IP Satellite Services and Applications Evolution towards the Future Internet

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Abstract. Satellite networks are evolving and changing its elements to converge with the NGN concept. The use of IP in satellite networks facilitates convergence, but also opens the door to integrate from the beginning the satellite IP services which would be part of the Future Internet. It is therefore necessary to analyze the applications and services that are typically susceptible of being used in a satellite network, so that its evolution goes online with the Future Internet. Actors and triggers of the evolution are analyzed as well as the critical points in the provision of services are identified.

Keywords: IP, Satellite, Services, Applications, Future Internet, NGN.

1 Introduction

For some time satellite systems have been evolved such systems capable of delivering interactive IP services. These satellite networks have changed its elements to converge with the NGN[1] (Next Generation Network) when necessary.

This shift to IP data networks facilitate the convergence with other networks, but so far has been carried out by adapting the system elements that typically have been used for broadcasting and not for interactive networks. Now it is open a door where from the beginning it is possible to integrate IP services via satellite, taking an active part in what would be the Future Internet.

It is therefore necessary to identify the applications and services that are likely to be used in a satellite network to promote its use and those who are most alien to it, to facilitate its convergence. This would evolve interactive satellite networks in line with the design of the Future Internet.

This paper analyzes some actors and triggers that would foster the development of the Future Internet and would identify the critical points in the taking off of services and applications over satellite networks. There are not only considered the Network aspects as the required connection bandwidth required or the necessary traffic engineering are considered, alongside higher-level factors that impose requirements to the lower levels.

1.1 NGN vs Future Internet

Integration in NGN does not necessarily imply a convergence with the Future Internet[2]. Therefore, firstly it is necessary to define the main differences

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between the two concepts in order to analyze the new requirements that satellite networks are aimed to meet. While Future Internet initiatives are more long-term oriented, NGN ones are solutions that may already be realistically incorporated in current networks.

The Future Internet initiatives[3], focused on the long term, should consider new requirements and principles to improve the experience of the new applications. At the same time, short-term initiatives as NGN are designed to improve the architecture of the Internet in such way that the requirements and principles of the Future Internet would still be met.

The efforts of the NGN initiative have focused so far on the network aspects needed to provide triple play services (i.e. telephone, high-speed Internet access and television services). However, recent studies on NGN do not include requirements related to the content-centric networks. It is expected that future studies on NGN may address some of these requirements, and their outputs will become a key point in the Future Internet development. Even so, at this point of the progress it is possible to outline the expected services and applications evolution needs towards the Future Internet.

1.2 High Level Requirements for Satellite Networks

High-level requirements include scalability features or the ease of access to the network as well as security, connectivity and mobility services. Alongside these high high level services new applications are expected to be provided by the Future Internet networks as well. These future expected applications would be the ones that would make a more social and collaborative network where users are both generating and consuming content; new content such as 3D, augmented reality, artificial intelligence or virtual reality. To support these new applications it is necessary to define from the start the new requirements that new networks would need.

Satellite networks are likely a key element in the new networks compliant with the future internet principles [4]. Their ubiquity makes satellite communications networks capable of providing the essential mobility or backhauling when terrestrial networks can not afford them. The Internet of the future must be therefore built from the "broadband for all" concept and regarding to satellite networks it is summarized in two concepts:

- Firstly, the ability satellite networks have to provide broadband services to everyone and everywhere. Satellite networks are an alternative for rural internet and the final solution to provide broadband Internet access to most unapproachable areas or in disaster relief operations.
- Secondly a network designed for competition is one of the most important elements of the Future Internet that shall be designed. That is, networks supporting flexible business models where multiple parties can participate in an open framework that supports participation and encourages innovation.

The interactive communications satellite networks are actually a solution for the "everyone and everywhere" Future Internet promulgated concept, but it is

necessary to evolve some technical aspects and the business model towards the concept of open competition between networks. For this end, it is not only necessary to provide the same applications and services that the terrestrial networks offer but also the generation of new features that only satellite networks would be able to grant, which all together would give the satellite business its own niche market. Potential services are: smart remote healthcare systems, smart systems for transport and mobility, environmental information systems and security systems.

This paper analyzes the technical enablers for emerging Future Internet capabilities such as:

- Increased service performance[5], by increasing data rates which depend mostly on physical layer aspects (RF power, G/T, waveform efficiency).
- Market segmentation: LEO satellites for handheld services and GEO for high broadband access.
- Polymorphism features to supply several services transparently to the user.
- Interoperability and integration with terrestrial networks and NGN services, that is to enforce terminal profiles and usage conditions
- Network virtualization to supply a common service access point with terrestrial networks.
- Information and content-centric Networking to provide contents from everywhere to everywhere and everyone.
- Innovative service coverage configurations with flexibility in the allocated power per beam, and in the beam bandwidth. Different and manageable connectivity scenarios with flexible channels routing. Support of direct connectivity between terminals and multicast mesh capabilities. Cellular network concept, with new frequency bands covering multiple spots in a coordinated way or covering selected areas that other networks cannot reach.
- Terminal handovers capabilities under different satellite or different networks.
- Full integration with small and handheld devices and VSAT antennas.

2 Future Internet Enablers for Satellite Networks

This section analyzes different R&D topics that are currently being studied within the Future Internet initiatives framework, in particular those related to the topics of the satellite networks world. Topics are analyzed from the perspective of the needed aspects to reach a new generation satellite network that meets the application or service requirements, trying to identify the enablers that would potentially achieve it.

2.1 Increased Service Performance

One of the key aspects in the Future Internet take-off is the next generation mobile radio technologies. An increased service performance is related to the

increase of the data rate. This depends mostly on physical layer aspects (RF power, G/T and waveform efficiency).

On one hand, new technologies should be designed to be cost-competitive, spectrum and energy efficient. But on the other hand technologies must be adapted for their use in mobile systems. This results in two points: the satellite is expected to be able to play an important role within the future internet; and the satellite must meet certain requirements.

Satellite communications are a natural way to provide mobility services to devices. However, problems mostly related to the antennas integration imply, prevent satellites from a full integration with mobile devices. However the Future Internet initiative is also a source of new ideas and opportunities to detect new action items. Thus, to solve those restrictions, some technologies must be improved:

- Adaptive modulation and coding schemes
- Multiple antenna and user detection systems
- Cross layer design
- Low latency transmission regimes

It is also expected within a Future Internet Framework that complementary technologies cooperate at nodes and terminal levels. That means an improvement in all nodes technologies (i.e. satellite payloads, terminals and hubs), network topologies (i.e. new system models with flexible architectures), and efficiency (i.e. is dynamic power and capacity estimations).

2.2 Market Segmentation

The Future Internet is the Internet for people. This means that each user must be part of it and feel their needs are met. So, the Internet of the future must be able to deliver in every location what the user wants and it must meet the user needs in terms of application, services, Service Level Agreement (SLA) and cost. A free open market based on segmented network services will foster undoubtedly the Internet ecosystem. There are two levels of market segmentation, internal and external.

For external market segmentation, satellite technologies must offer the same services than the ones offered by terrestrial networks. SATNET must be converted into both access networks and transport networks. Satellite technologies must converge and offer the same services as the rest of the networks (adopting the NGN structure) and must become transparent by user's choice. There is no doubt that the technology election will be based primarily on offering something unique. Thus, it is necessary a transformation into platforms (for the new generation applications and services) that only SATNET are able to offer. For example, satellites have a potential benefit in mobile communications, in long distance communication and in providing services in certain areas where other technologies would have difficulties (because of cost or complexity). These features are then the ones to be exploited for the competition with other networks.

On a second level, internal market segmentation would allow a potential growth of the satellite market. This is to generate a service differentiation allowing users to choose the most appropriate service to their needs. For example satellite orbit could differentiate some services (LEO satellites for handheld services and GEO for high broadband access) or different technologies could differentiate applications (interactive satellite network for internet access and transparent communications for content streaming). Network topologies can also differentiate the satellite network use. For example in GEO satellites, mesh topologies are the only ones able to provide real-time services such as VoIP or videoconference.

2.3 Poliymorphism

Market segmentation does not necessarily mean offering a unique service. It means providing the most appropriate service according to a need. However, the network of the Future Internet should be able to offer all kind of services, by transforming its physical or logical architecture to meet the service and application requirements.

Network virtualization helps to provide common services in a transparent way with respect to the physical network used. This gives the satellite networks of an external polymorphism feature that allows them to offer both their native services and interactive communications.

On the other side it is also necessary to encourage internal polymorphism, i.e. the topological transformation of the communications features as required. For example, the same satellite system can provide mesh or star topologies depending on the user requirements. Satellite networks can change their topology to implement hybrid satellites, hubs, terminals and gateways.

A hybrid satellite is one having transponders that can curse traffic in both transparent and regenerative modes. A hybrid hub would control and manage the two types of payloads and assign the capacity from the users to one or the other depending on the transmission needs. For example, if mesh connectivity is needed, the hub would assign capacity on the regenerative channels, while other traffic would use transparent capacity resources. A hybrid GW would be able to assist in establishing mesh connections directed to terminals acting as an entrance to other networks, but also to derive the transparent traffic received to other networks.

2.4 Interoperability and Integration

The integration with terrestrial networks and NGN services is totally necessary for success. The provision of any service must be possible in any network, therefore also in satellite networks. Applications must run transparently over the access network. In other words, an application must not be adapted to the network features, but instead the network is the one that must to meet the application and user profiles. A common SLA framework for terrestrial and satellite

networks has to be developed. This would allow for a best-service selection and would foster networks and services interoperability and integration, offering the user the most suitable service.

A Service Level Agreement Framework consists in a common set of rules, agreements and templates concerning on Service Level Agreement (SLA) that all network elements of all networks share and understand. Within this framework, two interconnected networks are aware of the equivalence and reciprocity of all SLAs applied from the original network to other networks. Therefore, it is easier for them to serve as both access or transport networks, as well as it facilitates the handover and backhauling procedures between networks better meeting and matching the required SLAs. To achieve these requirements, there must be an exchange of control and management signaling concerning to SLAs. Signalling is requiered to include information for requesting an SLA, to spread the possible SLAs within a network or to other networks and to indicate the status of compliance of these.

2.5 Network Virtualization

In order that the competition between networks becomes real and that the selection of one or another network does not become an impediment, satellite networks should be abstracted as a service layer with a common structure with other networks. This concept is referred to a network virtualization.

Satellites typically have a unique network architecture because of its transmission features. However, it is due time to convert their components to a new network generation structure, by converting the components of the old broadcast communications to interactive elements that meet the NGN specifications.

The service access points should be common to other networks and should be an SLA negotiation mechanism which enables satellite networks to: compete with other networks, perform handovers with them both to cover the segments terrestrial networks cannot reach or where better SLA is expected.

Stratification and virtualization of the network structure, would convert its elements (terminal, satellite, hub and Gateways) on simple nodes that can interconnect with other networks. The future of these elements would be to operate in a native IP form.

2.6 Information and Content Centric Networking

The inherent ubiquity of satellite systems allows us to clearly reduce the gap in the access to information. On one hand, it allows to send information and contents that otherwise would be very difficult to access. This becomes a reality in sensor networks such as Supervisory Control And Data Acquisition (SCADA) located in remote sites.

On the other hand, the satellite can provide access to information and content in places where other systems fail or whose deployment cost-effective. Thus the application layers in the satellite systems should also be transformed to an NGN structure fully integrated with other networks.

2.7 Connectivity Opportunities

Future Internet must allow, to connect applications where no connections were possible before and should allow innovative ways to connect users. Satellite is, in fact an innovative method to connect users in areas where otherwise would not be possible, or would at least be very difficult. Within this feature inherent to the technology, the satellite networks must be redesigned to allow connections and topologies demanded transparently from the users and applications. If so, they would provide the same services as terrestrial networks, but with the added value of features such as mobility or ubiquity.

New opportunities in configurations, topologies and connectivities include innovative service coverage configurations with flexibility in the allocated power per beam, flexibility in the beam bandwidth, different and manageable connectivity scenarios with flexible channel routing, support for direct connectivity between terminals and multicast mesh capabilities.

Satellite network innovative concepts may also allow new market opportunities. This is the case of the new designed Ka band cellular network concept. With new frequency bands covering multiple spots in a coordinated way or covering selected areas, a frequency reuse is possible and a total coverage in areas where other networks cannot reach.

2.8 Handover

Handover is the essence of the networks integration. Whether it implies a change in the access network or a certain handling of a transport network, it should be performed seamlessly, i.e. in such way the user does not feel it. Therefore a global mechanism that governs the SLA exchange process is necessary. Handover is a key question in satellite networks as multiple handovers due to different technologies (beam handover, device handover, other networks handover) could exist.

Handover affects mainly to the ground segments. The hub gateway or control part of the network has to connect some signaling functions with other networks to allow transparently handovers. It is necessary to implement the control functions which make the SLA of the service remain stable or at least, changes in the SLA should only be allowed under request. Finally, it is also necessary that the user terminals can provide a transparent service. In this sense, transparency enables satellite networks to become a real network capable of providing the same services with the same SLA as terrestrial networks do, but with improved features when necessary.

2.9 Devices Integration

Future Internet is the internet of things. Internet is expected to be shared by million of sensors and devices. Full integration with small sensors, handheld devices and VSAT antennas is necessary. This conflict with the actual concept

of satellite networks, where there is a fixed user terminal with a large antenna. While the current terminals should be kept, it is also necessary to develop new technologies that foster the use of satellite in handheld devices and tiny sensors. For this purpose there are two fronts of action.

On one hand, it is necessary to reduce the size of antennas used by the devices. Smaller devices cannot accommodate large antennas and cannot implement the required processing in interactive terminals. It is therefore also necessary to develop new chipsets with smaller modulators and processors.

This applies to both sensors and handheld devices, but in the case of the latter it is important to give them the mobility features. In this case the devices antennas need to be very directive whilst properly handling and controlling the possible replicas. It also implies that satellites potentially used for mobile communications must be situated closer to the earth and transmit enough power so that the devices can easily capture the signal (eg, LEO satellites).

On the other hand, it is possible to continue using general-purpose satellite technology, but in this case feeders that distribute the signal to small devices would be necessary .

All in all, the use of satellite in small devices, requires a revolution in technology, such revolution affects chipset improvements, physical devices, modulators and devices, as well as new techniques that allow greater power concentration in certain areas, such as those based on cellular beams.

3 Conclusion

The potential of IP satellite communications systems is very high, and it is necessary to carry out some technological developments to get all the benefits from Future Internet. This paper summarizes the role of IP satellite communications systems' solutions in terms of applications and services to be offered within the Future Internet concept, as well as the technical enablers that would be necessary to evolve satellite communications towards the new model.

Some adaptations to the Future Internet are easy to achieve, but others require an special effort. In particular, it is necessary to improve the effort in R&D and certain satellite technology elements that would enable the gradual converging towards NGN-compatible models, therefore meeting the requirements of the Future Internet.

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