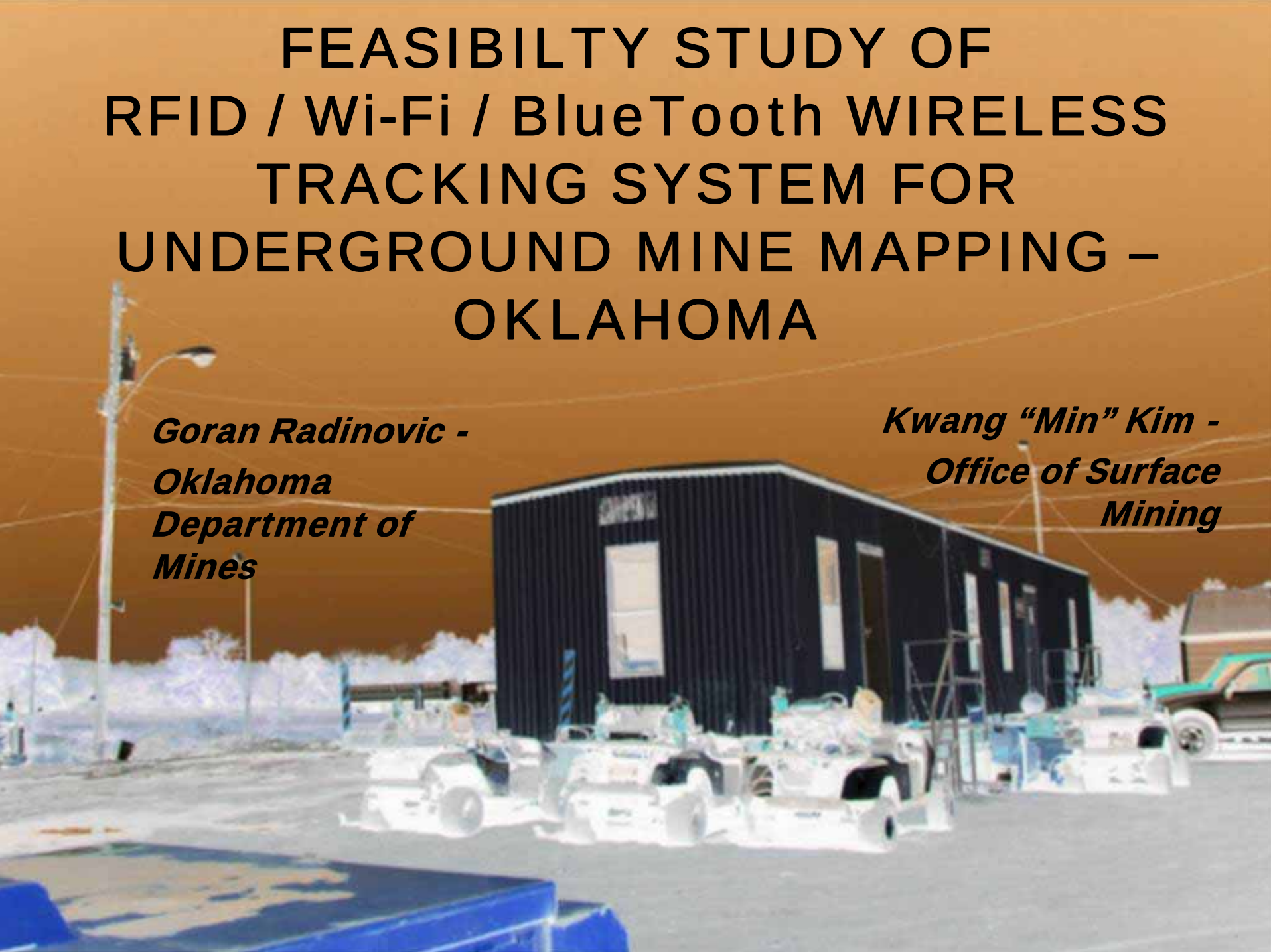
FEASIBILTY STUDY OF RFID / Wi-Fi / BlueTooth WIRELESS TRACKING SYSTEM FOR UNDERGROUND MINE MAPPING – OKLAHOMA

Goran Radinovic - Oklahoma Department of Mines

Kwang "Min" Kim - Office of Surface Mining



Overview

- **Purpose**
- **Local Positioning System (LPS)**
- **Site Conditions**
  - **WLAN Site Pre-Survey**
- **LPS Methods**
- **WLAN Site Survey**
- **Recommendations**
- **Conclusions**

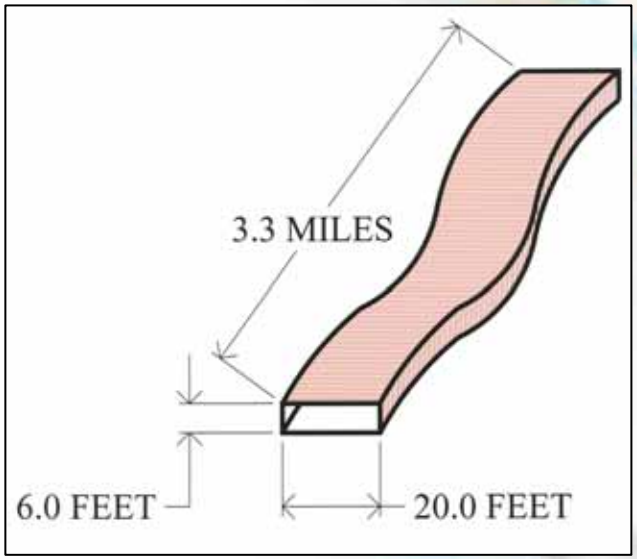
Purpose

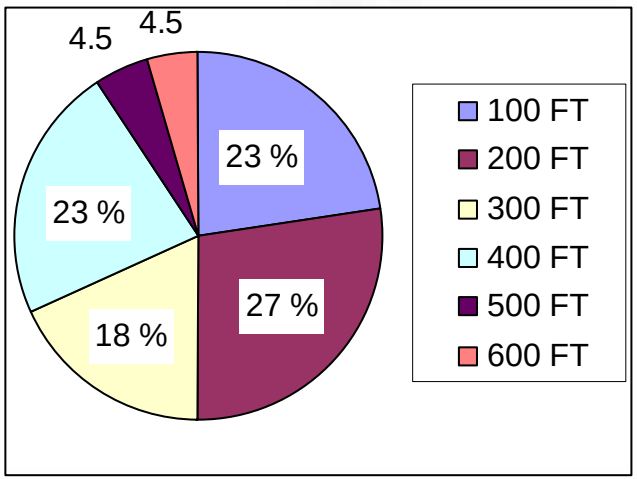
- **Examine mapping techniques which don't require GPS data collection**
  - **At mine entry & shaft locations – GPS does not work indoors**
  - **Traditional surveying techniques – total stations & prisms**
- **Local Positioning Systems (LPS)**
  - **Location Based Services (LBS)**
  - **Real-Time Location Systems (RTLS)**
- **Illustrate possibilities of utilizing LPS in Pollyanna No. 8 room-and-pillar mine in LeFlore County, Oklahoma. Focus on LPS alternatives – RFID, Wi-Fi, Bluetooth**

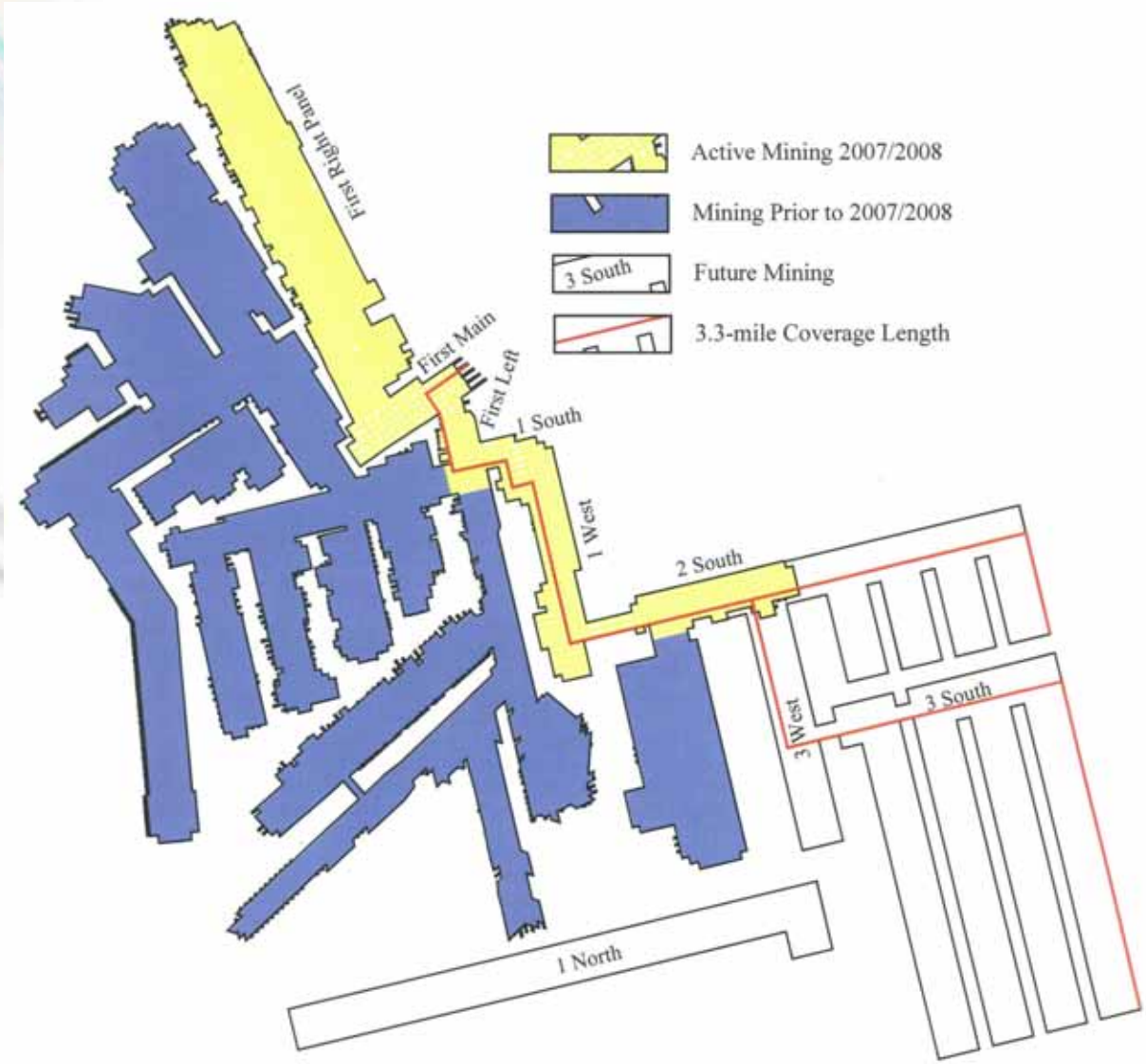
Local Positioning Systems

- **Use centralized server application to track variety of clients:**
  - **Personal digital assistants**
  - **Laptops**
  - **Handsets**
  - **Tags**
- **Existing applications**
  - **People/asset management tracking**
  - **Healthcare and mobile patient monitoring**
  - **Security**
  - **Emergencies**
  - **Location based network access/security**
  - **Games**
  - **Retail**
  - **Analysis of shopping behavior**
  - **Shopping**
  - **Advertisement**
  - **Marketing & Tour Guides**
  - **Mining**

Mine Layout


3.3 MILES
6.0 FEET
20.0 FEET

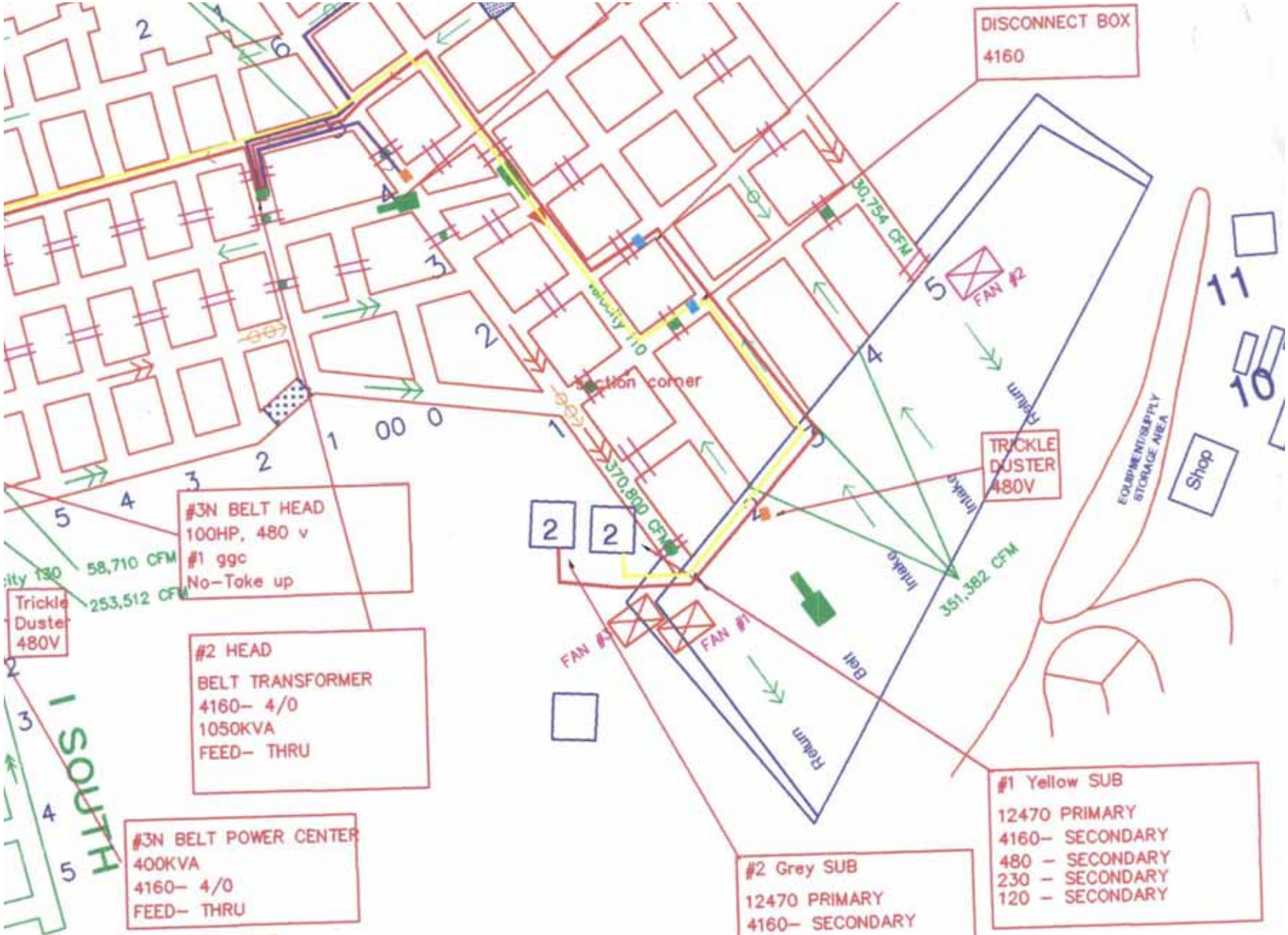

4.5
4.5
23 %
23 %
27 %
18 %
100 FT
200 FT
300 FT
400 FT
500 FT
600 FT


Active Mining 2007/2008
Mining Prior to 2007/2008
3 South
Future Mining
3.3-mile Coverage Length
First Right Panel
First Main
First Left
1 South
1 West
2 South
3 West
3 South
1 North

Site Conditions

- **Temperature – approximately constant at near 79°F**
- **Humidity**
- **Water Intrusion – wet floor conditions**
- **Air Flow – velocity less than 33 miles per hour**
- **Vibration – by coal removing equipment**
- **Electrical Cable (high-voltage) – non factor. Signal-to-Noise Ratio (SNR) not significant**

Site Conditions - continued



Site Conditions - continued

- **Conveyors and Heavy Machinery – non factor (SNR & RF interference)**
- **Dust – significant factor**
- **Chemicals**
- **Traffic – maximum of 22 persons transported via mantrip/golf carts moving at 20 mph = Worst-Case Design Scenario**

Local Positioning Systems (LPS)

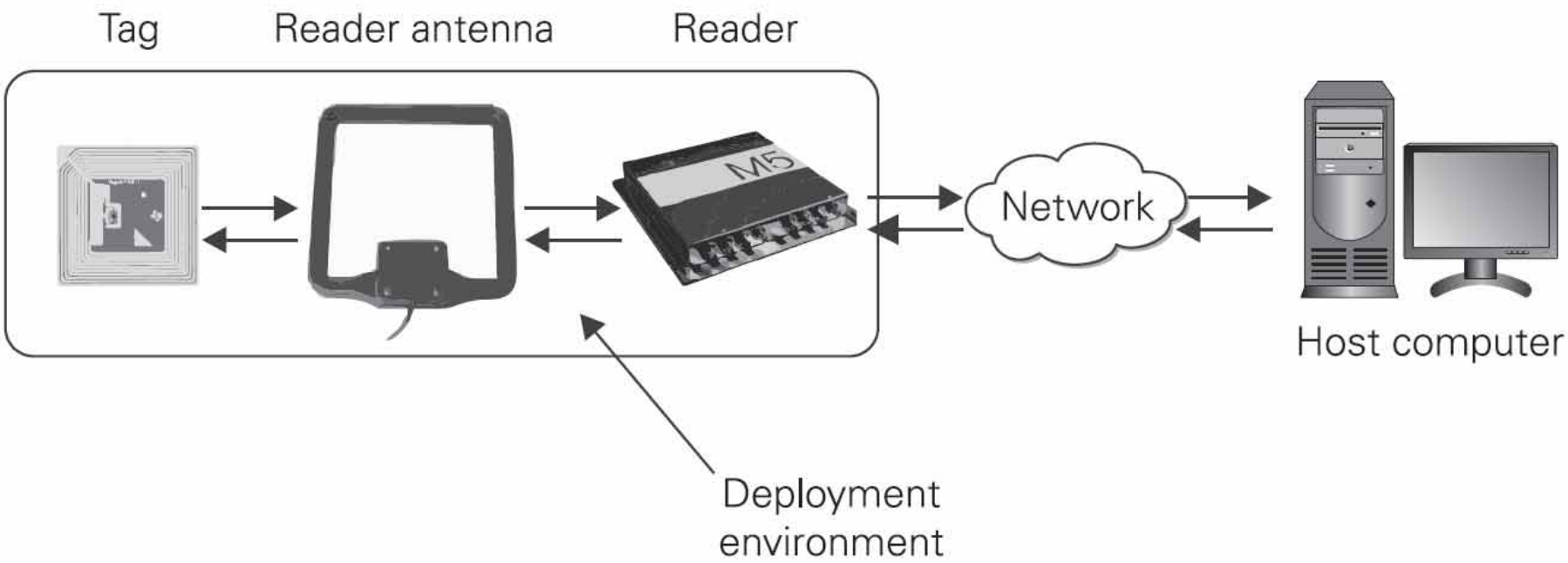
- **RFID, Wi-Fi, or Bluetooth**
- **Most are Network Based – network calculates positions**
- **Terminal Based – sensors are integrated into the mobile device & device calculates its own position to notify others about location through the network**
- **Most built upon WLAN 802.11 or Wi-Fi infrastructure**

Several Different Local Positioning Systems (LPS)

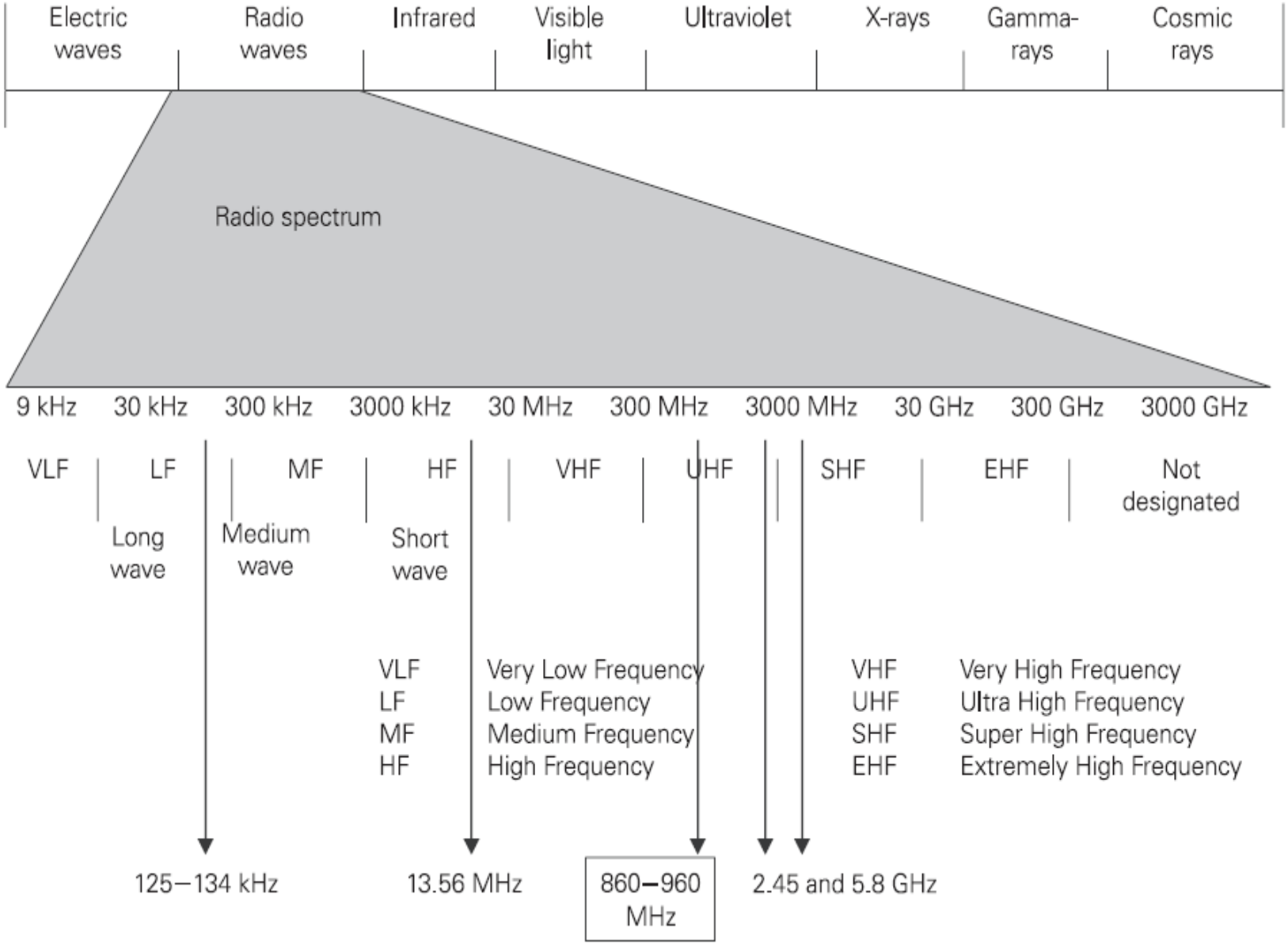
	MIT Cricket	Ekahau	AeroScout	BLIP Systems BlipNet
Deployment Range	Building	Building/local area	Building/local area	Building
Position Calculation	Mobile Device	Server (Ekahau Positioning Engine)	Server (AeroScout Positioning Server/Engine)	Server (BlipServer Positioning Engine)
Position Method	TOF Lateration & proximity (with one beacon)	Location fingerprinting using signal strength	TOF Triangulation (TDOA for absolute location; RSSI for symbolic location	Inquiries and pagings
RF Signal Used	RF (418-MHz) + ultrasound	802.11	802.11	Bluetooth
Transmitter	Beacon	Existing Wi-Fi nodes	Active RFID tags or Wi-Fi devices	Mobile device
Receiver	Listener	Ekahau Client	Aeroscout Location Receiver (TDOA), AeroScout Exciter (choke-point); standard Wi-Fi AP (RSSI)	BlipNode (Bluetooth AP)
Accuracy	1-3m (3.3-10ft)	1-3m (3.3-10ft)	1-5m (3.3-16ft)	10cm-10m (4in-33ft)

Typical RFID System

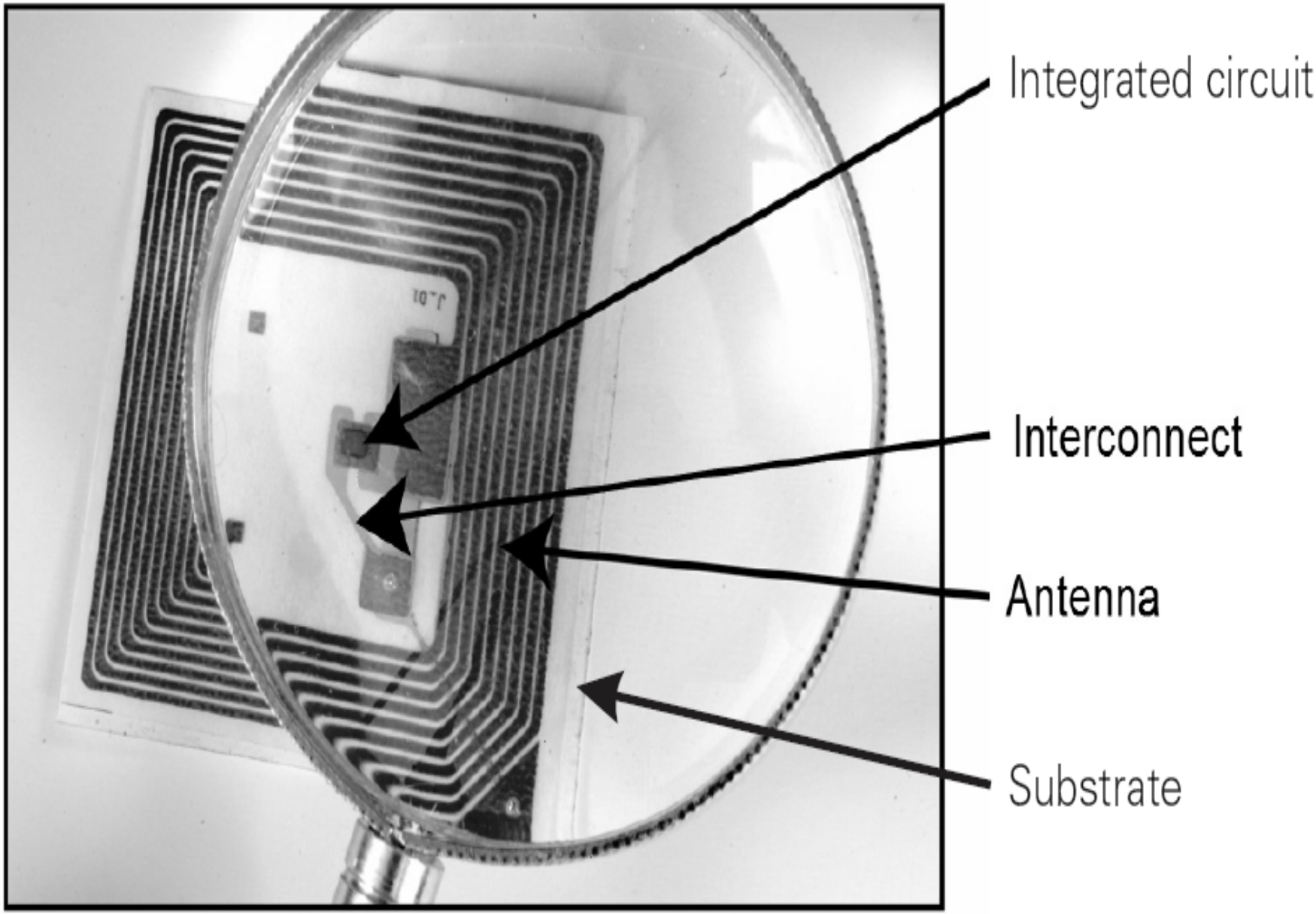
- **System employs active microwave tag which is powered with internal battery to assist back-end system & server for calculating its position relative to known antenna location**



RFID Frequencies



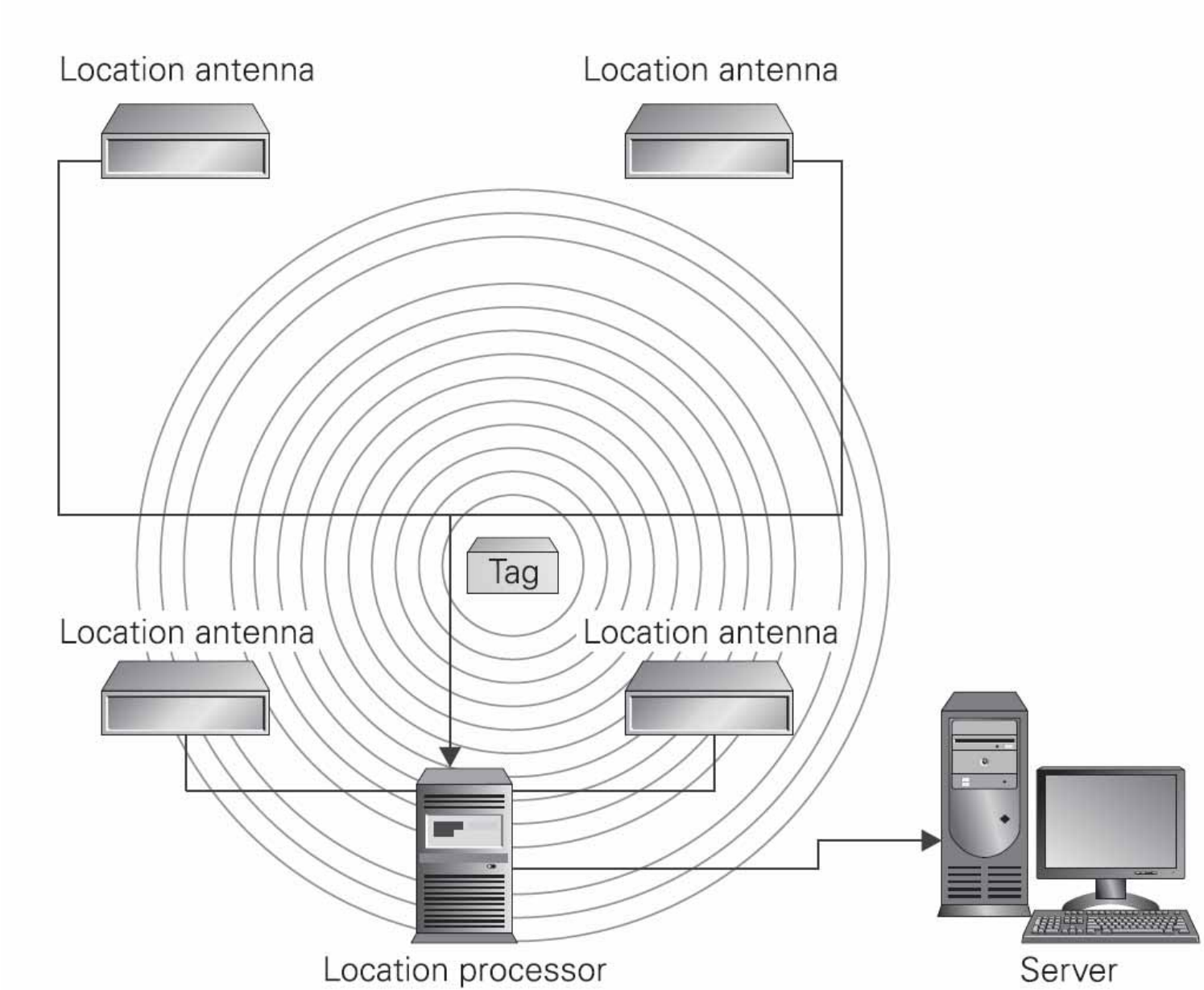
RFID Tag Components



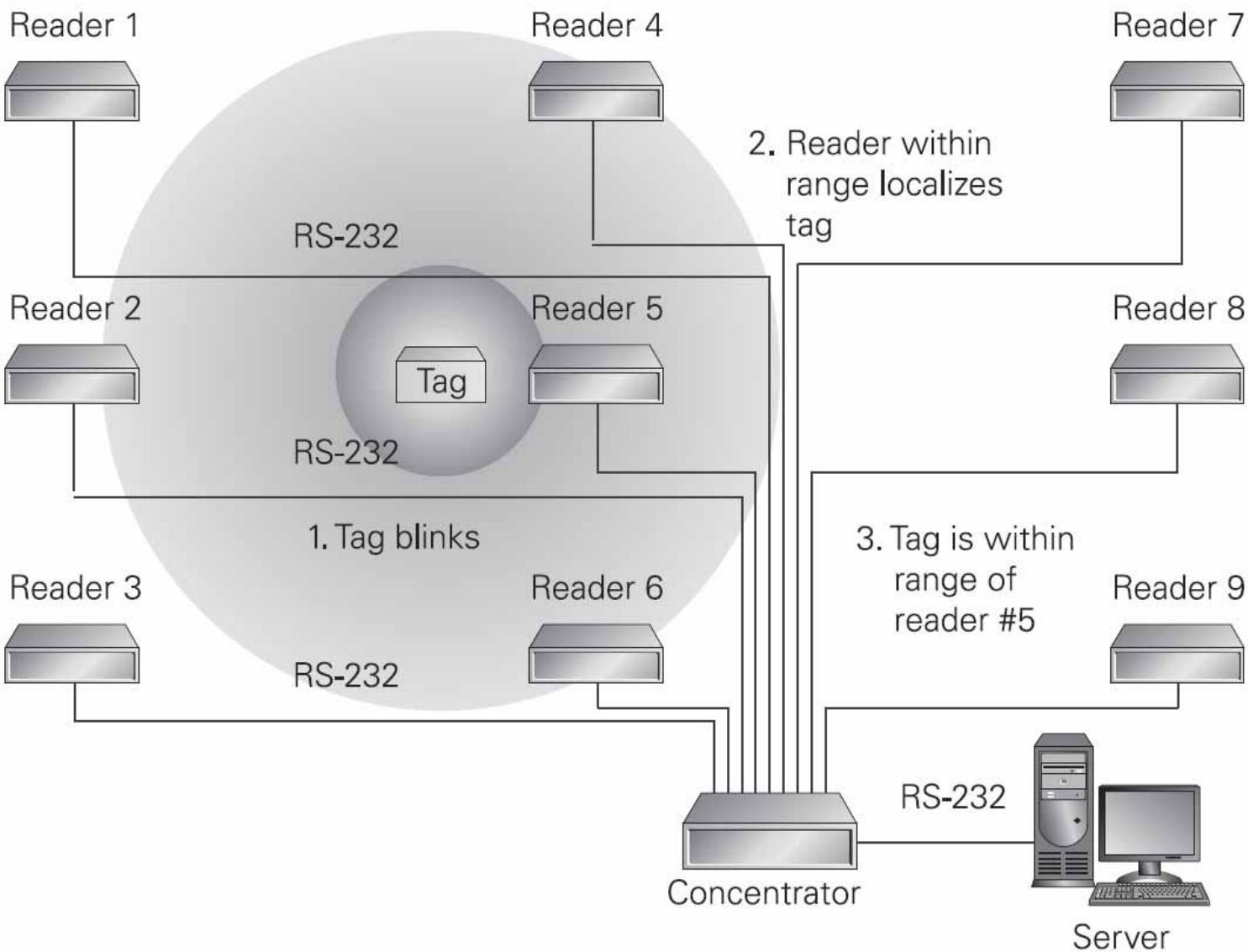
RFID Tag Types

- **Passive**
  - **No transmitter**
  - **Rely on inductive coupling for high RF**
  - **Rely on radioactive coupling for low RF**
  - **Range – up to 20 feet**
- **Semi-passive**
  - **No transmitter**
  - **Reflect signals from interrogator**
  - **On-board battery**
  - **Range – about 100 ft**
- **Active – Used for real-time location services (RLTS)**
  - **On-board power source**
  - **Can communicate with other active tags**
  - **Have read and write functions**
  - **Range – up to 750 feet**

Differential Time of Arrival RLTS



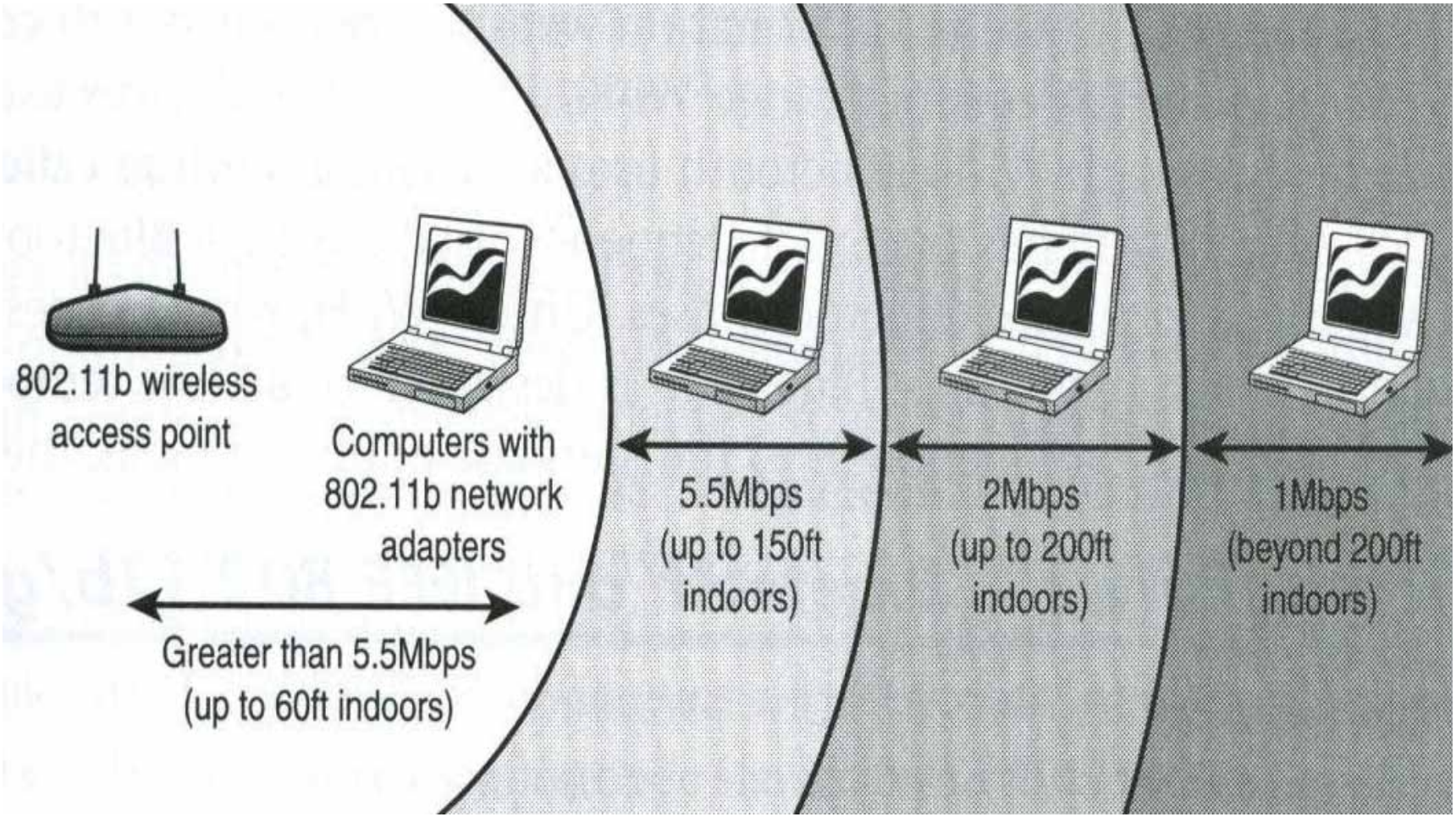
Received Signal Strength Indicator RLTS



Wi-Fi System

- **Institute of Electrical and Electronics Engineers (IEEE) 802.11 standard for wireless local area networks (WLAN)**
- **802.11a - 5 GHz spectrum with a bandwidth of 54 Mbps**
- **802.11b - 2.4 GHz spectrum with a bandwidth of 11 Mbps**
- **802.11g - 2.4 GHz spectrum with a bandwidth of 54 Mbps**
- **2.4 GHz ISM (industrial, scientific, and medical) band enacted by USFCC (United States Federal Communications Commission)**

Reduction of Signal Strength and Rated Speed with Distance



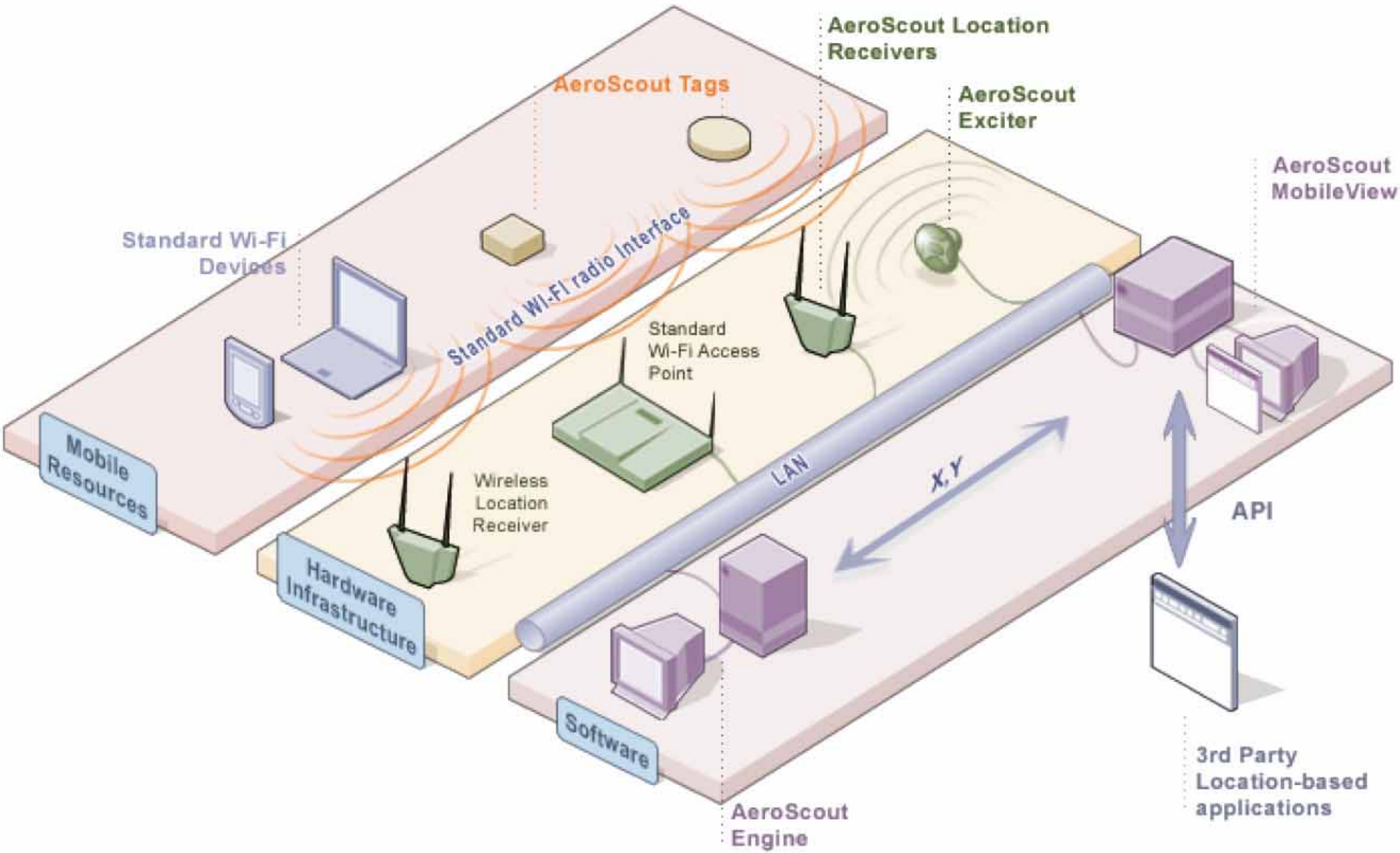
Bluetooth

- **Short-range radio standard (up to 100 meters)**
- **Hopping through 1600 frequency channels**
  - **800 transmit channels**
  - **800 receive channels**
  - **Bluetooth devices keep statistic over good and bad channels to prevent further interference**
- **Functional even in very noisy RF environments**
- **Limited in accuracy due to short range**

AeroScout

- **Long-life RFID tags (up to 5 years)**
- **Uses WLANs to locate laptops, PDAs, and other clients**
- **TDOA for large indoor environments**
- **RSSI for tight indoor environments**
- **Exciters**
- **Tags may be programmed remotely**
- **AeroScout Engine**

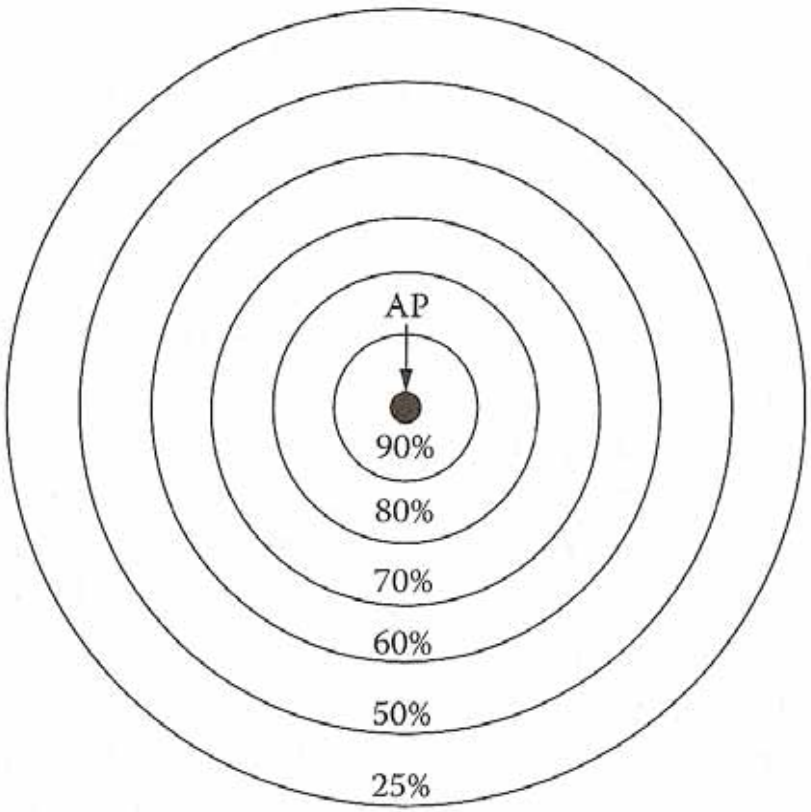
AeroScout Architecture

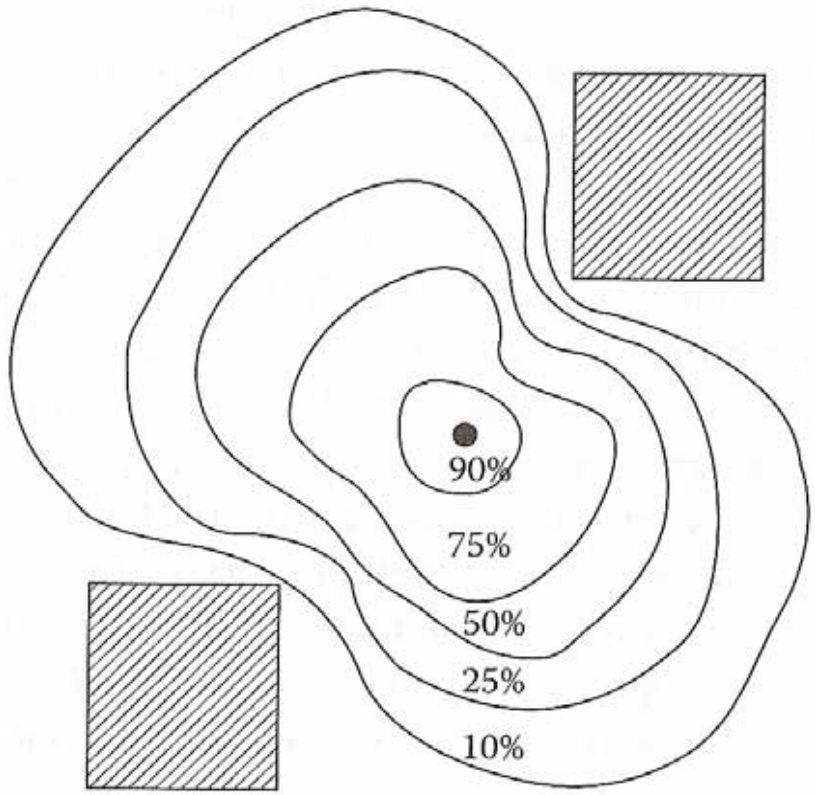


Ekahau & Location Fingerprinting

- **Software-based Wi-Fi location platform**
- **Ekahau Positioning Engine**
- **Recommended for sites with obstructions and multipath**
- **Radio mapping**
- **Location fingerprinting allows locating device with only one AP**
- **Requires a detailed site survey before the system setup & recalibration**

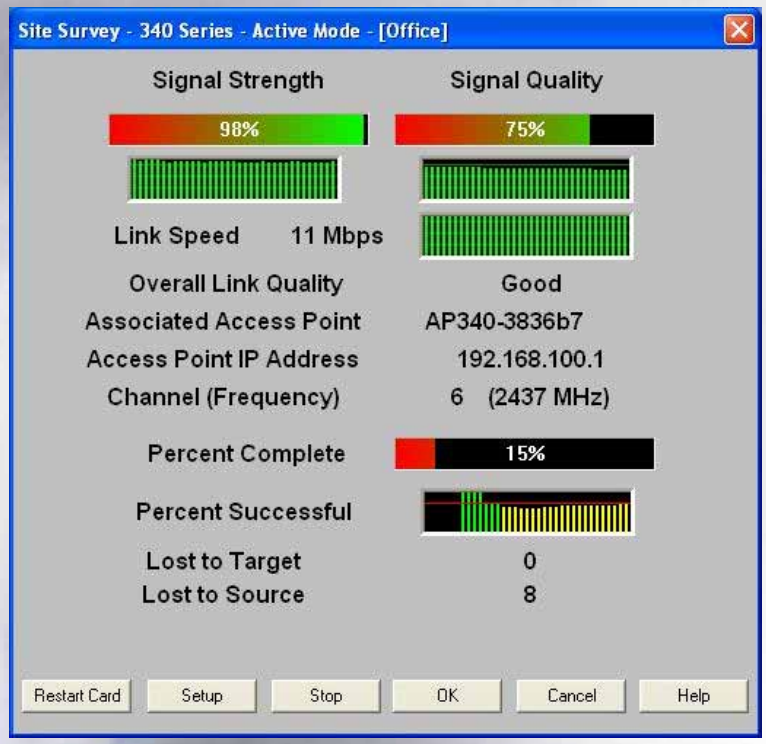
Location Fingerprinting

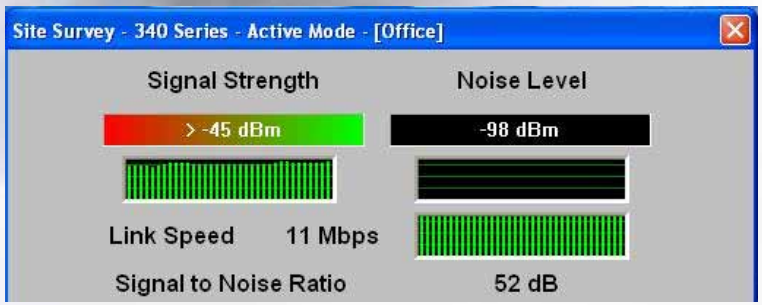




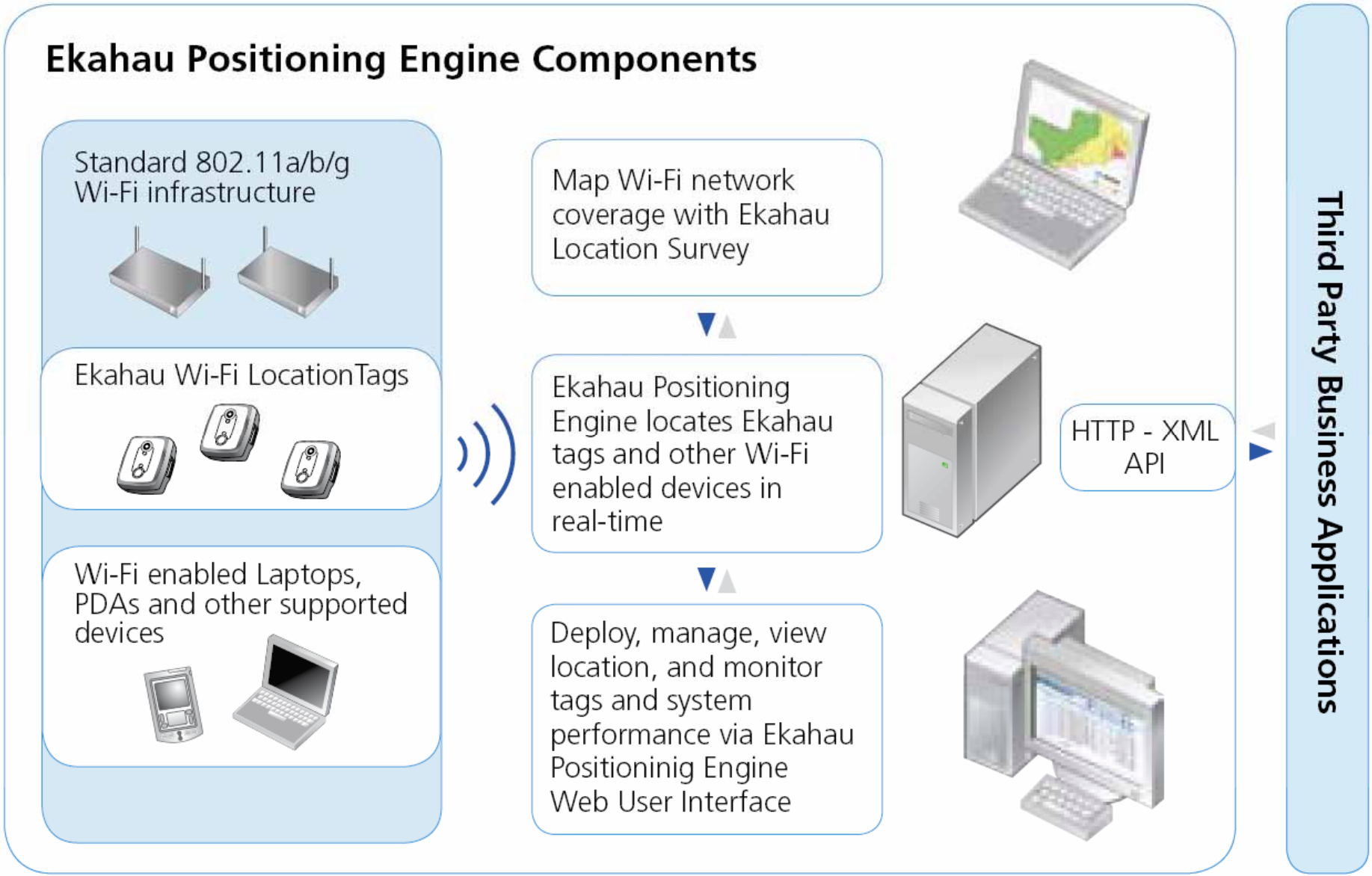
Site Survey

- **Collect sufficient information to locate, install, and configure RF parameters of the APs and antennas**
- **Performed by walking the proposed coverage area**
- **Signal-to-noise ratio (SNR)**





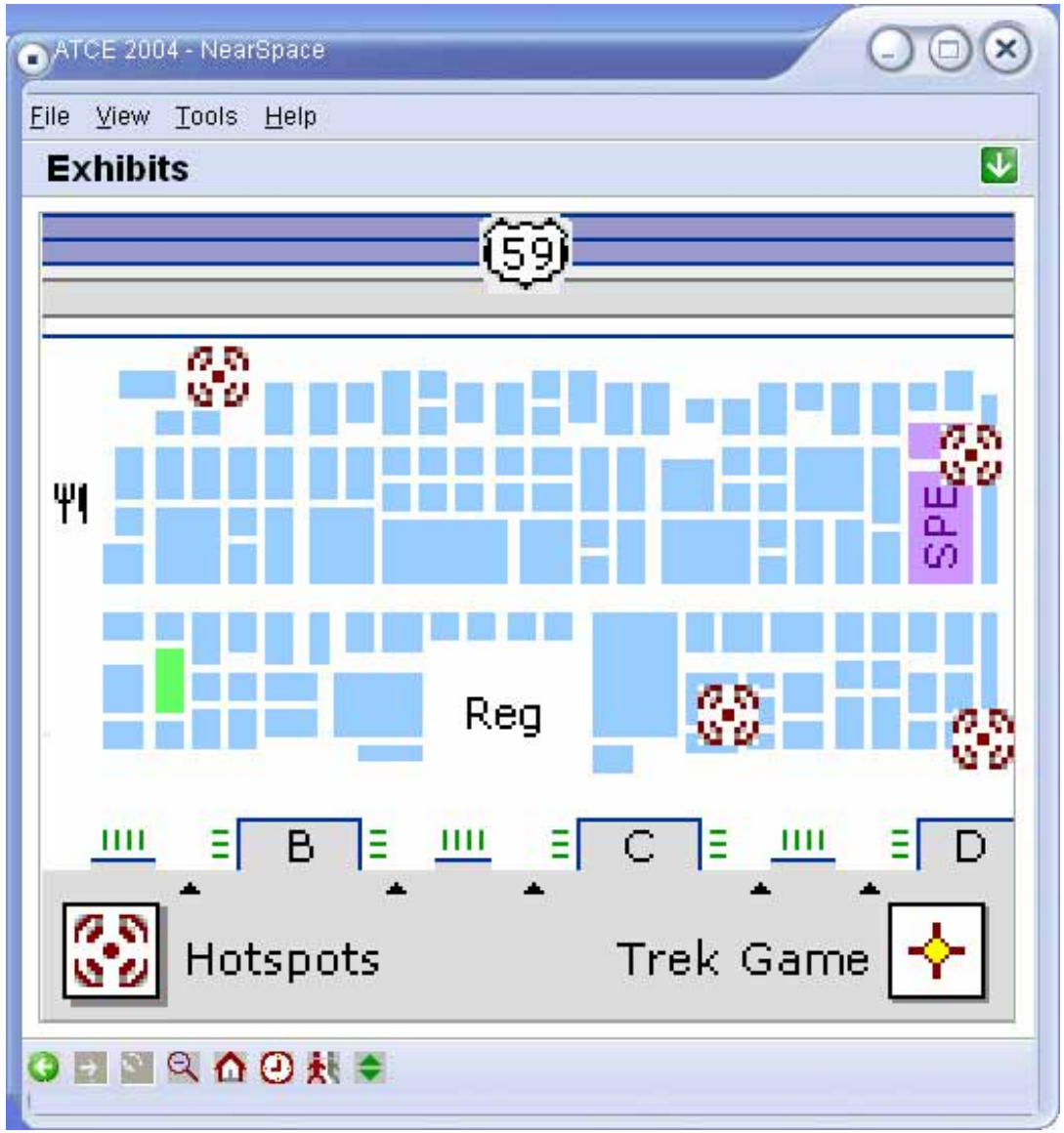
Ekahau Architecture



Mapping and Data Management

- **Handheld units – Personal digital assistants (PDAs)**
- **Spatial GIS servers provide data about static or mobile objects and users & upon request are set to return their location**
- **Indoor spatial information database might be created from digital maps such as CAD drawings**
- **RDBMS or XML databases are used to store location data**

Example of Mapping Application



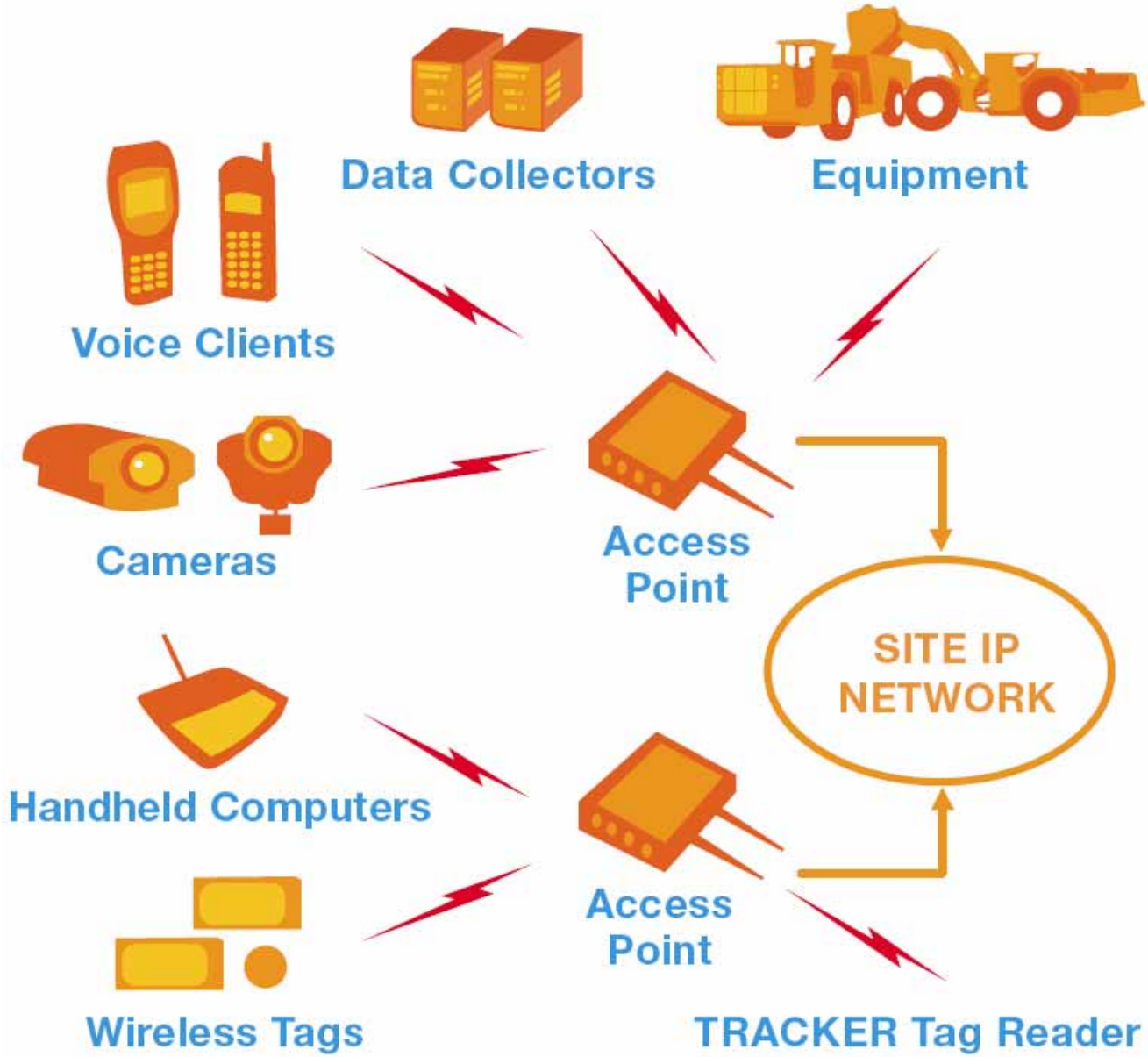
Recommendations

- **Questionnaire responses**
  - **Mine Site Technologies**
    - **Underground communications**
    - **Open pit communications**
    - **Technology already used in United States, Australia, Canada, China, Peru, Sweden, Chile and Tanzania**
  - **Extreme Endeavors**
    - **Underground miner tracking system**
- **Based on current site conditions at Pollyanna No. 8 underground mine**

Mine Site Technologies

- **ImPact Wireless Access Points**
- **Issue Wi-Fi RFID tags to employees**
- **Software to process and display miners' locations**
- **Accuracy depends on AP spacing – 2 to 4 feet with an Exciter**

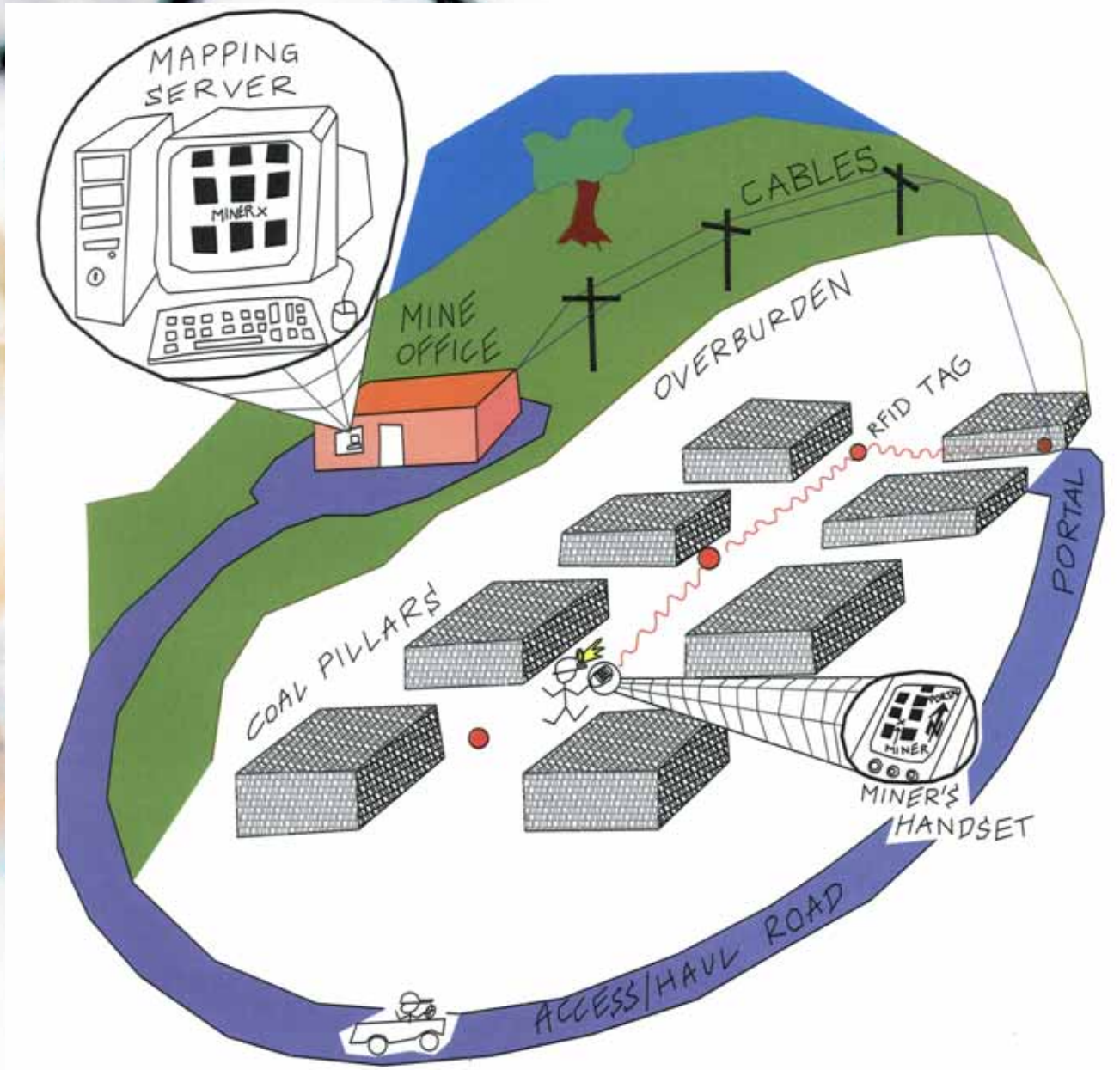
Mine Site Technologies



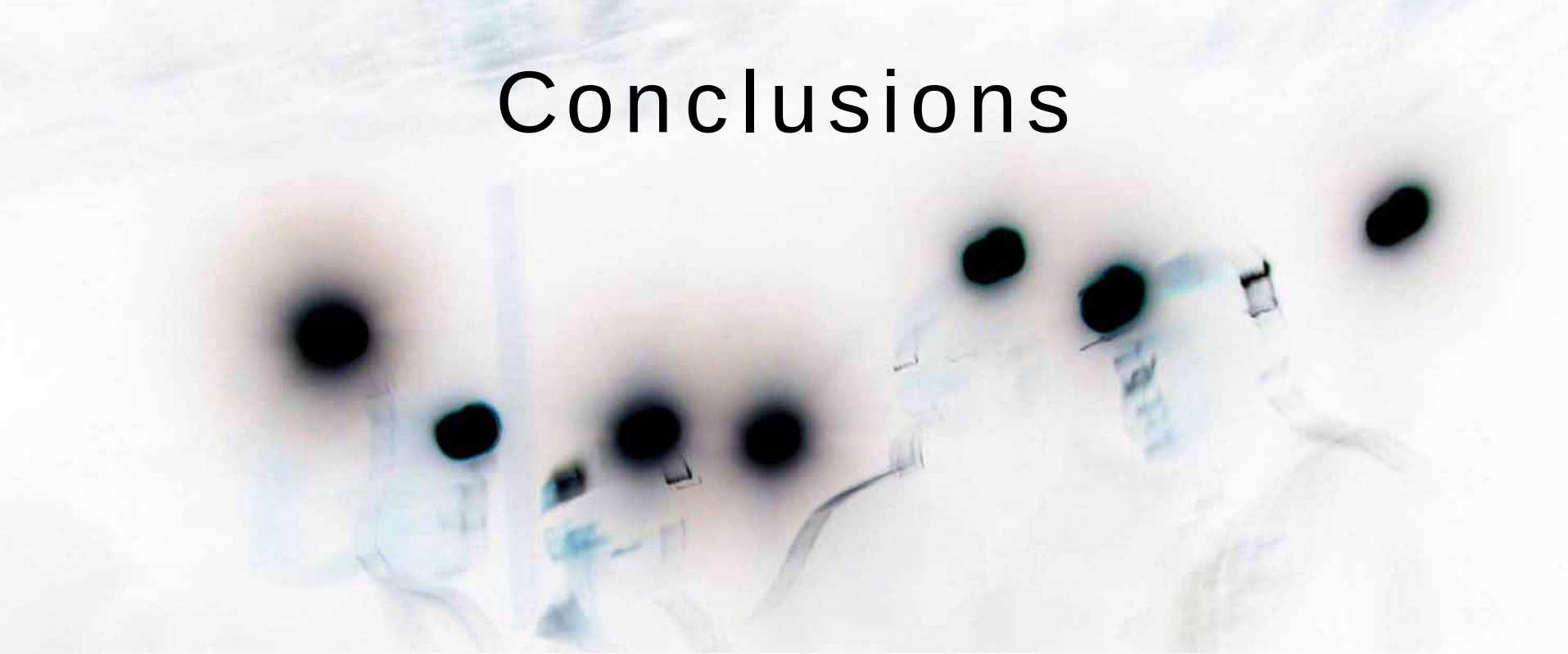
Extreme Endeavors

- **Tracking system (by Extreme Endeavors) coupled with a communication system (by Comtech Mobile)**
- **Reverse RFID (RRFID) tag and inertial sensor technology**
- **Real-time display on handheld device screen**
- **Extreme Endeavors contracted by NIOSH to develop RRFID**

Reverse RFID



Conclusions

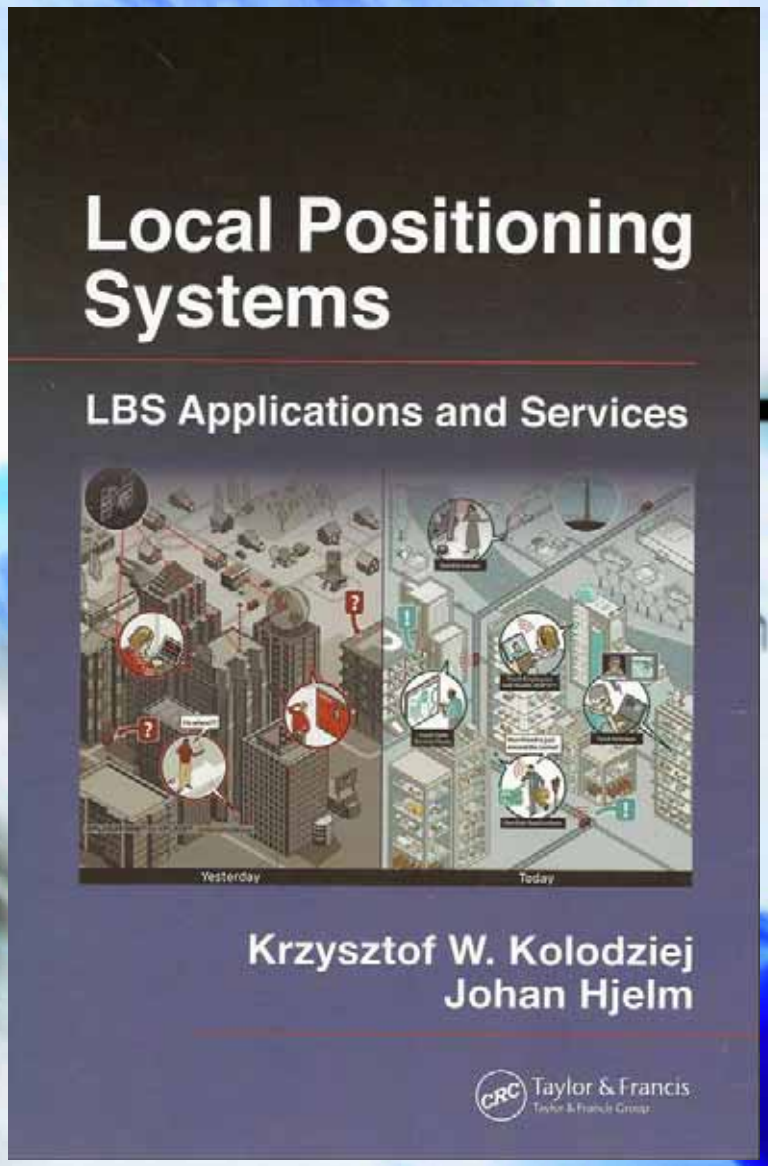


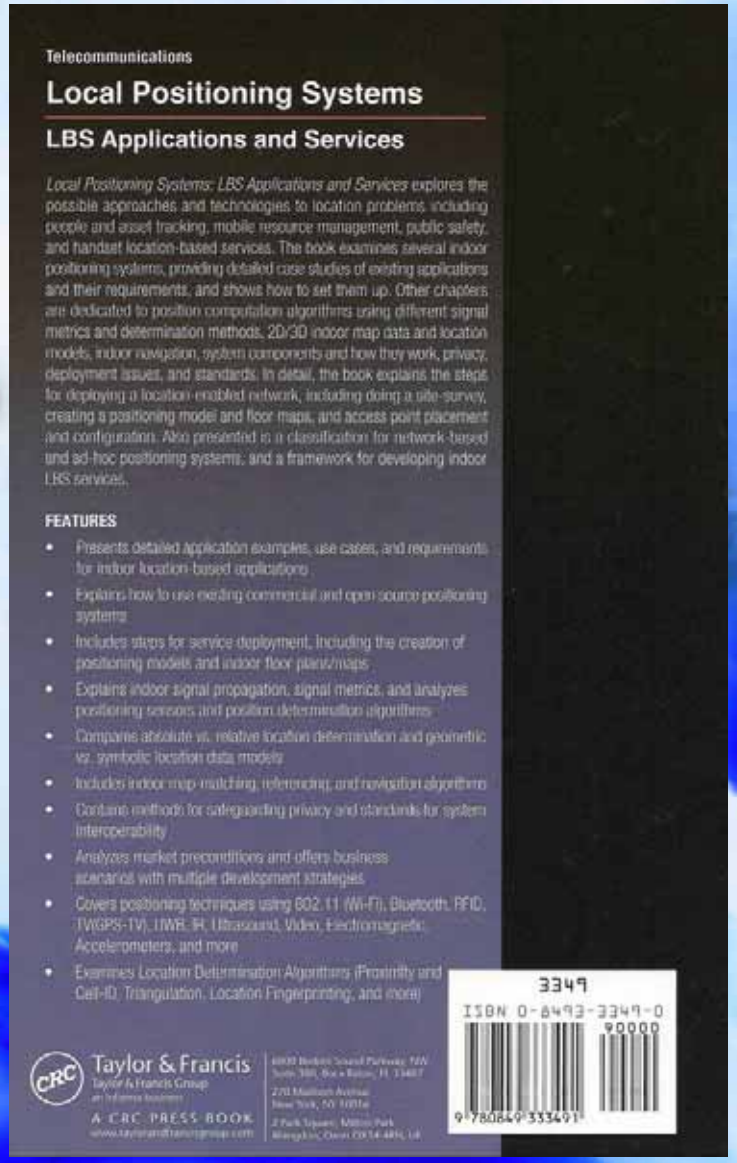
- **Wi-Fi WLAN system as preferred solution**
  - **Total cost by Mine Site Technologies = $60,000 to $100,000**
  - **$2,700 to $4,550 per user**
- **RRFID offers practical solution**
- **Tag Cost ~ $65 to $100**
- **Positioning software cost = Varies. $6,000 for EPE**

Conclusions – continued

- **Benefits**
  - **Learning about LPS technology as a geospatial technology**
  - **Increasing mapping accuracy & improving positioning methods in the underground mine environments**
  - **Improving mine communications, mine safety and emergency accident responsiveness**

Recommended References





Telecommunications

Local Positioning Systems

LBS Applications and Services

Local Positioning Systems: LBS Applications and Services explores the possible approaches and technologies to location problems including people and asset tracking, mobile resource management, public safety, and handset location-based services. The book examines several indoor positioning systems, providing detailed case studies of existing applications and their requirements, and shows how to set them up. Other chapters are dedicated to position computation algorithms using different signal metrics and determination methods, 2D/3D indoor map data and location models, indoor navigation, system components and how they work, privacy, deployment issues, and standards. In detail, the book explains the steps for deploying a location-enabled network, including doing a site-survey, creating a positioning model and floor maps, and access point placement and configuration. Also presented is a classification for network-based and ad-hoc positioning systems, and a framework for developing indoor LBS services.

FEATURES

- Presents detailed application examples, use cases, and requirements for indoor location-based applications
- Explains how to use existing commercial and open source positioning systems
- Includes steps for service deployment, including the creation of positioning models and indoor floor plans/maps
- Explains indoor signal propagation, signal metrics, and analyzes positioning sensors and position determination algorithms
- Compares absolute vs. relative location determination and geometric vs. symbolic location data models
- Includes indoor map matching, referencing, and navigation algorithms
- Contains methods for safeguarding privacy and standards for system interoperability
- Analyzes market preconditions and offers business scenarios with multiple development strategies
- Covers positioning techniques using 802.11 (Wi-Fi), Bluetooth, RFID, TV(GPS-TV), UWB, IR, Ultrasound, Video, Electromagnetic, Accelerometers, and more
- Examines Location Determination Algorithms (Proximity and Cell-ID, Triangulation, Location Fingerprinting, and more)

Taylor & Francis

A CRC PRESS BOOK

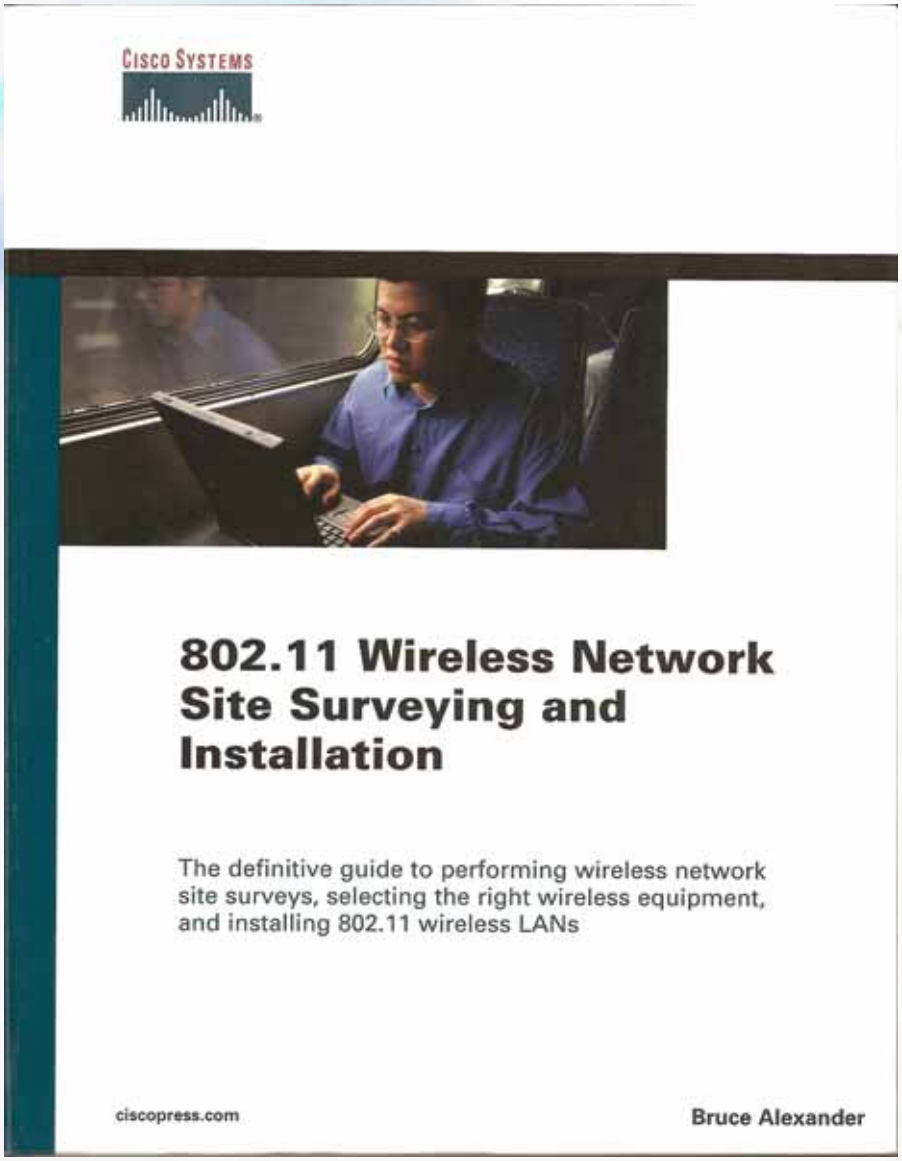
3349

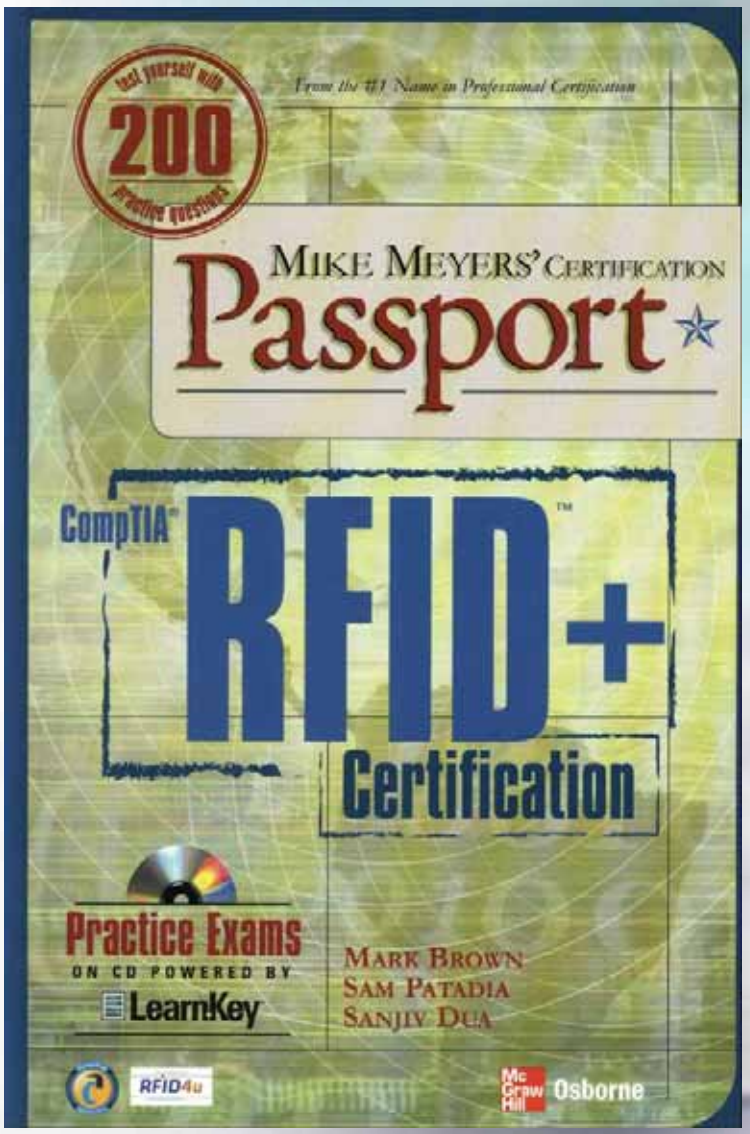
ISBN 0-8493-3349-0

90000

9 780849 333491

Recommended References





Comments