Multibeam Joint Detection

Initial Draft

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1 Introduction

1.1 Why joint multibeam processing?

Most modern satellite systems employ multiple spot beams because they allow higher carrier-over-noise values in the coverage area and the spatial reuse of spectral resources, thus satisfying higher throughput demands with a scalable cost. However, the side lobes of the beams' radiation patterns cause inter-beam interference, which is usually counteracted by assigning different frequency bands to adjacent beams, as illustrated in Figure 1.

However, this solution uses the spectrum inefficiently, and more aggressive frequency reuse alternatives have been proposed [1]. These alternatives require some processing, either at the transmitter or at the receiver, that mitigates the interference introduced by the higher frequency reuse [2]. Focusing on the return link, the maximum sum-rate is known to be achieved via successive interference cancellation with minimum mean-squared error filtering at each stage (MMSE-SIC) [3]. However, much simpler, linear alternatives, such as the zero-forcing (ZF) receiver or the plain MMSE receiver ([4, 5]) are also popular because of their lower computational complexity.

In the last years, many works have studied the performance, and also the practical implications of the techniques above. The performance of the return link of a full on-ground architecture was investigated in [6, 7], featuring an adaptive coding and modulation (ACM) enhanced DVB-RCS physical layer. Results showed an increase in throughput at the cost of some loss in availability when linear MMSE was applied; with MMSE-SIC, a significant improvement in throughput and availability was reported.

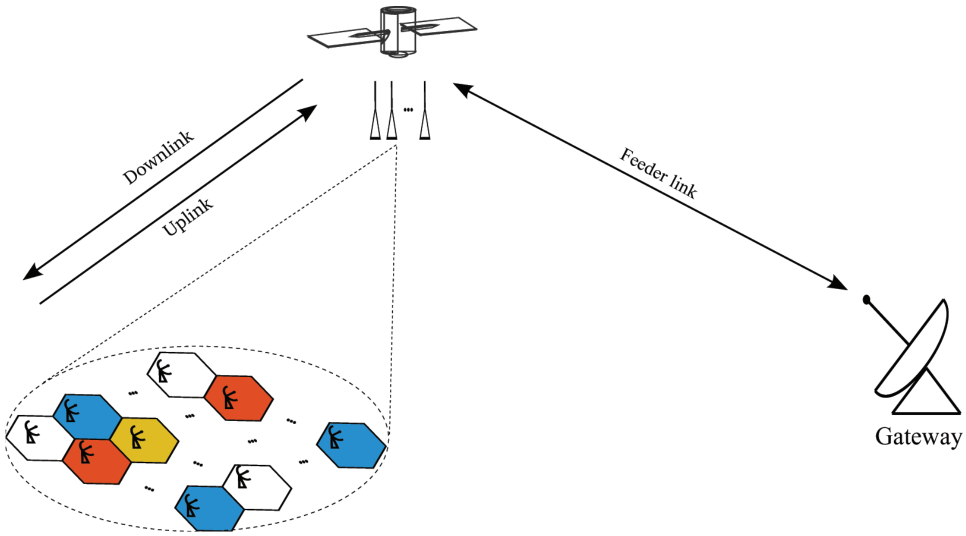

Figure 1: System model under consideration, depicting in this case fractional frequency reuse.

1.2 Signal model

In this section we will describe the signal model and notation to be used throughout the chapter. We will focus on a multibeam channel with K single-antenna terminals transmitting towards a single satellite equipped with $N \geq K$ antennas (Figure 2), even though some processing will exist on board whenever $N > K$ so that only K signals have to be sent to the gateway. The signal model reads as

$$\mathbf{y} = \sqrt{\gamma}\mathbf{H}\mathbf{s} + \mathbf{n} \tag{1}$$

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