Location Services for Healthcare

Class 3: Systems and Software

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This Week's Agenda

Monday   Overview

Tuesday   Tags and Sensors

Wednesday   Systems and Software

Thursday   Implementation Issues

Friday   Available Products and
                    Future Trends

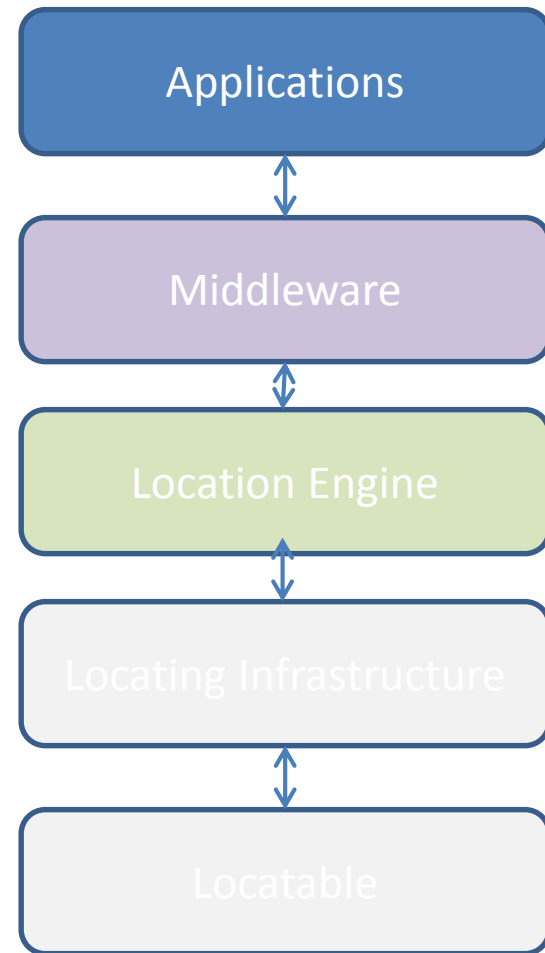Presented by:

Course Description

Location service refers to a set of devices and software that allow the tracking of all manner of items in an enterprise. In general these are real time tracking services. Thus, an enterprise has a real time picture of where everything that needs to be tracked is and can deploy, resupply and maintain all these items in a consistent manner. This is a truly Internet of Things (IoT) environment. In the healthcare environment, this level of management can be critical, and can also lead to major efficiencies. In this course we will review the general field of Real Time Location Services (RTLS) and then discuss their application of and use in a healthcare setting.

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Today's Agenda

- Overview
- Locating Engine
- Middleware
- Applications
- Conclusion/Next Class

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Overview

- Today we will discuss the upper three levels of the Real Time Location System (RTLS) architecture

- This consists of primarily of software components as opposed to the mainly hardware components in the lower two

Applications

Middleware

Location Engine

Locating Infrastructure

Locatable

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Overview

- The upper layers of the architecture make possible the functions of the RTLS system

- Generally there will be one Location Engine and Middleware component with multiple applications

- The layered architecture makes the system very flexible and updatable

  - Helps to keep up with the rapid changes in technology in this area

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Locating Engine

- The Locating Engine (LE) takes the measurements from the sensors in the Locating Infrastructure (LI) layer and computes the location
  - Several algorithms can be used, depending on the LI inputs and the required resolution/accuracy
  - The LE needs to keep track of a number of parameters and measurements simultaneously

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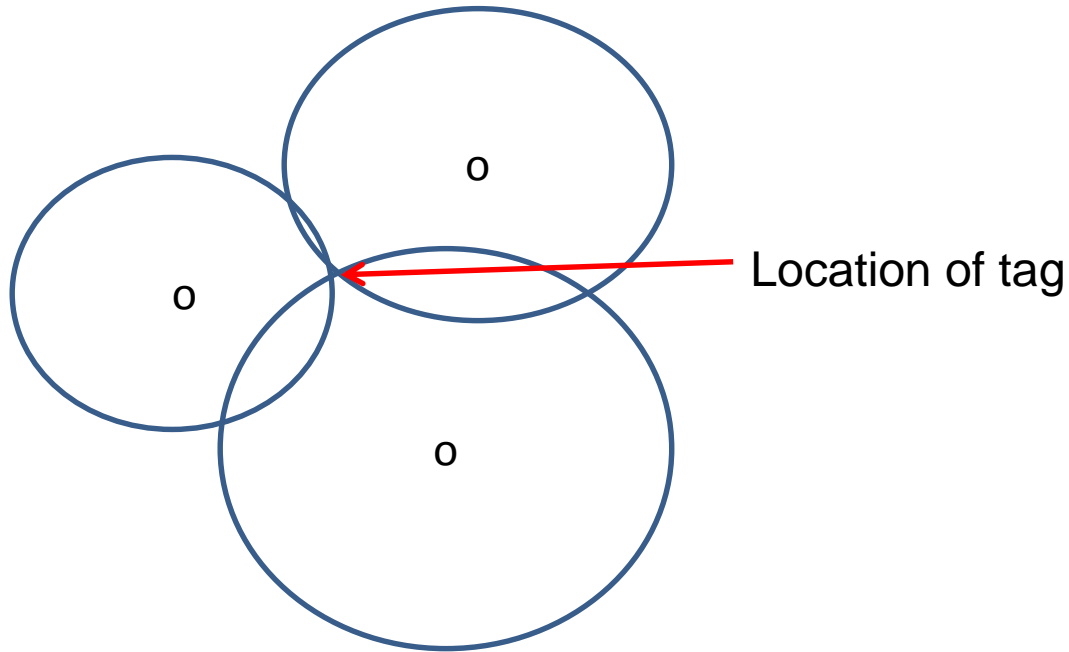
Locating Engine

- Algorithms
  - Trilateration
    - Know the distance from three different locations
  - Triangulation
    - Know angle from three different locations
  - Nearest Neighbor

Locating Engine

- Ranging methods
  - Angle of Arrival (AOA)
  - Time of Arrival (TOA)
  - Time Distance of Arrival (TDOA)
  - Time of Flight (TOF)
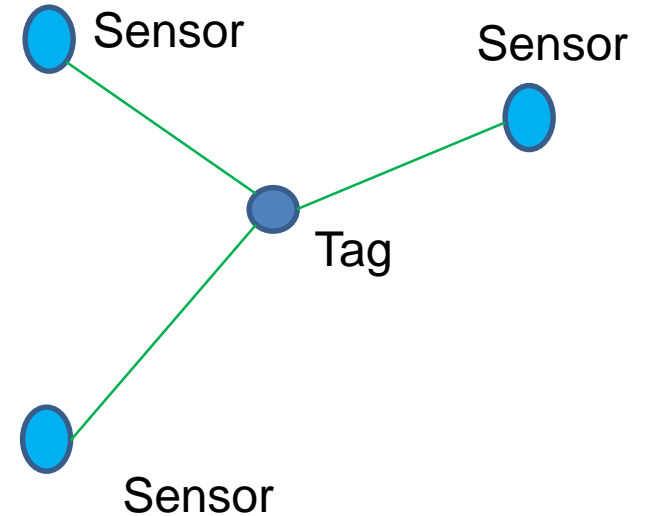 - Received Signal Strength Indicator (RSSI)
  - Round Trip Time (RTT)
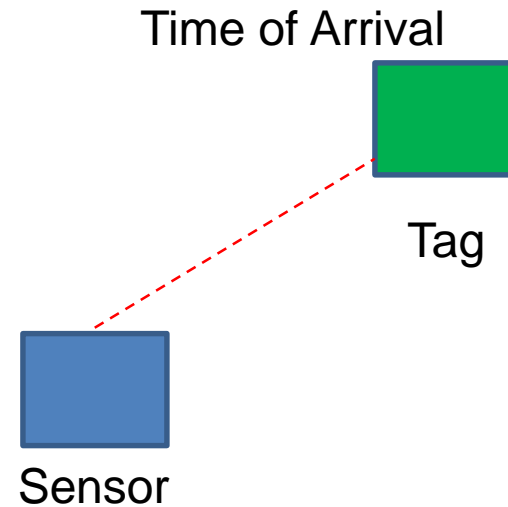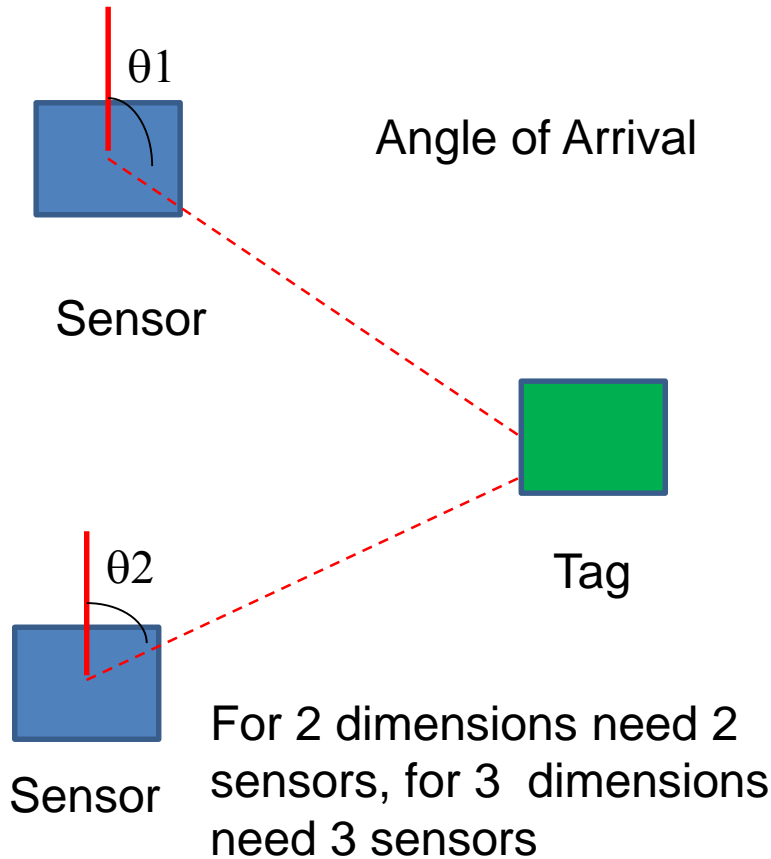
Locating Engine

Trilateration

o

o

o

← Location of tag

Know distance from each sensor to the tag

Triangulation

Sensor

Sensor

Tag

Sensor

Know angle from each sensor and the sensor positions

Locating Engine

θ1

Sensor

Angle of Arrival

Tag

θ2

Sensor

For 2 dimensions need 2 sensors, for 3 dimensions need 3 sensors

Time of Arrival

Tag

Sensor

In 2 dimensions use 3 sensors, for 3 dimensions use 4 sensors; uses trilateration

Time at which message starts from tag (t0)

t

Time at which message received by sensor (t1)
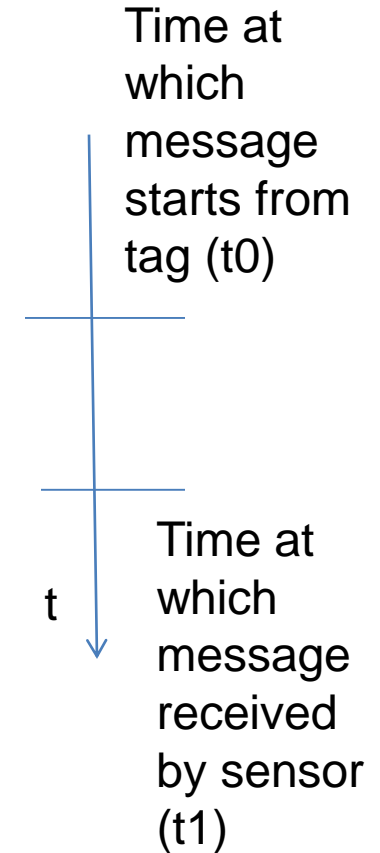
Locating Engine

- Some considerations for location algorithms
  - Several algorithms require high quality clocks and sometime synchronization between tags and clocks
    - Some, such as RTT do not require synchronization
  - Signal frequency affects accuracy of location
    - Higher frequency gives better accuracy
  - Knowing location of sensors precisely is critical

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Locating Engine

- Received Signal Strength Indicator
  - Uses the signal strength from several sensors to locate the tag
  - Techniques (using several sensors)
    - Nearest neighbor: assumes strongest signal is from the closest sensor
    - Scene analysis: a database with site survey data, using a real tag, is compared to the current measurements and the closest match is assumed as the position
    - Trilateration: compute signal loss (path loss in dB = C + 10 x n x log10(d)) This allows one to compute distance.

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Locating Engine

- As we have seen, the LE uses measurements from many sensors simultaneously

- Different algorithms use various numbers of sensors to compute the location based on the required resolution and number of dimensions

- The algorithms involved help determine where sensors need to be placed and how many are required

Middleware

- Middleware sits between the location infrastructure and the applications

  - Makes applications independent of the tag and RTLS technology

- Facilitates communication between applications

- Manages LE and LI (tag) layers

- Manages location data

- Applies business rules and process management

- Architecture scalability and system administration

  - Dynamic load balancing and failure management

Middleware

- LE and LI and tag management
  - Manages sensors and tags through applications
  - Monitors, starts and stops location engine
  - Tracks component history
- Location data management
  - Maps
  - Location database
  - Filters duplicate events and business rules
  - Consolidates multiple events for the same tag
  - Routes events to specific applications

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Middleware

- Database
  - Object information
    - Locatable
    - Locatable infrastructure
  - History
    - Object location
    - Object telemetry
    - Object Event
  - Maps
  - Computed locations

Applications

- Applications communicate with the Middleware to access location information, events, maps and each other
  - All inter-application communication goes through the Middleware
  - Provide an interface to mange the data stored in the Middleware
  - Manage the Middleware itself

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Applications

- There are a number of different functions application in a healthcare RTLS may provide:
  - Raise alerts based on configuration and business rules
  - Show current and historical alerts and locations of these
  - Send alerts as email, SMS, pager, pre-recorded messages to security
  - Take appropriate escalations

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Applications

- Mapping applications
  - Can provide a map with current location at of a locatable
  - Room map with all locatable items indicated
  - Show location of all locatable items required for a particular function

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Applications

- Applications can run on a variety of devices
  - Workstations
    - lots of display area; good for complex mapping
  - Laptops and tablets
    - availability of good graphics capability; not as much display area
  - Handhelds
    - Includes custom devices and mobile phones
    - Display area limited, but high portability
  - The layered and distributed nature of the RTLS system means that applications utilize a large amount of functionality based on other platforms

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Conclusion/Next Class

- We have discussed the top three layers of the RTLS architecture

- We have looked briefly at the algorithms used in the locating engine

- We have looked at the functionality of the middleware

- We have discussed applications

- Tomorrow we will talk about implementation issues, including security

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