Next Generation Multibeam Satellite Systems

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Satellite communication will play a central role towards fulfilling next generation 5G communication requirements. As a matter of fact, anytime-anywhere connectivity cannot be conceived without the presence of the satellite segment. Indeed, satellite communication industry is not only targeting popular markets (maritime, aeronautic, rural,) but also to high dense populated areas where the satellite will become an essential element to decongest the terrestrial wireless network.

In order to deliver broadband interactive data traffic, satellite payloads are currently implementing a multibeam radiation pattern. The use of a multibeam architecture brings several advantages in front of a single global beam transmission. First, as an array fed reflector is employed, the antenna gain to noise ratio can be increased leading to high gain in the achievable throughput. Second, different symbols can be simultaneously sent to geographically separated areas, allowing a spatially multiplexed communication. Last but not least, the available bandwidth can be reused in sufficiently separated beams, increasing the spectrum reuse in the overall coverage area. Whenever the system designers target the terabit satellite system (i.e. a satellite system offering a terabit per second capacity), the aforementioned multibeam architecture shall be reconsidered. Indeed, the achievable rates can be extremely increased in case a more aggressive frequency reuse is deployed and interference mitigation techniques are implemented either at the user terminal (multiuser detection) or in the transmitter (precoding).

Our study deals with the problem of precoding and linear filtering receiving methods for multibeam satellite systems when full frequency reuse is considered (i.e. all beams share the available spectrum). Concretely, we consider the particular restrictions of satellite communications which, in contrast to terrestrial communication systems, suffer from additional drawbacks.

First, the feeder link (i. e. the bidirectional communication link between the satellite and the internet backhaul connection) shall aggregate the overall data traffic leading to a very large rate requirement. This required data rate is even increased whenever linear filtering at the return link and precoding in the forward link are deployed. This is because the feed signals, which are larger than the number of beams, shall be computed on ground. In order to solve this problem, we propose a hybrid architecture where the satellite payload is equipped with a fixed processing. This on-board processing linearly transforms the received and transmitted data in order to keep the feeder link rate requirement low. The on board processing results to be the same for both return and forward links, leading to a large reduction of the payload complexity, mass and cost.

Second, as the data traffic can be generated by different Earth stations (gateways), the precoding method shall be designed accordingly. In contrast to previous works, this work studies the case where the collaboration between different gateways is limited. In addition to the aforementioned contribution, in this work some unexplored aspects of multi-gateway multibeam precoding are also investigated.

It is important to remark that proposed schemes (i.e. fixed on board processing and multiple gateway precoding) have been numerically evaluated considering broadband satellite standards (Digital Video by Satellite 2 and 2X) and channel models provided by the European Space Agency. Under this context, this work provides a close-to-real validation of novel techniques for next generation satellite systems.

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