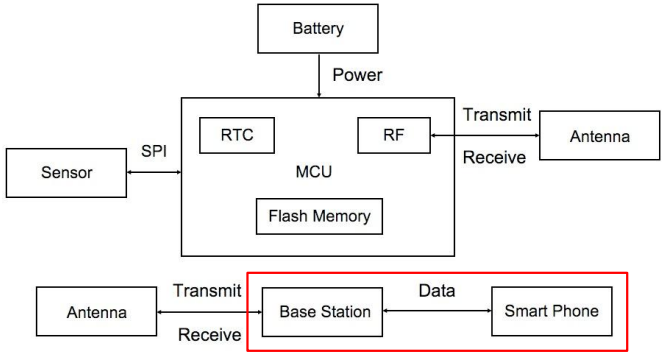
- Base Station is the system's access point
  - Collect readings from network
  - Configure duty cycle
- Creator CI20 microcomputer





Current Design - Data Extraction

- ➔ Smartphone will connect to base station via Bluetooth
- ➔ Base station will send smartphone all of its nodes' data
- ➔ User can define duty cycle for nodes to take readings



Resource/Cost Estimation

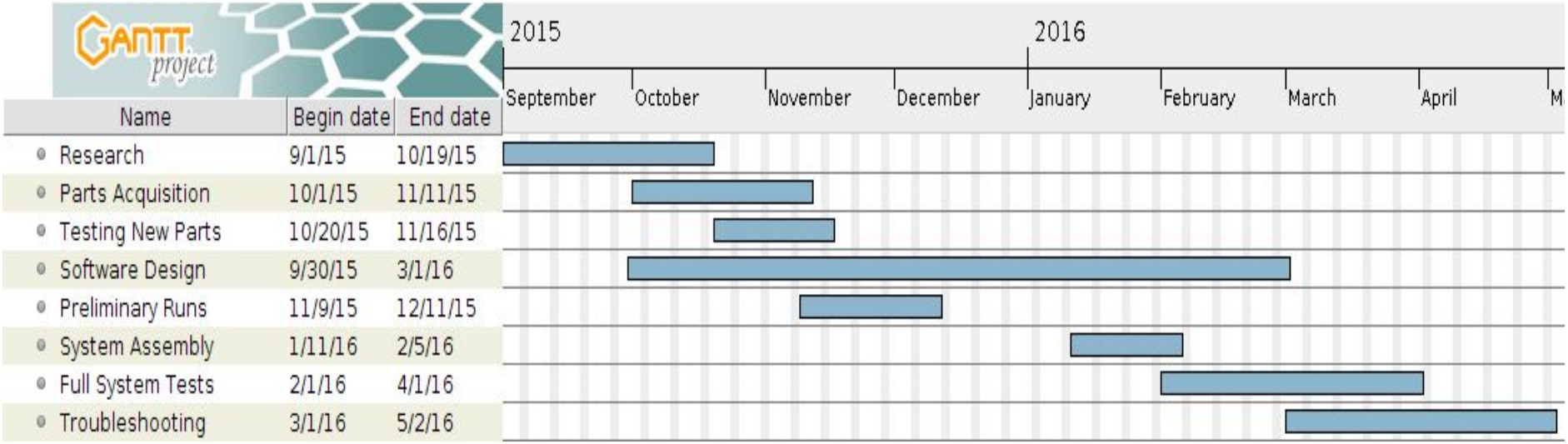
Part Name	CC1310	MX25Rxx35F	XDS100v2	CR2477	48-QFN or 48-TQFP - 3 Pack	SHT10	VJ 6040
Cost	$15.10	$1.22	$79.00	$6.50	$5.95	$7.20	$10.56
Type	Microcontroller	Flash Memory	Debugger	Battery	Breakout Board	Sensor	Antenna

Total Cost: $125.53
Cost for One Product: $39.36

Challenges

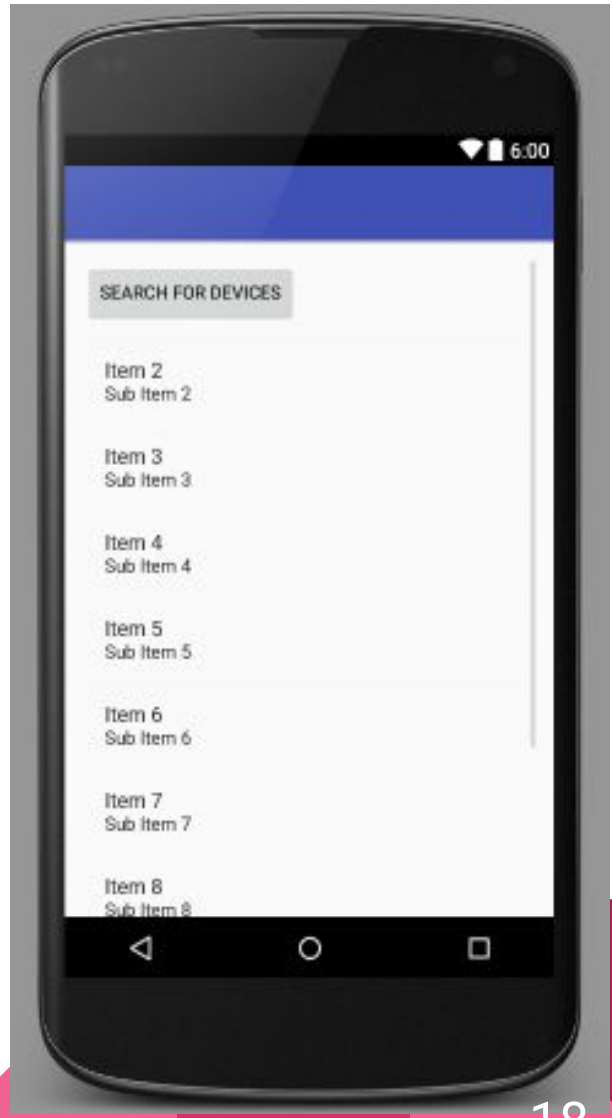
- Sensor Exposure
  - Expose the sensor indirectly to the concrete environment
  - Protect circuit from outside
- Temperature
  - Exposure to Iowa summer/winter temperatures
- Communication
  - Antenna bandwidth limits frequency
  - Frequency must be able to penetrate concrete

Project Schedule



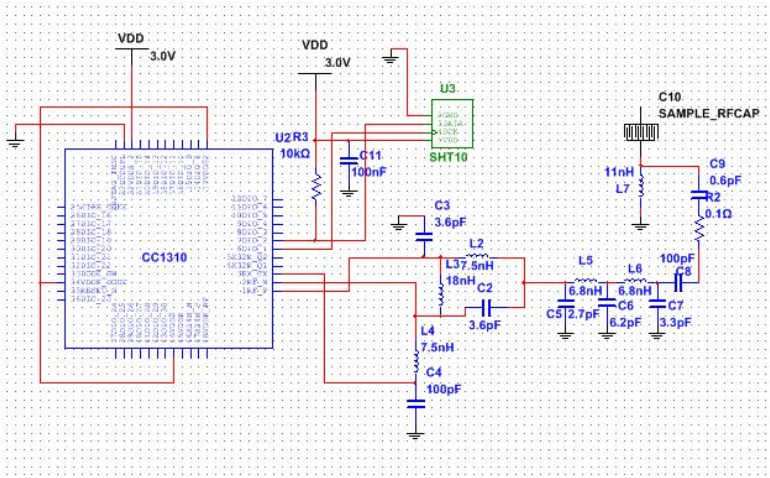
Current Status (Software)

- ➔ Bluetooth client Android app (for smartphone) connects to base station(s)
- ➔ In progress: Bluetooth server app (for base station)
- ➔ Embedded software in research phase



Current Status (Hardware)

- ➔ All parts received
- ➔ Digital circuit design
- ➔ Conceptual Printed Circuit Board (PCB) design is in progress

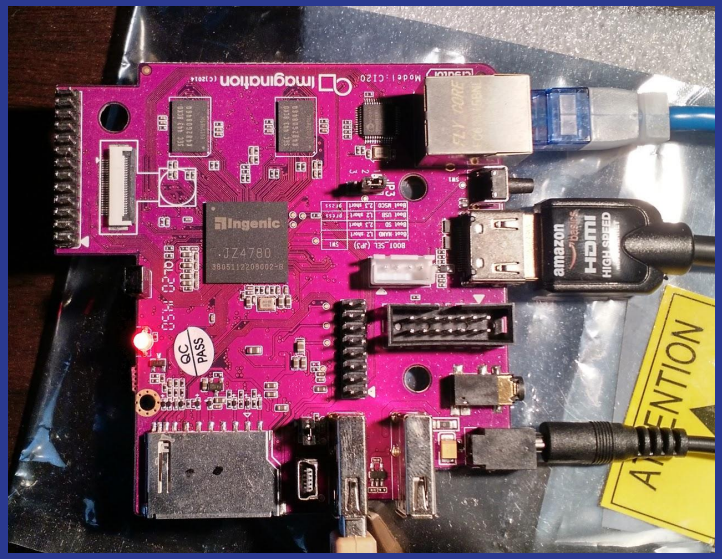


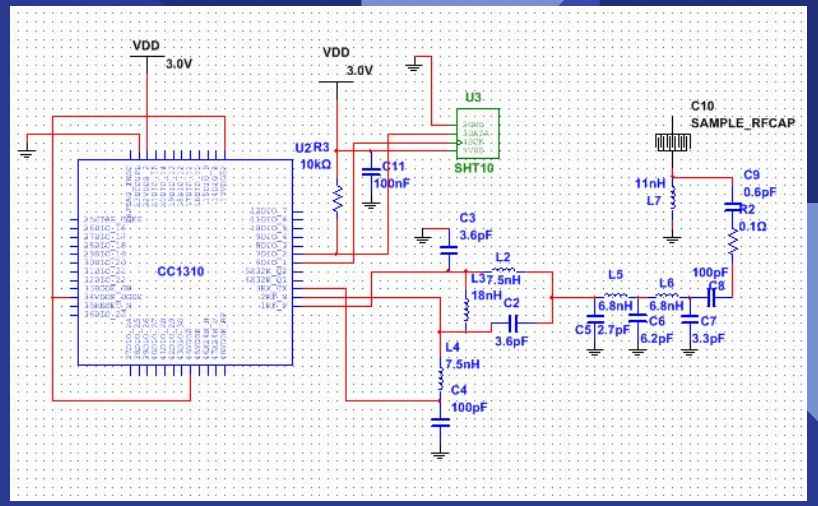
Plans for 492

- ➔ Finish PCB layout design
- ➔ Design and print the enclosure
- ➔ Finish and test microcontroller code
- ➔ Finish and test Android applications
- ➔ Testing communication function

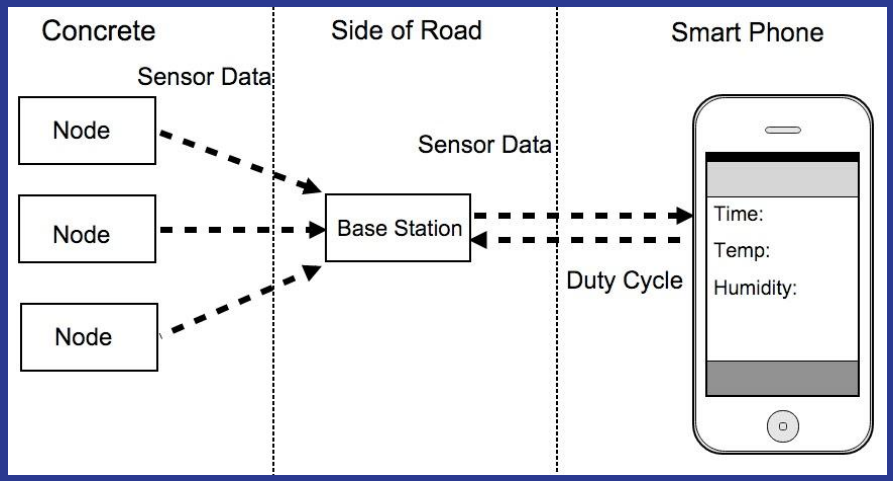
Member Contributions

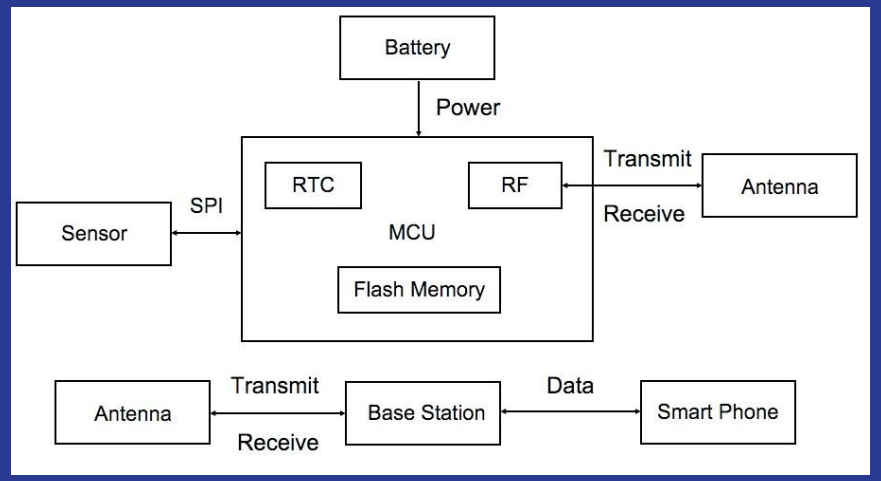
- ➔ Shen and Qichen: Digital circuit design and PCB layout
- ➔ Matt and Darnell: Android bluetooth client and server apps


Ingenic
JZ4780
QC PASS
amazon basics
HDMI
ATTENTION


VDD
3.0V
VDD
3.0V
U3
SHT10
U2:R3
10kΩ
C11
100nF
C10
SAMPLE_RFCAP
C9
0.6pF
R2
0.1Ω
11nH
L7
C3
3.6pF
CC1310
L2
L3 7.5nH
18nH
C2
3.6pF
L4
7.5nH
C4
100pF
L5
6.8nH
L6
6.8nH
100pF
C8
C5 2.7pF
C6
6.2pF
C7
3.3pF

Questions?


Concrete
Side of Road
Smart Phone
Sensor Data
Node
Node
Node
Base Station
Sensor Data
Duty Cycle
Time:
Temp:
Humidity:


Battery
Power
Sensor
SPI
RTC
RF
MCU
Flash Memory
Transmit
Receive
Antenna
Antenna
Transmit
Receive
Base Station
Data
Smart Phone