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Design Project Themes

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Each IoT design project will involve building an IoT system comprised of an IoT input device, IoT cloud, and IoT output device. The IoT input devices will have various input modules attached that can sense what is going on in the environment (e.g., light, temperature, motion, force, current, pulse, liquid) and be able to upload data into the cloud. We will be using Xively as our IoT cloud service. Each IoT output device will be able to download data from the cloud and will have various output modules attached to display data (e.g., LEDs, piezo buzzer, mini-printer) or react in some way (e.g., servo, relay for controlling appliances). The following diagram illustrates the overall approach we will be using in our IoT systems.

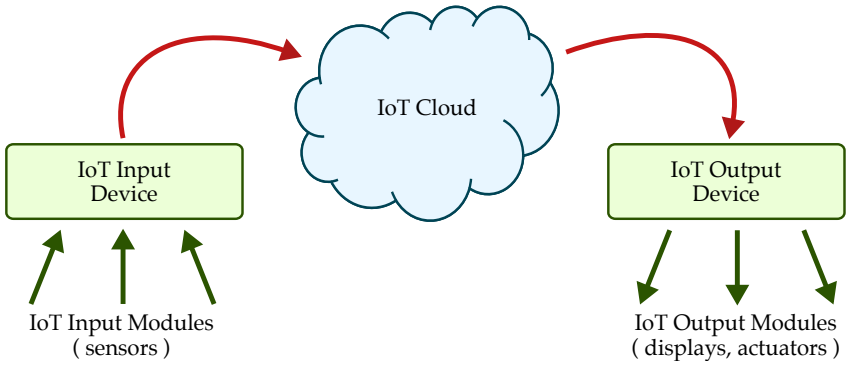

Figure 1: Diagram of IoT System Template

The IoT design projects will be centered around one of several themes: smart home, smart electrical power grids, early disaster warning, wildlife tracking, and wearable health monitoring. Each theme is described in more detail below along with links to relevant articles, research papers, and websites.

1. IoT Design Project Theme: Smart Home

There has been quite a bit of excitement lately about smart homes that integrate sensors into everyday objects around the home including thermostats, appliances, doors/windows, and lights. These sensors can automatically learn about our behavior and autonomously interact with the cloud to improve our standard of living.

In this project, scholars will build a simple smart home system that is capable of monitoring temperature, light, and/or motion and then either display status information or control another appliance. For example, a group might start by building an IoT input device with an infrared range finder input module to monitor motion for security purposes. Motion data would be sent into the cloud, and an IoT output device would periodically check this motion data to determine if it should initiate some kind of visual or audio alarm. As another example, a group might start by building an IoT input device with a temperature and light sensor. This environmental data would be sent into the cloud, and an IoT output device could periodically check this environmental data to control a fan or other appliance. Once scholars have designed, implemented, and tested a simple IoT system, they are also

welcome to increase the sophistication of their system by creatively integrating other input and/or output modules that fit with the IoT smart home concept.

- D. Pogue, "A Thermostat That's Clever, Not Clunky", *New York Times*, Nov 30, 2001.
  `http://www.nytimes.com/2011/12/01/technology/personaltech/nest-learning-thermostat-sets-a-standard-david-pogue.html`
- S. Frizell, "This Startup is Trying to Create the Internet of Your Home", *Time*, June 26, 2014.
  `http://time.com/2926400/at-your-service`
- Nest: Maker of smart thermostats and fire alarms.
  `https://nest.com`
- SmartThings: Maker of an entire smart home platform.
  `http://www.smartthings.com`
- Aros: Maker of smart air conditioners.
  `http://www.quirky.com/shop/752`

2. IoT Design Project Theme: Smart Power Distribution Grid

As the world moves towards renewable energy sources, our power distribution network must become more sophisticated. Renewable energy is less predictable compared to more traditional energy sources creating challenges on the power generation side. In addition, consumers are now locally generating their own power through solar panels or wind turbines creating a significantly more distributed power generation system. Many communities are integrating smart power meters into homes to enable consumers to conveniently monitor energy usage and enable the smart grid to intelligently interact with appliances in our homes. For example, smart appliances might automatically schedule their operation when energy is the cheapest. IoT devices can play a key role in monitoring the generation and consumption of energy to optimize total system efficiency.

In this project, scholars will build an IoT input device capable of sensing the current going through a standard extension cord as well as the voltage level provided to that cord. Scholars will experiment with three different types of light bulbs (incandescent, CFL, and LED) to measure their power consumption, before designing their IoT input device to upload this information to the cloud. An IoT output device can periodically check this power consumption data and use it to shed load through a relay output module. In other words, the IoT output device can turn off other lights in the system based on the current power consumption at the IoT input device. Once scholars have designed, implemented, and tested a simple IoT system, they are also welcome to increase the sophistication of their system by creatively integrating other input and/or output modules that fit with the IoT smart power distribution grid concept.

- The Smart Grid: An Introduction, *Department of Energy*.
  `http://energy.gov/oe/downloads/smart-grid-introduction-0`
- D. Pogue, "New Reasons to Change Light Bulbs", *New York Times*, March 20, 2013.
  `http://www.nytimes.com/2013/03/21/technology/personaltech/cheaper-led-bulbs-make-it-easier-to-switch-lights.html`
- B. Walsh, "Is This America's Smartest City?", *Time*, June 26, 2014.
  `http://time.com/2926417/is-this-americas-smartest-city`
- J. Morton, "Demand Response Programs", BUILDINGS, Jan 31, 2012.
  `http://www.buildings.com/article-details/articleid/13458/title/demand-response-programs.aspx`

3. IoT Design Project Theme: Early Disaster Warning System

There has been significant work on wireless sensor networks to help provide early warnings for various disasters. Small, inexpensive devices are distributed to monitor for flash flooding, earthquakes, or structural issues in tunnels and bridges. As our world becomes better instrumented, our society will be better prepared for both natural disasters as well as disasters caused by poor maintenance. For example, early flash flood warnings in developing countries can enable downstream villages to move to higher ground. As another example, instrumented tunnels could automatically notify the cloud when they detect structural integrity issues, and then the cloud can even autonomously send a robotic system to investigate.

In this project, scholars will build a simple early disaster warning system that is capable of monitoring water, motion, and/or flex. For example, a group might start by monitoring for abnormal water levels using a water sensor. Water level data would be sent into the cloud, and an IoT output device would periodically check this data to determine if it should initiate some kind of visual or audio alarm. As another example, a group might use a sensitive accelerometer to detect small unexpected motions in the spirit of early earthquake detection. Again, this data can sent into the cloud to produce an alarm with an IoT output device. Once scholars have designed, implemented, and tested a simple IoT system, they are also welcome to increase the sophistication of their system by creatively integrating other input and/or output modules that fit with the IoT early disaster warning concept.

- "Wireless Sensor Network Provides Early Flood Detection", Microsoft Research Brief.
  `http://research.microsoft.com/en-us/collaboration/focus/e3/sensornetwork.aspx`
- "Inside Story: Superstructures", The Economist, Dec 9, 2010.
  `http://www.economist.com/node/17647603`

4. IoT Design Project Theme: Wildlife Tracking System

Scientists have been increasingly turning to wireless devices such as collars that can be attached to wildlife for tracking purposes. These devices provide scientists with quantitative data on how animals interact with each other, how humans impact the ecosystem, and animal migration patterns. Current wildlife tracking systems are relatively simple, but in the future we can imagine much more sophisticated systems that use specially designed low-power computational platforms with peer-to-peer communication to be able to track animal behavior in a distributed fashion.

In this project, scholars will build a simple tracking system in the spirit of what scientists might use to track wildlife. An IoT input device will represent the sensor attached to an animal, and wireless beacons will be distributed around the lab. The IoT input device will monitor what wireless beacons are in range and upload this information to the cloud. An IoT output device can monitor the cloud to display tracking information and/or initiate some kind of visual or audio alarm if an IoT input device is close to a specific wireless beacon. Scholars can add more complex analysis for better localization by considering situations where multiple beacons are in range. Once scholars have designed, implemented, and tested a simple IoT system, they are also welcome to increase the sophistication of their system by creatively integrating other input and/or output modules that fit with the IoT wildlife tracking system concept.

- D. Mech and S. Barber, "Critique of Wildlife Radio-Tracking and its Use in National Parks", USNPS Report, Feb 6, 2002.
  `http://www.npwrc.usgs.gov/resource/wildlife/radiotrk`
- P. Juang et al., "Energy-Efficient Computing for Wildlife Tracking", ASPLOS 2002.
  `http://www.princeton.edu/~mrm/asplos-x\_annot.pdf`

- Lotex: Maker of wildlife monitoring systems.
  `http://www.lotek.com`

5. IoT Design Project Theme: Wearable Health Monitoring

Wearable computing is becoming more and more common. Activity monitors, such as Jawbone's UP, Nike's FuelBand, and Fitbit's Force, enable users to continuously record data on their exercise, sleep, and lifestyle. This data can then be used to make suggestions on healthier living. Google Glass provides users with a seamless heads up display and the potential for augmented reality. In the future, we can imagine wearable computing specifically tailored towards health monitoring. These devices can continuously monitor patients, and the corresponding medical data can be uploaded to the cloud for doctors to analyze.

In this project, scholars will build a simple wearable health monitor. An IoT input device will record pulse through a special sensor and motion through an accelerometer and upload this information to the cloud. An IoT output device, in the spirit of what might be in a doctor's office, will periodically display the users health data using a small thermal printer attached to the output device. Scholars can add more complex analysis to determine the users activity (sleeping, working, exercising) using the input sensors. Once scholars have designed, implemented, and tested a simple IoT system, they are also welcome to increase the sophistication of their system by creatively integrating other input and/or output modules that fit with the IoT wearable health monitoring concept.

- T. Bajarin, "Where Wearable Health Gadgets are Headed", *Time*, June 30, 2014.
  `http://time.com/2938202/health-fitness-gadgets`
- B. Wasik, "Why Werable Tech Will Be as Big as the Smartphone", *Wired*, Dec 17, 2013.
  `http://www.wired.com/2013/12/wearable-computers`
- Jawbone: Maker of UP activity monitor.
  `https://jawbone.com/up`
- Nike: Maker of FuelBand activity monitor.
  `http://www.nike.com/us/en\_us/c/nikeplus-fuelband`
- Fitbit: Maker of various activity monitors.
  `http://www.fitbit.com`