# The Smart Gird

## CMPT 417 – Spring/2010

Picture taken from http://ge.ecomagination.com/smartgrid/

# Stephen's Background

- **Computing Science MSc Student**
  - Senior Supervisor: Dr. Fred Popowich
  - Part of the NatLag Lab
  - Intelligent Agents, Data Networks, Embedded Systems
- **Professional Career**
  - 13 years in IT in various industries
  - 2 years as BCIT Researcher for Smart Grid
  - Software Systems Architect & Data Comm

# Lecture Outline

**Part 1: Subject Background**

**Part 2: Electric Utility 101**

**Part 3: The Beginnings of IT**

**Part 4: Intelligent Energy Systems**

**Part 5: Open Standards**

**Part 6: Research Interests**

# Part 1: Subject Background

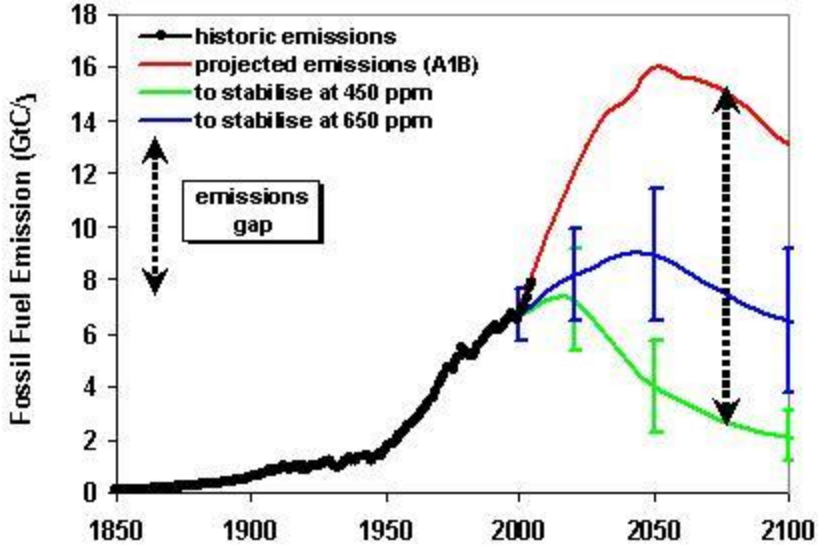
1. Background Video
2. Other Situational Factors
3. Alternative Energy Sources
4. Coal & The Environment
5. What Does It All Mean?

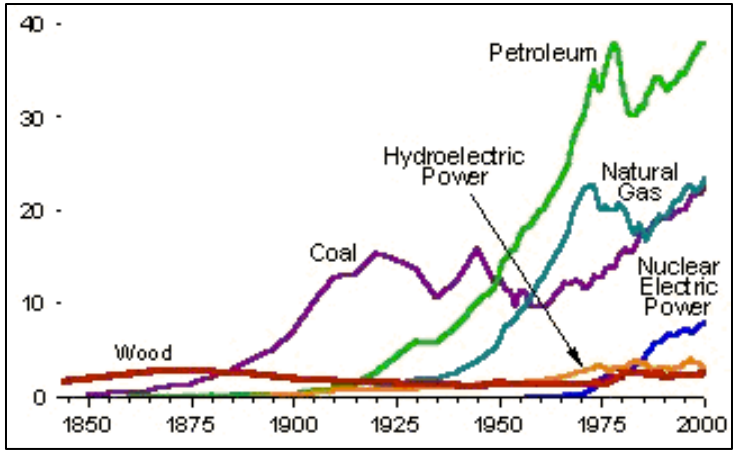
# Background Video

Movie taken from http://www.youtube.com/watch?v=7IBG2V98IBY

# Other Situational Factors

1. ~2050: The planet cannot heal itself.
2. Rising Energy Demand
3. Peak Oil ( $ ↑ as reserves ↓)
4. Can we use alternative energy sources?

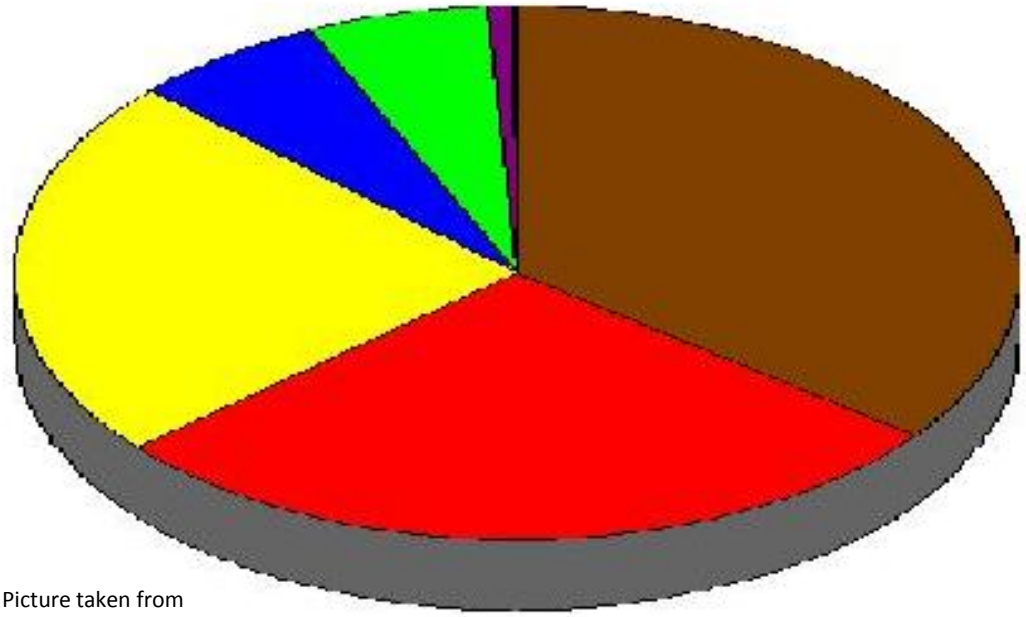



Pictures taken from http://en.wikipedia.org/wiki/Energy_in_the_United_States and http://www.watthead.org/2006_11_01_archive.html

# Alternative Energy Sources

1. **Wind Turbine**
2. **Photovoltaic**
3. **Tidal**
4. **Geothermal**
5. **Big Hydro**
6. **Run-of-River Hydro**



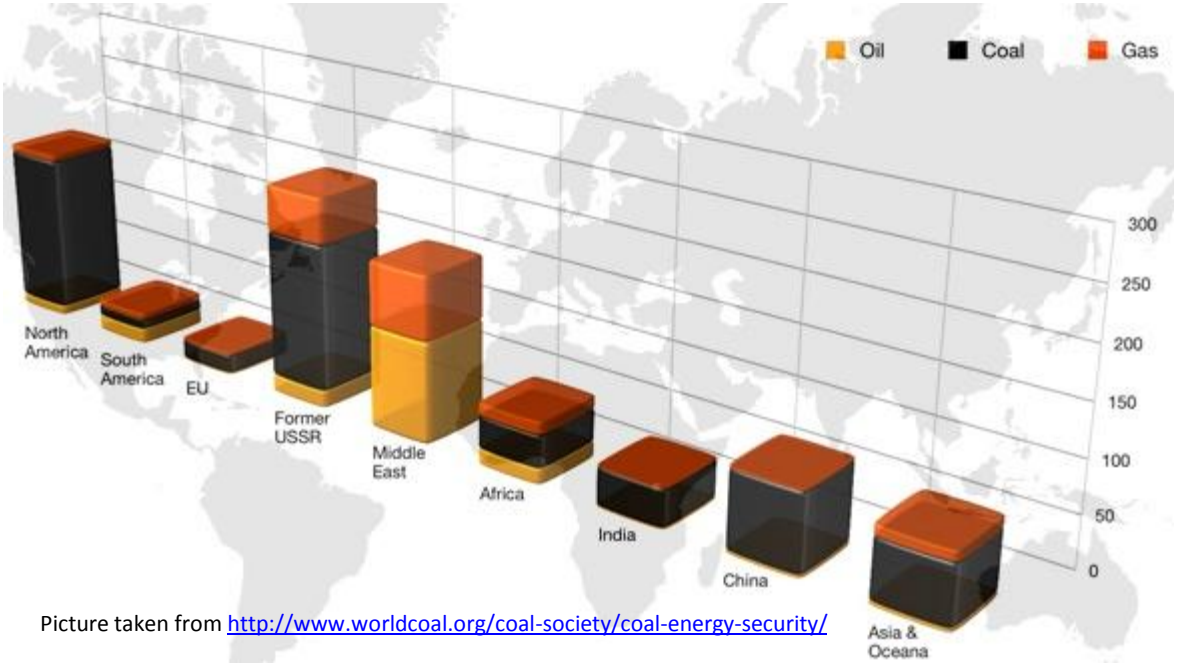
| | | | |
|---|---|---|---|
| Petroleum: | 3527 | ~ | 35.43% |
| Coal: | 2802 | ~ | 28.15% |
| Dry natural gas: | 2335 | ~ | 23.46% |
| Hydro-electricity: | 624 | ~ | 6.27% |
| Nuclear electricity: | 576 | ~ | 5.79% |
| Geothermal, wind, solar, biomass : | 86 | ~ | 0.86% |
| Geothermal, biomass, solar not used for electricity: | 5 | ~ | 0.05% |

**Total:** 9955

Picture taken from
http://en.wikipedia.org/wiki/Energy_development

# Coal & The Environment

1. **About 120 years of coal remaining.**
2. **Coal has to be part of the solution.**
3. **Carbon capture and storage (CCS).**




Picture taken from http://www.worldcoal.org/coal-society/coal-energy-security/

# What Does It All Mean?

**Questions, Comments**

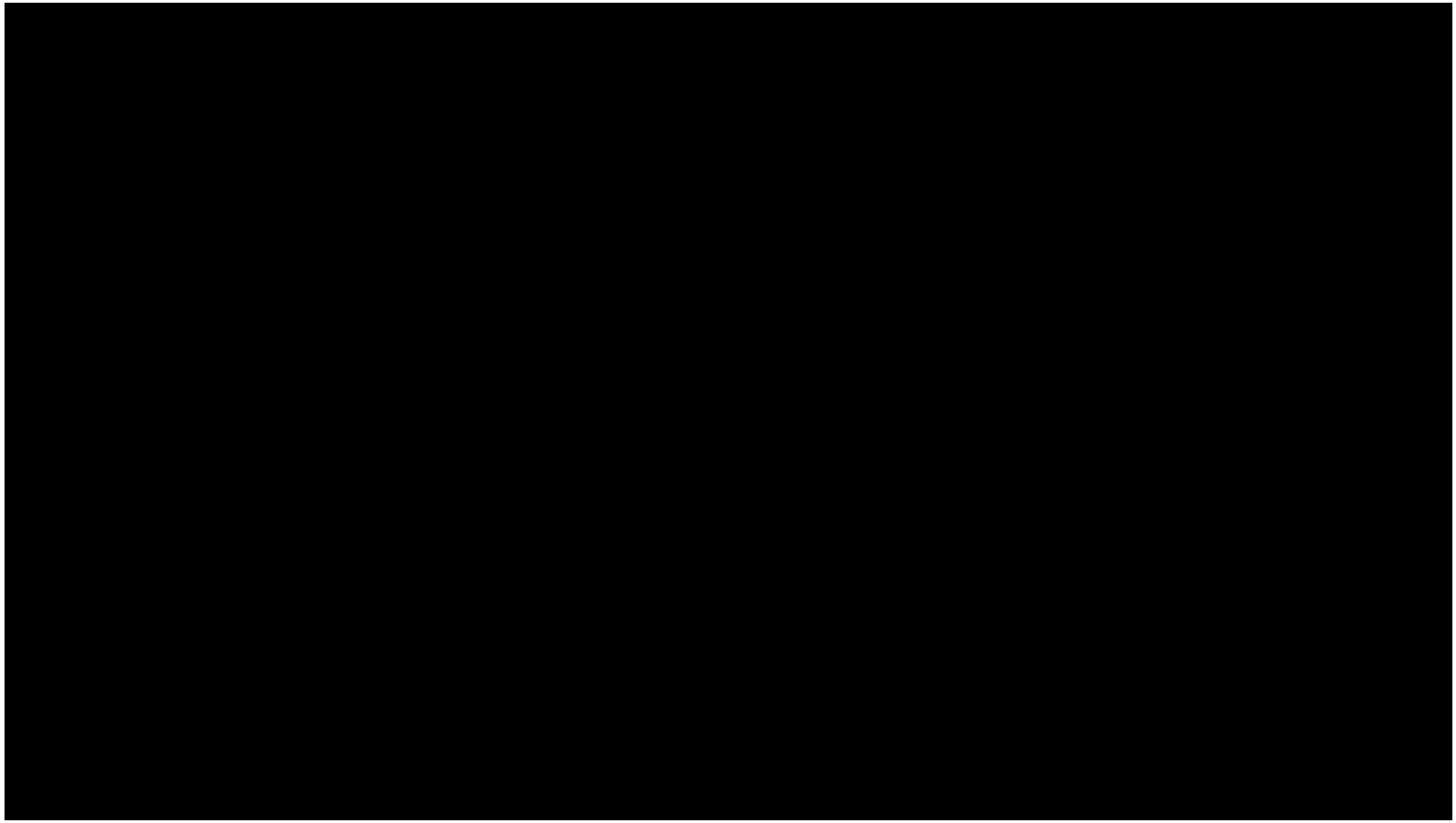
**&**

**Class Discussion**

# Part 2: Electric Utility 101

1. Background Video
2. The Electric Grid
3. The Issues in BC
4. Types of Grids
5. Future Electric Grid
6. BC Net-Importer or Net-Exporter?

# Background Video



Movie taken from http://www.youtube.com/watch?v=eSbYApshKVs

# The Electric Grid

**Generation**

- 1: Hydroelectric dam
- 2: Generator
- 3: Step-up transformer

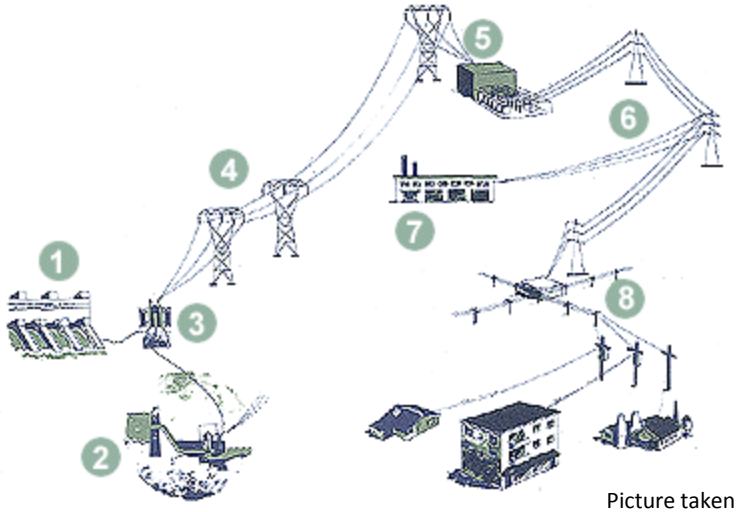
**Transmission**

- 4: High voltage transmission lines
- 5: Terminal Station
- 6: Sub-transmission lines

**Distribution**

- 8: Distribution substation

**Delivery**




Picture taken from
http://www.bchydro.com/about/our_system/generation/electric_generation.html

# The Issues in BC

1. Electricity in BC is cheap.
2. The is an aging infrastructure.
3. BC Government initiatives.
4. No GHG/$CO_2$ driving force.
5. Conservation through education and awareness.
6. Electricity theft (grow-ops).

# Types of Grids

**Main Grid**

- Owned by BC Hydro, ran by BCTC

**IPP (Independent Power Producer) ***

- Smaller private companies (alternative energy)

**Microgrid ***

- Large Business or Small community

**Nanogrid ***

- A building or a house.

*** MUST be able to be disconnected/re-connected from the main grid.**

# Future Electric Grid

Movie taken from http://www.youtube.com/watch?v=vpm1Q-4CIQA

# BC: Net-Importer or Net-Exporter?

**Questions, Comments**

**&**

**Class Discussion**

# Part 3: The Beginnings of IT

1. **The Data Network**
2. **AMI & Smart Meters**
3. **What is the definition of “smart”?**

# The Data Network

## WAN (Wide Area Network)

- To the destruction substation
- Included generation and transmission

## LAN (Local Area Network)

- From destruction substation to the delivery point
- The distribution side of the electric grid

## HAN (Home Area Network)

- From the delivery point
- Inside the building or a home

# AMI & Smart Meters

## Meter types: Electromechanical, AMR, AMI

- AMR: Automatic Meter Reading
- Advanced Meter Infrastructure: data collections, remote disconnect, tamper alarms, HAN gateway, security

## Proprietary Networks

- Offered by most meter companies.
- Bigger companies trying to go open standards

## Revenue Meters

- Use *de facto* protocols: SCADA, RS-485, Modbus
- Expensive but highly accurate.

# What is the definition of “smart”?

**Questions, Comments**

**&**

**Class Discussion**

# Part 4: Intelligent Energy Systems

1. **What is an EMS?**
2. **Why does the EMS needs Intelligence?**
3. **Do we need IA or AI?**

# Energy Management System (EMS)

A collection of equipment, systems, and tools used by the utility companies to manage the electrical grid.

Operators can monitor, control, and optimize the generation and transmission of energy across the grid.

**An End-to-End Solution**

# EMS an End to End Solution

**Back-Office Systems:**

- QoS, Energy Trading, and Cost Control
- Customer and Asset Management
- Rating, Billing, and Accounting

**Front-End Equipment:**

- Data Aggregation
- Programming: Tariffs, RTC, MD
- Network Management

**Field Components:**

- Data Communications
- Equipment: Meters, Sensor, and Controls

# EMS Network and Standards

Using standards provides an *open system* that utility companies want.

**IEC 61850** (Communication Networks and Systems in Substations)

**ANSI C12.19** (Utility Industry End Device Data Tables)

**ANSI C12.22** (Protocol Specification for Interfacing to Data Communication Networks)

**Open System = Success**

# EMS Needs Intelligence

Management and coordination of:

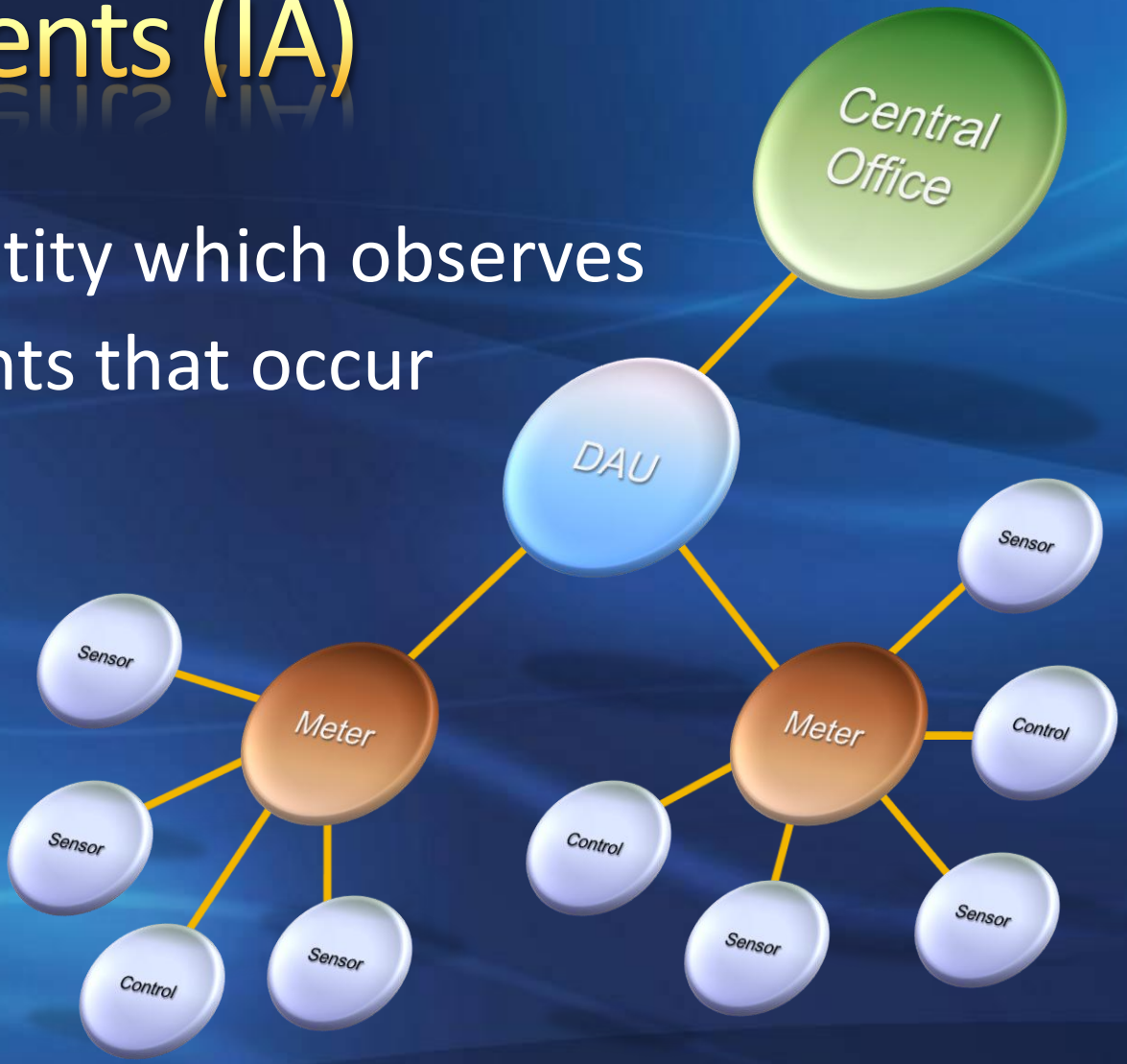
- **System Wide Events**
- **Fast Local Responses**
- **Efficient Data Distribution**
- **Network Optimizations**
- **Distributed Command and Control**


**IA or AI???**

# Intelligent Agents (IA)

An autonomous entity which observes and acts upon events that occur within the grid.

They can be interrogated for status and have their behaviours modified.



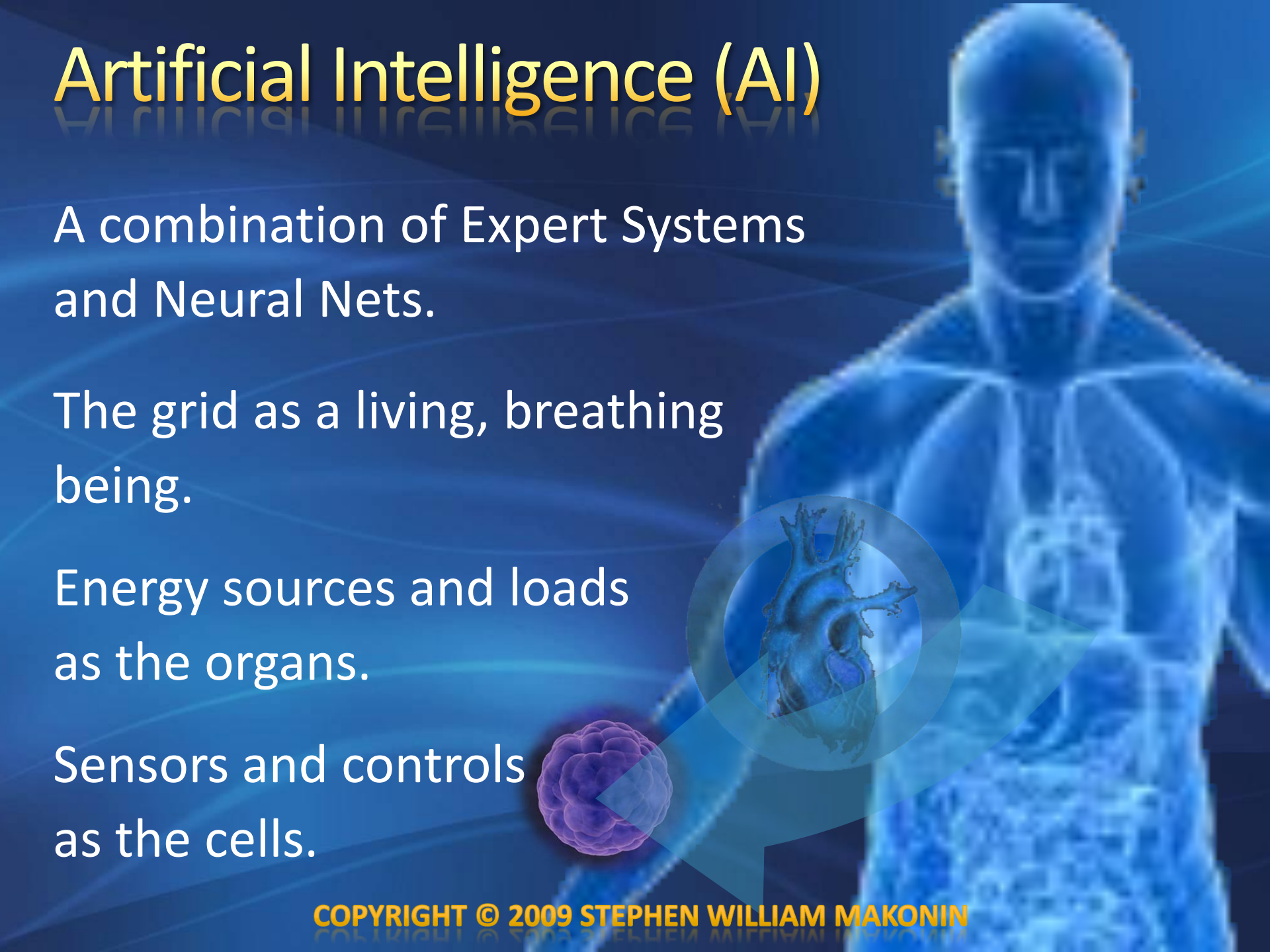
# Artificial Intelligence (AI)

A combination of Expert Systems and Neural Nets.

The grid as a living, breathing being.

Energy sources and loads as the organs.

Sensors and controls as the cells.

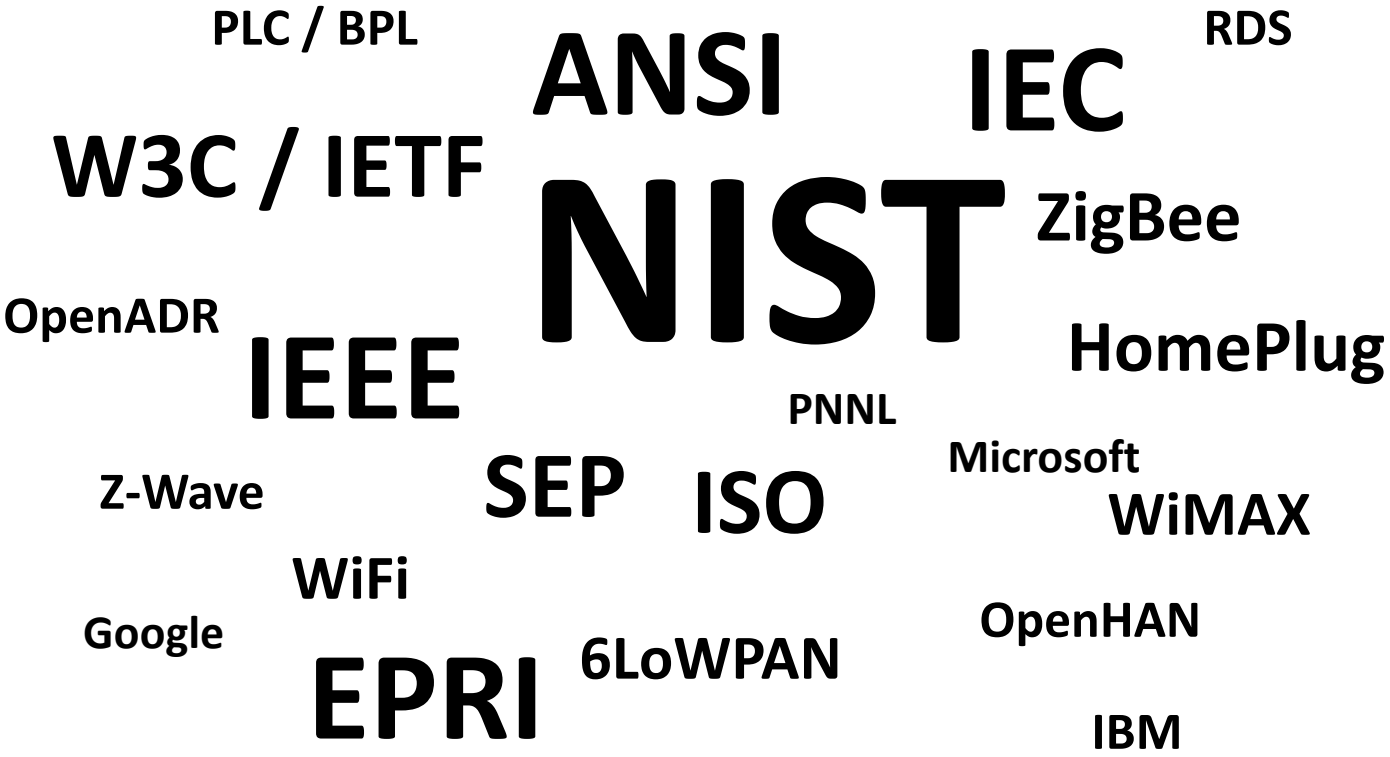


# Part 5: Open Standards

1. Standards Organizations
2. The NIST Framework 1.0
3. Do You See the Mess?

# Standards Organizations

**Everyone wants to create a standard!**



# The NIST Framework 1.0

1. **"Primary responsibility to coordinate development of a framework that includes protocols and model standards for information management to achieve interoperability of Smart Grid devices and systems…" [EISA Title XIII, Section 1305].**
2. **Identify 25 "must-have" standards.**
3. **Additional 50 standards for further review.**

# Do You See the Mess?

**Questions, Comments**

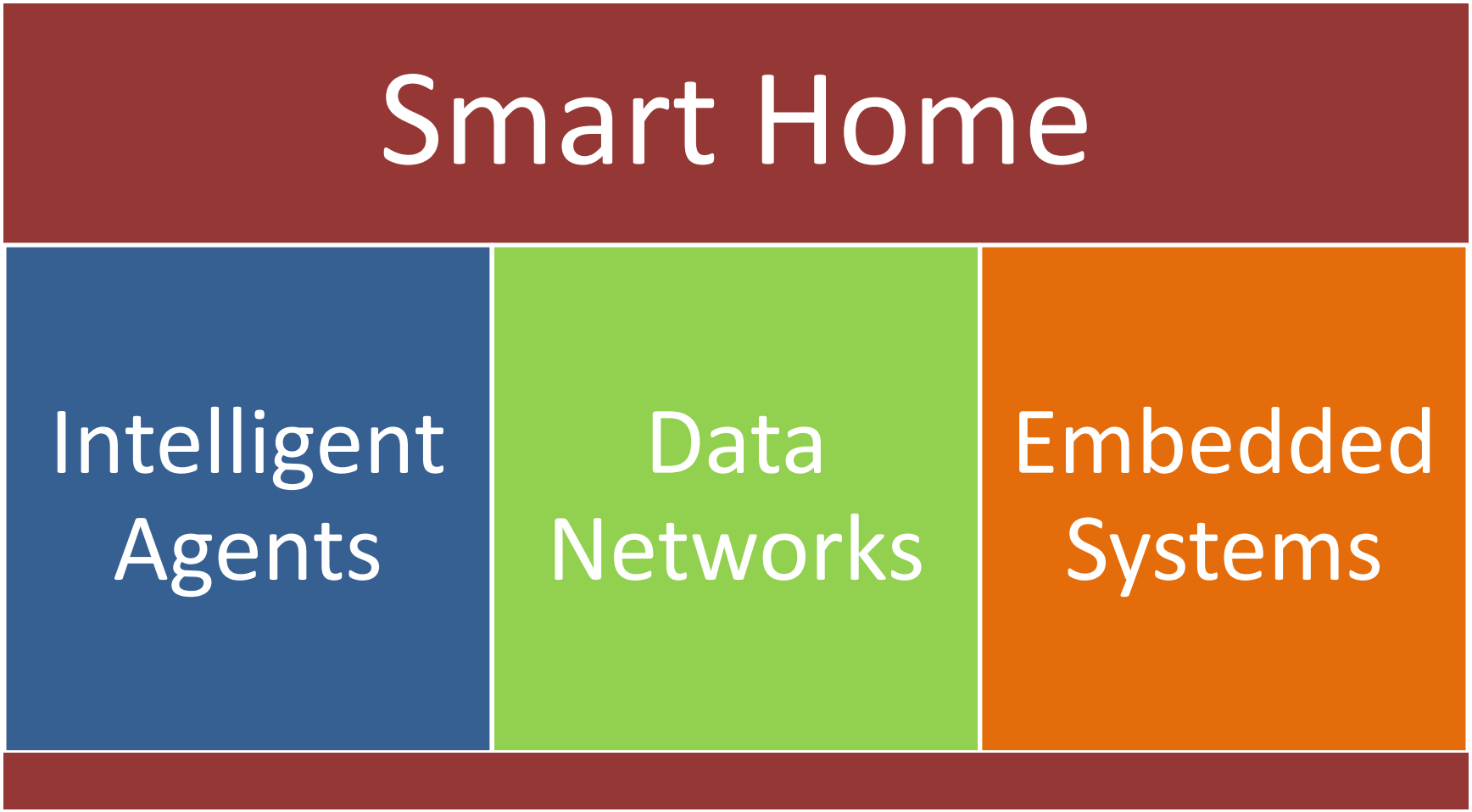
**&**

**Class Discussion**

# Part 6: Research Interests

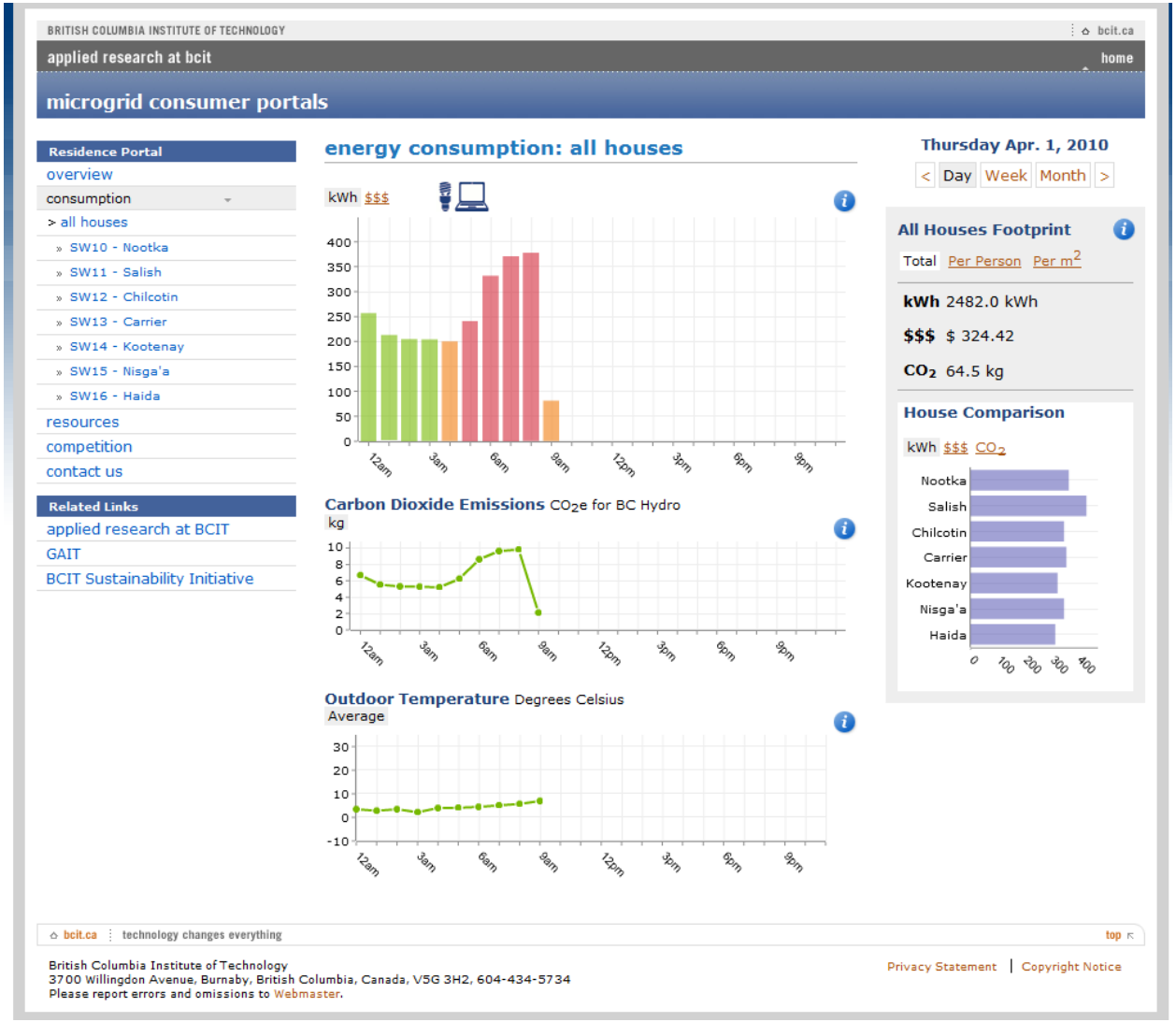
1. **Research Foundation**
2. **Stuff I Have Done**
3. **Interesting Questions**

# Research Foundation



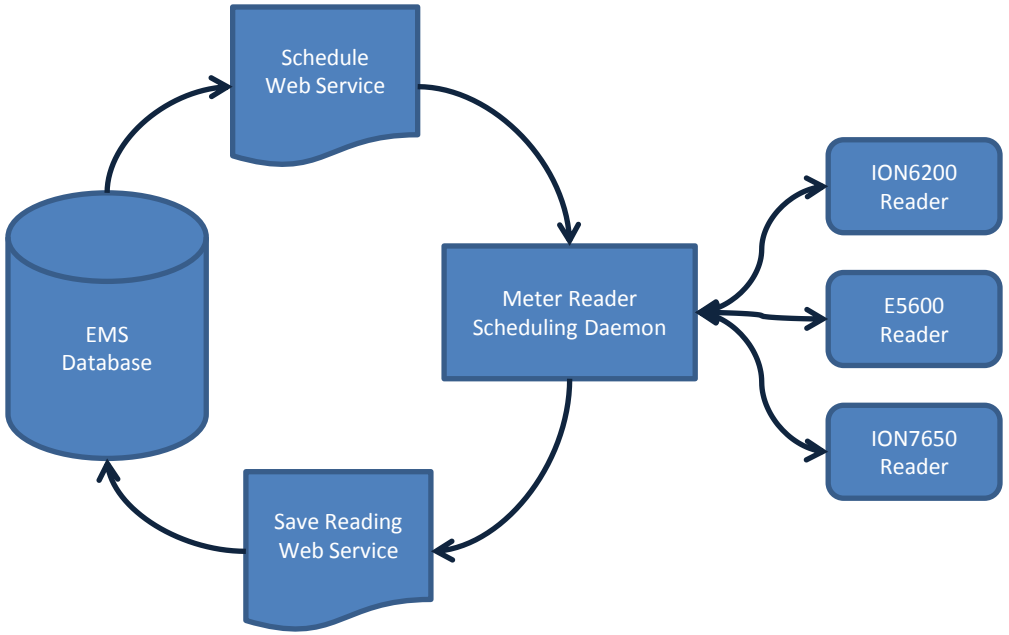
# Role of EMS Architect

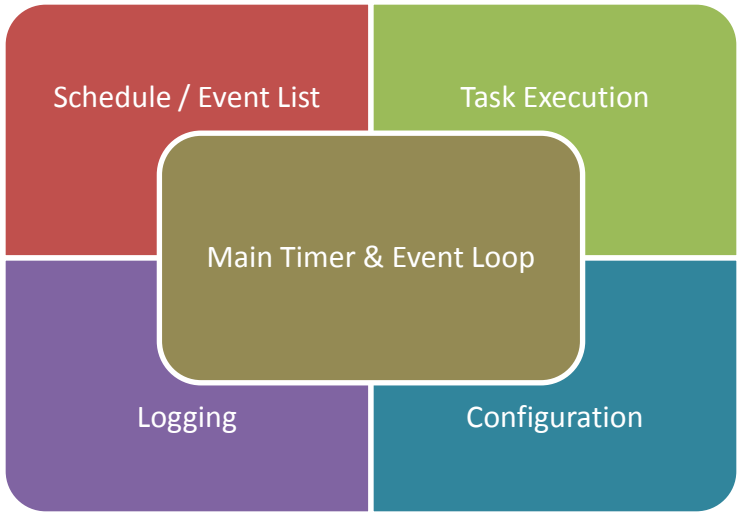
- Tracks energy usage
- N-Tier
- Web Service
- Web 2.0



# Developed a Scheduler

**High resolution scheduler to read meters execute tasks.**



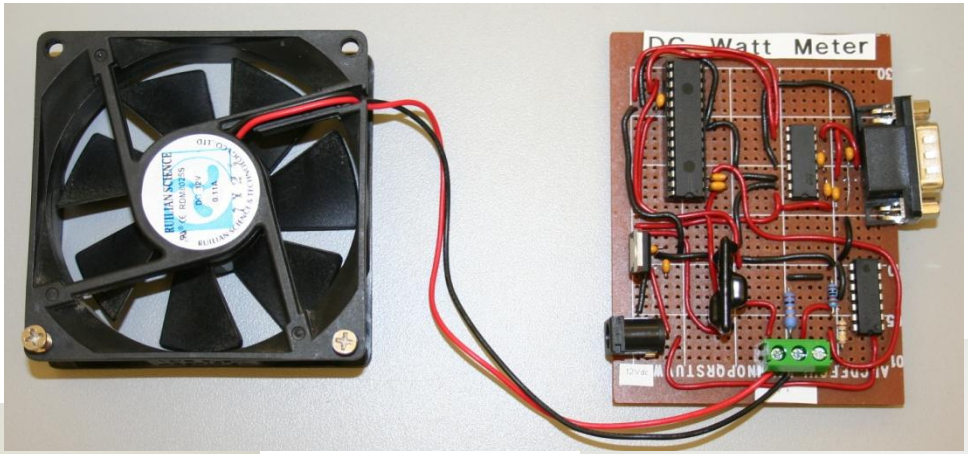



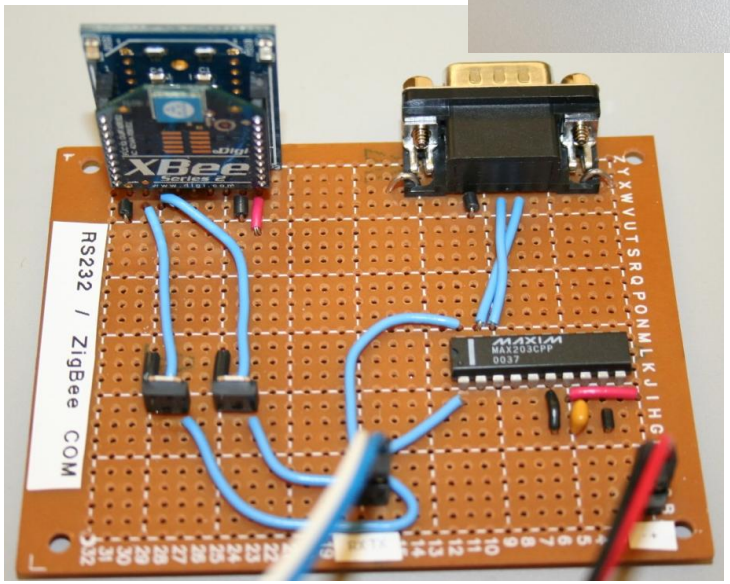
# Helped Integrate Hardware

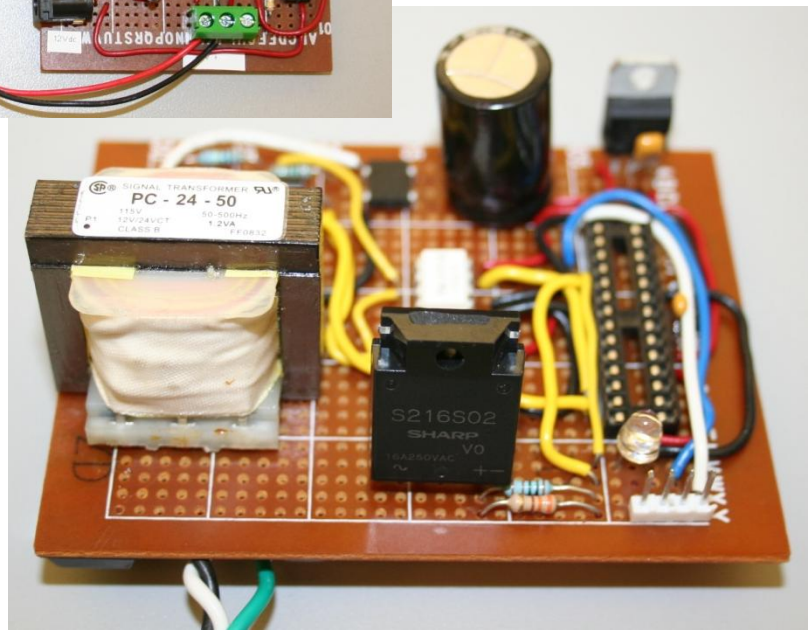
**Build load control boxes & meter enclosures.**


# EE Student Supervisor

## Tested ZigBee Protocol & Build Meters

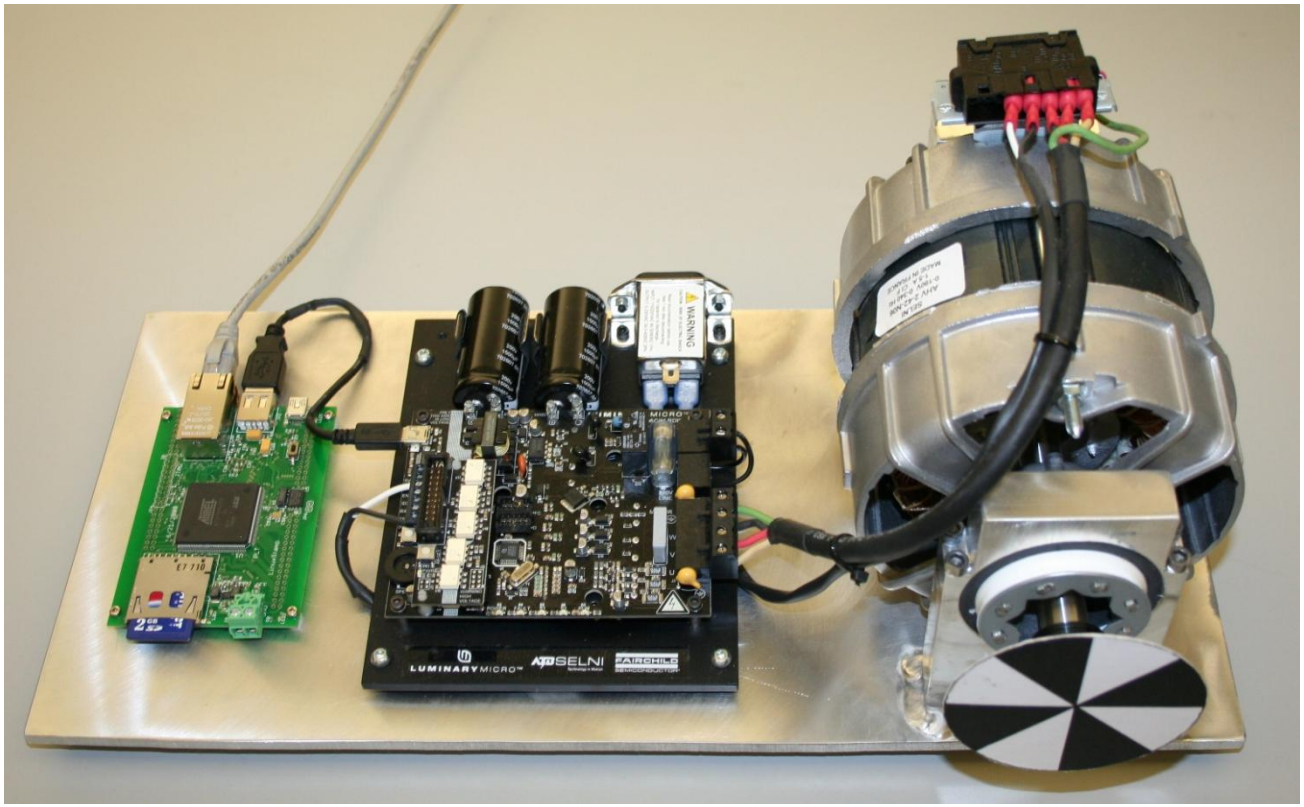


# Developed Other Prototypes

**Embedded web-based motor control.**



# Interesting Questions

**How do you scale a IA framework from single embedded MCU chip to full blown server?**

**How can you modify an IAs behaviour through local events while giving it access to a warehouse with GBs of historical data?**

**How can you create a decentralized MAS but still maintain a "sort-of" chain of command?**

**Is it possible to have IAs travel across a data network from equipment to equipment?**

# References


- Enrique Santacana et al., “Enrique Santacana,” *IEEE Power & Energy Magazine, Vol. 8 No. 2, Mar/Apr 2010.*
- IBM Documentaries (Sep. 2009), “IBM Smarter Planet: Efficient Grid Models for a Smarter Planet”. Available: http://www.youtube.com/watch?v=eSbYApshKVs.
- J. Berst, “Why the smart grid industry can’t talk the talk,” *Smart Grid News, Mar. 5, 2009.*
- National Institute of Standards and Technology (Jan. 2010), “NIST framework and roadmap for smart grid interoperability standards,” Release 1.0, [Online]. Available: http://www.nist.gov/public_affairs/releases/smartgrid_interoperability_final.pdf.
- *World Coal Institute*, http://www.worldcoal.org/coal/.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**Additional questions or comments?**


**Contact me at: stephen@makonin.com**