Embedded Systems

Introduction to the Wireless Sensor Network and Internet of Things
Outline

- Introduction to Wireless Sensor Network
- Introduction to the Internet of Things
- An application .. Home Automation
Wireless Sensor Network
Wireless Sensor Network

- **WSN**
  - A group of specialized transducers with a communications infrastructure for monitoring and recording conditions at different locations.
  - Consists of multiple detection stations called sensor nodes, each is equipped with a transducer, microcomputer, transceiver and power source.

- **Applications**
  - Automotive and aviation
  - Home automation – smart home
  - Video surveillance
  - Traffic monitoring
  - Medical device monitoring
  - Monitoring of weather conditions
  - Air traffic control
  - Robot control
Wireless Sensor Network

- WSN incorporates multiple of issues:
  - Deployment
  - Localization
  - Time Synchronization
  - Wireless Link
  - Medium Access
  - Power Management
  - Routing
  - QoS
Wireless Link

- **Communication protocols**
  - Set of rules and standards to format data and control data exchange

- **Link layer:**
  - Conversion of bits to radio signals

- **Network layer**
  - Addresses and routing

- **Transport layer**
  - Generates communication sessions

- **Application layer:**
  - Data formatting

![Diagram of the OSI network model and the TCP/IP protocol stack]
Wireless Link

- **Range**
  - Personal Area Network
  - Local Area Network
  - Neighborhood Area Network
  - Wide Area Network
Wireless connectivity

- **Varity of options**

<table>
<thead>
<tr>
<th>WiFi®</th>
<th>ZigBee™</th>
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<tbody>
<tr>
<td>Fast – 10Mbps++</td>
<td>Low power mesh network</td>
</tr>
<tr>
<td>Direct Internet connection</td>
<td>Smart metering &amp; lighting</td>
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<td>Home &amp; enterprise apps</td>
<td>Moving into home automation</td>
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<table>
<thead>
<tr>
<th>Bluetooth®</th>
<th>LoWPAN</th>
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<tbody>
<tr>
<td>Lowest power BLE</td>
<td>Low power &amp; long range</td>
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<tr>
<td>Connect to tablet/phone</td>
<td>Native IP-based network</td>
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<tr>
<td>Moving to industrial, automotive</td>
<td>Home gateways and security</td>
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<tr>
<th>G3-PLC Alliance</th>
<th>EtherCAT®</th>
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<td>Data over power lines (OFDM)</td>
<td>Fast, low latency Ethernet</td>
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<td>Developed for smart grid</td>
<td>Real-time industrial control</td>
</tr>
<tr>
<td>Lighting, solar, appliances</td>
<td>Information technology</td>
</tr>
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**Technologies**:
- NFC
- GPS
- RFID
- Bluetooth
- 2.4GHz
- SubGHz
- IEEE 802.15.4
- IEEE P1901.2
Sensors?

- Temperature and humidity
- Light
- Angle
- Infrared
- Tilt
- Force
- Acceleration
- Sound
- Vibration
- Capacitance
- Barometric pressure
- Magnets
- Gases
- Flame and smoke
- ....
Internet of Things
Internet of Things

- “The network of physical objects or ‘things’ embedded with electronics, software, sensors, and network connectivity, which enables these objects to collect and exchange data.”
- Denotes the connectivity of devices, systems and services that goes beyond the traditional machine to machine communications
  - Mesh networks, point to point, near field, sonar, …
- Simplified definition:
  - People and ‘things’ gets connected via cloud services
Internet of Things

- **IoT fields of interest:**

  - **Wearables**
    - Entertainment
    - Fitness
    - Smart watch
    - Location and tracking

  - **Building & Home Automation**
    - Access control
    - Light & temp control
    - Energy optimization
    - Predictive maintenance
    - Connected appliances

  - **Smart Cities**
    - Residential E-meters
    - Smart street lights
    - Pipeline leak detection
    - Traffic control
    - Surveillance cameras
    - Centralized and integrated system control

  - **Smart Manufacturing**
    - Flow optimization
    - Real time inventory
    - Asset tracking
    - Employee safety
    - Predictive maintenance
    - Firmware updates

  - **Health Care**
    - Remote monitoring
    - Ambulance telemetry
    - Drugs tracking
    - Hospital asset tracking
    - Access control
    - Predictive maintenance

  - **Automotive**
    - Infotainment
    - Wire replacement
    - Telemetry
    - Predictive maintenance
    - C2C and C2I
Internet of Things

- **IoT fields of study:**
  - Sensing a complex environment
    - Occupancy
    - Triangualization
  - Connectivity
    - No one standard fits all
  - Security
    - Hackers ?!
  - Complexity
    - Not everyone’s an expert!
  - Power
    - Should run for years!
  - Operating environment
    - How to run in a not-so-friendly environment?
Internet of Things

- IoT targets not only professional engineers, but whoever has the sense of design.
  - Cheap boards and platforms are available, starting < 10$
  - Simple programming and configurations tools
    - Python
    - Scratch
    - Lua
  - Fully integrated developing environment
  - Huge community
Python

- **Script language**
  - Code syntax is checked at runtime
  - Code is interpreted, not compiled (sort of)

```python
# import modules used here -- sys is a very standard one
import sys

# Gather our code in a main() function
def main():
    print repeat('Yay', False)
    print repeat('Woo Hoo', True)

# Defines a "repeat" function that takes 2 arguments.
def repeat(s, exclaim):
    # Returns the string s repeated 3 times.
    if exclaim:
        result = s + '!!!'
    else:
        result = s * 3
    return result

# Standard boilerplate to call the main() function to begin the program
if __name__ == '__main__':
    main()
```

- Comment
- Comment at the end of line
- Call a function
- Function definition
- Variable assignment
- Control statement
- Variable assignment
- Return result from the function
Scratch

- Visual programming language
IoT Example

Home Automation
Home Automation

- Automatic centralized control of a home’s lighting, HVAC (heating, ventilation and air conditioning), appliances, security locks of gates and doors and other systems
- Large, profitable market!
- Basic idea:
  - Sensors in advert places around home
  - Sensors communicates wirelessly with centralized control center
  - Control center takes actions according to a given rules
  - Home owner configures the control center, and gets notifications!
Home Automation

- openHAB
  - Open Home Automation Bus, open-source home automation framework
  - Runs on Windows, Linux, Raspberry Pi and BeagleBone
Supposed to be a demo with Wifi module attached to a sensor, but both are fried!

Questions?