Smart Irrigation System

C-Sprinkler

Team Chase Technologies

Presentation Outline

- Team Members
- Current Market
- System Overview
    - Hardware
    - Software
    - Mobile App
- Financial & Timeline
- Conclusion

Team Members

Gray (Yu Heng) Lin
- Chief Executive Officer

Chase (Youdao) Wen
- President & Chief Information Officer

Team Members

Abel Lin
- Chief Technology Officer
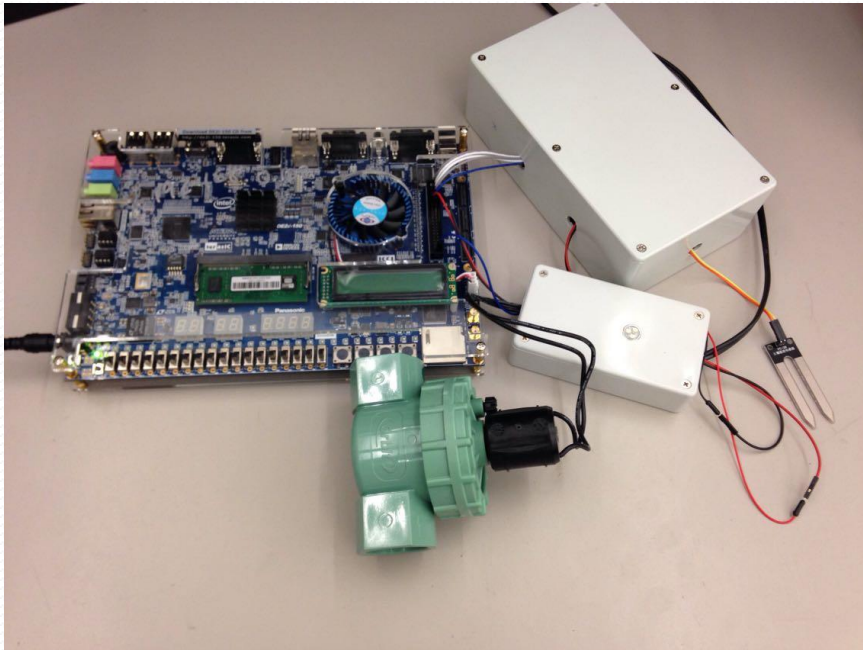
Yolanda Wu
- Chief Operation Officer

Yuchen Wang
- Chief Financial Officer

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What is C-Sprinkler

Smart Irrigation System

- Independent AI
- Remote control ability
- Environment monitoring
- Cloud Service

Functions and Features

- Traditional Features
  - Set timer
  - Direction change of sprinkler
- Smart Features
  - Automated irrigate
  - Mobile App
  - Multi-Clients
  - Environment monitoring
  - Reduce water usage

Motivation

- Internet of Things (IOT)
- Popularity of mobile phones
- Daily garden work

Market Potential

According to census of Canada

- In 2011, 20 million people are living in single-detached house

- 2% increase in the period from 1996 till 2006

- 68.4% of Canadian house holds owns their home with 7 million households owns a single-detached house

- By 2011, this number increased to 7.3 million

% of private dwellings owned
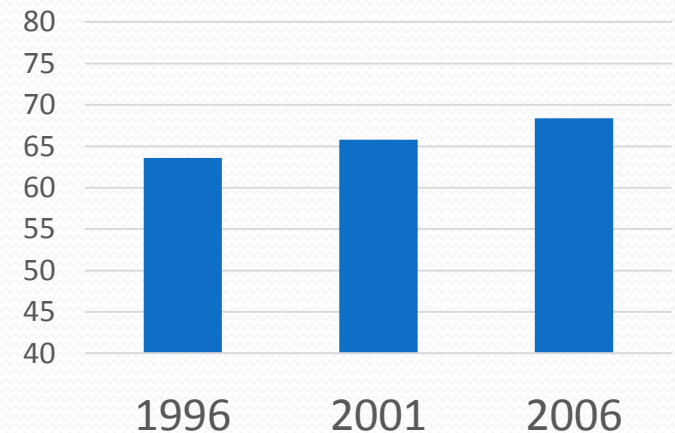
Internet of Things

- Google has spent 3.2 billion for Nest lab
- Later Nest lab acquired Drop Cam for 550 million
- With 3.75 billon, Google has created its own in-house platform for Internet of things

- Apple announced HomeKit, at their developer conference in San Francisco
- HomeKit is a set of develop tools for vendors to connect their Internet of things with Apple's ios devices
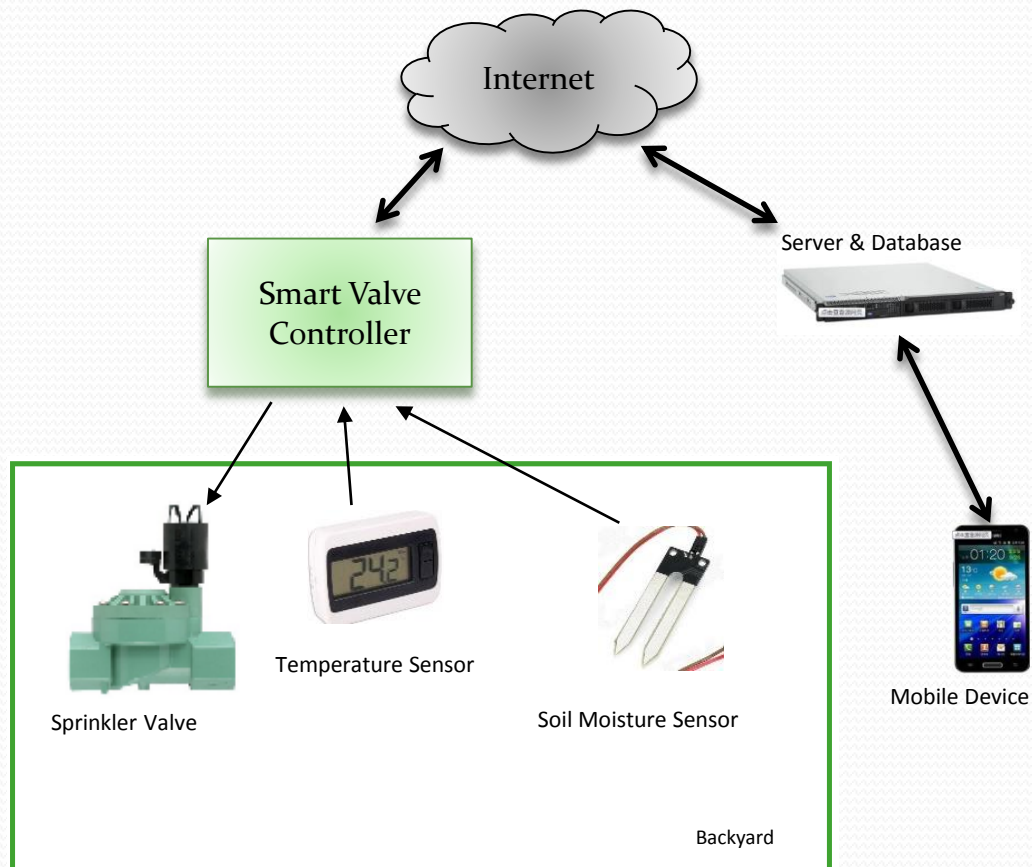
Current Competitions
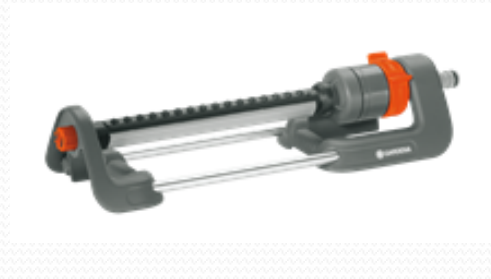
1. Most Basic sprinkler   2. Irrigation auto timer   3. The smart watering system
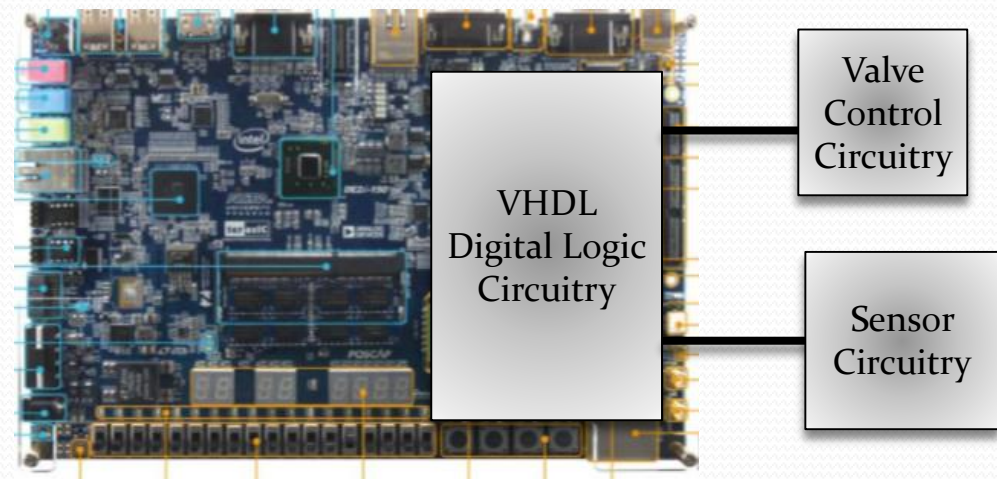
System Overview

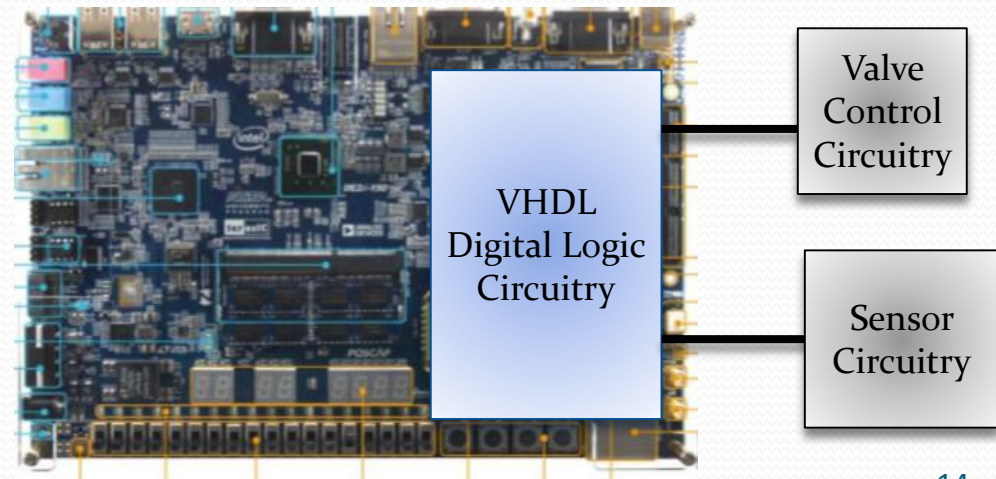# Hardware

Hardware Overview

- Overall Functionalities
  - Traditional Irrigations Functionalities
  - Temperature and Soil Moisture
  - Communicate with CPU

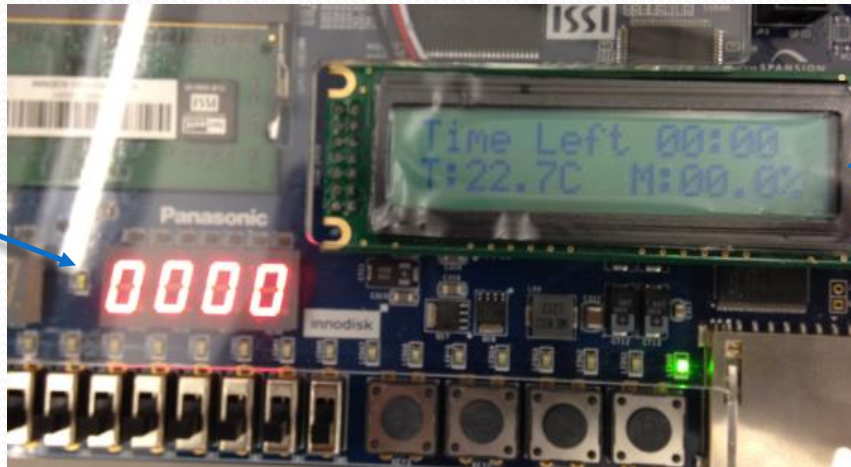# VHDL Digital Logic Circuitry

- Implementation
    - ALTRA Cyclone FPGA
- Why use FPGA
    - High Speed
    - High Design Flexibility
    - Reliable
- Main Logic Blocks
    - Timer Controller
    - LCD
    - Sensor Controller
    - PCIe Controller

Digital Logic Circuitry (Timer & LCD)

LED shows the Remaining time (only for debugging)

LCD shows remaining time, Temperature and Soil Moisture


Stop Start +   -

1. Pressing +/- allows time to be accumulated when device is idle and begin to decrease by pressing 'start' button
2. Add/Sub time will be implemented immediately if device is running
3. Time can be reset by pressing 'stop' button

Sensor Controller

- Functionalities
  - Activate the sensor when needed
  - Capture and process the sensor data based on the sensor timing and pattern
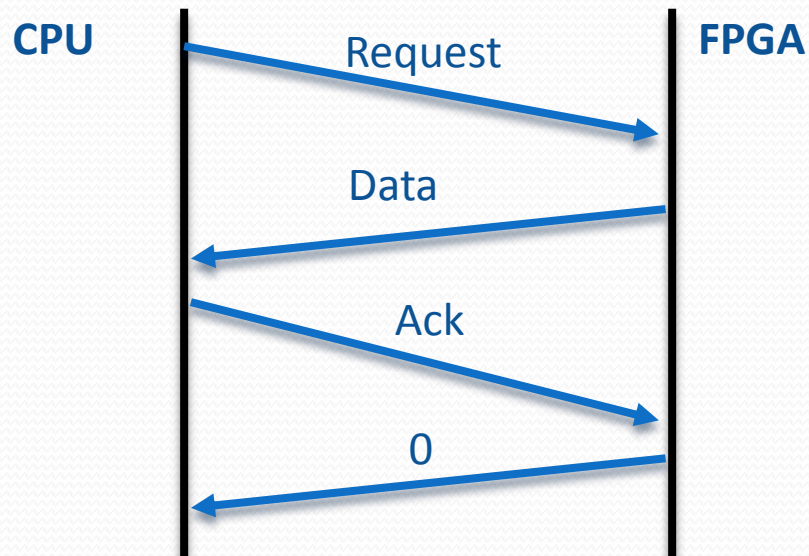 - Dispose current cycle if unexpected signals occur
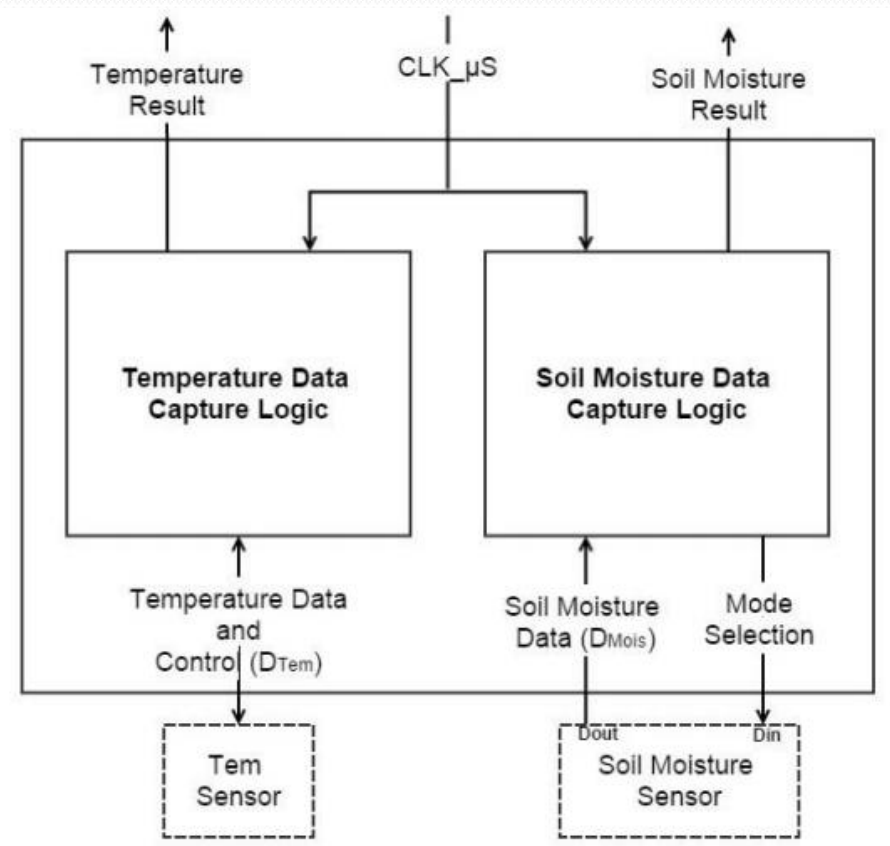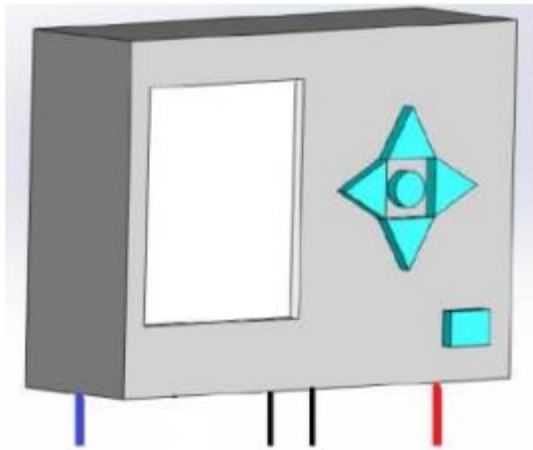
PCIe Controller

- Functionalities
    - Synchronized changed to processor
- Handshaking Process
    - Follows certain rules to prevent data lose

CPU   Request   **FPGA**

Data

Ack

0

Device Enclosure (Final Product)

Ethernet Cable

Sensor Connection

Valve Control

Sensor Circuitry

VHDL
Digital Logic
Circuitry

Valve
Control
Circuitry
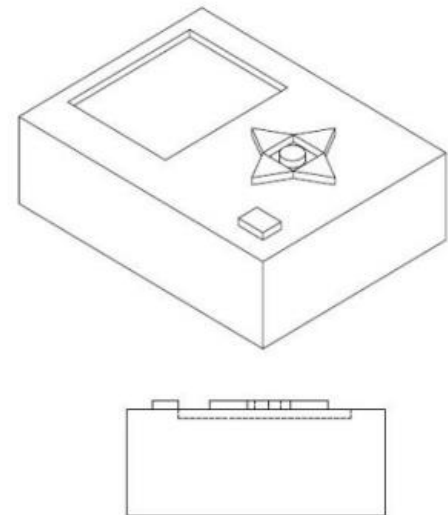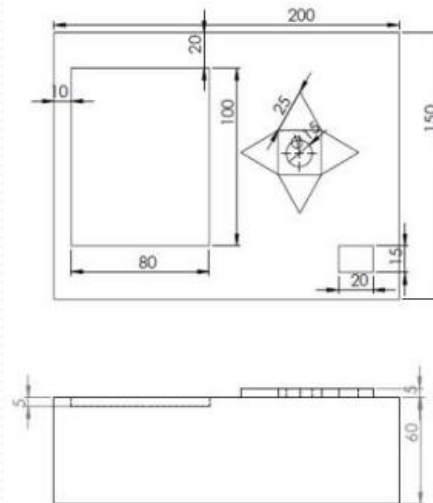
Sensor
Circuitry

- Provide stable environment measurement for the device
- Temperature Sensor: DH22 Sensor
- Soil Moisture Sensor : Moisture Brick + ADC3008

Prototype Vs Final Product
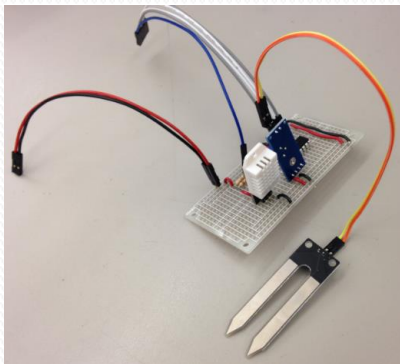
Prototype
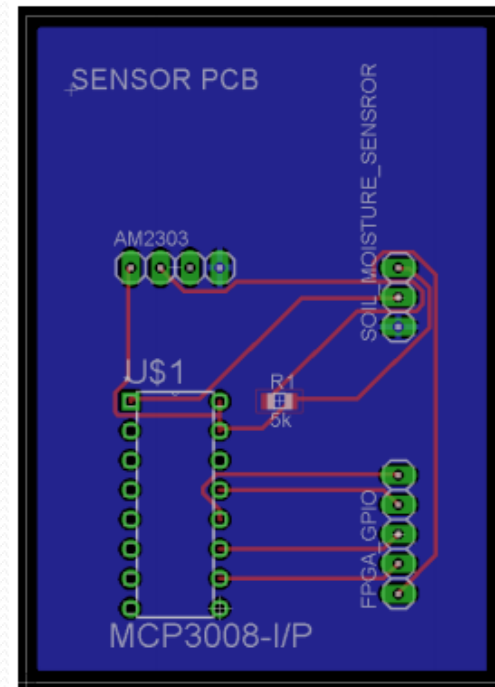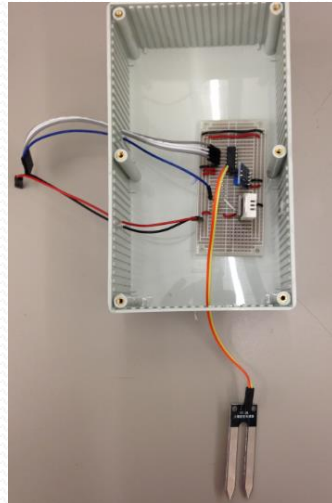
Final Product

Prototype Vs Final Product

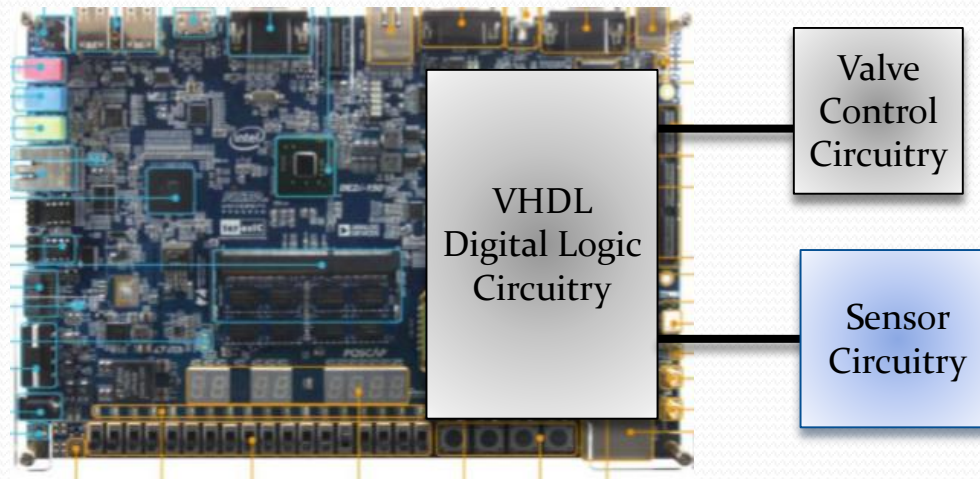| Item	Prototype	Final Product
Circuit Base	Perfboard	Printed circuit board
Enclosure	Yes	Yes
Sensor waterproof	No	Yes
Size	Larger to circuit size	Fit to circuit size
Circuit Protection	No	Yes
Soil Moisture Position	No requirement	Requirement varies based on soil type

Valve Circuitry

VHDL Digital Logic Circuitry

Valve Control Circuitry

Sensor Circuitry
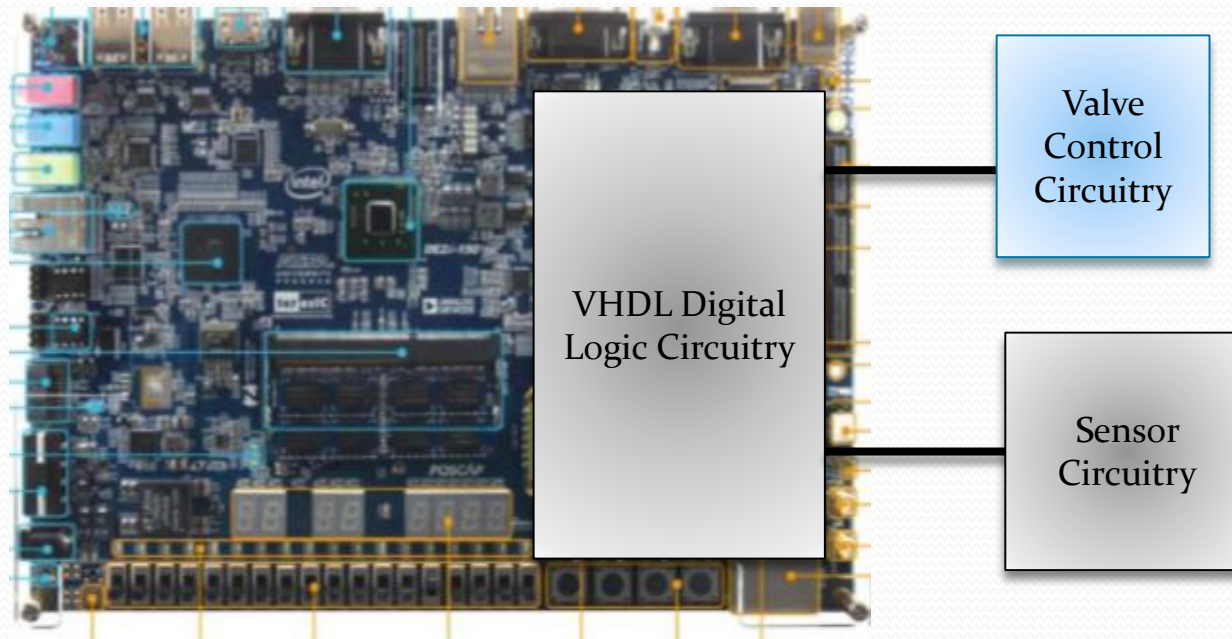
Valve Circuitry

- Control valve power (24VAC) depends on device output (3.3 V)
- Circuit is protected from 24 VAC by
  - Device controls the relay by bipolar junction transistor (BJT)
  - Diode protects the relay from electric arc
- Final product will assemble valve circuitry into the device

BJT

Relay

Indicator

Diode

23
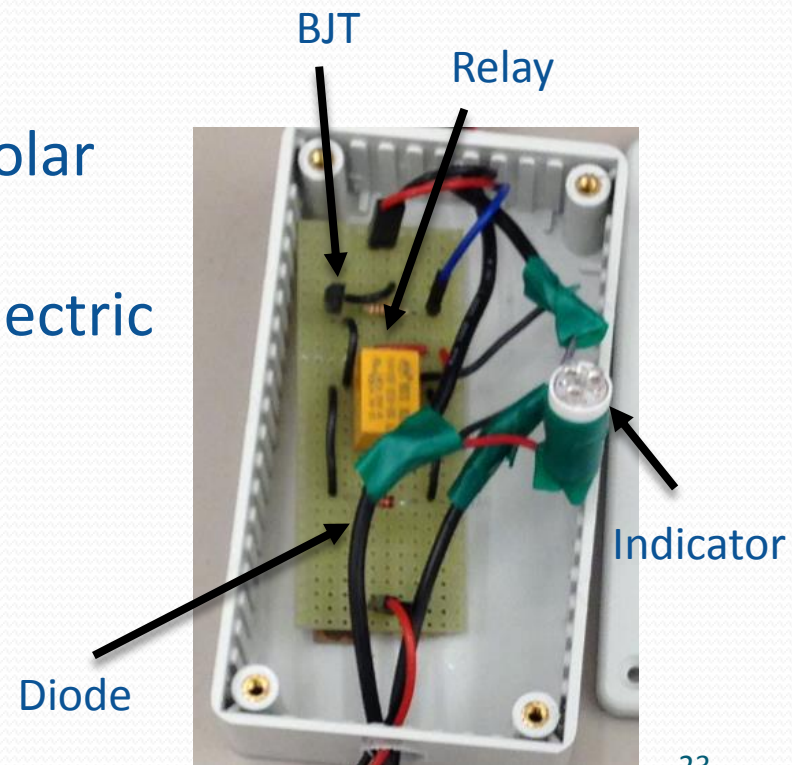
Valve Circuitry
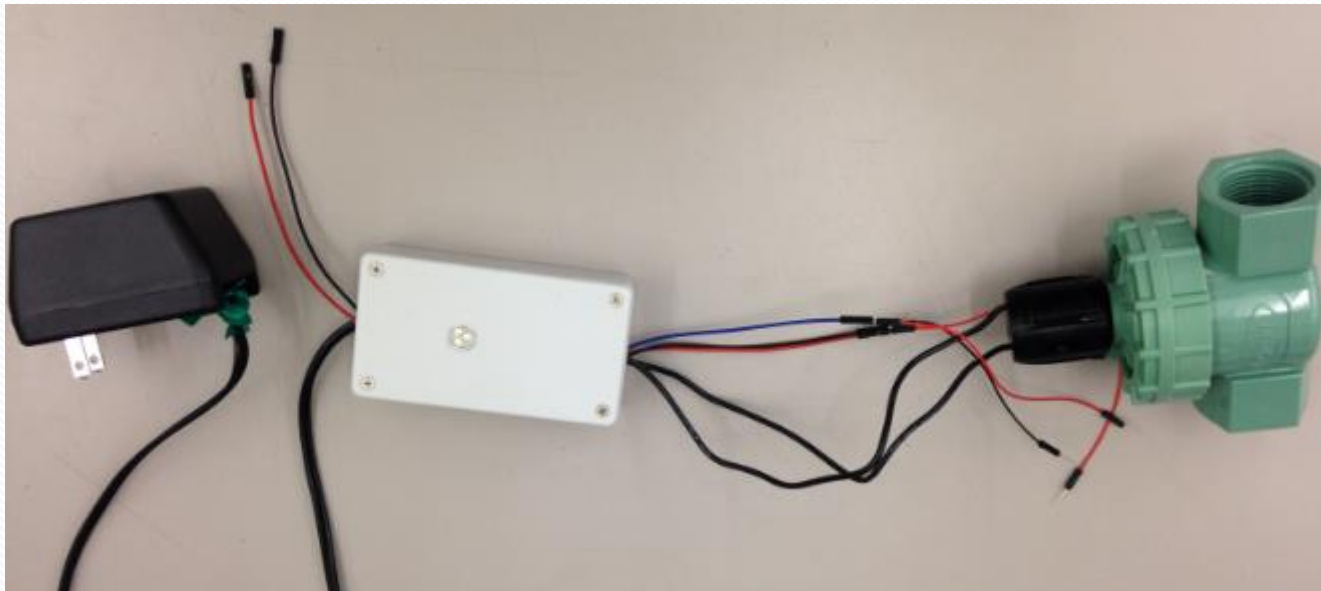
Software & Networking

cLogic – Embedded Software

- 3 Targets
    - Device work on itself, and no user input required
    - Users can monitor device remotely, and status update in real time
    - No complex set up

cLogic – Embedded Software

- Synchronizes with hardware
- Communicates with server
- Determines actions (logic)
- Provides developer a debug console
- Emulates the hardware while executing automation test

cLogic – Embedded Software

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11 Threads, handles different tasks concurrently

Function	Child functions	Purpose
Valve Timer	Timeline tracker	Manage timer
Tunnel	Tunnel Connection Tunnel Timer	Maintain connection with server
Hardware handler	Fetch Cycle Send Time	Synchronize sensors and time data
Scheduling Agent	Forecast checker Block policy checker	Determine actions from all the conditions
Measurement Agent		Push sensors data to server
Engineering Screen	UI Manager Control Panel Logger Forecast Agent	Display information for debugging Allows users to overwrite system
Emulation Mode	Automation	Updates sensors data in emulation mode

Real World Internet

Irrigation Control Unit

Irrigation Control Unit

Irrigation Control Unit

Mobile Client

Networking
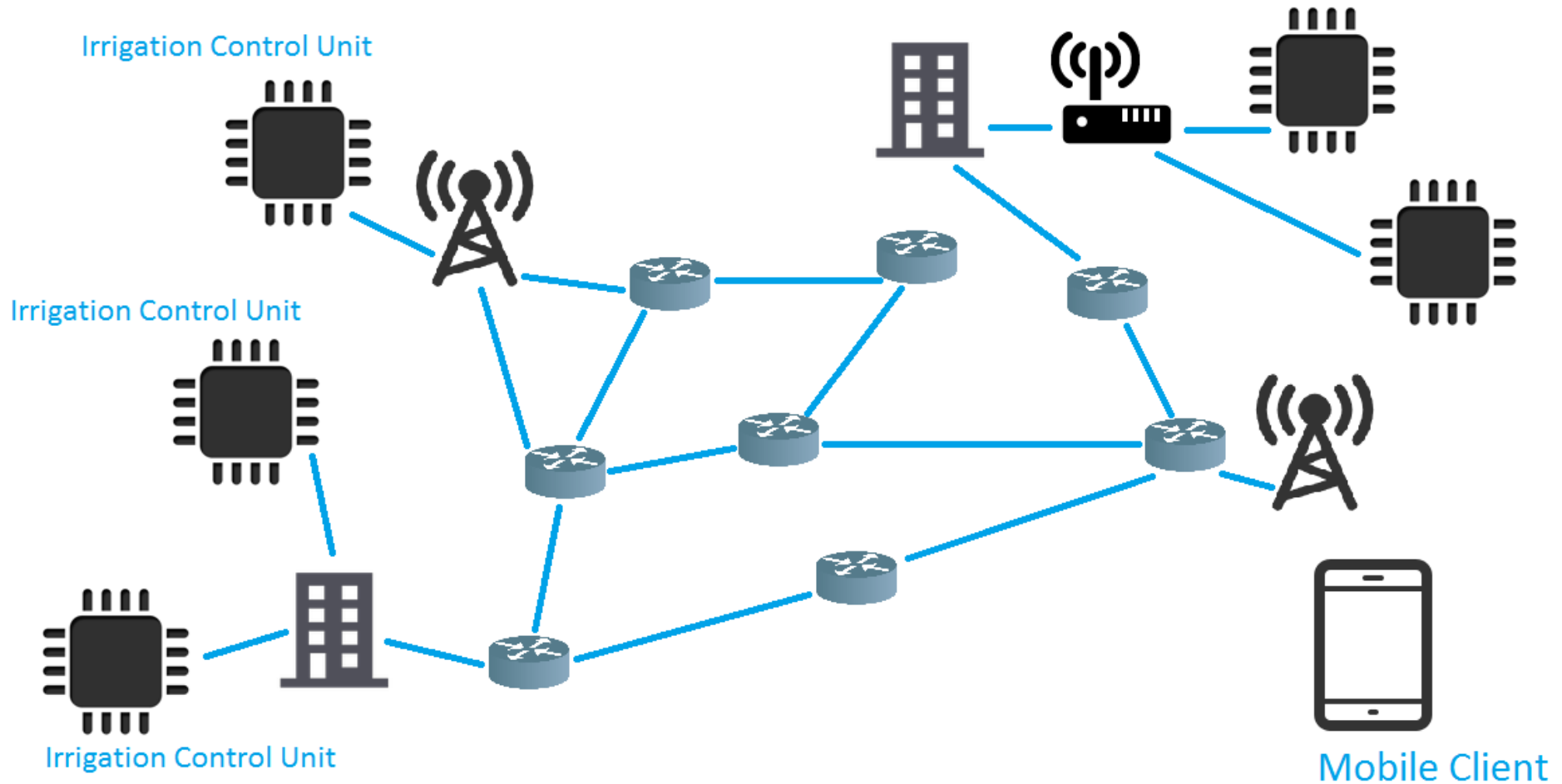
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Our solution: Application Overlay Network
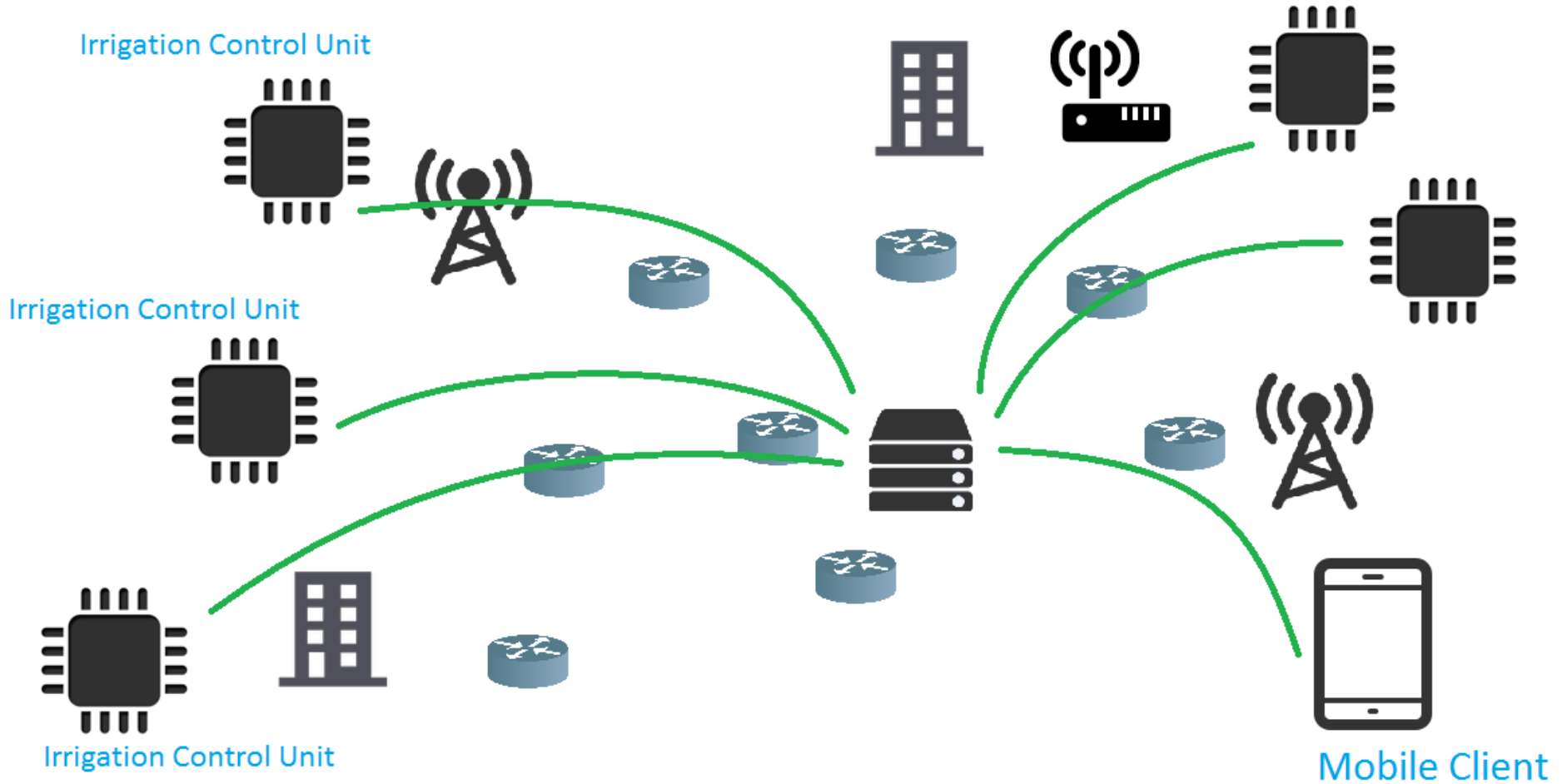
Networking

Sever and Networking Architecture

Database

Mobile Client

Server

Irrigation Control Unit
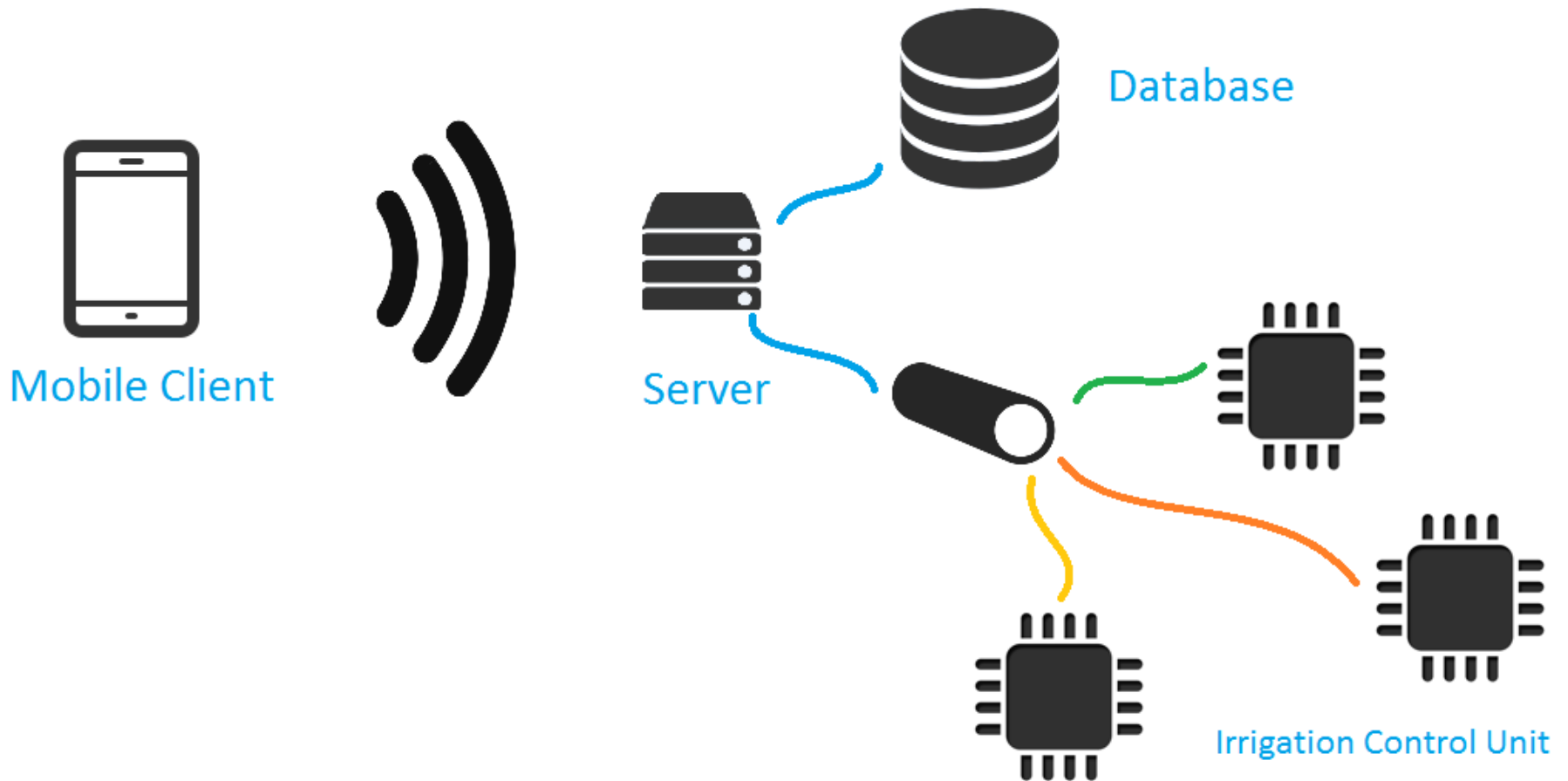
Networking

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– DataConnector API

– Designed a Java class library for communication

– Developer only needs to call the library for requesting data and sending commands

– Easy deploy to developers

– Easy to update communication handshaking and policies on server and clients

– Cross platform

Networking

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- Multi clients connection

- Amazon EC2 Cloud Services

- Distribute 1000 cLogic clients for our trial test with automation test cases

- Developed a web HTTP command line interface, and group management console, using DataConnector

- Debugging using logging file in automation

Traffic and Performance Analysis

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- 1 minutes heart beat message
    - 183 byte from Server to Client
    - 132 byte from Client to Server

- Tunnel Traffics
    - Request status message (req) / Sync at every 5 seconds when at request page
    - 168 byte from Server to Client
    - 237 byte from Client to Server

- Time change functions (add, sub) / When pressing control buttons
    - 163 byte from Server to Client
    - 234 byte from Client to Server

(data analyzed in wireshark)

Traffic and Performance Analysis

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Per minute request	cLogic		requestor		Server	
	Download	Upload	Download	Upload	Download	Upload
1 heatbeat	183	132	none	none	132	183
12 sync req	2016	2844	2844	2016	4860	4860
10 keys pressed	1630	2340	2340	1630	3970	3970
Average for 20% of user using Tunnel	912.2	1168.8	1036.8	729.2	1898	1949

Unit in bytes

In a 70Mbps/6.5Mbps link

Upload bandwidth of sever is the bottleneck

$((6.5/8)*1000000)/1949 =\sim 25,000$

Theoretically, our server can handle ~25,000 clients

Web Graphic User Interface

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- Currently only for debugging purpose

- Multi client control

http://cancunlab.ca/dc_test/

Mobile App

Mobile App: Structure

![Team Chase Technologies logo]
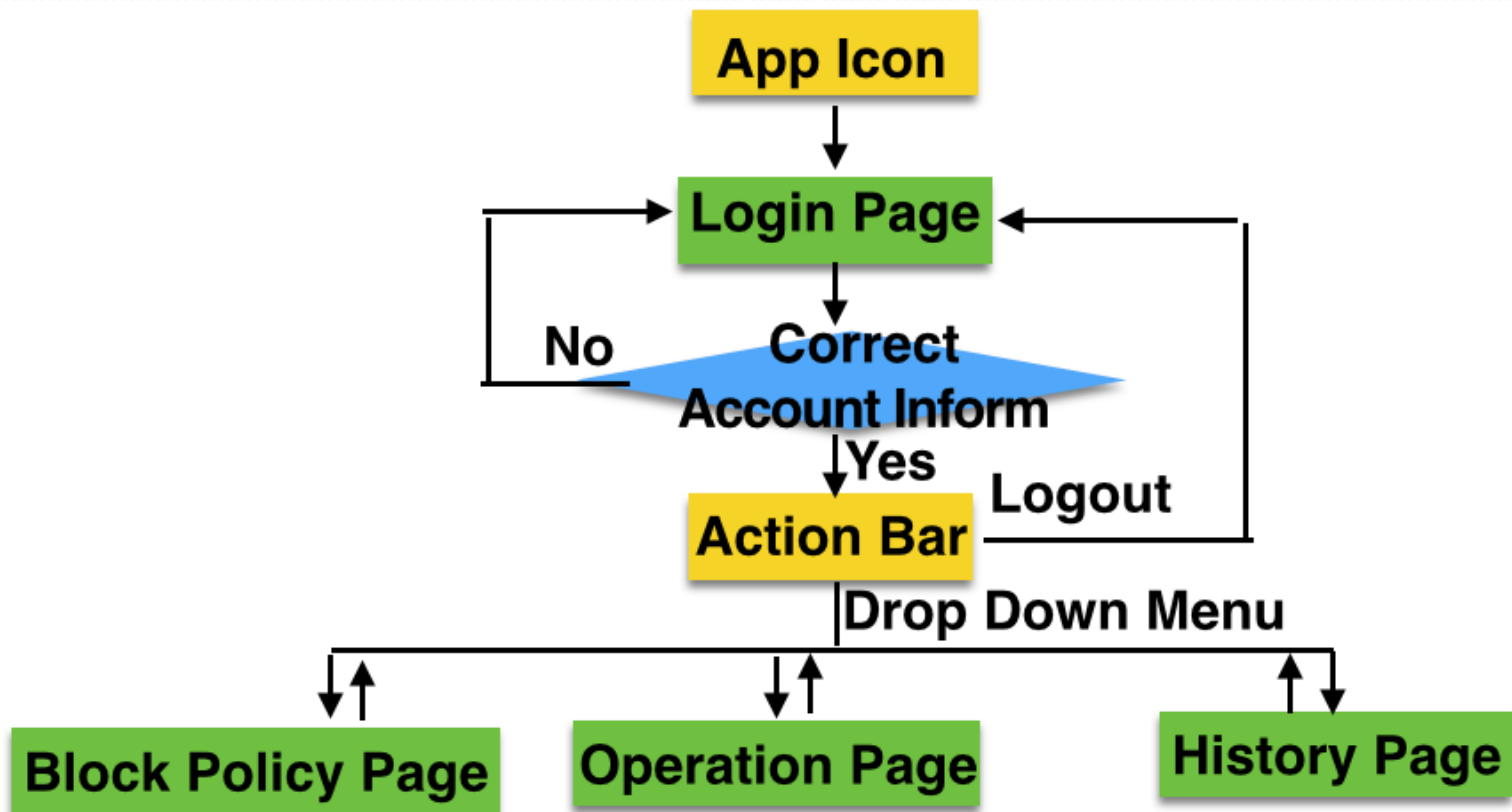
Mobile App: Log in Page

- Correct User Name and Password required

- Key to Access all other Pages
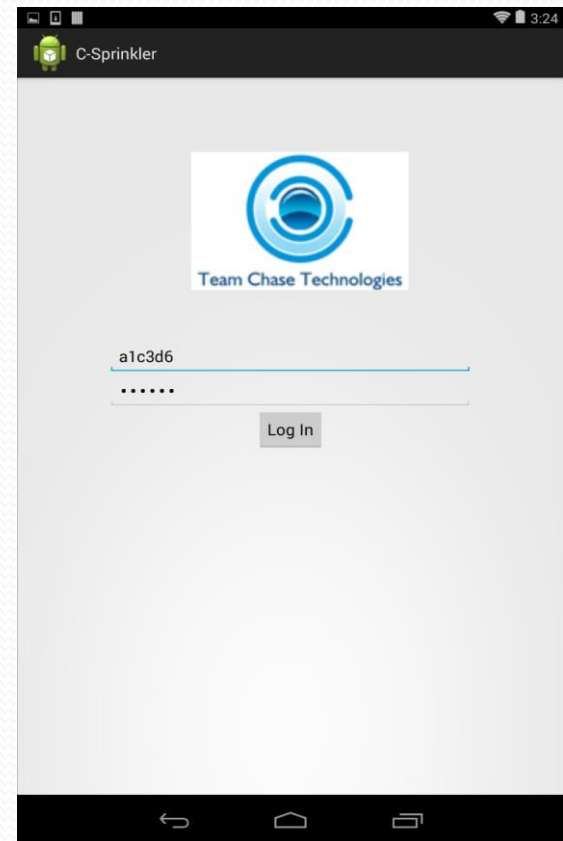
Mobile App: Operation Page

- Operation Control
    - Start/Stop
    - Plus/Minus Time

- View Weather Forecast (Yahoo API)
    - Select Location
    - Display Temperature and Weather
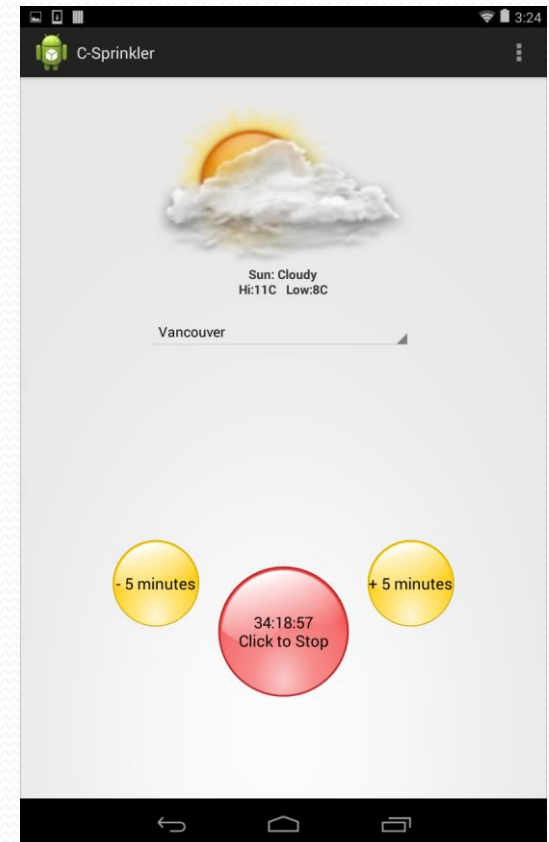
Mobile App: History Page
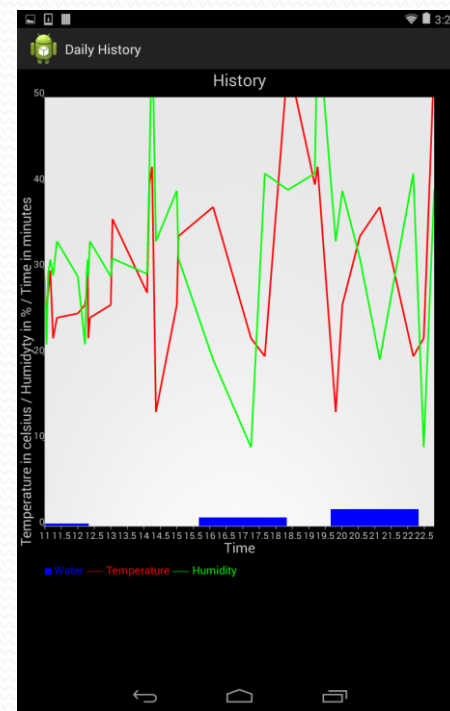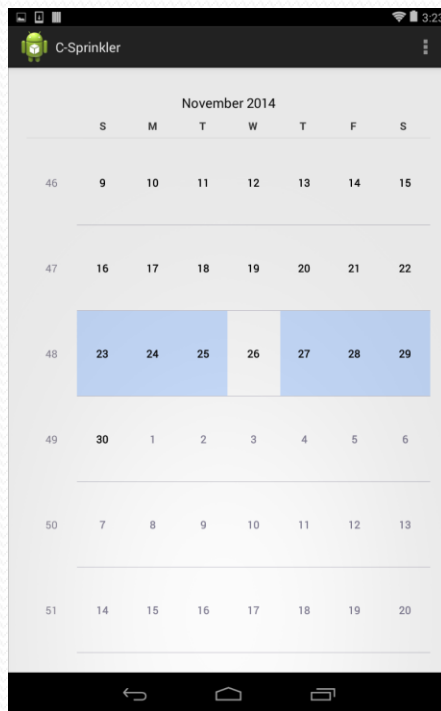
- Clickable Calendar
- Select a Day

- Display Temperature Chart
- Display Humidity Chart
- Display Operation Time

Mobile App: Block Policy Page

- Block Time Modification

  - Add Entries

  - Remove Entries
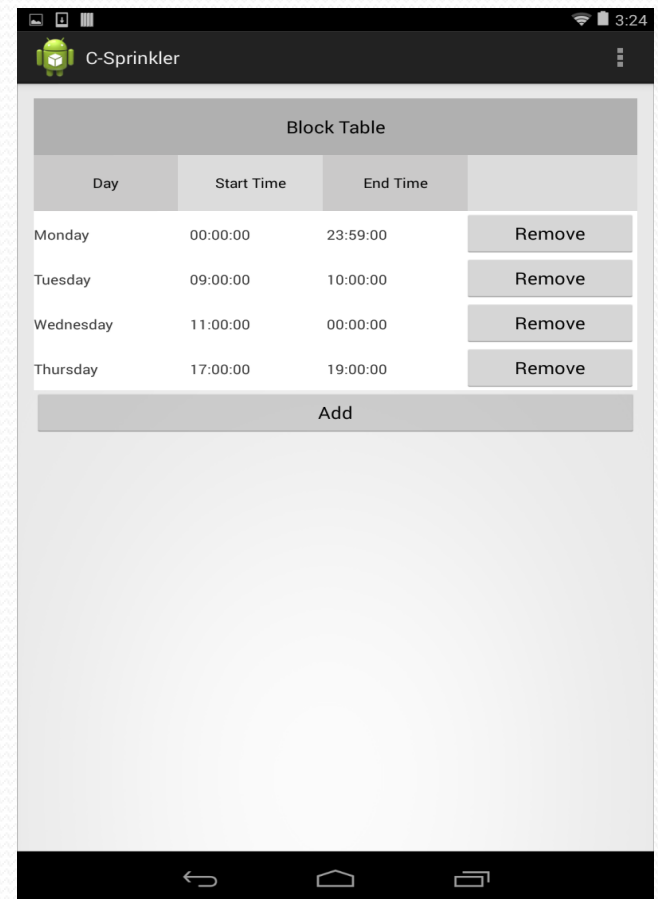
Project Cost

Item	Est. Cost (CAD)	Actual Cost (CAD)
DE2i-150 FPGA Development Kit	Borrowed	Borrowed
Electronic Components	55	50
Soil Moisture Sensor	10	5
Wire and Jumpers	15	15
Motion Sensor	10	5
DHT22 Sensor	10	10
10 Bit ADC	5	3
5V Relay	5	3
24V DC LED	0	9
Irrigation Auto Inline Valve	20	17
Plug in Transformer 24V	20	20
Small plastic enclose	0	21
Others	100	80
TOTAL	195	188

Project Schedule

Task Name	Duration
⊿ Software Development	64 days
⊿ Scope	10 days
Topic decision and project scope	3 days
Project Proposal documentation	7 days
⊿ Analysis and Requirements	20 days
project requirements and specification	1 day
initial system design	2 days
resource allocation, cost and risk analysis	1 day
Functional Specification documentation	12 days
⊿ Design	31 days
Overall system design	3 days
general software	3 days
general networking	3 days
general hardware	6 days
Design specification report	15 days
finished design	0 days
⊿ Development	40 days
Networking development	10 days
Android development	20 days
Software application and driver development	20 days
Hardware circuitries development	15 days
Oral Progress Report	1 day
Hardware logic development (VHDL)	15 days
Networking integration	20 days
Written Progress Report	13 days
System integration	10 days
finished development	0 days
⊿ Testing and Demo	7 days
performance test and modification	3 days
stability test and modification	3 days
final test	1 day
project demo	0 days

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Future Plan

- Better UI interface
- Implement of calculation algorithm
- Choice of architecture solution
- Expand usage of system

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Knowledge Gained

- Small Company Start Up
- Team Communication
- PCB Design
- VHDL Coding
- Android App Development
- Networking Optimization
- QA & Integration Process

Summary

- Successfully in achieving the basic functionalities in our first prototype

- Mobile app on Android platform is running

- Sensor performance is unstable which will be replaced in future

- Additional features must be implemented into final product

Special Thanks

Dr. Rawicz
Prof. Whitmore
TA –   Jamal Bahari
　　　 Lukas Merhi
　　　 Mona Rahbar

Reference

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[2] The Internet of Things (2014) IBM. Retrieved from http://www-01.ibm.com/software/info/Internet-of-things/

[3]2006 Census Data Production (2010) Statistics Canada. Retrieved from http://www12.statcan.gc.ca/census-recensement/2006/dp-pd/92-596/P1-2.cfm?Lan%20g=eng&T=PR&PRCODE=01&GEOCODE=01&GEOLVL=PR&TID=0

[4]Private households by structural type of dwelling, by prince and territory (2011 Census) (2013) Statistics Canada. Retrieved from http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/famil55a-eng.htm

Question Period

Demo