Wireless Network Application - Indoor Positioning

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Outline

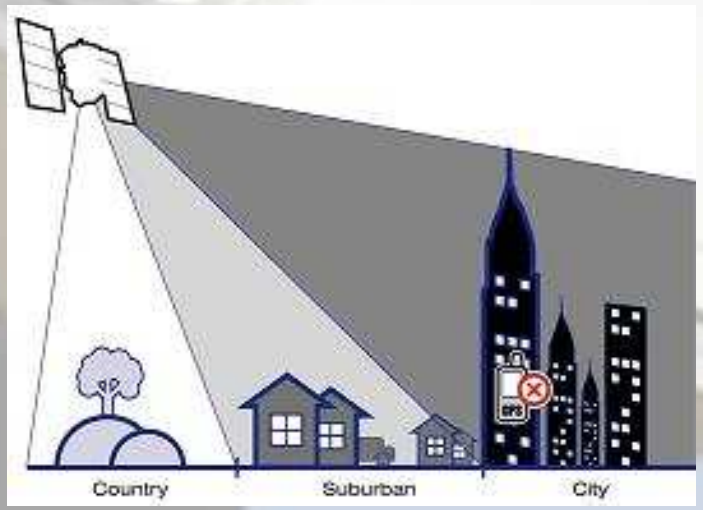
- Introduction
- Basic Concepts
- Technologies for Implementation
- Applications

Introduction

- Positioning System is designed to find location coordinate of target(s)
- Navigation System works together with Positioning System to locate people/object in a map
- Positioning Systems:
  - Global Positioning System (GPS)
  - Indoor Positioning System

Introduction

- GPS is generally used for
  - Outdoor applications
  - Large scale applications (Fast moving object)
- However, GPS is not available in indoor
  - because GPS signal is too weak to receive in a building
  - because of multipath signal propagation (Non-LOS)



Introduction

- Instead of using GPS signals, indoor wireless networks can be used for indoor positioning.
- We can easily find wireless signals from
  - Wireless Access Points
  - Wireless Local Area Networks (WLAN)
  - Wireless Personal Area Networks (WPAN)
  - Wifi, Bluetooth, …
  - Various handheld devices

Introduction

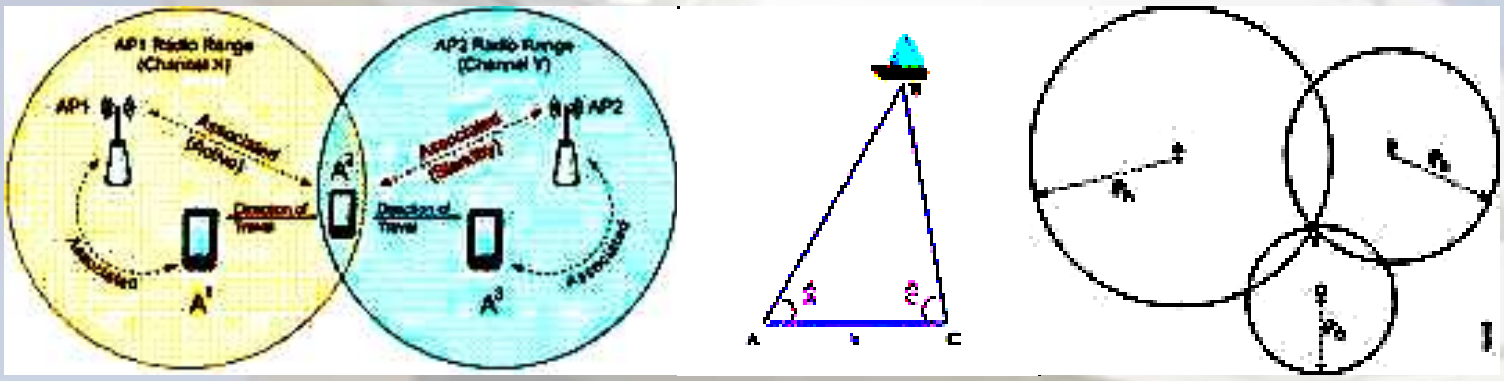
- Indoor positioning system estimates location coordinate based on the availability of wireless communication signals around the area.

Introduction

- With the increasing number of wireless access points and handheld devices within an indoor area, we are able to locate a wireless target using three or more reference signals

Basic Concepts

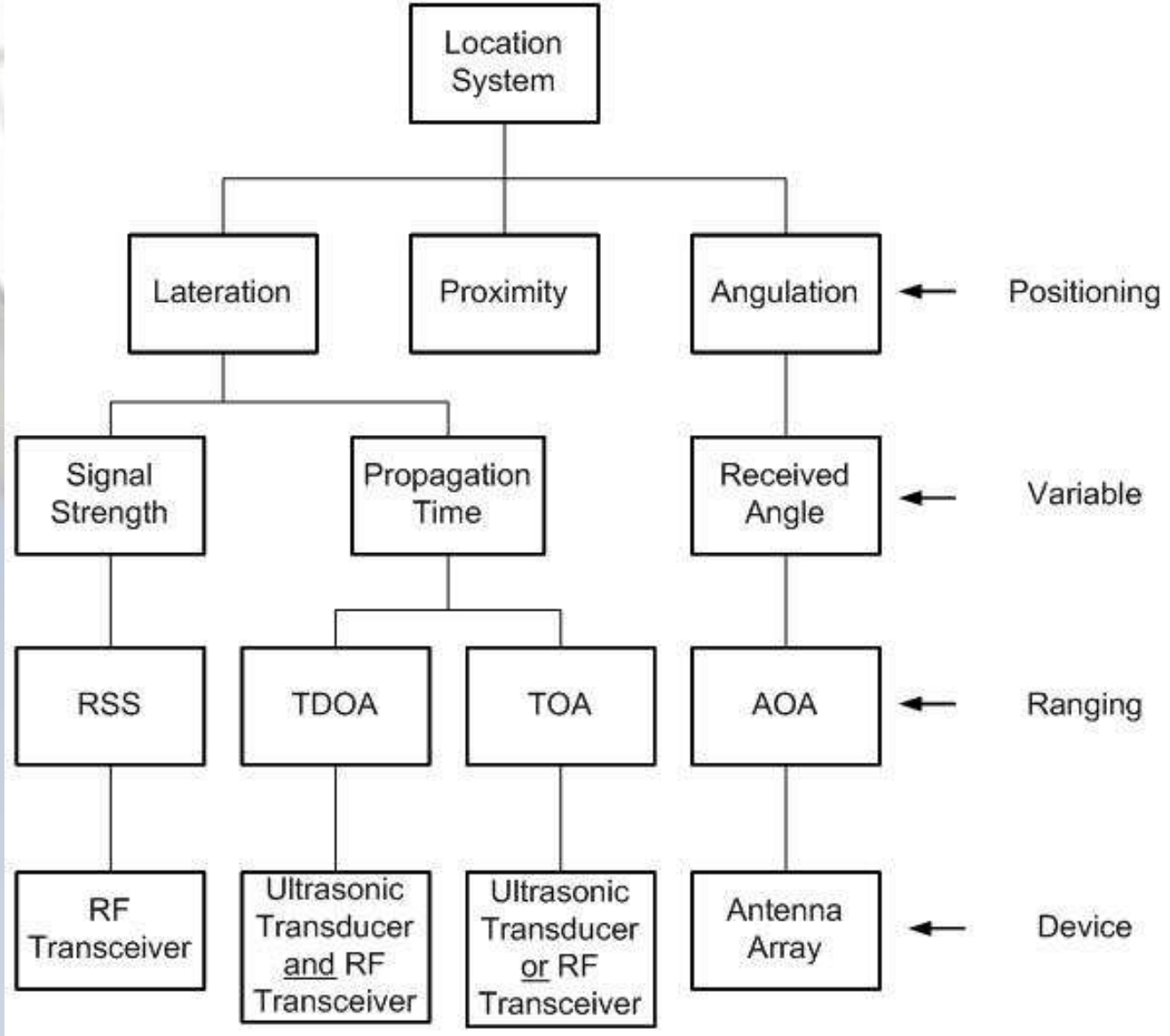
- Positioning methods
  - Proximity: detection and approximation
  - Triangulation: combine angle to estimate location
  - Trilateration: combine distances to estimate location



Basic Concepts

- Ranging (signal parameter estimation)
- Angle of Arrival (AOA):
  - measure ANGLEs of arrival for Triangulation
- Time of Flight/Time Difference of Arrival(TOA/TDOA):
  - measure DISTANCEs for Trilateration
- Received Signal Strength(RSS):
  - measure DISTANCEs for Trilateration

Basic Concepts

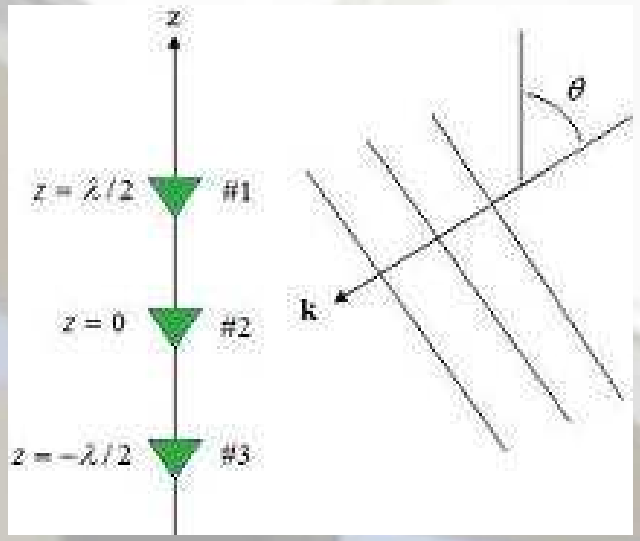


Basic Concepts

- The following combinations are generally considered:
  - Triangulation, AOA
  - Trilateration, TDOA with Ultrasonic Ranging
  - Trilateration, RSSI

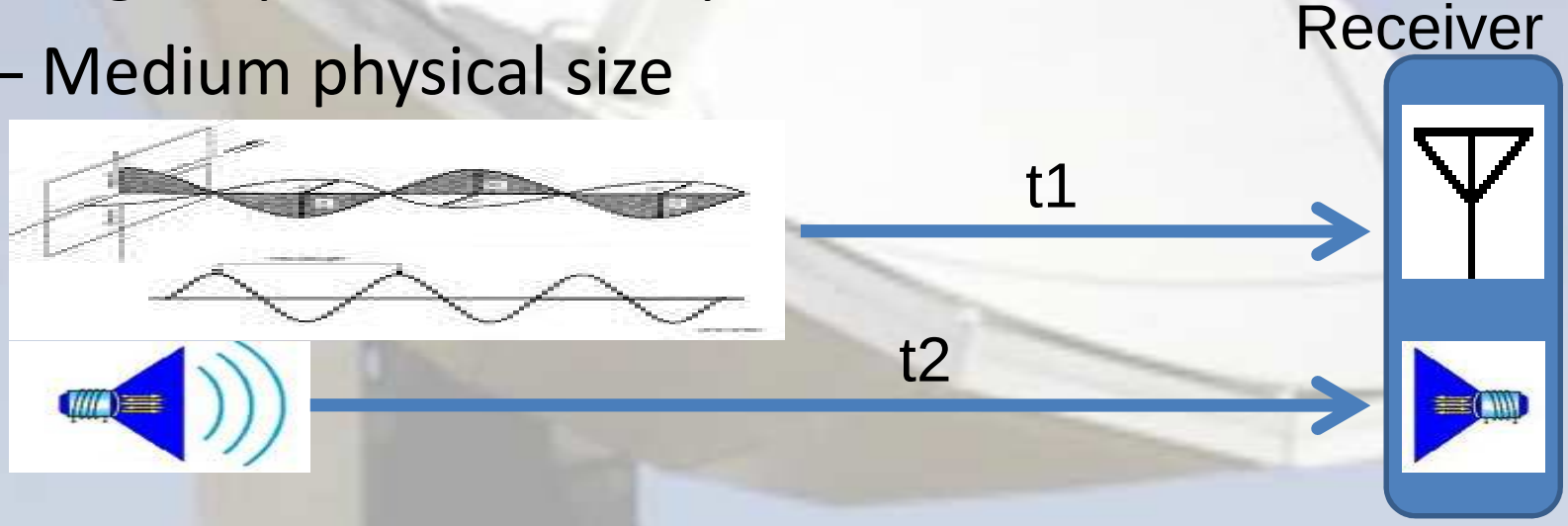
Basic Concepts

- Triangulation, AOA
  - Medium accuracy
  - Expensive antenna array
  - Receiver size is big
  - Configuration is not flexible



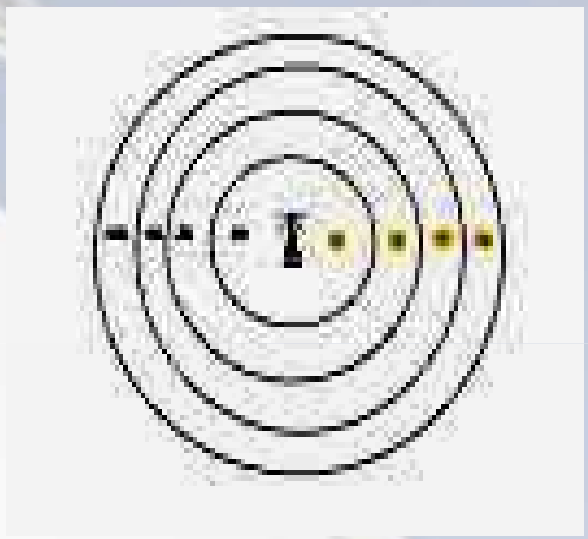
Basic Concepts

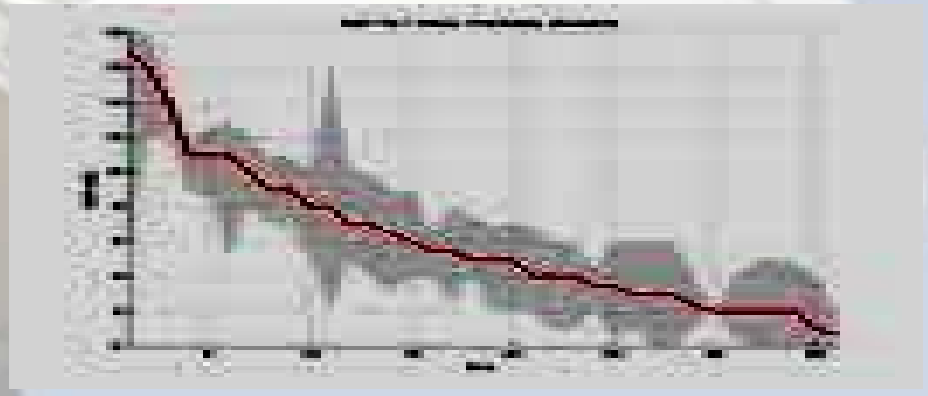
- Trilateration, TDOA (Ultrasound + RF)
  - Can be very accurate (cm)
  - Additional components (Ultrasonic Transducers)
  - Ultrasonic transducers are directional
  - Higher power consumption
  - Medium physical size



Basic Concepts

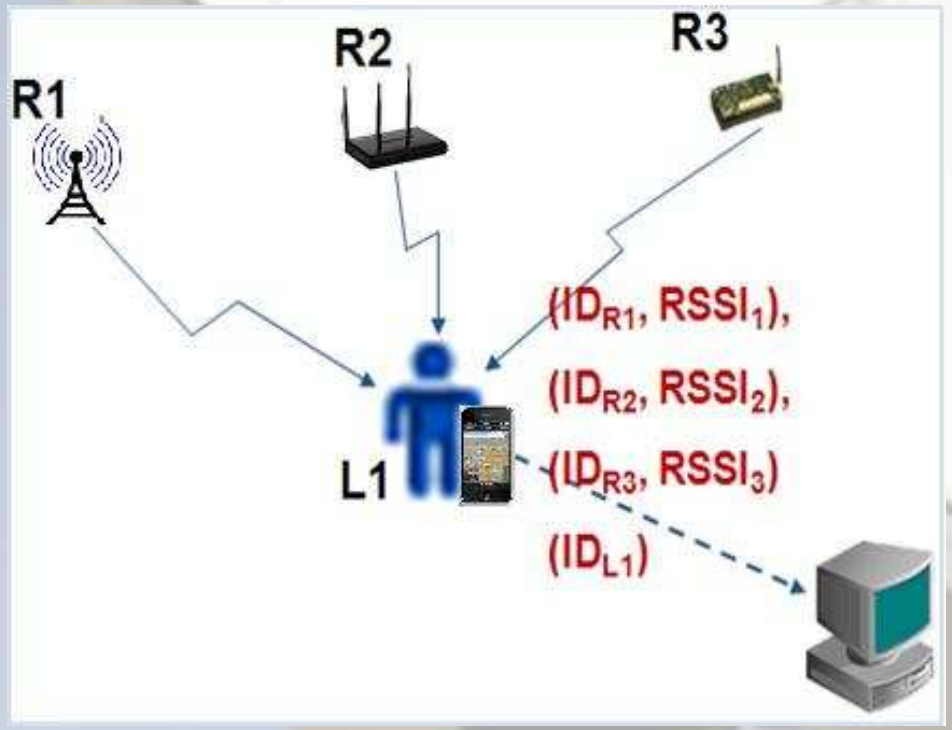
- Trilateration, RSSI
  - Using existing RF modules
  - Very low power consumption
  - Very small physical size
  - Ease of implementation
  - Accuracy (0.8 ~ 2 meters)





Basic Concepts

- RSSI readings can be used to indicate the location of person or object



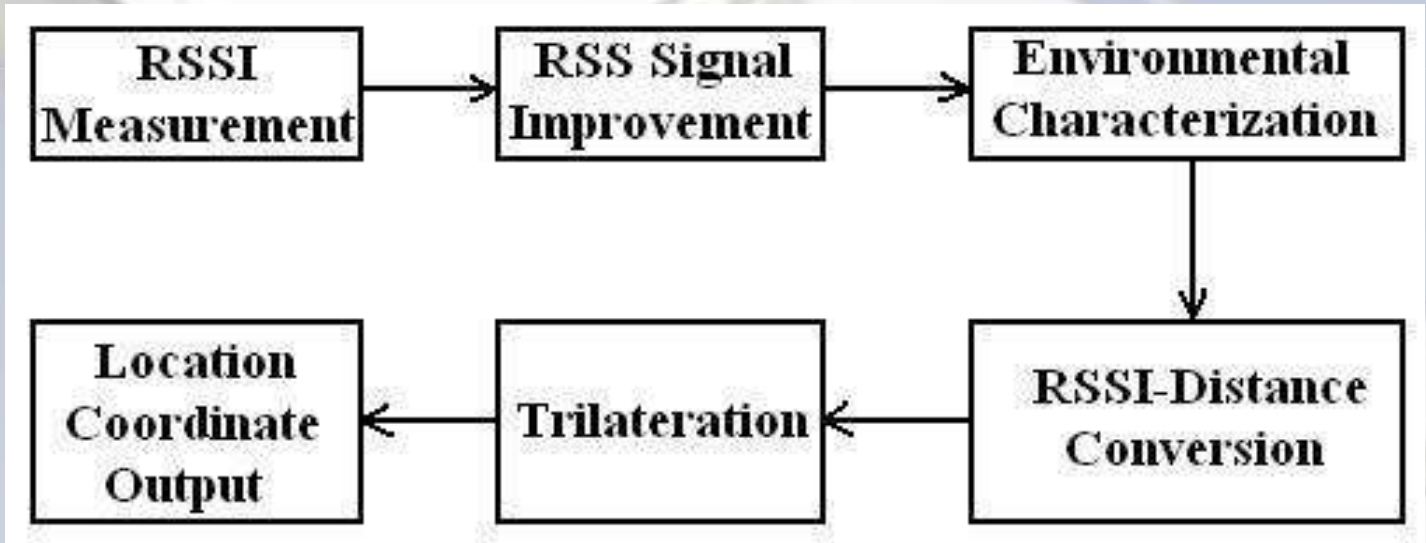
R1, R2, And R3: Reference Nodes

L1: Target Node

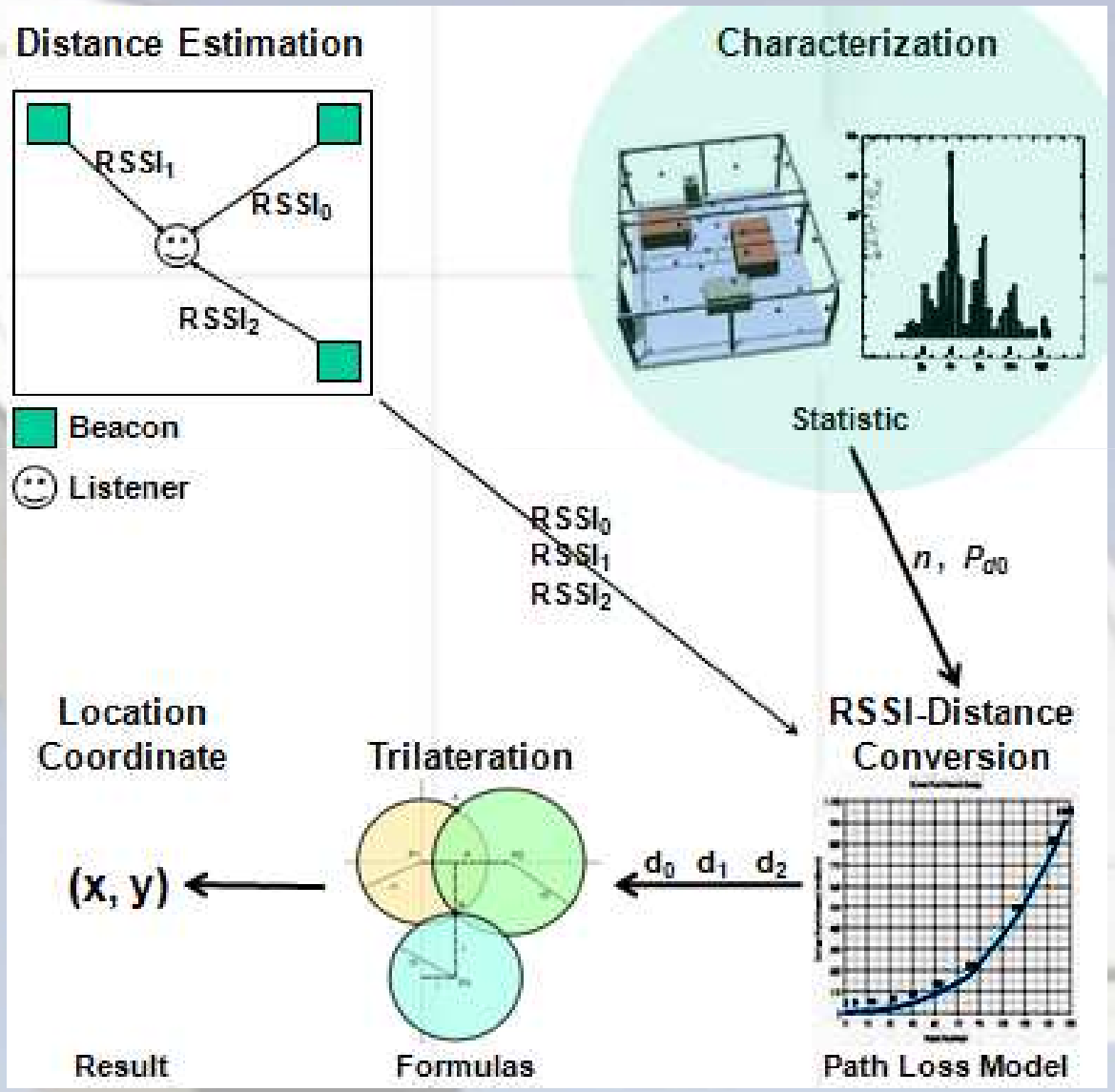
PC: Location Monitoring Server

System Block Diagram

- To estimate fine-grained location coordinate, the following steps are necessary:

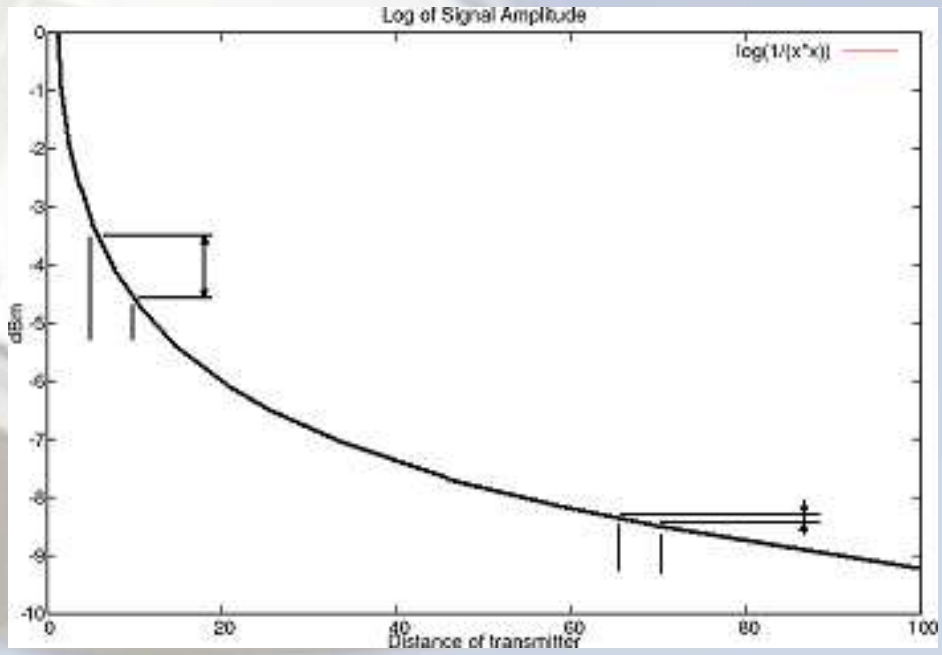


System Block Diagram



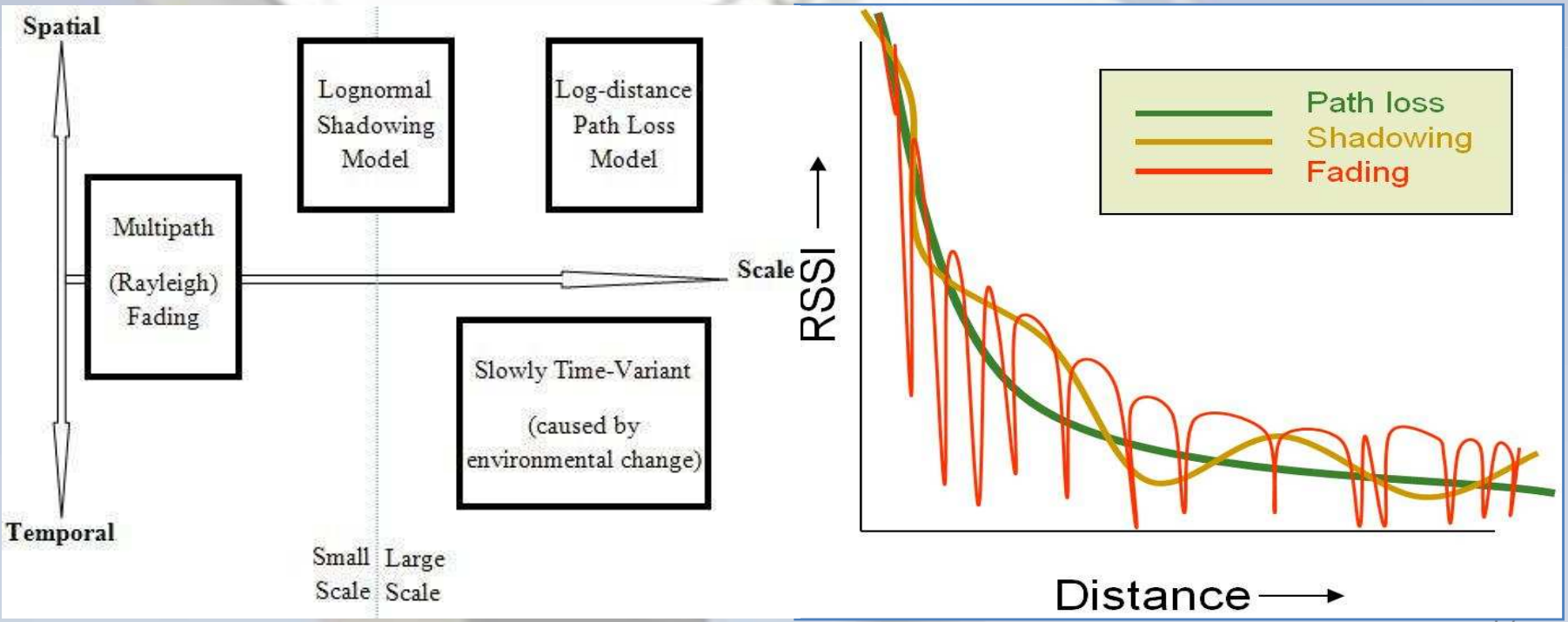
RSS Resolution versus Distance

- Sensing Resolution:
  - Smallest change it can detect
- When the distance between transmitter and receiver is
  - Near: good resolution
  - Far: worse resolution



RSSI Signal Processing

- When RSSI is used in indoor environment, it can be uncertain, fluctuating, and less accurate due to
  - Multipath fading effect (Rayleigh fading)
  - Indoor shadowing effect

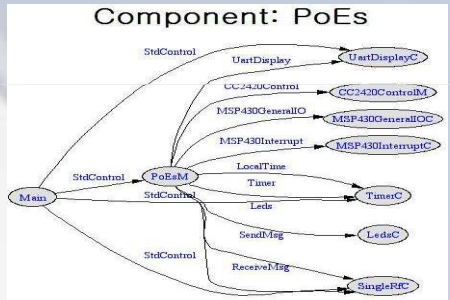


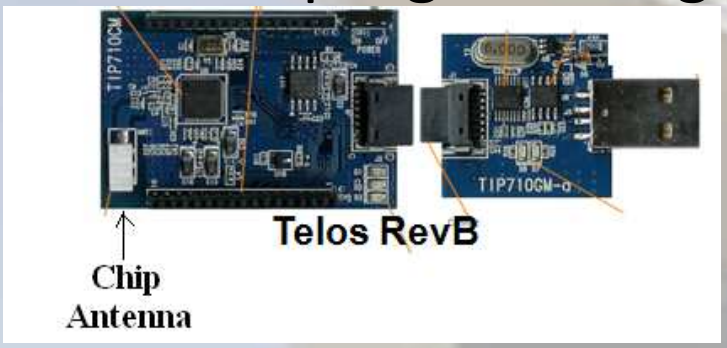
Research Direction

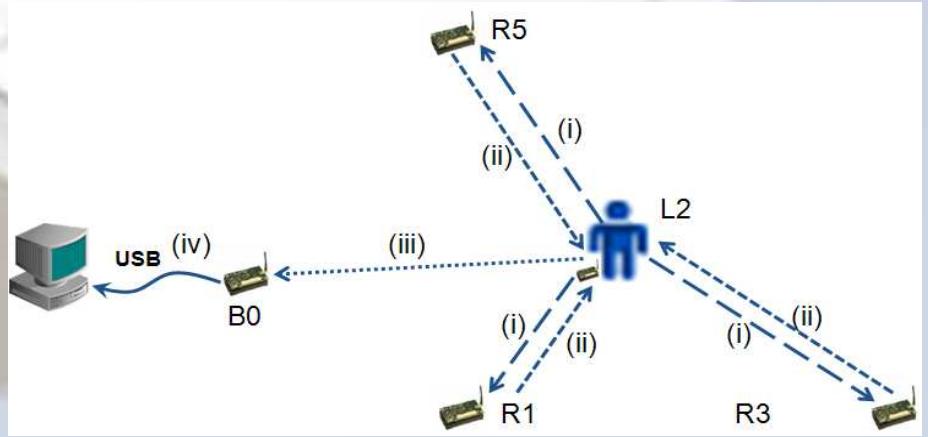
- Novel location estimation algorithms
  - Propagation Model (Indoor model)
  - Positioning Algorithm (iterative approach, multi-node lateration)
- RSSI signal processing to improve signal quality
- Environmental Characterization: provide better system calibration

Technologies for Implementation

- Wireless Sensor Network:
  - Wireless sensor nodes: Mica, MicaZ, Telos, Imote…
  - Wireless interface: IEEE802.15.4
  - Wireless module: TI Chipcon's CC2420
  - OS: TinyOS
  - NesC programming







Technologies for Implementation

- Cricket Indoor Location System
  - TDOA, RF + Ultrasound
  - Multilateration
  - Accuracy: 2 ~ 4 cm

Technologies for Implementation

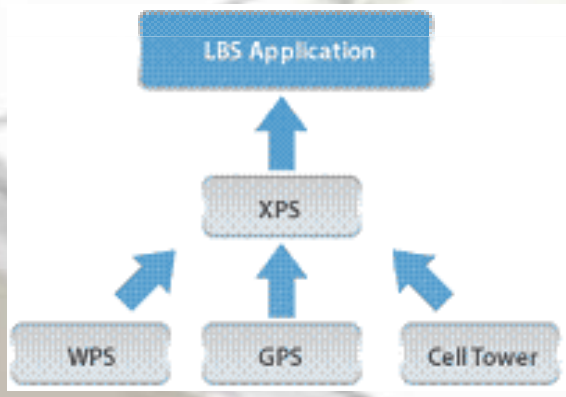
- Ubisense RTLS
  - Ultra Wideband (UWB) radio signal
  - AOA + TDOA
  - Good accuracy
  - 2D and 3D Navigation

Technologies for Implementation

- Ekahau RTLS
  - Wi-Fi based RTLS
  - Wireless Interface: IEEE 802.11
  - RSSI

Technologies for Implementation

- Hybrid Positioning
  - GPS signal + Cellular signal + Wifi + Bluetooth…
  - Navizon, Xtify, Skyhook, … and etc.

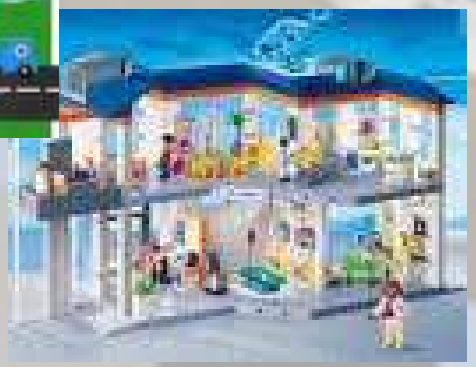


Applications

- Warehouse tracking
  - Items management
  - Important equipment tracking
  - Vehicle movement
  - Worker's activity

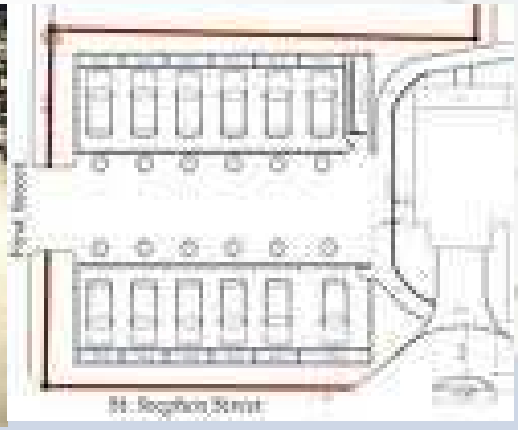
Applications

- Hospital / Healthcare
  - Patient's tracking for emergency
  - Elderly people tracking for safety
  - Doctors/nurses tracking for immediate call
  - Activity monitoring for diagnosis



Applications

- Indoor Car-park Management
  - Locate empty lot
  - Reserve an empty lot
  - Display the route to reserved lot
  - Not necessary to remember where you park your car, as long as you are still holding the parking ticket/ID



Applications

- Shopping Centre
  - To find the location of shop immediately
  - To find nearest path to the destination
  - Optimized path planning
  - Partners/Children finding

Our Research in SCT, Sunway University College

- Topic: Indoor Positioning and Navigation System
- Supported by Sunway University College Internal Grant
- Looking forward to seek:
  - Research funding, projects, consultation
  - Research colleague, PhD/Master students
  - Research collaboration

Thank you very much

End of presentation