CMPSCI 677 Operating Systems **Spring 2014**

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26.1 Distributed Pervasive Computing

26.1.1 Introduction

Pervasive computing is a concept where computing is everywhere and anywhere. It is also called as Ubiquitous computing. As systems evolved, computing has become cheaper and it has become possible to embed computing into all possible devices like watches, smart TVs, cars, pair of glasses and even fridges. All these computing devices is also referred to as *internet of things*. This led to a new field of study called, in computer science, as *Sensor Networks*, where large number of these devices are inter-connected form networks of sensors.

26.1.2 Smart sensor architecture

Typically, there are two types of architectures to design smart sensors:

1. Low-power sensors: In this architecture, devices/sensors are extremely low power hence are not capable of connecting to internet directly. Data from the device is uploaded to cloud via a mobile device. Cloud provides analytics and provides feedback to phone.
2. Internet-enabled sensors: In this design, sensors are capable of directly uploading data to cloud and receive feedback.

26.2 Sensor Platforms

26.2.1 Introduction

Sensor platforms are considered as highly resource constraint devices. These devices typically run on ultra low-power controllers and have low-power radios for communication. A typical sensor platform has a communication bandwidth of 10-200 kbps and runs on 8-bit CPU with a memory of 4kb. Sensor platforms are battery operated therefore they are not only resource constrained but are energy constrained too.

In short, these devices have high resource and energy constraint with low network bandwidth, has small computation power with small memory, has tiny flash storage and are battery driven.

26.2.2 Issues

1. *Batter Power*: Size of battery and its capacity has direct impact on the packaging and operating time of the device. Researchers have been working towards designing battery-less devices which harvest

energy from ambient power sources like wireless RF signals, wind and solar.

2. *Data aggregation*: There are various design issues that arise when there is a network of sensors. Data aggregation is one of the issue where sensors have to relay data from their peers to a gateway because all sensors in the network may not have enough wireless range to communicate directly to a gateway. This leads to a challenge of routing within a wireless sensor network. A simple way of routing is to relay packets sent by peer sensors towards gateway. A more intelligent way is to aggregate the information sent by multiple sensors before transferring the aggregated data to the gateway.

3. *Duty cycling*: Duty cycle is defined as the percentage of time the device is up and running. Duty cycling is used to make devices more energy efficient by turning off major portion of its hardware modules when not in use. It becomes extremely important to synchronize duty cycles of all the devices when they are participating in a inter-connected network.

26.3 Green Computing

26.3.1 Introduction

Green Computing is an new area that has emerged that focuses specifically on energy issues in computing systems. Energy issues have been researched on for a long time now. But they have become more important with the recent growth of data center sizes. Data centers have exploded in size with huge number of servers and on an aggregate they consume a lot of energy hence high electricity bill. Making data centers more energy efficient will lead to significant reduction in maintenance costs.

Greening of Computing: Greening of computing deals with the issue of designing more energy-efficient hardware and software systems.

Computing for Greening: Computing for greening deals with the use of information technology to make physical infrastructure energy efficient. For example, making homes, offices, buildings and transportation consume less energy.

26.3.2 Reduction of server power consumption

The following are a few ways to make data centers more energy efficient

1. Energy Proportionality: When server is idle, server consumes around 50% of its peak power. So, this is an important factor to consider while designing an intelligent power management system.
2. Produce better hardware with lower power consumption.
3. Intelligent power management
   (a) Turn off servers when the overall utilization is low.
   (b) Use virtualization techniques to achieve power efficiency. For example, consolidate virtual machines to fewer hardware machines and turn the rest off.
4. Cost reduction in cooling server farms. Techniques like temperature aware cooling consolidation and direct air cooling can be applied to reduce the consumption of power for cooling data centers.

26.3.3 IT for Greening

Smart Buildings: Consider building as an example of a distributed system with senors to monitor power consumption, occupancy and temperature in various sections. All these sensors continuously send data to a server which runs its intelligent algorithms to figure out energy optimized, for example, air conditioning system by turning on or off air coolers in different sections of the building.

This example uses widely used *Sense*→*Analyize*→*Respond* approach to control air conditioning system of the building in an energy efficient manner.