TUTORIAL TITLE
Indoor Geolocation Systems: Theory and Applications

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PART NUMBER AND TITLES (IF PRESENTATION IS DIVIDED INTO SEVERAL PARTS)
1 part only

TOTAL PRESENTATION TIME
~ 3.5 hours

TOTAL NUMBER OF SLIDES
273 slides

TUTORIAL SUMMARY
The goal of this tutorial is to introduce and discuss *Indoor Geolocation Systems: Theory and Applications* research and development processes for over 20 years.

The first part of the tutorial is dedicated to the theory of indoor geolocation systems which consists of five sections. In the first section we introduce geolocation systems. In the second section we classify the state of the art radio geolocation
The second part of the book consists of indoor geolocation applications which are discussed in 7 sections. In section 6 we propose and assess three Giftet Inc pseudolite-based indoor geolocation systems. It is assessed that the GPS and GLONASS signal structures of the 1990s were inadequate to overcome the three main design concerns; namely, (1) the near-far effect, (2) the multipath effect, and (3) the anti-jam effect. We propose three pseudolite-based indoor geolocation systems as alternative solutions to near-far, multipath, and anti-jam effects which are (1) C-CDMA, (2) OFDMA, and (3) MC-CDMA pseudolite-based indoor geolocation systems. In section 7 we research, discuss, analyze, and propose the design in detail of the C-CDMA pseudolite-based indoor geolocation system based on its principle of operation, its transmitter, the indoor channel, and its receiver design and issues associated with obtaining an observable to achieve indoor navigation 99.9% of the time and integration with GIS maps or a geospatial database and MATLAB and Simulink implementation. In section 8 we research, discuss, analyze, and propose the design in detail of the OFDMA pseudolite-based indoor geolocation system based on its principle of operation, its transmitter, the indoor channel, and its receiver design and issues associated with obtaining an observable to achieve indoor navigation 99.99% of the time and integration with GIS maps or a geospatial database and MATLAB and Simulink implementation. In section 9 we research, discuss, analyze, and propose the design in detail of the MC-CDMA pseudolite-based indoor geolocation system based on its principle of operation, its transmitter, the indoor channel, and its receiver design and issues associated with obtaining an observable to achieve indoor navigation 99.999% of the time and integration with GIS maps or a geospatial database and MATLAB and Simulink implementation. Section 10 of the tutorial is dedicated to implementation illustration specifications of indoor geolocation systems in five areas. In the first area of section 10 we discusses the RF engineering, antennas, and propagation. In the second area of section 10 we discuss indoor geolocation technologies. The third area of section 10 is dedicated to indoor geolocation service architecture. The fourth area of section 10 is dedicated to indoor geolocation management and information assurance. And the fifth area of section 10 is dedicated to indoor geolocation capital planning and investment control. Section 11 is dedicated to advanced signal processing on indoor geolocation systems with emphasis on integration of indoor geolocation systems data with image, video, camera, voice, GPS, mobile and wireless networks, Radio, TV, and/or radar data. The last section (or section 12) of the tutorial is dedicated to our assessment of these systems which concludes the following.

First, a C-CDMA indoor geolocation system is a potential candidate for indoor positioning, with data rate up to 3.2 KBPS, pseudorange error, less than to 2 m and phase error less than 5 mm and overall to provide centimeter level position and velocity accuracy 99.9% of the time. Second, an OFDMA indoor geolocation system is another potential candidate with a totally different signal structure than the C-CDMA indoor geolocation systems. Third, a MC-CDMA indoor geolocation system is a potential candidate to achieve centimeter level position and velocity performance accuracy 99.999% of the time and data rate up to 5 MBPS.

Accurate geolocation and precise location estimation will:

1. Improve the overall performance by providing very accurate position, velocity, and timing information especially when integrated with GIS or geospatial database.
2. Improve the overall efficiency by reducing the amount of error allowed in the geolocation information which will result in $$$ several hundred millions to billions savings to our nation’s tax payers money.
3. Improve the overall productivity by providing very accurate geolocation, geo-intelligence, and geo-reference information.
4. Save human lives during fire-fighter and emergency rescue operations thus become the most valuable tool in the hands of E911 personnel.
5. Improve the standard of living in the way people think, communicate, do business, do science, educate their children, in the way universities operate, in the way future government or government will function and navigate in a much greener and energy efficient society.

KEYWORDS

GLOSSARY TERMS/DEFINITIONS
1. Radio geolocation system
2. State of the art indoor geolocation system
3. Indoor geolocation channel model
4. Indoor geolocation systems navigation algorithms
5. Advanced signal processing time and frequency estimation algorithms
6. Pseudolite based indoor geolocation systems
7. C-CDMA indoor geolocation systems
8. OFDMA indoor geolocation systems
9. MC-CDMA indoor geolocation systems
10. Specifications for implementing indoor geolocation systems

TEXT/SOFTWARE

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QUIZ
Q1: Name one Geolocation System that is currently widely available in the market?
A1: (a) GPS; (b) GLONASS. (c) E911; (d) Wi-Fi positioning, (e) Mobile positioning.
Q2: What are the two main concerns with these systems indoors?
A2: (a) Multipath; (b) Indoor Channel Impairments; (c) Near-far effect; (d) Cross-channel interference; (e) Signal Design.

Q3: Name one state-of-the-art Indoor Geolocation Systems

A3: (a) Giftet Inc C-CDMA; (b) Giftet Inc OFDMA; (c) Giftet Inc MC-CDMA; (d) WPI (Multicarrier) Precision Locator (e) Wi-Fi and Mobile Indoor Positioning.

Q4: What is the main advantage of the C-CDMA/OFDMA/MC-CDMA indoor geolocation system?

A4: (a) Eliminates the near-far effect; (b) Reduces Multipath effect; (c) It is a more suitable system for the indoor channel model; (d) It offers an improved signal design.

Q5: Will GPS/GLONASS provide better accuracy than C-CDMA/OFDMA/MC-CDMA indoor geolocation system?

A5: False

Q6: Will GPS/GLONASS provide better interference protection than C-CDMA/OFDMA/MC-CDMA indoor geolocation system?

A6: False

Q7: Of the three indoor geolocation systems C-CDMA/OFDMA/MC-CDMA which is the best one and why?

A7: MC-CDMA because of the multi-dimensional orthogonally signal design (structure) description.

Q8: Name one advanced signal processing algorithm suitable for indoor geolocation applications?

A8: (a) Global Maximum likelihood; (b) Markov Chain, Monte Carlo Global Search and Integration for Bayesian.

Q9: Name of software that can be utilized to analyze, model, and simulate indoor geolocation systems

A9: (a) MATLAB; (b) Simulink.