

Managing integrated satellite-5G networks: techno-economic evaluation of a brokerage role

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Abstract—Demand from new applications poses technological challenges for future communication networks. For specific use cases, satellite networks can provide a complementary solution to terrestrial deployments. However, combining 5G and satellite networks requires close collaboration between different stakeholders, which poses new business challenges. This paper aims to evaluate, from a business-model point of view, the role of a radio-resource broker when integrating satellite communication into 5G networks. The paper concludes that a broker can lead to efficiency gains, if certain technical challenges are overcome and if it is overseen by a regulatory body. The broker is envisaged to operate on a medium time-scale of the order of hours, resulting in some degree of automation in resource allocation.

Keywords—business model; broker; satellite communication; 5G networks.

I. INTRODUCTION

Market demand and new emerging applications push the technological evolution of digital services and applications and pose different technical challenges, such as spectrum sharing, beamforming and heterogenous network coordination. These technical challenges have to be addressed in order to move towards the fifth generation of the cellular networks, known as 5G. Satellite communications have several advantages that can help 5G networks to achieve these technical challenges [1]:

- Ubiquity: Satellite can provide a high-speed coverage across the globe.
- Mobility: Satellite is the unique readily technology able to provide connectivity anywhere.
- Broadcast: Satellite can efficiently deliver rich multimedia and other content across multiple sites simultaneously.

Hence, integrating satellite communication into 5G networks enables a broad range of use cases where the benefits of satellite can be leveraged [1]. Though the technical challenges resulting from this integration, such as virtualization of satellite network function or the radio resource allocation policy, have been studied [1] [2], there are also challenges raised due to the shift in business modelling context. This integration leads to interactions between multiple stakeholders (mobile network operators – MNOs - and satellite network operators – SNOs, but also regulators, spacecraft manufacturers, service providers, content distributors and hardware vendors). The main differentiator compared to the traditional non-integrated

network, however, is the presence of multiple MNOs and SNOs. Although the interaction can be direct, it can quickly become very complex if multiple stakeholders are involved. Hence, this paper introduces the role of a **broker** to handle negotiations between the different network operators and presents an assessment of this role from a techno-economic perspective.

II. CONCEPT OF THE BROKER

Integrating satellite communication into 5G networks causes management issues. This raises several questions: who bears the risk in case of a failure in the network? How to manage the network of another operator? How to get the best offer for a specific location with specific requirements? How to forecast demand to justify investment? Therefore, a trusted third party, known as an aggregator or a broker, can be the appropriate solution for these unprecedented challenges.

The concept of the broker developed by the SaT5G project is consistent with the layered approach of the ETSI MAN framework [3]. The Network Service Orchestrator (NSO) provides the highest entry point for network domain administrators (SNO or MNO side); this allows (re)configuring network and infrastructure resources in semi-autonomous manner. The broker represents the business layer that can facilitate and automate the negotiation between operators and trigger the action of domain-specific NSOs. We propose to use a business model of a single broker to deal in satellite resources, acting as the primary interface between MNOs and SNOs. The economics of this process are impossible to quantify exactly, but under the assumption of an efficient market, the extra costs due to the broker should be at least cancelled by the price reductions caused by a more competitive market.

In order to get the best SNO offers, the MNO addresses the broker with specific resource requirements (e.g. type of satellite connectivity (LEO, MEO or GEO), bandwidth, time limits, QoS (quality of service) class, and geographic coverage). After having received the request from the MNO, the broker gets quotes from all the registered SNOs, and runs an internal algorithm to match the MNO's needs with the SNOs' offers. Then, the broker reports the best quote to the MNO or reports that SNO offerings meeting his resource requirements are not available. In the first case, in which resources are available, the MNO can decide to either accept, hence sends back to the broker a confirmation to reserve the resource, or refuse the offer. In the second case, it is possible that it decides to request different

resource requirements or finish the negotiation process. The messages exchanged between the MNO, the broker and the SNO are presented in the sequential diagram in Figure 1:

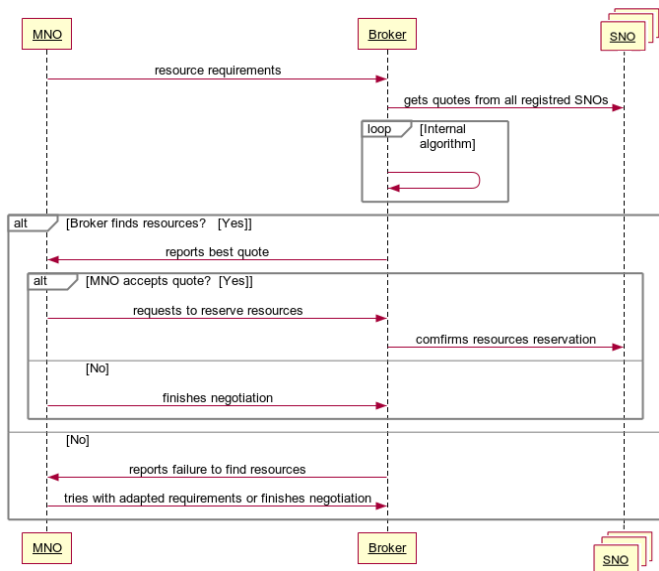


Figure 1 Satellite capacity request via the broker

III. IMPACT ASSESSMENT OF BROKER INVOLVEMENT

As mentioned above, the goal of the broker is to add clarity and efficiency to the negotiation process, but of course also adds an additional stakeholder. This section will explore its benefits and challenges.

A. Benefits of the brokerage

The main advantage of the broker model is the simplification of the trading relationships – typically, both terrestrial and satellite operators need to deal only with one external entity to obtain or sell satellite resources. Essentially, this means that the purchasing of satellite resources is outsourced. To ensure a win-win process, it is necessary that the brokerage service is overseen by an efficient regulatory body, much as stock markets are overseen by governmental financial regulators.

Using one trusted party for managing the interactions also leads to more security and certainty, because the risk of dynamic spectrum allocation is moved to the broker, which means that the involved operators can more easily build their business cases for dynamic capacity offerings. By implementing strong cryptographic codes and advanced network security, the broker can set in place an inherently resilient and secure platform for transactions.

B. Brokerage challenges

To enable the role of the broker in a heterogeneous network composed of satellite and mobile resources, one first challenge consists in the specification of the interfaces between the different domains (i.e. terrestrial, satellite and broker), which need to provide features for optimized resources allocation. Among interfaces management and high-level features, there are technical constraints that have to be tackled in the satellite system that may limit the choices at certain locations such as:

- Need to repoint between GEO HTS to change SNO (e.g. motorised reflectors, flat panel arrays and fully electronic antennas can address this);
- Different SNOs use different vendor equipment (e.g. a standardised based approach using mostly VNFs can address this).

Moreover, the broker introduces techno-economic challenges. In this regard, the market place (bidding models, pricing schemes, etc.) that is implemented by the broker is a crucial aspect to be addressed for delivering a dynamic, flexible tool. When using a model that fits many operators there is a risk that a single transaction is not optimal for the trading parties involved, especially when compared to a process that optimises each individual transaction. Thus, we should compare the benefits of faster configuration and transaction through the broker with individual processes that are more standardized but less flexible.

IV. CONCLUSIONS AND FUTURE WORK

The business model for 5G networks is quite complex due the involvement of many stakeholders and to the use of heterogenous networks and the network virtualization. Satellite communication is seen as a key enabler towards achieving the 5G challenging goals, and integrating the SNO actor in the picture adds more complexity to the business-modelling task. Inspired by the MANO architecture, the broker role was introduced in this paper as a solution for the multi-stakeholder management and interaction in the integrated satellite-terrestrial network of the future. The paper described the interactions between the MNO, broker and SNO and ended with a qualitative assessment of the benefits and challenges of using brokerage.

Future work in this domain includes detailing the broker’s internal resource allocation algorithm, as well as how the negotiation process is affected by fixed versus dynamic capacity requests. Finally, the impact of the broker on the business case of both terrestrial and satellite operators can be evaluated quantitatively, by performing a techno-economic comparison of the interactions with and without brokerage.

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