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Assuring Space Mission Success

Calculating Channel Capacity for Satellite Communication Systems

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Project Description: Research in Industrial Projects for Students (RIPS) Program - 2014

(Institute for Pure & Applied Mathematics – IPAM)

Project Title: Calculating Channel Capacity for Satellite Communication Systems

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Project Description:

As satellite communication operators move towards being more agile and responsive, they need to develop innovative solutions to meet the increased demands of satcom-on-the-move users. The use of satellite systems, in the implementation of mobile communication, involves a complex propagation environment. Additionally, the communication capacity that a particular satellite system can satisfy is highly dependent on the satellite channel model. This channel model should be based on accurate estimation and modeling of real-world propagation statistics and combine the effects of weather loss, multipath fading, ionospheric scintillation, and any diversity-based mitigation techniques that may be employed.

The purpose of this RIPS project is to develop a method for calculating channel capacity for mobile satellite communication systems. The first part of the study will include a literature search to better understand methods for calculating the capacity of classical channel models, such as Addititive White Gaussian Noise (AWGN) and Rayleigh fading. The second part of the study will be to adapt these models to include more complex satellite communication channels including the effects of weather, multipath, ionospheric scintillation and mitigation techniques using frequency, time, or space diversity. The development of a channel capacity model for mobile satellite users will be of great benefit to our corporate customers as they try to determine innovative ways to modernize their current satellite systems using commercial technologies in a low-cost environment.

Work to be Done and Deliverables:

The proposed study for the summer of 2014 includes the following activities:

1. Review basic communication and classical channel capacity theory,
2. Determine the unique characteristics and parameters of satellite channels that will affect communications capacity, and
3. Modify existing channel capacity methods analytically or through simulation techniques.

The third task is performed to calculate the channel capacity of a satellite system for different carrier frequencies and bandwidth, while accounting for the effects of weather, multipath fading, ionospheric scintillation, and diversity-based mitigation techniques. The final report should include a mathematical description and/or simulation results for the techniques developed.

Status of Field:

Over the past several years, The Aerospace Corporation (Aerospace) has played a key role in evaluating throughput and capacity performance for many satellite communication systems. Modeling and simulation tools have played vital roles in these analyses; evaluating the performance of existing and future satellite architectures and validating the performance of various designs. These modeling and simulation tools have been designed for current communication systems which, for the most part, have not included commercial SATCOM systems. However, given current development goals to make cheaper satellite systems and the need for mobility and higher data services, the satellite operators are likely to adopt more commercial technologies to efficiently meet user demands. As the satellite operators move toward a more balanced approach to meet bandwidth demands, it will be vital for Aerospace to have the model and simulation tools in place to evaluate the performance of a diverse fleet of satellite systems.

References:

1. To Be Supplied

Prerequisites:

1. Advanced Calculus
2. Discrete Math
3. Probability and Statistics
4. Advanced Physics
5. Numerical analysis
6. Introduction to Computer Science

Required: U.S. Citizenship

Keywords:

Satellite Communication Systems, multipath fading, terrestial multipath, ionospheric scintillation, Channel Model Theory