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Design of A Reliable Communication System Using Cloud-Based Technologies for Corrosion Monitoring System

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Design of A Reliable Communication System Using Cloud-Based Technologies for Corrosion Monitoring System

Topics of Discussion

- Overview
- The Army/IPFW Corrosion Monitoring System (CMS) Architecture and System Design
- The Deployed Army/IPFW CMS System
- The CMS System and Communication Subsystem Reliability Issues
- Designed and Implemented Communication Infrastructure Improvement
- SaaS Cloud Service, and Cloud Storage
- Conclusion

Overview

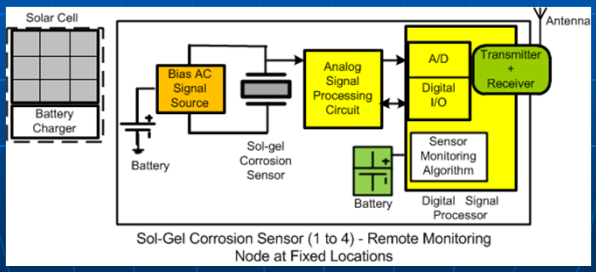
- The project: “Micro-Nano Technology Sol-Gel Corrosion Monitoring System,” 2011-2013
  - Project sponsor: Army Construction Engineering Research Laboratory, IL: Richard Lampo and Michael McInerney
  - Project Team
    - Principal Investigator: Max S. Yen
    - Co-Pis: Paul I-Hai Lin and Dong Chen
    - Graduate Students: MengWei Li, Robert Tilbury, Muhammad Shoaib Mansur
    - Undergraduate EE Student: Steve Groff

Overview (continue)

- The Accomplishments
  1) “Examination of Corrosion on Steel Structures by Innovative Nano Sol-Gel Sensors,” by Max Yen, Dong Chen, **Paul Lin**, Bakul Dave, Steve Groff, Emily Hauter, Richard Lampo, and Michael McInerney, NCAE 2012 Corrosion Conference, to be held on March 11-15, 2012, Salt Lake City, Utah
  2) “Corrosion Sensor for Monitoring Early-Stage Environmental Corrosion of Steel Structure,” Dong Chen, Max yen, and Paul Lin, U.S. Provisional Patten Application #61763523, Feb. 2013
  3) “Micro-Nano Technology Sol-Gen Corrosion Monitoring System,” New Tech Showcase Demo & Presentation, Indiana University-Purdue University Fort Wayne, April 24, 2013.
  4) “A Corrosion Monitoring System for Early-Stage Warming of Environmental Corrosion of Structures and Infrastructures,” Technology Showcase, at 2013 Taipei International Invention Show & Technomart, Sept. 26-29, 2013.

System Architectures of Corrosion Monitoring System: Initial Design (Nov. 2011)

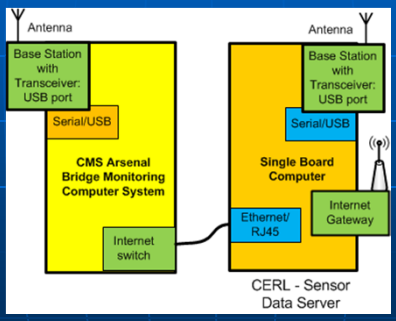
- Wireless Sensor Nodes powered by solar panels, with Internet Gateway for Remote Access



Sol-Gel Corrosion Sensor (1 to 4) - Remote Monitoring Node at Fixed Locations

IPFW/Army CMS System Architecture Version 1: Wireless Sensor Nodes, with Internet Gateway (Nov. 2011)

- Not implemented due to the concerns of wireless signal interference from other deployed sensor monitoring system



The IPFW/Army Corrosion Monitoring System Deployed at RIA Bridge, Rock Land, IL

- Designed CMS monitoring system architecture
- Designed and built Sol-gel, Cylindrical, uncoated and coated with tar-coal epoxy.
- Designed and built the analog signal processing circuits for Sol-Gel based sensors and cylindrical sensors
- Designed and built the RS-485-based DAQ sensors boxes and cabling system
- Completed the testing and installation of CMS at IPFW
- Installed the CMS system at Army Rock Island Arsenal Bridge, Rock Island, IL, May 2013
- Encountered problems in the areas of Internet Networking and Communication, and followed up with solutions that we will be discussed …

The IPFW/Army Corrosion Monitoring System

- A Windows XP embedded computer: RS-485, Ethernet ports
  - DC 12-24V powered, diskless, central controller and data server
  - Thermaelectric cooler
  - Running the program with "Centralized Data Polling Algorithm" to collect data from six sensor nodes at 30 minutes fixed interval, with time stamp data

The IPFW/Army Corrosion Monitoring System

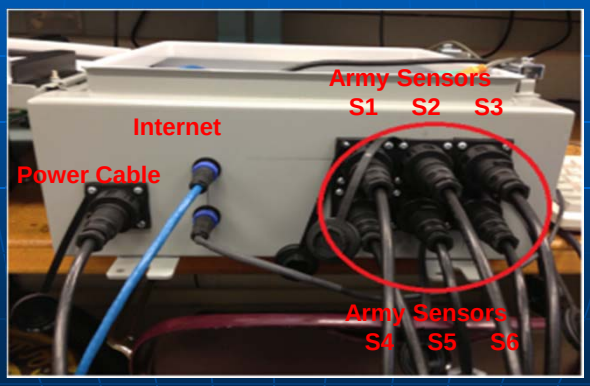
- Six RS-485-based Sensor Nodes
  - DC 24V, ±12V, Power Source
  - Microcontroller-based with built-in commands, 12-bit ADC
  - Analog signal processing circuits, calibrated for four types of corrosion sensors

The IPFW/Army Corrosion Monitoring System

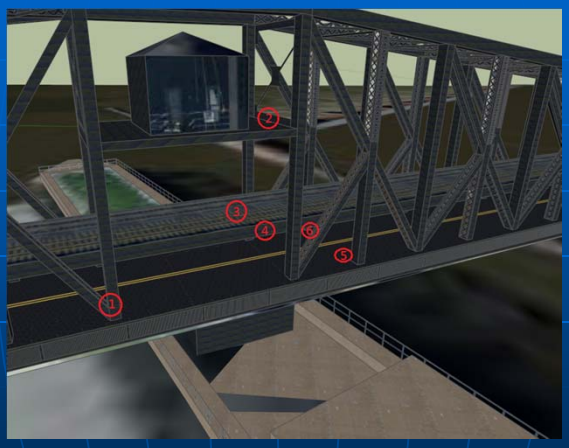
- Six RS-485-based Sensor Nodes
  - S1, S2: Coal-tar Epoxy Coated Sol-Gel Sensor
  - S3, S4: Sol-Gel Sensor
  - S5: Stainless Steel Cylindrical Sensor (coal-tar epoxy coated)
  - S6: A36 Cylindrical Sensor (coal-tar epoxy coated)

The IPFW/Army Corrosion Monitoring System

- The Assembled Corrosion Monitoring System in an weather proofed enclosure and 100 ft to 150 ft cables and connectors



The IPFW/Army Corrosion Monitoring System: Sensor Locations



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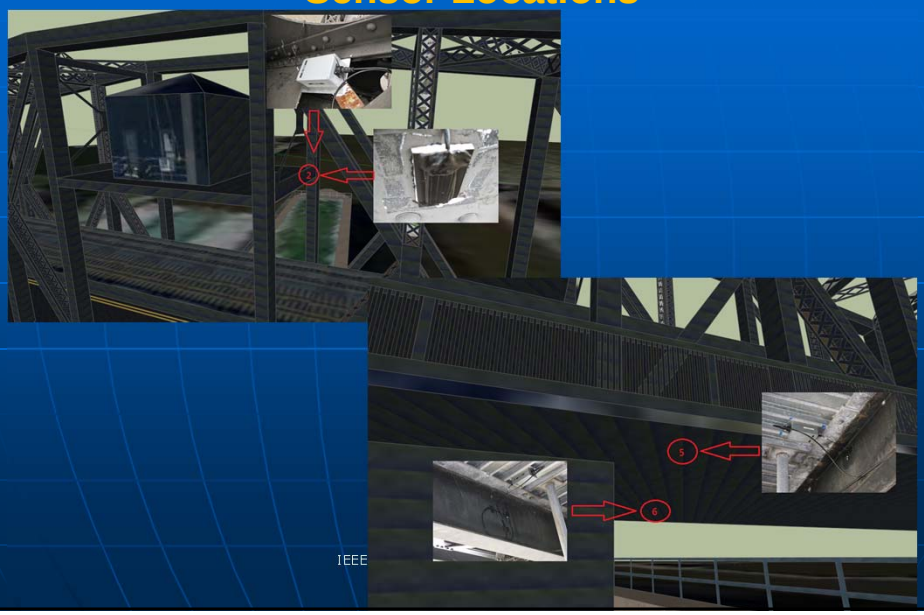


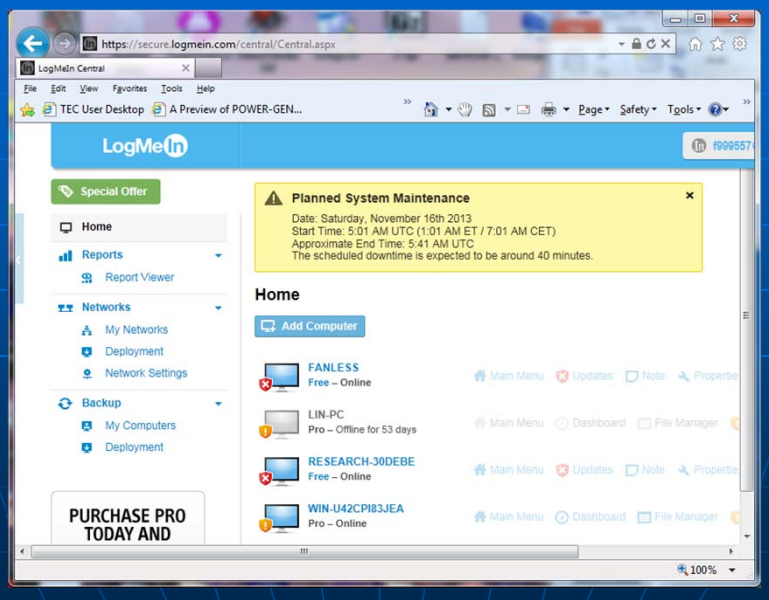
Installed Cloud Services

- The following cloud services were installed on IPFW/Army CMS system, at RIA bridge, Rock Island, IL on May 2013:
  - The LogMeIn Hamachi: SaaS (Software as a Service), On Demand Network Virtualization
  - LogMeIn Pro: SaaS, remote access to computers for files, applications, and backup service
  - DropBox – Cloud Storage Service
    - Stored data & files are encrypted, and
    - Kept securely on storage service via Amazon's S3 storage (Simple Storage Service)

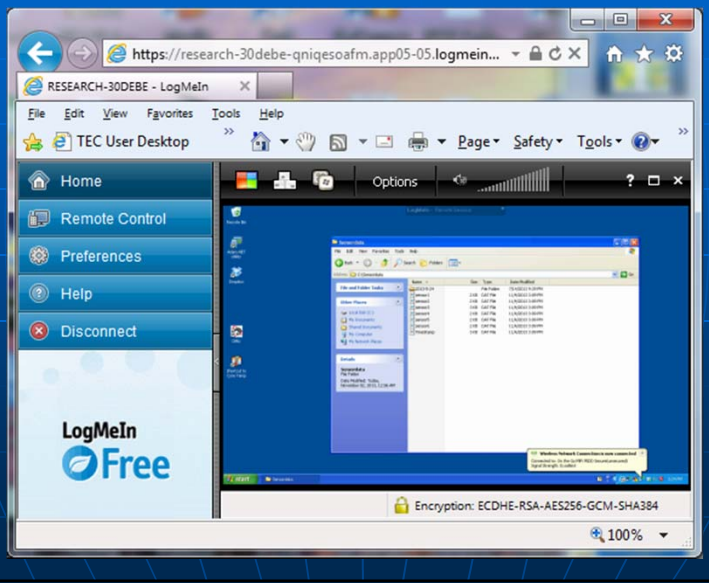
Features of LogMeIn SaaS Cloud Service

- LogMeIn Pro, SaaS Cloud Service, Supporting Features
  - Remote Access
  - Web-based User Interface
  - User management
  - Computer search
  - **Online/Offline status**
  - **Reporting**
  - 256-bit SSL encryption
  - Audit logging
  - Computer grouping
  - Host configuration
  - **Advanced reporting and analysis**
  - etc

The LogMeIn – SaaS Cloud Service



The Windows XP Embedded Data Server: Remotely Accessed through LogMeIn – SaaS Cloud Service



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Dropbox - Cloud Storage Service

- All sensor data collected in a 30 minutes interval at Rock Island Arsenal bridge.
- Automatically saved into Dropbox storage setup at Embedded computer/data server.
- These data saved in Dropbox storage is also synchronized and available to the real-time sensor data processing and web display system setup at IPFW.

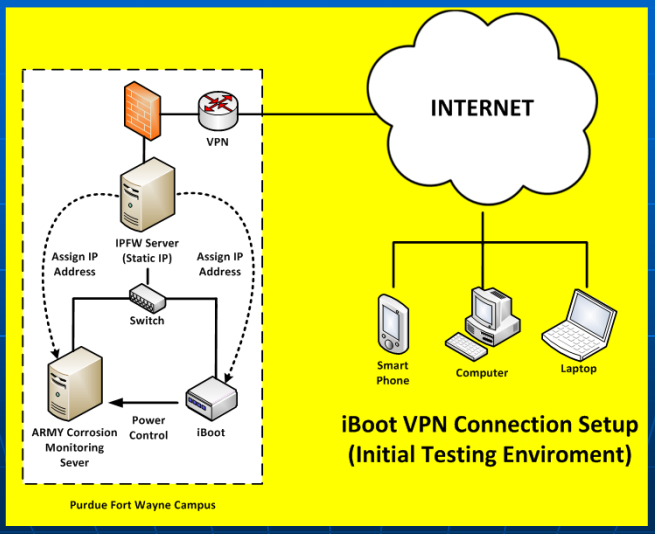
The IPFW/Army CMS Issues and Solutions: First Problem

- The installed corrosion monitoring system was successfully collecting data from May 24-26, 2013; then it was offline from May 26 for 1 day, and then was offline since May 29.
  - Need to install an UPS for the corrosion monitoring system to ensure the system's reliability. (added)
  - Suspected that high inrush current trip the circuit breaker (replaced with one with high current rating)

The IPFW/Army CMS Issues and Solutions: First Problem

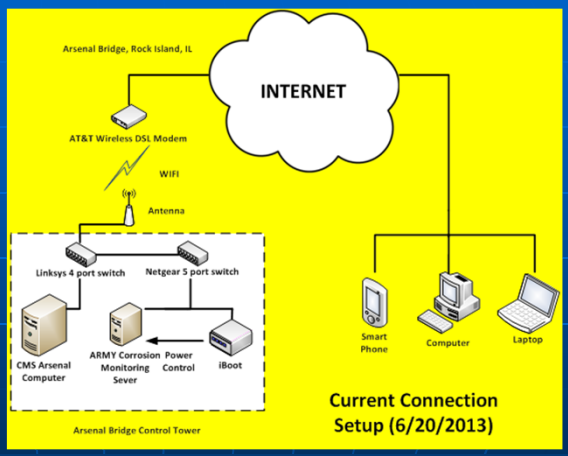
- The installed corrosion monitoring system was successfully collecting data from May 24-26, 2013; then it was offline from May 26 for 1 day, and then was offline since May 29.
  - Need to install a remote computer starter to ensure that the corrosion system can be restarted remotely.
    - Readjust BIOS Power Management Setting of the Windows XP embedded data server: "Power Lost Resume Control – Turn on"
    - iBoot remote starter was tested at IPFW, but not able to function properly due to the fact that a static IP is not available from its current ISP

The IPFW/Army CMS's Networking Subsystem Improvement: Successfully Tested at IPFW



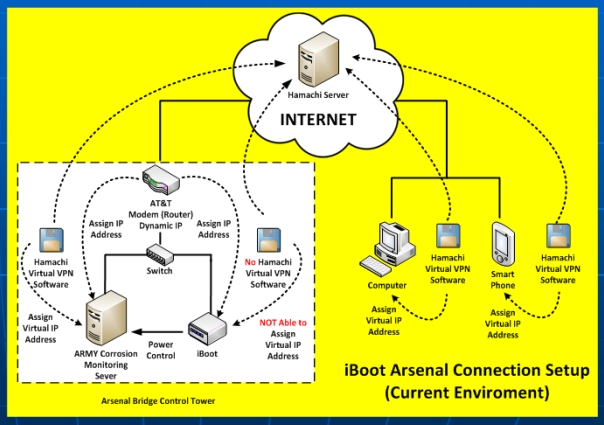
The IPFW/Army CMS's Networking Subsystem: Failed iBoot Configuration at RIA Bridge

- iBoot's IP address is assigned by the AT&T modem (router) with a dynamic IP address.
- To ensure iBoot functional properly, a static IP address and a router with port forwarding function, but current AT&T modem (router) does not met either one of those requirement



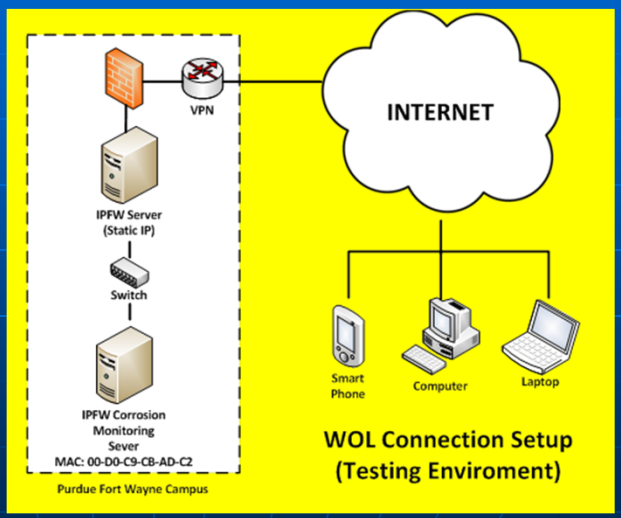
The IPFW/Army CMS's Networking Subsystem: Failed iBoot with LogMeIn Hamachi Configuration at RIA Bridge

- iBoot with LogMeIn Hamachi VPN – SaaS Cloud service
- Assigned a virtual IP address to the CMS which is different than the physical IP address assigned by the router.
- Failed



The IPFW/Army CMS's Networking Subsystem: Tested OK with Wake-On-LAN (WOL) Technology using Magic Packet Configuration at IPFW

- But Failed at RIA site
- A static IP is required



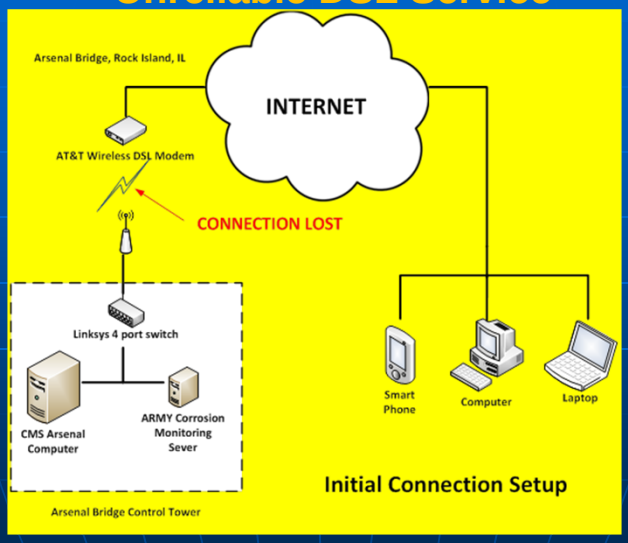
The IPFW/Army CMS's Networking Subsystem: Problems and Tested Solution

Solution Item	Status	Result
Hamachi Virtual VPN software	Tried	Failed due to not able to assign IP to iBoot
iBoot Utility Manager	installed	Successfully installed utility manager, but failed due to no static IP

The IPFW/Army CMS: Second Problem - Unreliable DSL Service

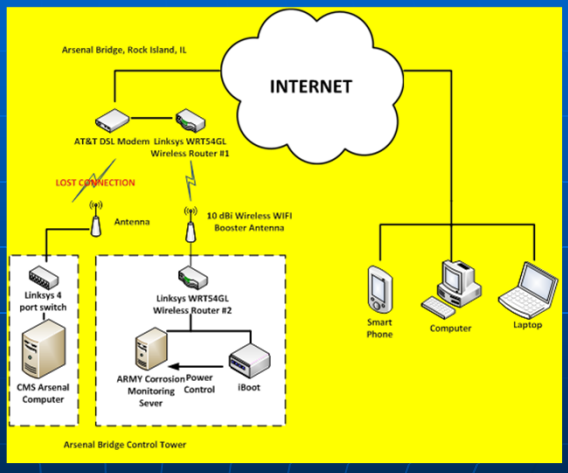
- It was found that CMS Data Server was running normally since our previous maintenance work. The logged data with time stamps shows that the Windows XP Embedded was function properly.
- Further investigation showed that was the communication failure instead of the system failure. The connection between the AT&T DSL modem and the Linksys 4 port switch was lost therefore all the communication from outside to the CMS had been lost.
- 2nd maintenance and patched work at the RIA bridge on July 11-12, 2013

The IPFW/Army CMS: Second Problem - Unreliable DSL Service



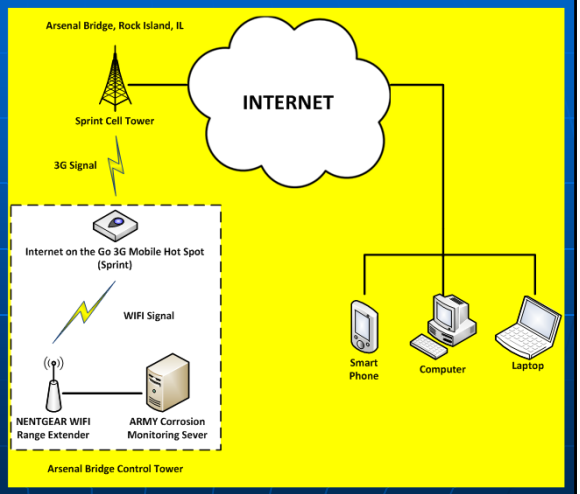
The IPFW/Army CMS: Solution 1 for Unreliable DSL Service

- Reroute Internet connection through a 10 dBi wireless WiFi booster antenna and two routers
- One works as transmitter, another serves as receiver
- **Tried but not implemented due to the access control rights to the AT&T DSL router**



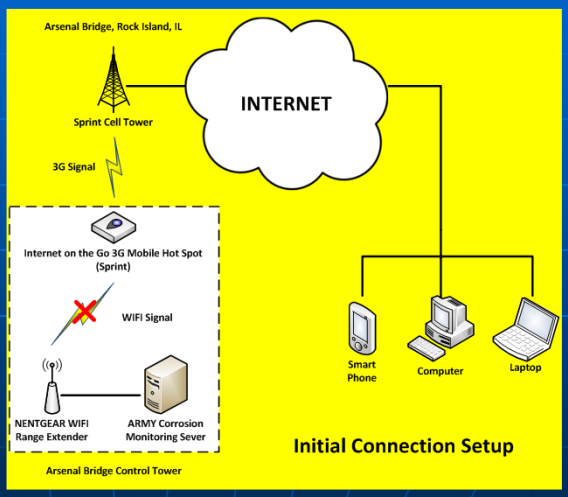
The IPFW/Army CMS: Solution 2 for Unreliable DSL Service

- Added a WiFi Hotspot, with AC cooling fan with a thermostat, connected through 3G cellular network



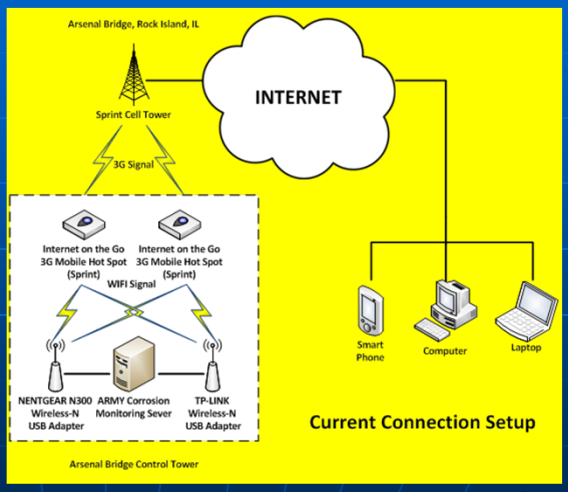
The IPFW/Army CMS Communication Subsystem: Problem 3 – Unstable WiFi Hotspot

- Implemented and running OK for almost a month; communication was lost again on Aug. 16, 2013



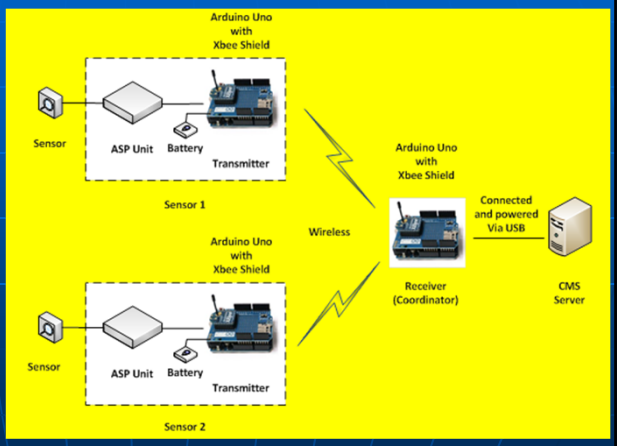
The IPFW/Army CMS Communication Subsystem: Solution to Unstable WiFi Hotspot

- Two WiFi hotspots and two USB WiFi adapters were installed and configured.
- The system has been running continuously for over two months.



IPFW/Army CMS Communication Subsystem: Additional Improvement in Progress

- Improved RS-485 communication between local sensor data nodes to data server through a Zigbee-based Mash Network (Xbee and Arduino microcontroller board



Conclusion

- Unreliable networking and communication issues with dynamic IP
- Real world solutions implemented
  - Support or enable remote Internet-based on/off control of the Windows XP-based embedded data server computer
  - Two WiFi Hotspots to support Internet networking and communication without static IP address
- Future improvement
  - Add a ZigBee-based Mash network and extra DAQs to Improved RS-485 communication reliability and sensor node redundancy