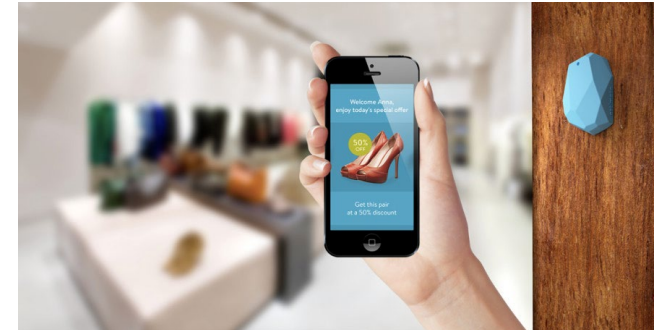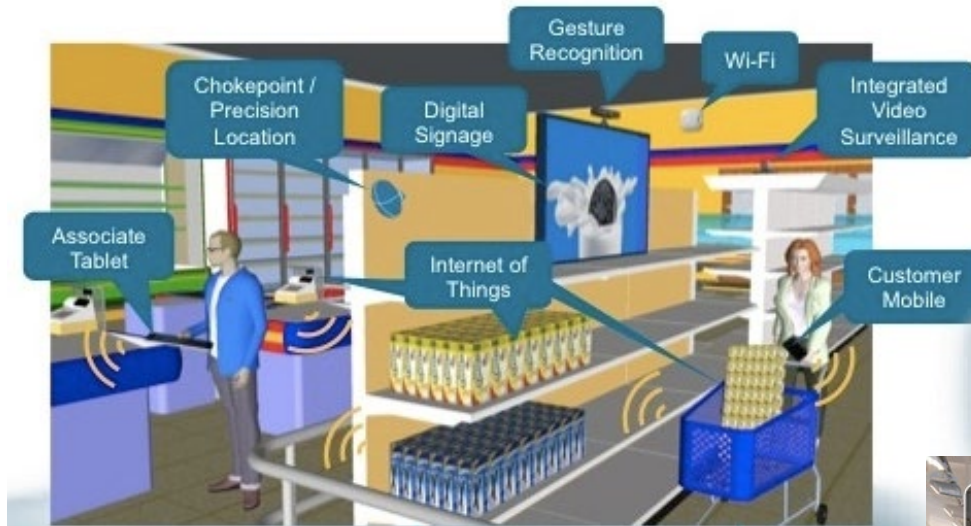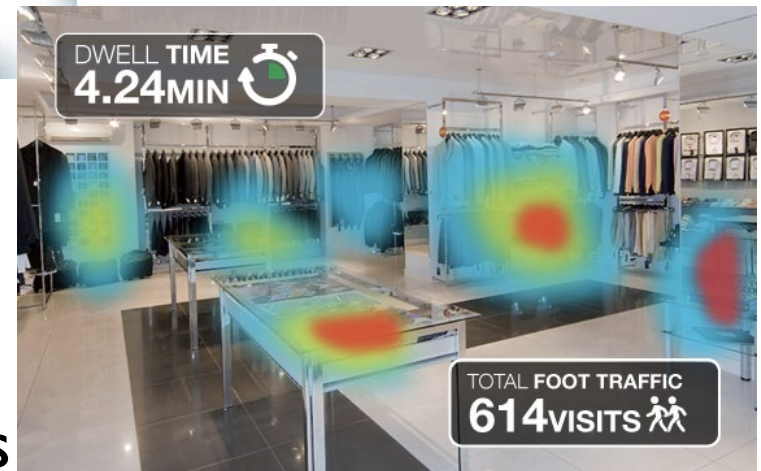# CS 439: Wireless Networking

## IoT Applications

# Scenario: Smart Retail



Use technology to enhance the user's personal and social experience and the company's business potential

# Scenario: Smart Retail



**Goals**

**Product identification and information
Directed coupons and discounts**

# Scenario: Smart Retail

**Challenges**

**Product detection**
**Channel contention**

# Scenario: Smart Retail



**Localized IoT Hub**

**User-to-Hub
Personalized
Shopping**

# Scenario: Smart Retail



**Localized IoT Hub**

**Hub-to-Product
Inventory control and
device management**

# IoT-enabled Inventory Management



**Labeling/inventory systems are prone to error**

# IoT-enabled Inventory Management



Labeling/inventory systems are prone to error

Automate label on shelf based on BLE label in products

# Product Tracking

What should the shelf label display?

# Product Tracking

**What should the shelf label display?**

**Find nearest product**

# Product Tracking

**What should the shelf label display?**

**Find nearest product**

**Is standard ranging-based localization enough?**

# Product Tracking

**What should the shelf label display?**

**Find nearest product**



**Is standard ranging-based localization enough?**

**Not accurate enough for small shelf spacing and small products**

# Product Tracking

**But absolute location is not necessary**

# Product Tracking

**But absolute location is not necessary**

**Need a nearness ordering!**

**Relative location instead of absolute location**

# Relative Proximity



What product is closest to me?

# Relative Proximity
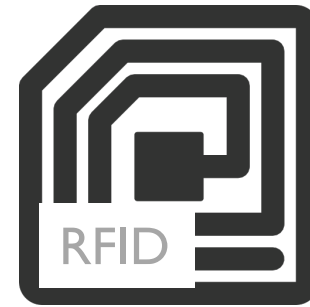


**What is the best wireless technology to use?**

What product is closest to me?

# Which Technology best fits IoT?

# Which Technology best fits IoT?

**BLE-based devices**

**Radios already in most smartphones**
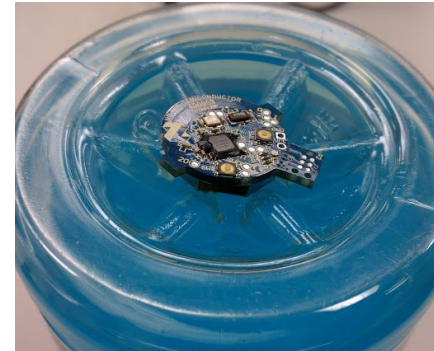**Devices easy to acquire**
**Low energy**
**Cheap**

# The Smart LaBLE System
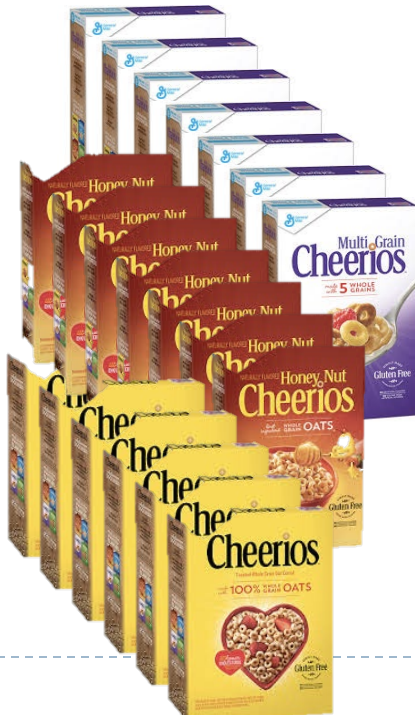
Attach **BLE** tags to each product

**Smart LaBLEs**
**Build nearness ordering**
**Display product info related to nearest product**
**Update every minute**

# Product Tagging in Dense Environments

**Low-frequency beaconing
Conserves energy
Reduces contention**

**Not all products need to beacon frequently!**

# Smart LaBLEs in Dense Environments

Tell duplicates
to reduce
beacon intervals

# Smart LaBLEs in Dense Environments



## Challenges

Dynamic configuration
BLE devices save energy in transmit only mode

# Directed Advertisements



**Target specific users/groups with customized information**

# Directed Advertisements

**Challenge: Information overload**

**Encryption/Decryption can be expensive**
**Checking every packet cryptographically wastes time and energy**
**Store environments can serve many users**

# Directed Advertisements
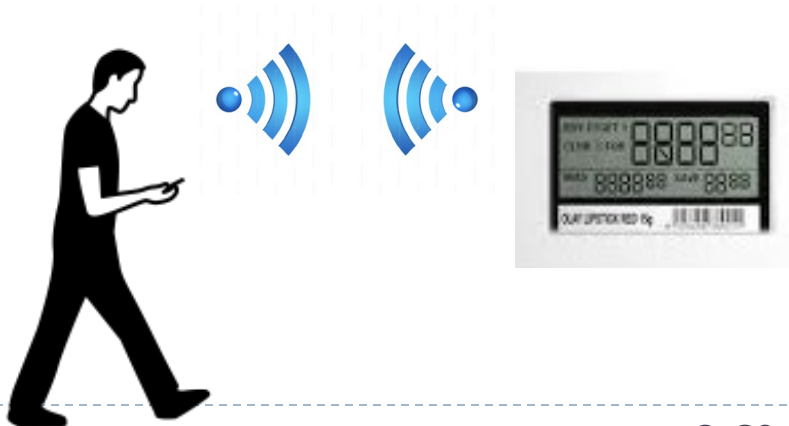
**Challenge: Information overload**

**How do we balance allowing users to know which advertisements are for them without breaking our security model?**

# Directed Advertisements

**Challenge: Servicing Many Users**

**Limited bandwidth**
**Limited communication range**
**Selecting potential users**

# Directed Advertisements

**Challenge: Servicing Many Users**

**How does the store broadcast enough information to support all potential users?**

# Directed Advertisements

‣ Current directions

  ‣ Which packets are for me?

    ‣ User-specific or group-based pairings, need to listen to all

    ‣ Each is assigned a unique id, encoded into a bitmap

    ‣ Given limited BLE payload, bitmap must be hashed to fit

  ‣ Too many users

    ‣ Use embedded, hardware-based implementations of our cryptographic algorithms

      ☐ Cheap parts, easily added to devices

      ☐ Expose simple primitives for easy application design

# Prototype Retail System
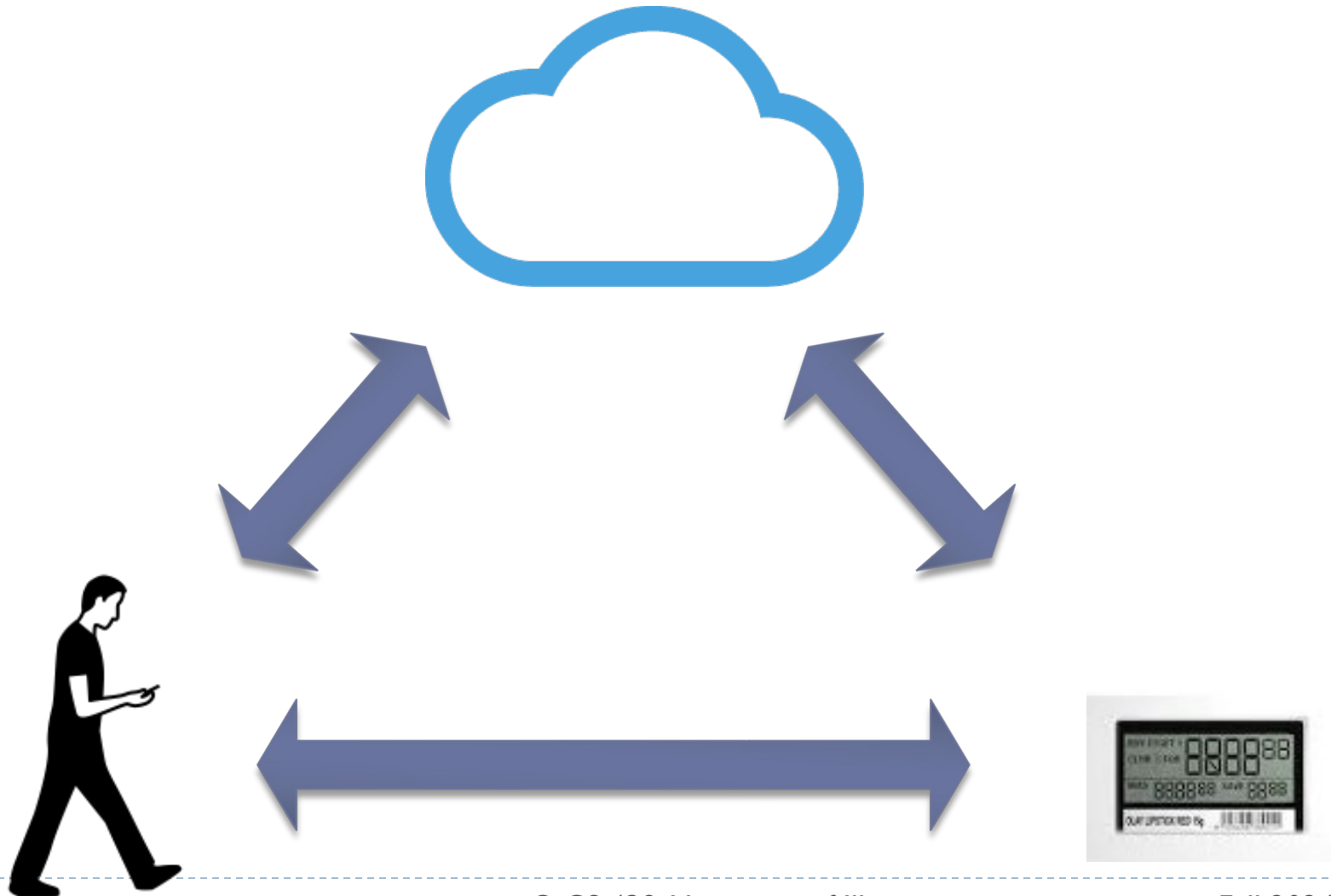
# Prototype Retail System

Cloud application

**Cloud application**

Manage user's key material
Maintain store inventory
Determine advertising

# Prototype Retail System

**In-store hubs**

Custom BLE devices
Aggregate product information
Distribute localized
information Provide
localization and user tracking

# Prototype Retail System

**Smartphone app**

User registration
Receive and display information
from in-store hubs
Allow users to interact with
checkout registers, etc.