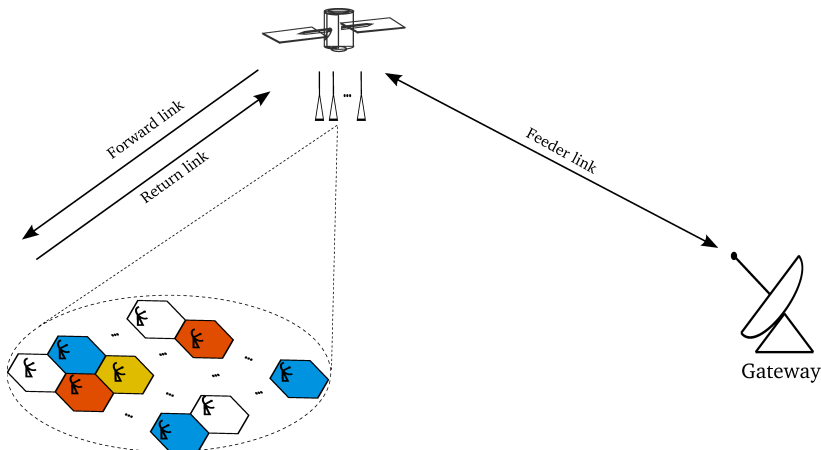# Improving the Return Link of Multibeam Satellite Systems

Jesús Arnau
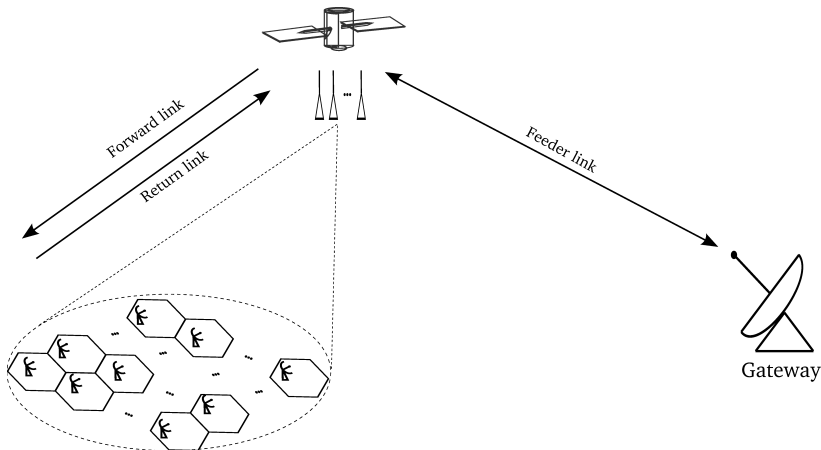
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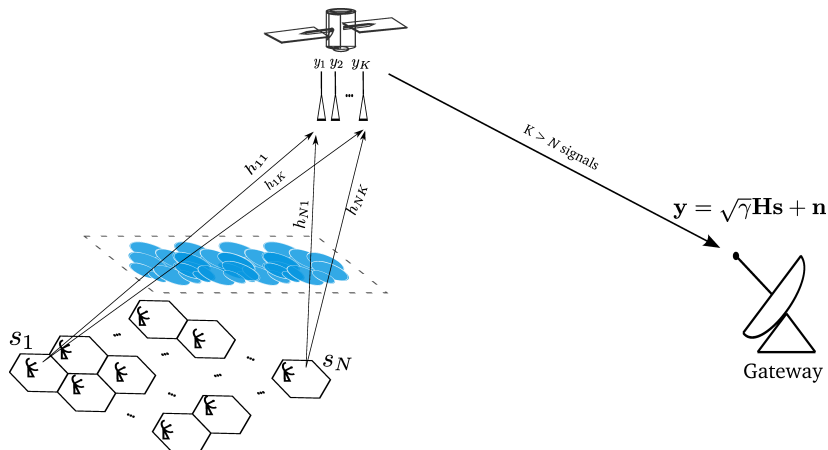
Multibeam satellites and their challenges
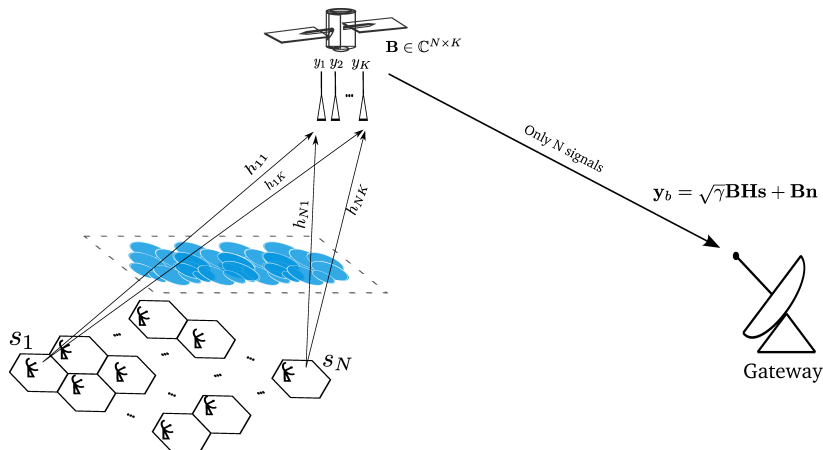
Multibeam satellites and their challenges

Forward link

Return link

Feeder link

Gateway

Multibeam satellites and their challenges

$$\mathbf{y} = \sqrt{\gamma}\mathbf{Hs} + \mathbf{n}$$

Multibeam satellites and their challenges

Multibeam satellites and their challenges

$$\mathbf{B} \in \mathbb{C}^{N \times K} \text{ \textcircled{1}}$$

$$\mathbf{y}_b = \sqrt{\gamma}\mathbf{B}\mathbf{H}\mathbf{s} + \mathbf{B}\mathbf{n}$$
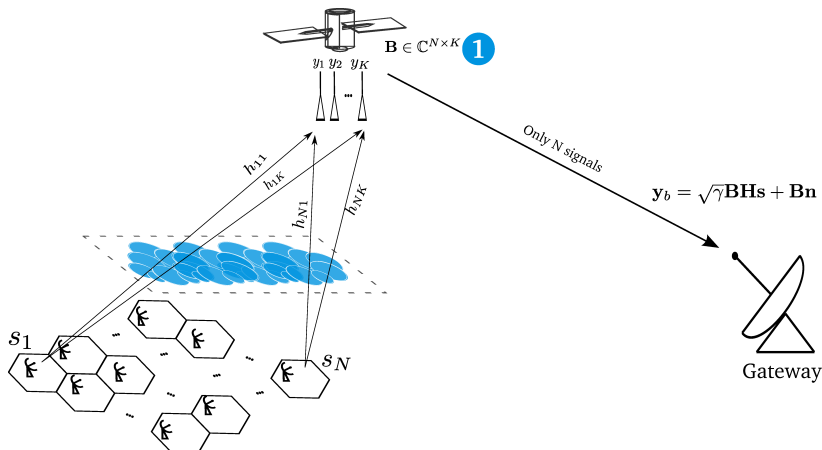
Multibeam satellites and their challenges
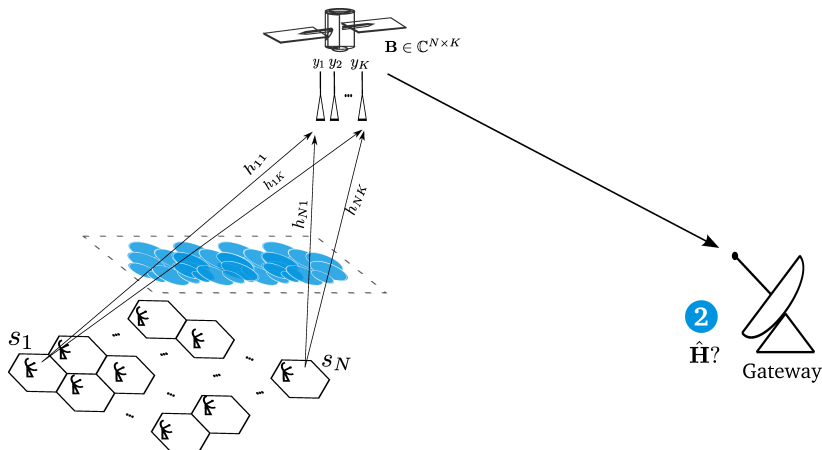
Multibeam satellites and their challenges
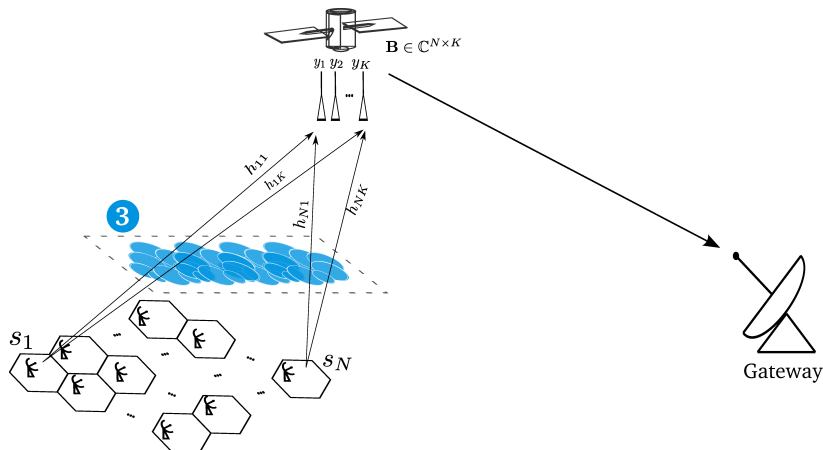
First challenge: hybrid beamforming

Assume a linear MMSE receiver and a fixed on-board beamformer.

Analytical result

The error with hybrid beamforming **is larger or equal** than the error with on-ground beamforming.

- A sufficient condition to attain the equality: $\text{range}(\mathbf{B}^H) = \text{range}(\mathbf{H})$.

- A consequence of $\sigma_i(\mathbf{H}) \geq \sigma_i(\mathbf{PH})$ with $\mathbf{P} = \mathbf{B}^H \left(\mathbf{BB}^H \right)^{-1} \mathbf{B}$.

[1] J. Arnau, Devillers, B., Mosquera, C., and Pérez-Neira, A., "Performance study of multiuser interference mitigation schemes for hybrid broadband multibeam satellite architectures", EURASIP Journal on Wireless Communications and Networking, vol. 2012, p. 132, 2012

Second challenge: imperfect channel estimation

The gateway knows $\mathbf{H}$ as $\hat{\mathbf{H}} = \mathbf{H} + N_0/L\mathbf{E}$.

Effect on the error, $\left(1 + \frac{K}{L}\right)$ trace $\left(\mathbf{I} + \frac{1}{N_0}\hat{\mathbf{H}}^H \mathbf{\Sigma}^{-1} \hat{\mathbf{H}}\right)^{-1}$?

Solution

- For large values of K,N, the error becomes **deterministic**.

- There exists a matrix $\mathbf{T}(L,K,N,N_0)$ with the same trace.

Can be obtained in closed form solving a system of $N + K$ equations.

[2] Arnau, J.; Mosquera, C., "Multiuser detection performance in multibeam satellite links under imperfect CSI," Forty Sixth Asilomar

Conference on Signals, Systems and Computers, 4-7 Nov. 2012

Some simulation results
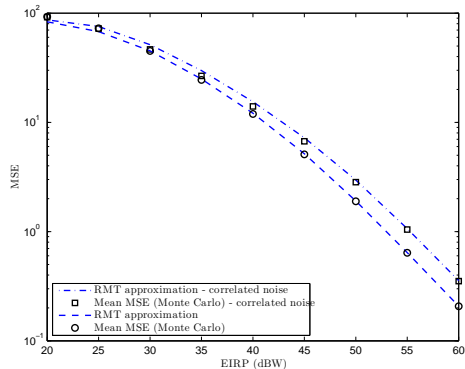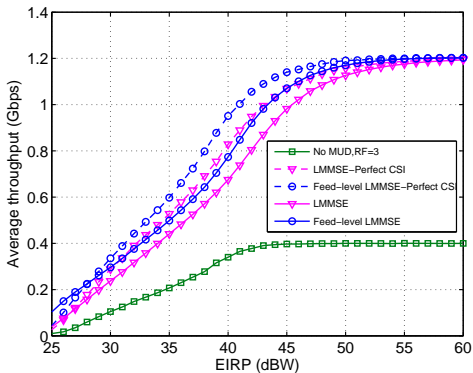
[3] Arnau-Yanez, J.; Bergmann, M.; Candreva, E. A.; Corazza, G.E.; De Gaudenzi, R.; Devillers, B.; Gappmair, W.; Lombardo, F.; Mosquera, C.;

Perez-Neira, A.; Thibault, I.; Vanelli-Coralli, A., "Hybrid Space-Ground Processing for High-Capacity Multi-Beam Satellite Systems," Global

Telecommunications Conference (GLOBECOM 2011), 5-9 Dec. 2011

Third challenge: the effect of the channel

Channel model very different from usual MIMO systems, $\mathbf{H} = \mathbf{DG}$.
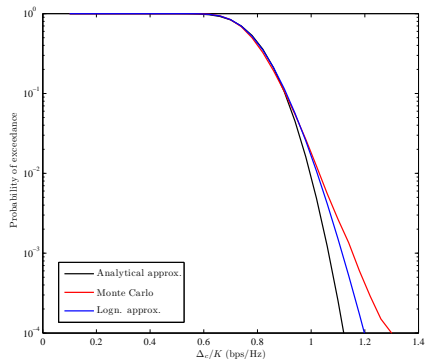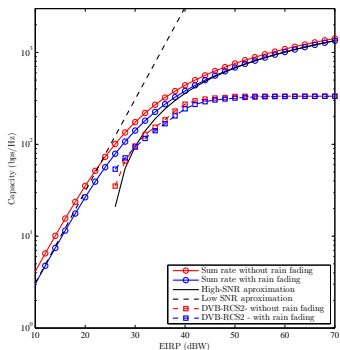
[4] Arnau, J.; Mosquera, C., "Performance analysis of multiuser detection for multibeam satellites under rain fading," 6th ASMS and 12th SPSC, 5-7 Sept. 2012

[5] Christopoulos, D.; Arnau, J.; Chatzinotas, S.; Mosquera, C.; Ottersten, B., "MMSE Performance Analysis of Generalized Multibeam Satellite Channels," Communications Letters, IEEE , vol. 17, no. 7, pp. 1332,1335, July 2013.

Future perspectives

- High capacity feeder links to cope with bandwidth demands.

- Possibility of multiple coordinated gateways.

- Improvements in the payload.

- Studies with spatially correlated rain attenuation.

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