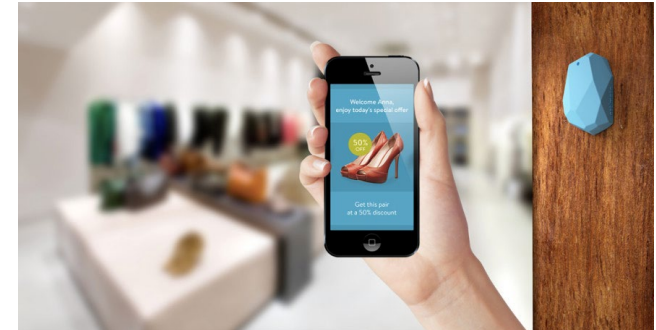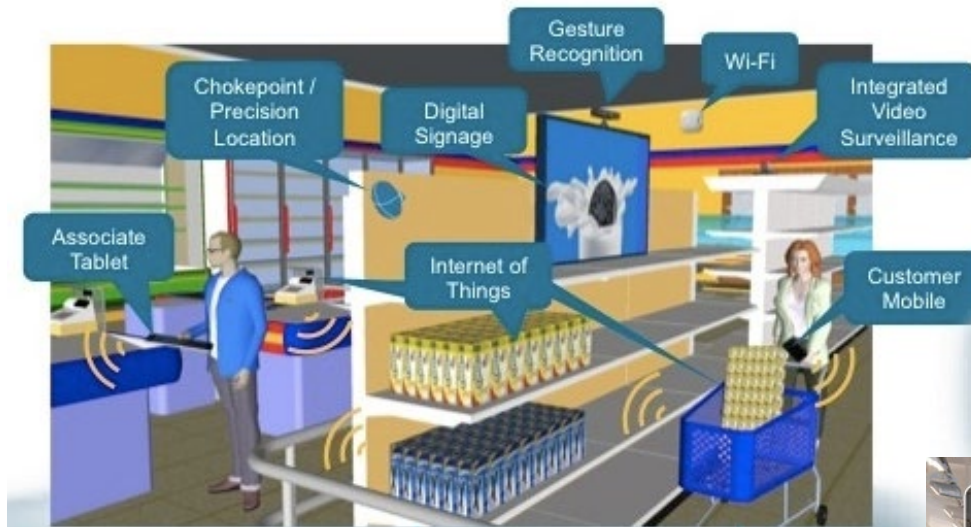# CS 439: Wireless Networking

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
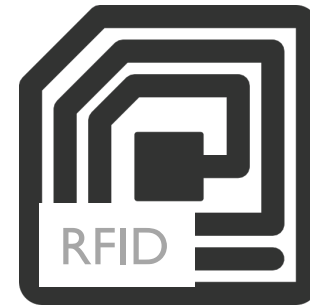

What is the best wireless technology to use?

What product is closest to me?

Which Technology best fits IoT?

Which Technology best fits IoT?

BLE-based devices

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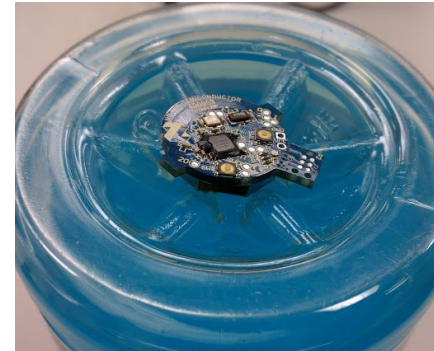**Devices easy to acquire**
Low energy
Cheap

The Smart LaBLE System

Attach BLE tags to each product

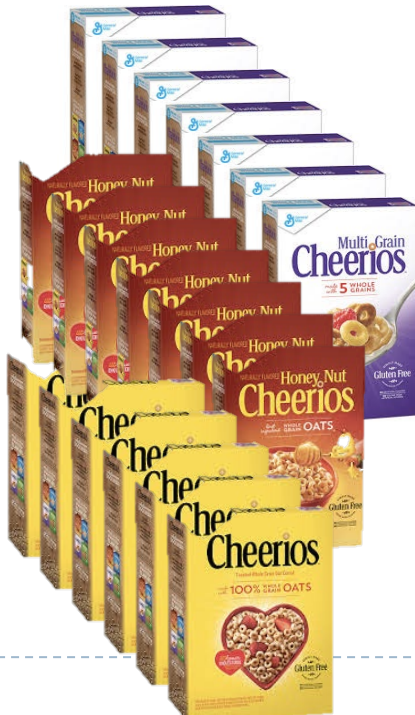Smart LaBLEs
Build nearness ordering
Display product info related to nearest product
Update every minute

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

Use Lamina to 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?
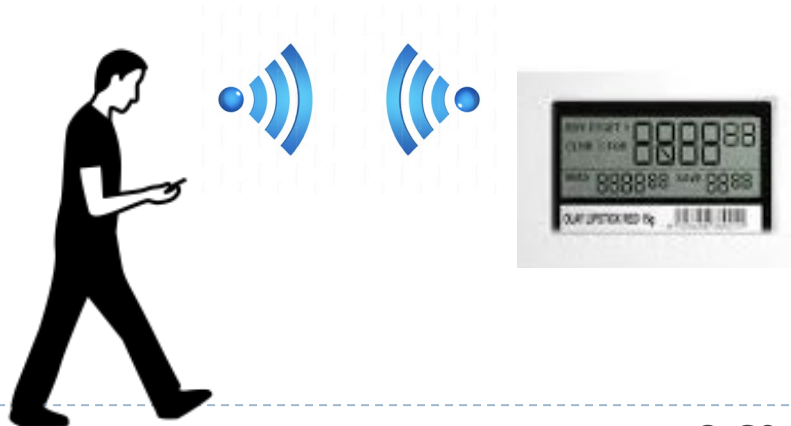
Directed Advertisements

<div style="border: 1px solid black;">

Challenge: Servicing Many Users

Limited bandwidth
Limited communication range
Selecting potential users

</div>

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
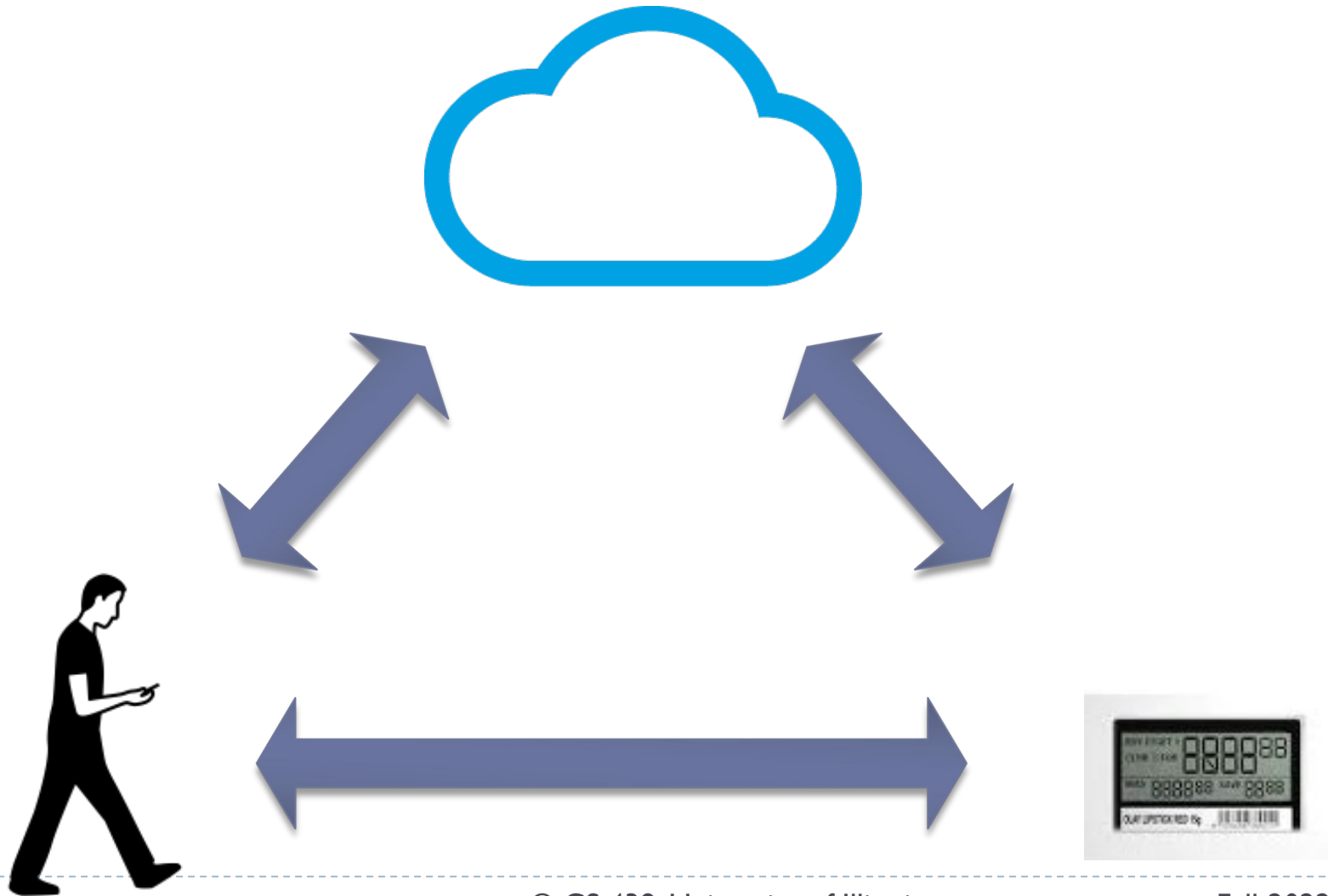
  ▸ Too many users

    ▸ 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

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.