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Advanced Monitoring of Cold Chain using Wireless Sensor Network and Sensor Cloud Infrastructure

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Internet of Things

Background

- Initially the internet was designed for computers
- It was intended for people to connect to other computers and servers to access and download documents
- With evolution of technology, advancement in electronics took place and resulting in creation of smaller devices having high processing capabilities

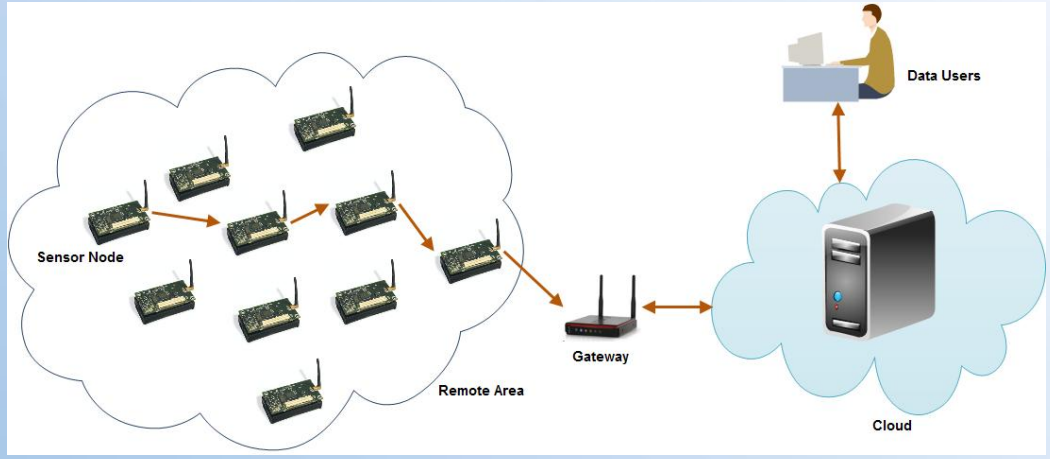
Internet of Things

- With the devices, large network of sensors began to emerge
- In 1989, first internet device was created – The Internet Toaster [1]
- In 1992, another device ‘The Trojan Coffee Pot’ was created [2]
- In 1999, the term ‘Internet of Things’ was coined by Kevin Ashton with the concept of computers getting and giving info about real world without assistance from people [3]

Internet of Things

Wireless Sensor Network

- WSNs are the most important constituent of IoT. They are provided with unique identifiers and ability to transfer data to cloud



Internet of Things

- There are many platforms for WSNs

- These hardware relays the physical world data to virtual world
- The platforms take the messy details of microcontroller programming and wrap it up in an easy-to-use package

Internet of Things

Sensor Clouds for IoT

- Sensor clouds are built to manage data from physical world objects
- They turn physical world data into useful information through which people can know more about their environment

Cold Chain

- Is the process of maintaining optimal conditions during transport, storage and handling of temp sensitive products
- Process starts at the manufacturer and ends with the administration of product to the client
- Focus of cold chain is on pharmaceutical products, chemicals and groceries
- Exposure leads to loss of potency that is not reversible

Current Monitoring Technologies

- Data Loggers [4]
  - Placed in package with product
  - To start monitoring, the logger is initiated
  - Upon receiving the product, data from logger can be downloaded via USB creating PDF report
- Chemical Indicators
  - Self-adhesive labels for individual packages
  - The color change indicates exposure

Current Monitoring Technologies

- Sensor Network [5]
  - Mountable graphic recorders
  - Measures environment conditions using sensor probes
  - Allows remote data access

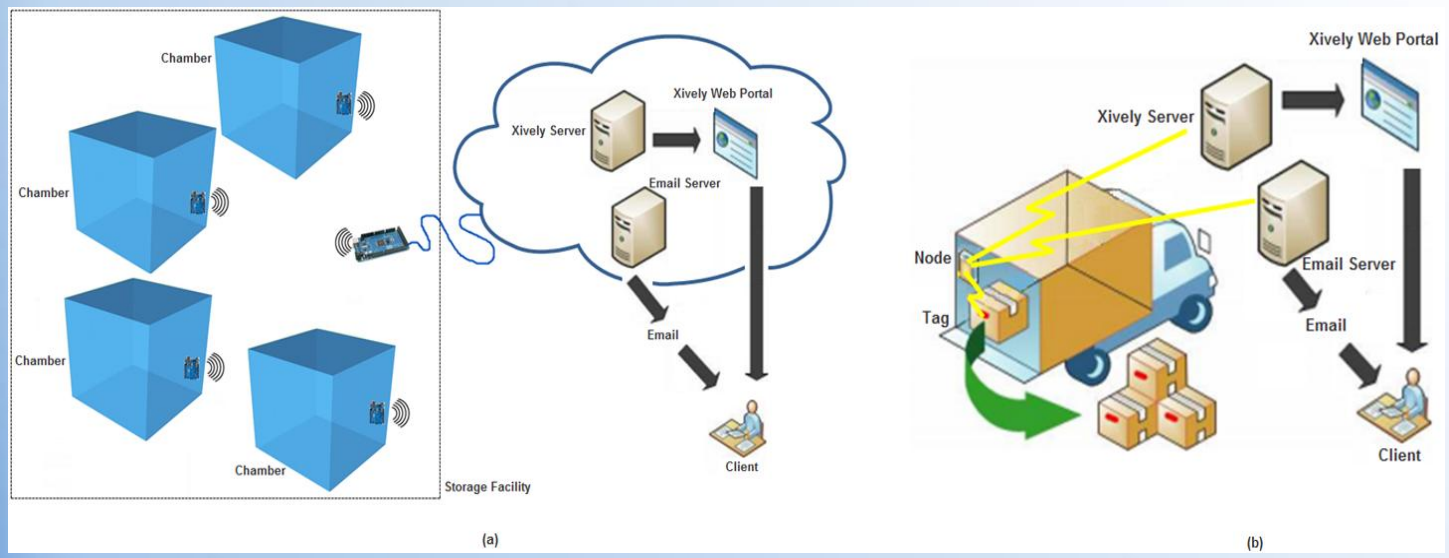
- RFID [6]
  - Implemented by DHL
  - Sensor is packed inside DHL package
  - Sensor sends data to the web Portal via reading devices along the way for real-time monitoring

Proposed Architecture

- The operation is governed by the functionality of the Internet of Things
- The architecture is composed of two infrastructures: Sensing Entity and sensor cloud
- The environment to be monitored are of two types: Transport facility and storage facility
- The storage facilities are warehouses and units at manufacturing facility and distribution sectors while transport facilities transport the products between these facilities

Proposed Architecture

The two monitoring systems (a) Storage facility (b) Transport facility



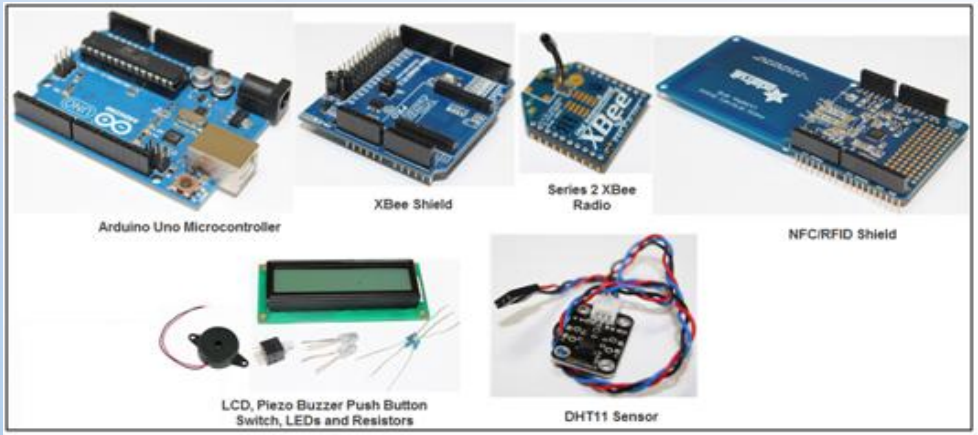
Proposed Architecture

- The WSNs are based on Arduino prototyping platform
- In the environments, two parameters are measured: Temperature and Humidity
- Other measured variables taken into account are the NFC/RFID Tags which are read through Reader for products moving in and out and Node voltage to keep track of the power supply

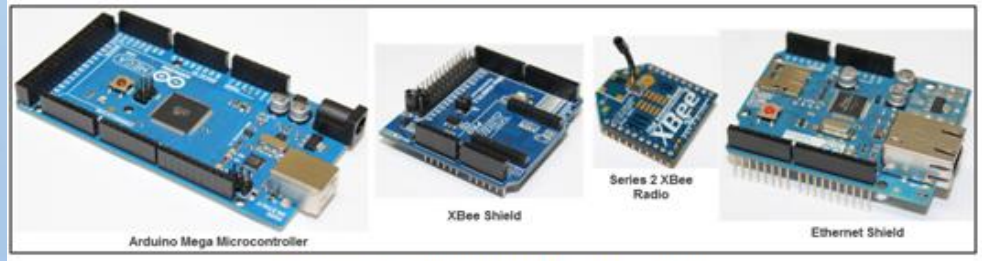
System Operation

Storage Facility

Storage facility hardware:



Hardware components of node



Hardware components of base station

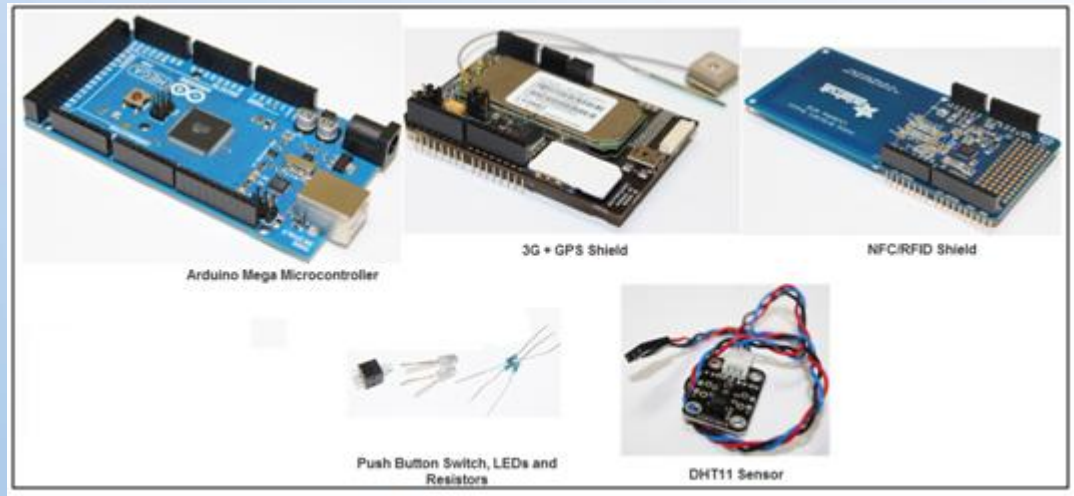
System Operation

- The node measures the temperature, humidity and node voltage at a fixed interval and NFC/RFID tags within the interval
- Data is transmitted to the data to Base Station using ZigBee
- The Base Station receives the data and prepares it
- The NFC/RFID tags are prepared and emailed. The temperature, humidity and node voltage is uploaded to Xively

System Operation

Transport Facility

Transport facility hardware:



Hardware in transport monitoring

System Operation

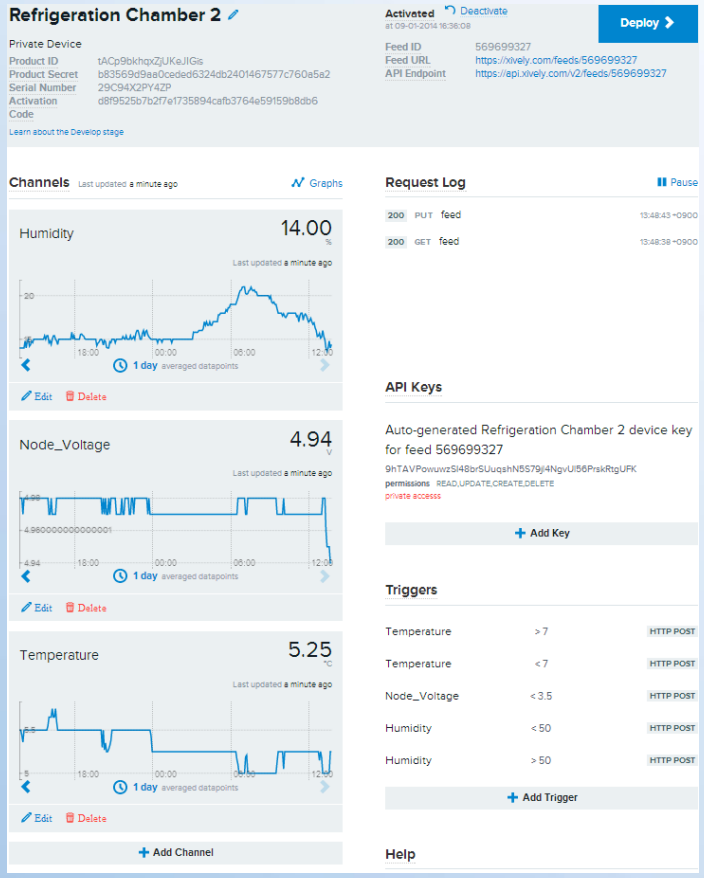
- The node measures the temperature, humidity and node voltage at a fixed interval. NFC/RFID tags can be read within the time interval
- After interval elapses, data is prepared for upload.
- The process is similar to the storage facility system

Discussion

- On Xively, the monitoring of environment conditions are carried out which happens in real-time
- The features include data visualization, maps and trigger. Maps are essential for monitoring the transport facility
- The trigger is fired when abnormal conditions occur. Zapier service is used to interface Xively with notifying application. The notifying application used is email service

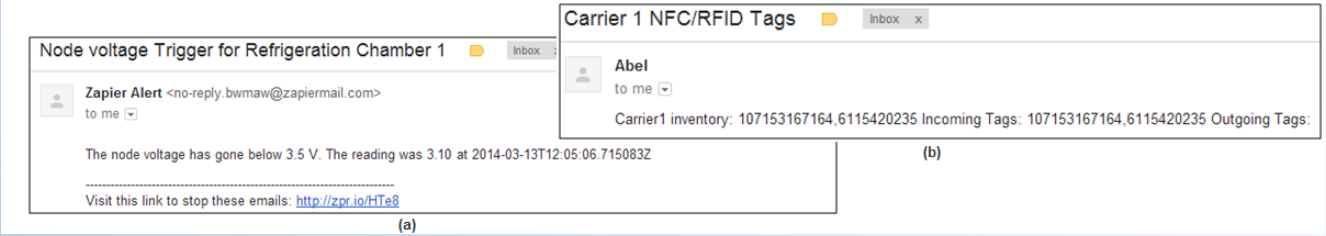
Discussion

Xively web portal:



Discussion

Email notifications (a) trigger alert (b) NFC/RFID tags



Conclusion

- Cold chain monitoring using IoT has been proposed
- WSN with Arduino has been created and interfaced with Xively sensor cloud for real-time monitoring
- The integration has been possible with Arduino libraries and hardware and the Web 2.0 technology

References

[1] *The Internet Toaster*. Available: http://www.livinginternet.com/i/ia_myths_toast.htm

[2] Q. S. Fraser. (1995). *The Trojan Room Coffee Pot*. Available: http://www.cl.cam.ac.uk/coffee/qsf/coffee.html

[3] K. Ashton. (2009). *That 'Internet of Things' Thing*. Available: http://www.rfidjournal.com/articles/view?4986

[4] *Simple & Easy Cold Chain Data Logging. Available: http://www.vaisala.com/en/lifescience/products/coldchain/Pages/CCL100.aspx?utm_medium=alias&utm_content=coldchain*

[5] *SM500F. Available: http://www.abb.com/product/seitp330/de276b6db94ebbdcc125711b005e7d23.aspx*

[6] *Cool Solution - DHL SmartSensor*. Available: http://www.dhl.com/en/about_us/innovation/product_development/smartsensor.html