Interference Analysis for on the Move Satellite Communication Systems

INTERFERENCE ANALYSIS FOR ON THE MOVE SATELLITE COMMUNICATION SYSTEMS

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ABSTRACT

We consider on the move satellite systems with geostationary satellites. Using the antenna pointing distribution of Weerackody and Gonzalez, we derive tight upper and lower bounds on the interference to adjacent satellites from the on the move platforms. We then compute the distribution of the interference and the system outage probability. Simulation results are provided demonstrating that our estimates are very good.

1. EXTENDED ABSTRACT

In recent years, there has been a growth of interest in providing satellite internet to moving platforms. Examples of commercial applications include providing Internet to fast moving trains, ships, etc. in the Ku band. Other applications include the use of UHF band for communications to soldiers on the move by the MUOS system [1]. Future commercial applications are being envisioned in the the Ka band, where there is an abundance of bandwidth.

In all the above cases, the underlying satellites are geostationary, and are separated by a minimum separation angle (approximately 2°). In order for the system performance to be satisfactory, mobile devices must be endowed by antennas with good pointing accuracy to the desired satellites so that the impact of interference to/from adjacent satellites be minimized. However, this is a challenging task for a moving platform because of potential rapid movements of the mobile unit, and limitations on the cost and size of the mobile device antennas. Pointing inaccuracies, relatively wider beam patterns (for smaller size antennas), multipath make it very difficult to avoid interference to/from adjacent satellites. This can severely limit the communications throughput unless frequency planning is used. Such a frequency planning reduces both the spectral efficiency and efficiency of transponder usage, which is not economically desirable if we have to support broadbands data rates to a large number of users. In the worst case, when an omni-directional antenna is used at the mobile unit (as is the case in the MUOS system [1]), and no frequency planning is employed, reflections of the signal from the ground could produce multipath effects at the desired satellite. Additionally, interference to/from adjacent satellites becomes a very significant issue.

This motivated us to study the aggregate interference caused by a set of mobile users in a geostationary satellite coverage area to a neighboring geostationary satellite. Additionally, we will also consider the effects of downlink transmissions by the neighboring satellites to the mobile receiver. Our approach is based on the modeling of the statistics of motion induced antenna pointing errors proposed by [2]. We then use a geometric argument to produce an upper and a lower bound on the interference to/from the adjacent satellites to/from the mobile platform given the underlying antenna pointing inaccuracy (see Figure 1). We then average these bounds over the distribution of the antenna pointing accuracy and mobile platforms to produce tight upper and lower bounds on the average and estimate the distribution of the interference. A central limit theorem approach is then used to produce Gaussian approximation to the distribution. Finally, we use this to compute system outage probability in the presence of adjacent satellite interference.

The numerical results resented hereafter are concentrated on the validation of our bounds as well as the influence of various parameters upon the outage probability of error. In Figure 2, we plot the off-axis angles under which the interfering aircrafts see the desired satellite β[1]. The exact off-axis angles are obtained via extensive simulations and the bounds are derives analytically. As observed in Figure 2 our bounds are very tight for different satellite angular separation α.

[1] we use these bounds to derive the bounds of the interference

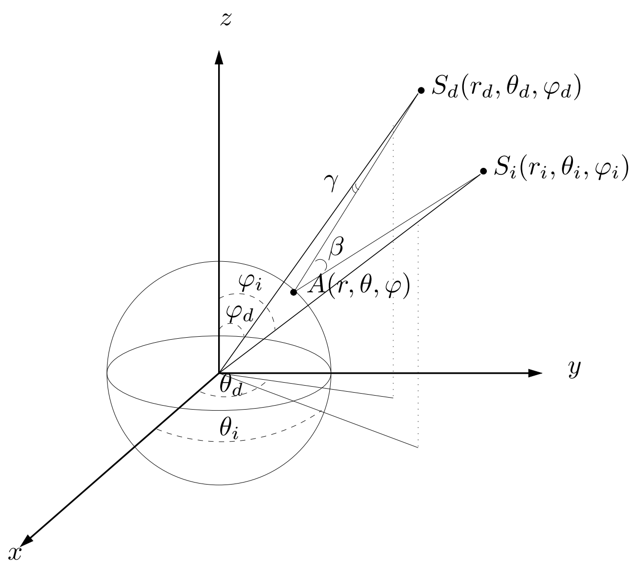

Fig. 1. Configuration of the system.

In addition, we compute the outage probability $P_{out} = \Pr[\text{SINR} < \delta]$. A 14.25 GHz carrier frequency has been assumed. We also assume a small aperture antenna with diameter $d = 0.3$ meter. We consider that the antenna pointing error has a Gaussian distribution with mean zero and variance σ_ϕ^2.

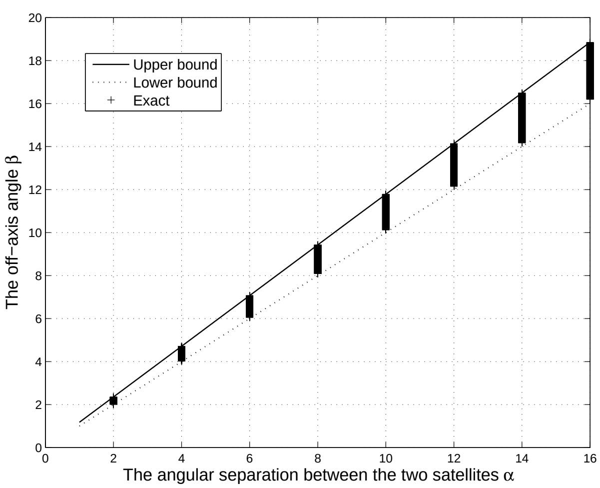

Fig. 2. The off-axis angles β.

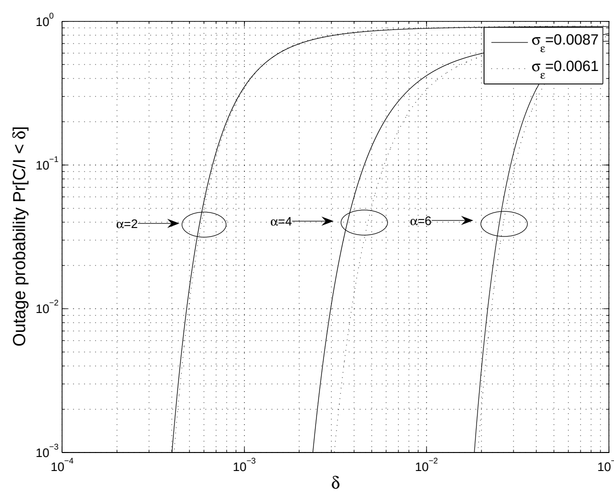

Fig. 3. The outage probability.

Figure 3 shows the variation of the outage probability for different angular separation values $\alpha = 2, 4,$ and 6 and different variance values, $\sigma_\phi = 0.0087$ and 0.0061 radian. As expected, it is seen that the outage probability increases as the variance σ_ϕ^2 increases and the angular separation α decreases.

2. REFERENCES

[1] J. Nicholson, "Status of the Mobile User Objective System," *Military Communications Conference (MILCOM) 2006*, pp.1-4, 2006.

[2] V. Weerackody and L. Gonzalez, "Motion induced antenna pointing errors in satellite communications on-the-move systems, " *IEEE Conference on Information Sciences and Systems*, pp: 961-966, 2006.