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Poster Paper

Techno-Economic Gains Analysis of Services over an Information-Centric Integrated Satellite-Terrestrial Network

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Abstract: We present a techno-economic analysis of services deployed over integrated satellite-terrestrial networks which employ an Information-Centric Networking (ICN) architecture. Our methodology provides a systematic procedure to assess the gains of various service integration scenarios, initially identifying the technical capabilities for which ICN can provide advantages and considering the requirements of each scenario, and then combining the pure technical gains with economic and market impact factors. This allows us to prioritize scenarios based on their techno-economic impact for adopting an ICN architecture to integrate satellite and terrestrial networks.

Keywords: Information-Centric Networking, Content-Centric Networking, Internet Architecture, Satellite, Terrestrial, Techno-economic Analysis.

1. Introduction

The Internet was designed assuming a host-centric communication model based on identifying and establishing connections between host end-points. Current Internet usage however is focused on content dissemination and retrieval, irrespective of the content's location and transparent to the network access technology. This shift in Internet usage has led to the introduction of various work-arounds or patches, such as CDNs, proxies, Deep Packet Inspection (DPI), which mediate communication between content providers and consumers to improve content delivery. Many research initiatives have started to investigate Information-Centric Networking (ICN) as the fundamental paradigm for the Future Internet. ICN decouples the data (service) from the actual devices storing (providing) it through location-independent naming. This decoupling helps tackle problems such as host mobility, since now we identify information/content (which remains the same irrespective of its location) rather than communication end-points (which may change or move). Identification of content at the network layer facilitates data caching in network elements (in-network caching) and more efficient content delivery exploiting multi-source and multi-path transfer, without resorting to add-on, often proprietary and costly overlay solutions.

At the same time, satellite technologies have for a long time been used for wide-area content broadcasting. Satellite's wide-area coverage and broadcasting capabilities can be significant for the Future Internet, hence their integration with terrestrial networks in a way that exploits the advantages of each technology is important.

The migration from the current Internet architecture to a future network architecture is critical for the latter's success. The migration should initially focus on services and scenarios where a Future Internet architecture exhibits the largest gains, considering both technical and economic factors. The goal of this paper is to analyze the techno-economic gains of integrating terrestrial and satellite networks using an ICN architecture. Our methodology initially involves identifying the functional capabilities and their corresponding technical gains from the adoption of ICN for integrating satellite and terrestrial networks. Then, we identify the relative importance of the functional capabilities for various service integration scenarios. The final step combines the technical gains with the economic and market dimension, by considering the deployment costs and the market segment or the market segment increase for the various integration scenarios.

The remainder of this paper is structured as follows. In Section II we report on related work. In Section III we briefly describe the service integration scenarios that we consider, in Section IV we perform the techno-economic analysis of these scenarios and in Section V we conclude the paper.

2. Related Work

The authors in [8] and [5] present a socio-economic analysis of the Publish-Subscribe Internet architecture [6], proposed by the PSIRP project [7]. The analysis investigates several architectural design strategies within a set of socio-economic scenarios, focusing on two main inter-domain functions of ICN architectures: rendezvous (or resolution) and inter-domain topology formation. Key questions investigated include the number of interconnection providers and the number of rendezvous providers that will exist when the market reaches equilibrium and the incentives for providers to interconnect. The results of these papers suggests that ICN architectures should first target the government sector, initially with the adoption of overlay mechanisms in the current Internet, followed by the adoption of native mechanisms that modify the backbone's network layer. The current paper differs from [8] and [5] in that it proposes a systematic techno-economic analysis methodology that can rank service integration scenarios according to the technical gains that are achieved when using an ICN architecture for integrating satellite and terrestrial networks. The proposed methodology identifies the specific technical capabilities that ICN can provide benefits. Moreover, our methodology also considers the economic dimension through the deployment costs and the market segment size of the considered services; such market factors are typically taken into account when a company considers entering/investing in a market or expanding the services it offers. In contrast, the work of [8] and [5] does not investigate different services.

The work of [11] develops an engineering-economic model to investigate the incentives for various network players to deploy nodes with storage capabilities to support ICN architectures, and the implications of these incentives on protocol design, industry structure and other policy issues, such as competition and network-neutrality. In contrast, the current paper does not focus exclusively on one capability of ICN, caching, but considers all capabilities for which ICN can provide gains. Additionally, we consider different services deployed over an ICN architecture for integrating satellite and terrestrial networks.

3. Application Scenarios for Satellite Terrestrial Integration using ICN

In this section we briefly describe the service scenarios that have been identified for satellite and terrestrial integration, [9] and [10]. The requirements and each service scenario and the gains from adopting ICN are discussed in Sections 3.2 and 3.3.

1) ***Hybrid broadcast IPTV***: This scenario considers a satcom system, e.g. based on a GEO satellite with a star topology, deployed together with a terrestrial network and offering IPTV broadcast services. User devices or access provider gateway nodes are multihomed and can receive the IPTV stream either over the satellite or over the terrestrial network.

2) ***Professional and VPN networks in remote areas***: This scenario considers professional or institutional (non–military) services in areas where there is no terrestrial

infrastructure. Typical environments are offshore platforms, facilities in remote areas or locations with continuous scientific exploration activities.

3) ***Mission-critical communication services***: This involves mission critical services for emergency, public safety or military communications. Such services are necessary in remote or dangerous areas where terrestrial infrastructure cannot be deployed or is too costly, and in scenarios where the terrestrial infrastructure is damaged or overloaded.

4) ***Smart M2M transport***: This scenario involves the exchange of data between vehicles and centralized platforms, or between the vehicles themselves. The data can include location information, vehicle and environmental sensor data, and road information.

5) ***Smart M2M surveillance***: This involves monitoring the behaviour, activities, or other status information, for both people and objects. Such data is typically transmitted to a control centre, which processes the data and issues alarms or control commands.

6) ***Smart M2M energy grid***: This scenario includes Automatic Meter Reading (AMR), fault detection/preventive maintenance, power loss identification, demand management, consumption monitoring, condition & quality monitoring, and infrastructure security.

7) ***Hybrid terrestrial/satellite on the move***: This scenario involves vehicles (trains, ships, aircrafts) that move over areas that are only partly covered by terrestrial networks, or that exceed the maximum speed that terrestrial technologies can support. Services include Internet access, tele-surveillance, performance reporting, voice or video services, etc.

8) ***Satellite fixed broadband access***: This scenario considers fixed broadband satellite access in rural areas and regions lacking any terrestrial infrastructure. Applications include P2P file sharing, web browsing, multicasting, and dissemination of user generated content.

9) ***Extended cellular/4G backhauling***: Integrating satellite with a terrestrial cellular 3/4G infrastructure allows providers to extend their services towards isolated areas, where no terrestrial infrastructure exists, has been destroyed, or its deployment is costly.

4. Techno-Economic Analysis

This section contains the techno-economic analysis of the above scenarios, when ICN is adopted for integrating satellite and terrestrial networks. The input to the analysis is, in addition to the list of integration scenarios, the functional capabilities that can benefit from ICN adoption, the importance of these capabilities for each integration scenario, and economic/market data such as deployment costs, market segment size and market forecast. The outcome of the techno-economic analysis is the relative importance of the service integration scenarios for ICN adoption, which considers both the technical gains of ICN, its cost of deployment, and the market impact of each corresponding service.

4.1 – Methodology

Figure 1 depicts the key steps of the proposed techno-economic analysis methodology. The first step involves identifying the functional capabilities for which ICN can provide gains, and which correspond to technical requirements of the integration scenarios. In this study we consider the following functional capabilities: caching, broadcasting/multicasting, mobility support, capacity, and content-based traffic engineering and resilience.

The second step involves quantifying for each functional capability the technical gains that are achieved when an ICN architecture is adopted for integrating satellite and terrestrial networks, compared to the case of a legacy IP-based architecture. The third step involves quantifying the relative important of the functional capabilities for each service integration scenario; this relative importance depends on the technical requirements of each scenario. The second and third step consider solely the technical gains obtained with the adoption of an ICN architecture and the technical requirements of each service integration scenario.

The fourth step considers economic and market aspects. Economic aspects include the cost of deploying an ICN architecture. The market aspects can include the market share of each service and its projected market increase. The techno-economic gains weighted by market impact allow us to rank the integration scenarios: scenarios with the highest techno-economic impact are those that should be considered first to adopt an ICN architecture.

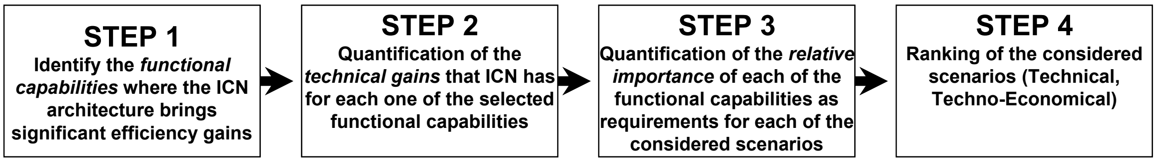

Figure 1: Techno-economic analysis methodology

4.2 – Functional capabilities for which ICN provides gains

The second step of our analysis involves quantifying for each functional capability the relative gains that can be achieved with the adoption of an ICN architecture. Table 1 shows the relative gains for each functional capability, using the characterization "Very High", "High", and "Medium". Next we justify the relative gains for each functional capability.

Table 1: Relative technical gains from ICN adoption

Caching	Broadcasting/ Multicasting	Mobility	Capacity	Content-based traffic engineering/ resilience
High	Very High	High	Medium	High

Caching: Caching in IP networks is based on location-dependent URLs. By exposing location-independent content names at the network layer, ICN's in-network caching can be more effective, since it is based on the actual content, independent of its location, which in turn can lead to more efficient content delivery. On the other hand, content-based caching in IP requires Deep Packet Inspection (DPI), which is costly, since headers above the network layer need to be processed, and ineffective when the packet payload is encrypted. Another widespread alternative for content dissemination are Content Delivery Networks (CDNs). CDNs provide an overlay solution which is network-agnostic. Hence, CDNs do not consider the location of data or the network load, which often leads to longer transfer delays and inefficient use of network resources, e.g. when data is transferred from a remote location rather than from a local server in the domain of the user requesting the data [1].

Multicasting/broadcasting: ICN natively supports multicasting, through the receiver-driven nature of content requests and location-independent content names. Moreover, in the PSI architecture [6], multicast trees are encoded using Bloom filters, which do not require state in intermediate forwarding nodes and use a simple AND operation to decide if a packet should be forwarded to a particular outgoing interface. On the other hand, IP multicast never managed to make its way in the Internet for various reasons, including difficulties in group management, effective scheme for address allocation, lack of security and lack of support for network management [2]. Application Layer Multicast (ALM) has been proposed as a solution, but introduces some performance penalties [3]. For example, Scribe [4], a popular ALM solution, creates delivery trees that can be larger than IP Multicast trees by 1.7 times on the average and 4.2 times in the worst case.

Mobility: ICN architectures promote a receiver-driven information request model, where nodes receive only information they have requested or subscribed to. This is in contrast to the current Internet's model where the sender has full control of the data he can send. Additionally, ICN's request model and content transfer from sources to receivers is connectionless, in contrast to TCP's connection-oriented (statefull) end-to-end control that involves location-dependent addresses. Both the above features allow mobiles that have changed their position (attachment point) to simply re-issue requests for information they didn't receive while they were connected to their previous attachment point or while they were disconnected. Hence, delay/disruption tolerant operation in addition to mobility is supported without requiring cumbersome solutions such as mobile IP.

***Capacity*:** ICN architectures support both multipath and multisource data transfer. Multipath and multisource allow the same receiver to obtain parts of the same file through different paths, either from the same source (multipath) or from different sources (multisource). Such bandwidth aggregation can considerably increase the transfer throughput compared to single path transmission. Moreover, the above capabilities can support multi-homing, without requiring additional complexities such as assigning different IP addresses to different network interfaces, as in the case of legacy IP networks.

Content-based traffic engineering and resilience: By exposing content names in the network, the latter can apply content-based traffic engineering. This includes content-based path selection, content-based QoS support and prioritization, and content-based policies. All these mechanisms involve modifying how data is handled and transferred across the network based on the type of content, taking into account both the requirements of the corresponding application and user or provider policies related to the type of content. Moreover, content-based traffic engineering together with multipath transfer improves resilience, since a problem at a node or link that affects a single path would not stop data transfer altogether, since alternative paths can be readily used.

4.3 – Integration scenario requirements

Step 4 of our methodology involves quantifying the relative important of the functional capabilities for each integration scenario, which is shown in Table 2.

The requirements with the highest importance for the hybrid broadcast IPTV are broadcasting/multicasting and capacity. This is due to the bandwidth requirements for video streaming, especially in the case of advanced forms of video like HDTV, 3DTV, and ultra HDTV, and for large audiences interested in receiving live streams. Certainly content-based QoS and service differentiation is also important to deliver the necessary video performance, while caching is important for enabling playback functionality and for efficient delivery of on-demand video streams. Finally, since end-stations are considered stationary, mobility support is not required for this scenario.

For professional and VPN networks in remote areas, capacity and content-based traffic engineering/resilience have the highest importance, since this scenario can involve transferring massive amounts of data, hence requires high capacity, in addition to QoS support for time critical data. Caching, broadcasting/multicasting, and mobility follow in importance. Caching can be helpful for accessing non real-time data from multiple locations, while broadcasting/multicasting can help disseminate data to multiple remote locations. Mobility support is somewhat less important since users are typically nomadic, and do not need continuous connectivity which would require smooth handovers.

Mission-critical communication services share similarities with the professional and VPN networks in remote areas scenario, which is why some requirements show similar importance. In this case, capacity and content-based traffic engineering/resilience have the highest importance due to the amount of transferred data and time criticality, respectively. Broadcasting/multicasting, mobility, and caching come next in importance. Broadcasting/multicasting is needed for communicating the same information to groups of users. Mobility is needed to support mobile users requiring mission-critical communications. Caching is less important, and can reduce the need for multiple redundant transmissions of the same content.

For smart M2M transport, caching, broadcasting/multicasting, and mobility have the highest importance: caching can be used to avoid multiple transmissions of the same information, broadcasting/multicasting is necessary for efficiently disseminating information to large groups of nodes (e.g. fleets), and mobility support is crucial since this scenario mainly involves moving vehicles. Capacity comes next in importance, since this scenario can involve transferring bulky content (e.g. maps, vehicle status information). Content-based traffic engineering/resilience is less important, and necessary in cases of emergencies and for disseminating to vehicles safety related information.

Table 2: Integration scenario requirements

	Caching	**Broadcasting/ Multicasting**	**Mobility Support**	**Capacity**	**Content-based TE & resilience**
Hybrid broadcast IPTV	Medium-High	High	None	High	Medium-High
Professional and VPN networks in remote areas	Medium-High	Medium-High	Medium-Low	High	High
Mission-critical communications	Medium	Medium-High	Medium-High	High	High
Smart M2M transport	High	High	High	Medium-High	Low
Smart M2M surveillance	Medium	High	None	Medium-High	High
Smart M2M energy grid	Medium-High	High	None	Low	High
Hybrid terrestrial/satellite on the move	Medium-High	Medium	High	Medium	Medium
Satellite fixed broadband access	Medium-High	High	None	High	Medium-High
Extended cellular/4G backhauling	Medium-High	Medium	High	Medium-High	Medium-High

Content-based traffic engineering/resilience is however of high importance for smart M2M surveillance, where applications require real-time and highly reliable reporting of alarms and asset status updates. Broadcasting/multicasting is also of high importance when the number of devices located in the area under surveillance is huge (e.g. thousands of sensors monitoring a forest or a large factory). Capacity comes next in importance. Caching, on the other hand, has lower importance, since content mostly travels from sensors towards a control center. Finally, mobility support is not required in this scenario.

The most important requirements for the smart M2M energy grid scenario are again broadcasting/multicasting, due to the potentially large number of monitoring sensors, and content-based traffic engineering/resilience, due to the criticality of the energy grid infrastructure. Caching comes next as it can assist in saving scarce network resources when grid sensors are organized in ad-hoc deployments. Capacity is of relatively low importance compared to the other requirements, since the amount of data transferred in this scenario is expected to be low. Finally, mobility support is not required.

For hybrid terrestrial/satellite on the move, mobility support has the highest importance, since this scenario involves mobile users (often moving at high speeds). Caching comes next in importance since the ability to pre-fetch and cache content can improve the performance of some applications/services offered to highly mobile users. Capacity, broadcasting/multicasting, and content-based traffic engineering/resilience come next in importance since content must be delivered quickly to potentially large audiences (e.g. broadcast infotainment content to users travelling on a train or ship), and different types of content may need to be routed via different access network (QoS-based routing).

The two requirements having the highest importance for satellite fixed broadband access are broadcasting/multicasting and capacity, since applications such as P2P file sharing, web browsing, and content multicasting require high network capacity and efficient multicasting/broadcasting. Next in importance is caching, which can avoid multiple transmissions of the same content, and content-based traffic engineering, in order to support applications/services with different performance requirements. Finally, mobility support is required in this scenario.

For extended cellular/4G backhauling, mobility support has the highest importance, due to telephony being one of the services offered over cellular networks. Caching, capacity and content-based traffic engineering/resilience come next in importance, due to the need for supporting high transfer capacity for Internet access in 4G networks, and timely delivery of content and time-critical services (e.g. for the case of backhauling telephony). Broadcasting/multicasting is of some importance, e.g. for mobile video distribution.

4.4 – Overall technical gains for each integration scenario

From the data in Table 1 and Table 2 we can estimate the technical gains for each integration scenario, when an ICN architecture is used to integrate terrestrial and satellite networks. To do this we must first assign a value to the technical gains shown in Table 1. In this study, we consider the following values: Very high=0.25, High=0.20, and Medium=0.15; note that only the relative values of these quantities have significance. We will denote with G_c the gain that using an ICN architecture has for functional capability $c \in C$, where C is the set of functional capabilities.

Next, we assign values to the importance of each functional capability for the scenarios in Table 2. Specifically, to each level of importance we assign the following values: None=0, Low=1, Medium-Low=2, Medium=3, Medium-High=4, High=5; as before, only the relative values of these quantities have significance.

Let I_c^s be the importance of functional capability $c \in C$ for the integration scenario $s \in S$, where C, S is the set of functional capabilities and the set of integration scenarios, respectively. The overall technical gain for integration scenario *s* is given by

$$Technical\ Gain^s = \sum_{c \in C} G_c \times I_c^s \quad . \qquad (1)$$

The technical gain computed using (1) for each service integration scenario is shown in Figure 2. This figure shows that the highest technical gains from the adoption of ICN are achieved for the extended 4G backhauling, smart M2M transport, mission critical communications, and professional and VPN networks in remote areas scenarios. Medium technical gains are achieved with the satellite fixed broadband access, hybrid terrestrial/satellite on the move, smart M2M surveillance, and hybrid broadcast IPTV scenarios. Finally, the lowest gains are achieved with the smart M2M energy grid scenario.

An alternative to a native deployment of an ICN architecture, is to deploy an architecture as an overlay to the current Internet. The advantage of such an alternative is the lower overall cost, which is investigated in the next section. This advantage comes at the cost of not fully achieving all the gains of ICN. In particular, we can assume that in an overlay deployment the gains for the different functional capabilities are achieved in a different percentage. Specifically, in this study we assume that for caching, broadcasting/multicasting, and mobility support an overlay ICN deployment can achieve 80% of the overall gains that are achieved with a native deployment. The reason for this is that the above functionalities do not require ICN functionality in all network nodes. On the other hand, we can assume that for the capacity and content-based traffic engineering/resilience capabilities an overlay deployment can achieve only 20% of the overall gains that can be achieved for these capabilities with a native deployment. This can be justified by the fact that these capabilities involve mechanisms (e.g. multi-path/source transfer and QoS support) in most of the network nodes, which require knowledge of the content name. Based on the above, we can compute the overall technical gains for the various integration scenarios assuming an overlay deployment (Figure 2). Figure 2 shows that, as expected, the technical gains of an overlay deployment are smaller compared to the technical gains of a native deployment. However, the relative gains for different service integration scenarios are now different: The smart M2M transport scenario has the highest technical gains for an overlay ICN deployment; This is due to the fact that an overlay ICN deployment can achieve most of the gains for caching, broadcast/multicast, and mobility support, which are of high importance for the M2M transport scenario (Table 2). The extended 4G backhauling, hybrid terrestrial/satellite on the move, mission-critical communications, and professional & VPN networks in remote areas have a medium technical gain. Finally, the satellite fixed broadband access, smart M2M energy grid, smart M2M surveillance, and hybrid broadcast TV scenarios have the lowest technical gains.

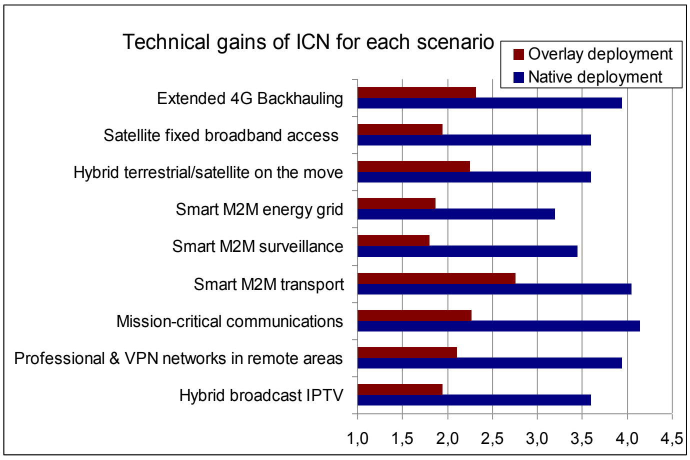

Figure 2: Technical gains of native and overlay ICN deployment, for different service integration scenarios. The values are computed using (1). Note that only the relative values are important.

4.5 – Techno-economic gains

The analysis up to now considered only the technical gains from the adoption of ICN for satellite and terrestrial integration. In addition to the technical gains, the related cost for adopting ICN is important. As an example of estimating the costs of an ICN infrastructure, we examine the case of Content-Centric Networking (CCN) [13], which is one of the most prevailing ICN architectures, considering both a native and an overlay deployment.

According to [14], a CCN backbone router would require an additional cost of 130.000$ compared to a legacy IP router (e.g. the Cisco Series 1 which costs around 135.000$[1]). An edge-router (e.g. the Cisco 7507) costs approximately 14.900$[2] and according to [14] a CCN edge router would require an additional 3.000$. Hence, a CCN deployment requires an additional investment of 100% for each backbone router and 20% for each edge router.

Based on the above, in a native deployment the average extra cost for upgrading all the edge routers and 80% of the backbone routers to become CCN-enabled is

$$\frac{(N_E \times 0.2 \times C_E + 0.8 \times N_B \times 1.0 \times C_B)}{(N_E \times C_E + N_B \times C_B)},$$

where N_E is the number of edge routers, C_E is the cost of an IP edge router, N_B is the number of backbone routers and C_B is the cost of an IP backbone router. If we assume that edge routers are approximately two orders of magnitude more than backbone routers, and as discussed above backbone routers are approximately one order of magnitude less expensive than edge routers, then from the last equation we have:

$$\frac{(100 \times N_B \times 0.2 \times \frac{C_B}{10} + 0.8 \times N_B \times 1.0 \times C_B)}{(100 \times N_B \times \frac{C_B}{10} + N_B \times C_B)} = \frac{(2 \times N_B \times C_B + 0.8 \times N_B \times C_B)}{(10 \times N_B \times C_B + N_B \times C_B)} = \frac{2.8}{11} = 25.4\%.$$

Hence, a native ICN deployment would cost 25.4% more compared to a legacy IP network.

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[1] http://www.isptrader.com/network-hardware/cisco/crs-4s/cisco-crs-1-series-4-slots-carrier-routing-system (Last Accessed: 08/02/2013)

[2] http://www.isptrader.com/network-hardware/cisco/cisco7507-ch/cisco-7507-7-slot-2-cybus (Last Accessed: 08/02/2013)

If instead of a native ICN deployment we choose an overlay deployment where only 20% of the backbone routers and all the edge routers are upgraded, then the additional cost compared to a legacy IP network would be 13.7%:

$$\frac{(2\times N_B \times C_B + 0.2\times N_B \times C_B)}{(10\times N_B \times C_B + N_B \times C_B)} = \frac{2.2}{11} = 13.7\%$$

The techno-economic gains for the various integration scenarios can be obtained by dividing the technical gain of each scenario (Figure 2) with the cost of the native or overlay deployment estimated above. The results are presented in Figure 3, which shows that the techno-economic gains are higher for a native compared to an overlay ICN deployment.

4.6 – Techno-economic gains weighted by market impact

Next we consider the market impact together with the techno-economic gains estimated above. The market impact of each integration scenario can be estimated based on the relative market size in 2012 for the services that correspond to each scenario (middle column in Table 3) or the estimated relative market size increase in the period 2012-2016 (right column in Table 3). The estimations and related data were obtained within the context of the ESA φSAT project [12].

Table 3: Market impact based on relative market size for 2012 and relative market size increase percentage

Scenario	Market size % (2012)	Market size increase % (2012 – 2016)
Hybrid broadcast IPTV	90,5%	66,1%
Professional and VPN networks in remote areas	2,3%	2,9%
Mission-critical communications	1,6%	0,6%
Smart M2M transport	0,7%	4,0%
Smart M2M surveillance	0,3%	3,7%
Smart M2M energy grid	0,2%	1,6%
Hybrid terrestrial/satellite on the move	2,2%	7,2%
Satellite fixed broadband access	1,7%	12,5%
Extended cellular/4G backhauling	0,4%	1,4%

The techno-economic gain weighted by market data is given by

$$Weighted\ Techno\text{-}Economic\ Gain^s = Techno\text{-}Economic\ Gain^s \times M^s \,, \qquad (2)$$

where M^s can be the market size percentage (for 2012) or the market size increase percentage (for the period 2012-2016), which are shown in Table 3, for service integration scenario s. The techno-economic gains, in the case of native ICN deployment, weighted by the market impact are shown in Figure 3.

We make two observations regarding Figure 4: First, due to the very high percentage of overall satellite revenues being TV broadcasting, the hybrid broadcast IPTV integration scenario has the highest weighted techno-economic gain. Second, because of the large increase in the market size for some services, such as backhauling, satellite fixed broadband access, and M2M, the weighted techno-economic gain for the corresponding integration scenarios exhibits a large increase when considering the market size increase percentage. This is unlike the gain of the broadcast IPTV scenario, which despite having the largest value, exhibits a reduction when considering the market size increase in the period 2012-2016 in comparison to the 2012 market size.

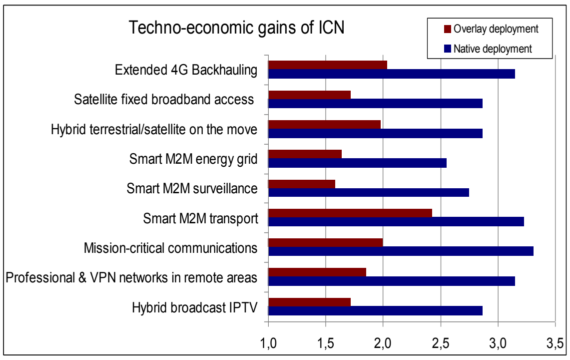

Figure 3: Techno-economic gains of different scenarios for both native and overlay ICN deployment

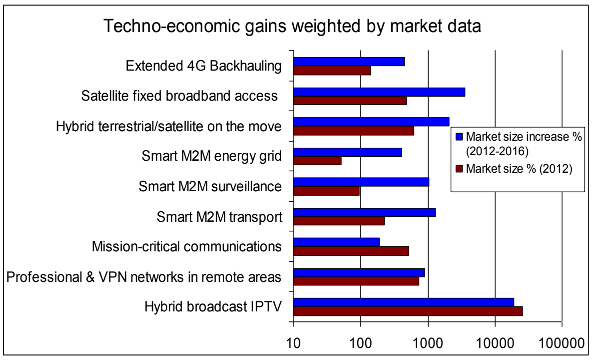

Figure 4: Techno-economic gains weighted by relative market size and relative market size increase[3]

5. Conclusions

We present a systematic procedure to assess the gains of various service integration scenarios, initially identifying the technical capabilities for which ICN can provide advantages and considering the requirements of each scenario, and then combining the pure technical gains with economic and market impact factors. This allows us to prioritize scenarios based on their techno-economic impact for adopting an ICN architecture to integrate satellite and terrestrial networks. Our methodology is generic, and can be used to assess the impact of various satellite and terrestrial integration scenarios, considering technical, economic, and social factors.

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[3] The x-axis in this figure is logarithmic and the values shown were obtained by multiplying the values estimated using (2) with 10^4.