

Application Lecture 4: Pervasive and Social Sensing

7COM1030 – Multicast and Multimedia Networking

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Topics

- ▶ Pervasive Sensing
- ▶ Social Sensing
- ▶ Internet of Things

Pervasive Sensing

- ▶ The need for understanding, serving, and controlling the physical world demands the emergence of **sensing everywhere**. Collaborative and pervasive sensing is the future.
- ▶ People's ownership of smartphones can make pervasive sensing a reality.



Picture from *Wireless Multimedia Sensor Networks: Challenges and Opportunities*, Sajal K. Das, University of Texas, 2011

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Key Roles of Smartphones

- ▶ Smartphones as **sensing nodes**:
 - A typical iPhone 5 has eight built-in sensors: accelerometer, GPS, ambient light, dual microphones, proximity sensor, dual cameras, compass, and gyroscope.
- ▶ Since smart phones are rich in processing and storage resources, they can act as **management nodes** in a wide range of sensor network deployments.
- ▶ Well-established wireless/mobile technologies act as reliable and hassle-free underlying communication protocols.
 - WiFi, bluetooth, GPRS, 3G, 4G...



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Sensors in Modern Smartphones

- ▶ Dual microphones (audio sensor)
- ▶ Dual cameras (image sensor)
- ▶ GPS (location sensor)
- ▶ Accelerometer and gyroscope (orientation sensor)
- ▶ Magnetometer (magnetic sensor)
- ▶ Motion sensor
- ▶ Ambient light sensor
- ▶ Proximity sensor
- ▶ Finger print sensor (identity sensor)
- ▶ Barometer (air pressure sensor)
- ▶ Altimeter (altitude sensor)

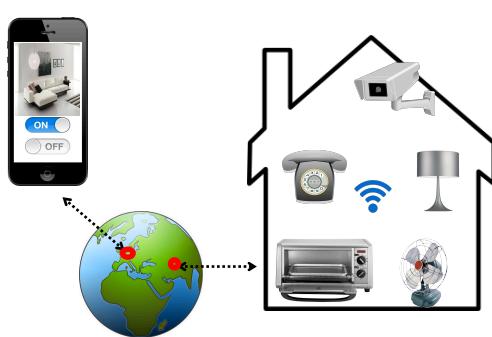


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Remote Surveillance on iPhone

- ▶ Truly wide area communication – iPhone can be anywhere away from home
- ▶ Control appliances and electronic devices
- ▶ Live surveillance video feed
- ▶ Cost may incur on personal mobile data usage, such as 3G, 4G



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Example of Social Sensing App

- ▶ Not compulsory to establish friend circles
- ▶ Location-aware imaging sharing
- ▶ Short data lives to achieve “live data”
- ▶ Categories: traffic, news, traffic, emergency
- ▶ Questions remain for the areas of applications



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Social Sensing

- ▶ Social sensing is a cutting-edge concept that takes advantage of both smartphone sensing and social network activities.
 - Still in research stage.
- ▶ A background reading paper is provided: *Reading/Smartphone Based Social Sensing*
- ▶ To understand social sensing, it is also essential to obtain knowledge of social networks.

Sociability

- ▶ **Sociability** is a metric that measures the strength of a user's connection to his/her social group.
 - In other words, it represents the quantity and quality of his/her relations with other users in the social network.
- ▶ This measurement can be derived based on network constraint.
- ▶ In a social network, the **network constraint** for a node quantifies the strength of the node's connectivity.
 - For any two persons in a social network, a person with lower network constraint value is considered to have higher strength in terms of connectivity.

Network Constraint

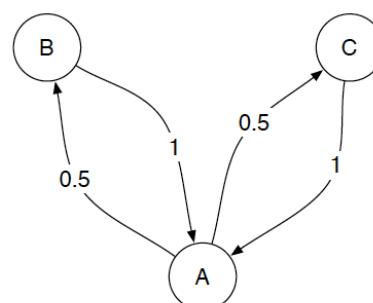
- ▶ The network constraint N_i for a node i in a social network is measured as:

$$N_i = \sum_j (p_{ij} + \sum_q p_{iq}p_{qj})^2, q \neq i, j; j \neq i$$

- ▶ where p_{ij} is the proportion of time i spent with j , i.e., the total time spent by i with j divided by the total time spent by i with all users in the network.

Example Scenario

- ▶ Assume that A spent 5 hours with B and 5 hours with C, and B and C did not spend any time with each other.
- ▶ The fraction of time A spent with B is 0.5 and with C is 0.5 and these are represented as weights in the graph. However, B has spent time only with A, therefore the weight of the edge (B,A) is one, similarly the weight of edge (C,A) is one too.
- ▶ The ranking with respect to decreasing order of sociability (or increasing order of network constraint) is: A(0.5), B(1.25), C(1.25). Since A distributes his/her time between two contacts, he/she is less constrained than B and C, therefore A is more sociable.



A is more sociable than B,C.

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Topics

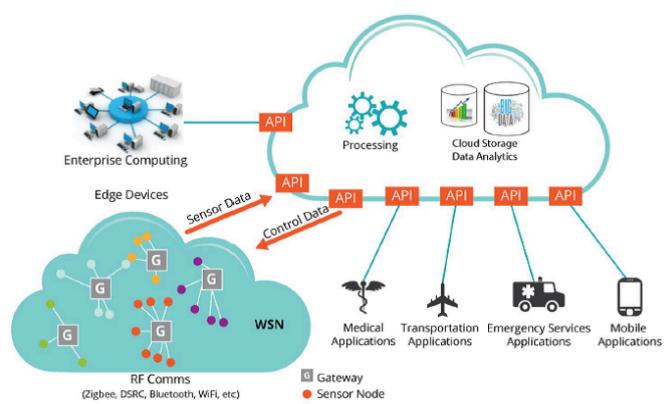
- ▶ Pervasive Sensing
- ▶ Social Sensing
- ▶ Internet of Things

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The Big Idea

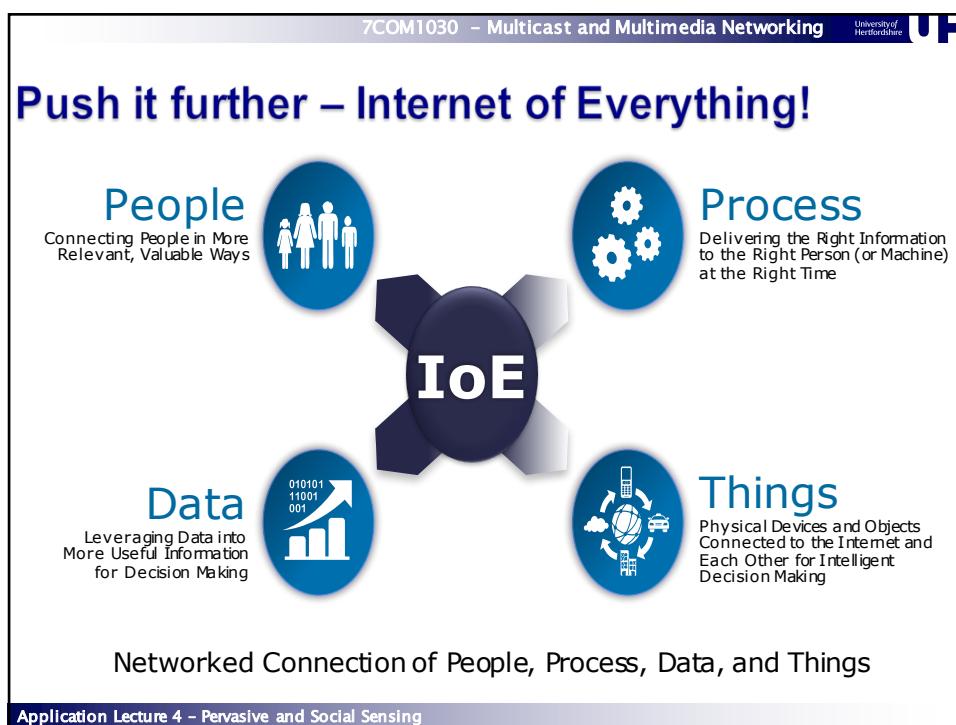
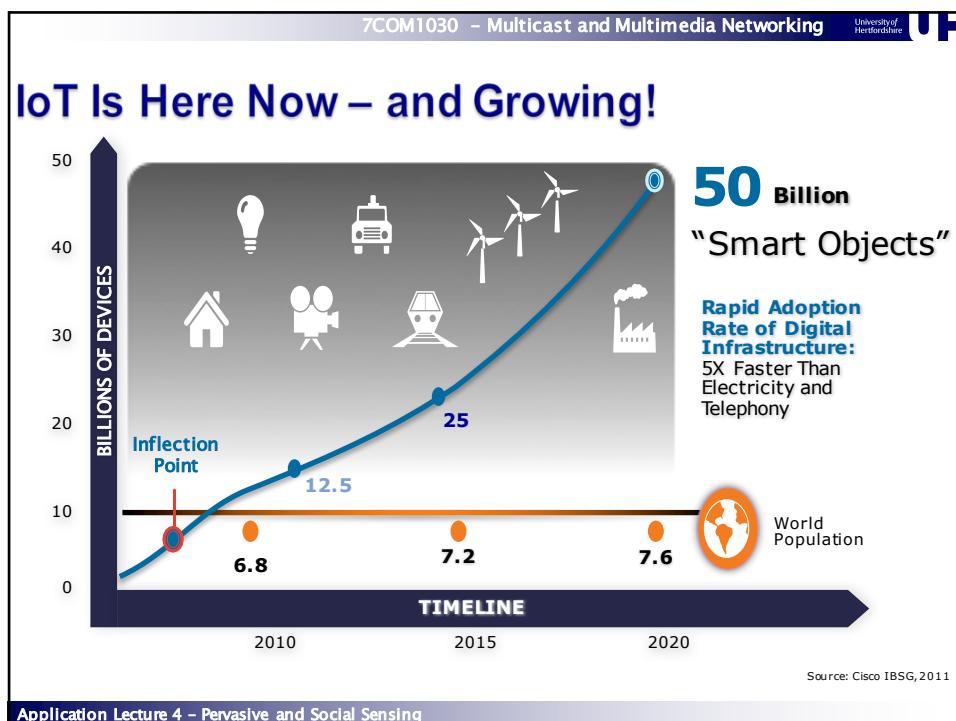
- ▶ The Internet of Things is the intelligent connectivity of physical devices driving massive gains in efficiency, business growth, and quality of life.



The diagram illustrates the architecture of the Internet of Things (IoT). It shows a hierarchy of components and their interactions:

- Edge Devices:** Represented by a cloud containing a Wireless Sensor Network (WSN) and Radio Frequency (RF) communications (Zigbee, DSRC, Bluetooth, WiFi, etc.).
- Enterprise Computing:** Represented by a cluster of servers and databases.
- Cloud-based Processing:** Represented by a cloud containing processing units, cloud storage, and data analytics.
- Applications:** Represented by icons for Medical Applications, Transportation Applications, Emergency Services Applications, and Mobile Applications.
- APIs:** Represented by red boxes labeled "API". They facilitate communication between the different layers and components.
- Data Flow:** Red arrows indicate the flow of data and control information between the components. "Sensor Data" flows from the WSN to the cloud. "Control Data" flows from the cloud back to the WSN.
- Legend:**
 - Gateway (represented by a square icon)
 - Sensor Node (represented by a circle icon)

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Concept! Vision! Revolution!

| | | |
|-----|----------|-----------------|
| IoT | Big Data | Cloud Computing |
|-----|----------|-----------------|

- ▶ Although these names are only a few years old, they have existed in our lives for decades.
- ▶ Probably more of a business revolution than a technological revolution.



The diagram illustrates the Cloud Internet of things (IoT) and its various applications:

- Vehicle, asset, person & pet monitoring & controlling:** Icons include a car, a suitcase, a dog, and a person.
- Agriculture automation:** Icons include a tractor and a water drop.
- Energy consumption:** Icon includes a lightbulb.
- Security & surveillance:** Icon includes a camera and a lock.
- Building management:** Icons include a water faucet, a lightbulb, and a water drop.
- Embedded Mobile:** Icons include a smartphone and a laptop.
- M2M & wireless sensor network:** Icons include a network of nodes and a sensor.
- Everyday things:** Icons include a computer monitor, a lamp, a chair, a shoe, and a wallet.
- Smart homes & cities:** Icons include a city skyline, buildings, and a house.
- Telemedicine & healthcare:** Icons include a medical bed, a laptop, and a car.
- Everyday things get connected for smarter tomorrow:** Icons include a plug and a lightbulb.

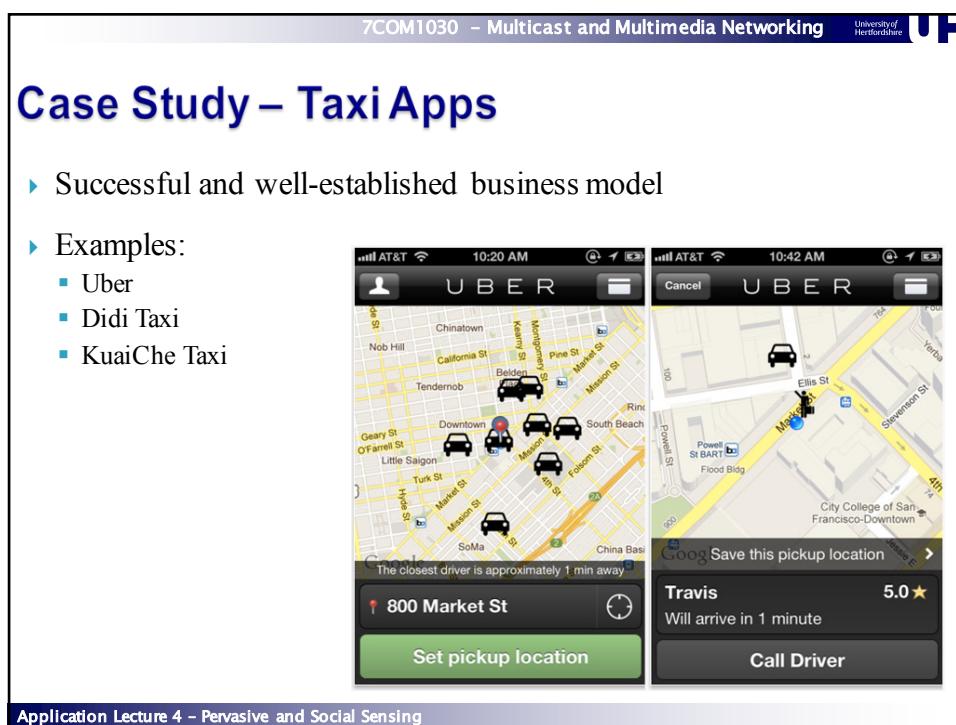
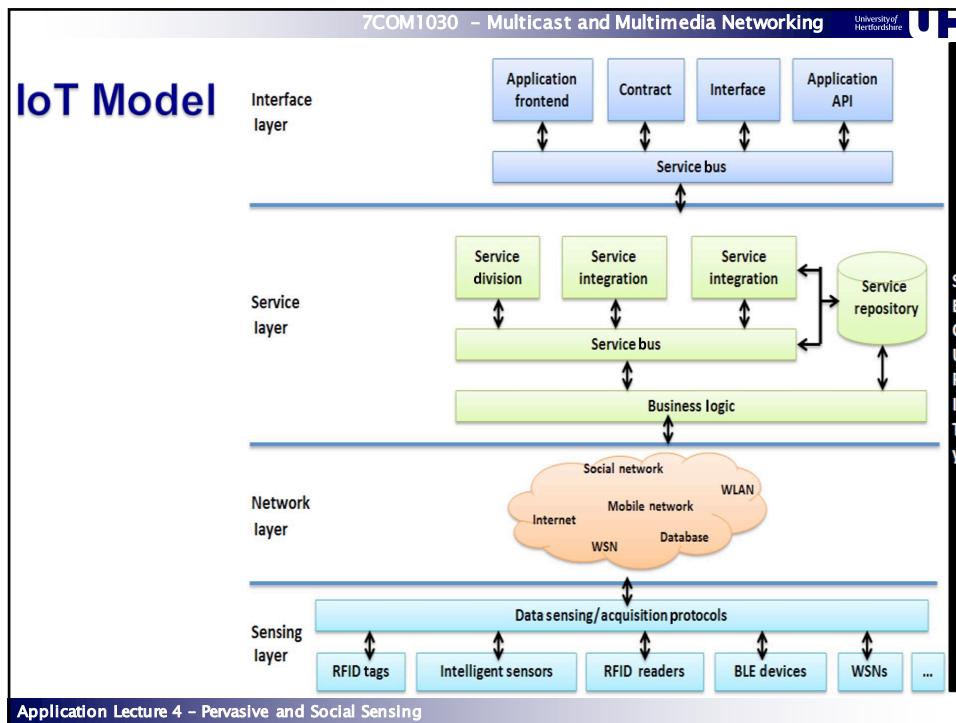
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Service Oriented Architecture for IoT

| | | | | | | | | | | | | |
|---|-------------|--------------|---------|-----------|---------|-----------|----------|--|-----------------|---------------|------------------|---------------|
| <table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td>Application</td></tr> <tr><td>Presentation</td></tr> <tr><td>Session</td></tr> <tr><td>Transport</td></tr> <tr><td>Network</td></tr> <tr><td>Data Link</td></tr> <tr><td>Physical</td></tr> </table> <p style="text-align: center;">OSI Model</p> | Application | Presentation | Session | Transport | Network | Data Link | Physical | <table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td>Interface Layer</td></tr> <tr><td>Service Layer</td></tr> <tr><td>Networking Layer</td></tr> <tr><td>Sensing Layer</td></tr> </table> <p style="text-align: center;">IoT Model</p> | Interface Layer | Service Layer | Networking Layer | Sensing Layer |
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Internet of “Taxis”

1. User sends these data to the cloud.
 - GPS location of the source and the destination
 - Money matters, e.g. tip?
2. Cloud computes things.
3. A few things are selected.
4. One thing answers the request.
5. Direct contact between user and the thing in the app
6. Service begins.
7. Service monitoring.
8. Bill.

```

graph TD
    Cloud((Cloud)) --> GPSUser[GPS sensor]
    Cloud((Cloud)) --> GSTaxi[GPS sensor]
    GPSUser --> User((User))
    GSTaxi --> Taxi((Taxi))
    User <--> Taxi
  
```

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Case Study – Retail Delivery

- Using IoT in the logistics domain is one of the earliest ideas of application, and it is still a primary category of service.
- As simple as this can be in terms of technical implementation, the user experience still major improvement.
 - Again – IoT is a business war! Service providers have to think about the business worth first.

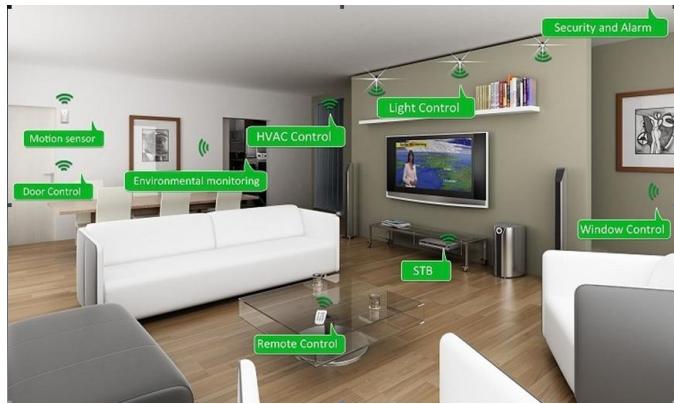
The image displays two side-by-side screenshots of mobile delivery applications. The left screenshot shows the Amazon Prime Now app interface, featuring a map of Welwyn Garden City and surrounding areas. It highlights delivery routes and landmarks like Sherards Park, Lemsford, and Stanborough. A delivery window of 8:00 PM - 10:00 PM is shown, along with the message "Omer has your Morrisons at Amazon order and is out making deliveries". The right screenshot shows the Meituan app interface, displaying a map of Shanghai with delivery routes and landmarks like Jinshan Wetland Park and Huanghe Road. It includes a delivery estimate of "预计送达09:14" (Estimated arrival at 09:14) and a rating of "4.8分" (4.8 points) for the delivery person "李国章 [美团快递]". Both screenshots show the phone's status bar at the top, including signal strength, battery level, and time.

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Case Study – Smart Home

- ▶ There is definitely a growing need for smart home facilities in the market.
- ▶ The current bottleneck is the underlying communication technology for transmitting real-time surveillance videos. Hopefully 5G will solve it.



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Questions?

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