# Techno Economic Assessment of Immersive Video Services in 5G Converged Optical/Wireless Networks

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# Techno Economic Assessment of Immersive Video Services in 5G Converged Optical/Wireless Networks

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**Abstract:** The economic feasibility of a 5G media service in converged optical/wireless networks for crowded events in venues shows a ~6.5years payback period. Sensitivity analysis highlights the impact of tariffs and CAPEX on net present value.
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## 1. Introduction

Latest global mobile data traffic forecast [1] predicts an enormous growth of traffic volume driven mainly by increases in the number of connected devices and popularity of traffic hungry applications such as personalized media mobility in urban environments, augmented reality location based gaming and/or collaborative interactive transmedia narratives. This calls for a fundamental change in network infrastructures to offer features such as extremely high data rates and capacities, on-demand service-oriented resource allocation and automation [2].

A wide range of radio access technologies such as millimeter wave transmission, massive multiple-input multiple-output (MIMO) and others, are under considerations. Nevertheless, demands for higher capacities and more scalability pose a serious challenge for future communication networks. Converged optical/wireless networks have emerged as a strong candidate to fulfill the stringent 5G requirements [3]. The proposed solutions are novel architectures consisting of radio access nodes together with an optical fiber backhauling system, controlled by a suitable network management logic able to support 5G use cases. Network Functions Virtualization (NFV) [4] and Software Defined Networking (SDN) [5] are two important technologies, adopted with the aim of increasing flexibility and achieving cost/energy efficiency. NFV and SDN use embedded IT resources in the network to offer added value services, e.g. innovative media services, improving the end user's Quality of Experience (QoE) and creating new business opportunities for service providers. With a closer look to the added value services, it is possible to infer that they are complex operations composed by one or a set of software applications, i.e. virtual network functions, cooperating together towards a common goal. For example, an end to end innovative media service in a crowded sports event is composed of a series of software modules, including a firewall and video applications. A virtual machine imitates the functionalities of a specialized "hard-wired" device like a firewall. This virtual device helps pre-filtering the incoming video files from end users to the mobile network edge. Non-blocked contents are directed to a video production application designed for sport events. The video processed by the application is then broadcasted locally to end users allowing them a 360 vision of the goal. To guarantee the QoE at any traffic status the whole media service is constantly monitored and optimized by a Self-Optimizing Network (SON/Self-X) functionality [6] against the agreed QoE metrics identified by the Service Level Agreement (SLA).

Despite successful technical demonstrations, clear economic incentives are essential to justify required investments in the technology under consideration. Factors including capital and operating costs (CAPEX / OPEX) as well as revenue generation potentials ultimately determine the viability of a solution to be deployed. The purpose of the present techno-economic analysis is to translate technical capabilities into projected economical figures to determine the viability of service offering over the proposed converged optical wireless solution.

## 2. Study Assumptions and Methodology

5G vertical sectors, especially media, are witnessing the emergence of many innovative added value services. The provision of Immersive Video Service (IVS) in Crowded Events (CE) is an example of attractive cases under development by many important players in the media sector. In a CE, a high number of end users are concentrated in a small geographical area for a relatively short duration, typically ranging from few hours to a week. Well-known examples of CE are sport events or concerts in stadiums, exhibitions hosted by dedicated venues and international events spread over a university campus or even an entire city. IVS enables the possibility of sharing HD video contents, anywhere, at any time and via any device, with the opportunity of (perceived) real-time interaction with the system and among users. In addition to traditional video content delivery systems in which users only play the role of content consumers, the IVS also offers the possibility to create and share video contents in real-time, within a pre-defined group of peers. It is worth to mention that IVS offers video transcoding capability, i.e. input video files can be converted to a desired format/quality if needed. More details about this specific service can be found in [7].

Table 1
Users and Target Data Rates

| Service bundle | Data rate per user | Tariff (€/event) | Applications |
|---|---|---|---|
| Gold | 7 Mbps | 1 | voice, text, images, streaming HD video |
| Silver | 1.7 Mbps | 0.5 | voice, text, images, streaming SD video |
| Bronze | 0.5 Mbps | 0.25 | voice, text, images, compressed video |

In this study, we focus on IVS offering for sporadic CE venues, like stadiums or concert halls. These venues are mainly characterized by their area and number of attendees. In particular, we considered a large stadium (e.g. Wembley) with a typical number of attendees of ninety thousands and an approximate area of 40000 $m^2$.

Users are classified depending on their Service Level Agreement (SLA) and intended applications into different classes that define their target data rates, as presented in Table I [8]. It is worth noting that according to the reference architecture proposed in [9], to meet the multi tenancy requirements even for the basic service bundle, i.e. Bronze, IT resources are used to host radio access related VNFs. It is envisaged that during the first year when launching the service, the percentage of Gold bundle users will be small. This percentage figure will gradually increase as 5G technology matures allowing higher data rates and a better QoE as will be discussed later on.

To determine the number of radio network resources needed for a particular venue, three main factors are considered for planning purposes: 1) the maximum aggregated data rate 2) the coverage area 3) limitation on the number of end users subscribed to a single radio access node. The current 4G LTE-A standard allows a maximum downlink data rate of 403 Mbps and currently available SC units allow a maximum of 64 simultaneous subscribed user per single radio access node. However, as 5G technology matures aggregated downlink data rates of more than 1 Gbps SC hardware allowing 128 concurrent subscribers or more are expected. We are also assuming a typical coverage area of 800 m2 per radio access head. The IT resource planning strategy relies on calculating the minimum number of resources to support a non-blocking service. In other words, the network resource planning follows a worst case strategy [10][11] to guarantee that all service requests in a CE are admitted by the system. It implies that any service denial is due to IT resource unavailability not the radio networking resources. Our in house techno economic analysis tool is based on the ECOSYS TE tool and is designed in a way that takes all the above mentioned points into account.

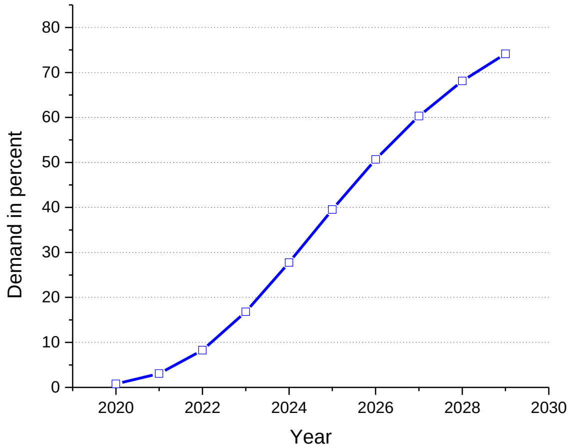
The selected study period is set to 10 years beginning in 2020 (the expected year of 5G introduction) and ending in 2029 being a reasonable time for the described technology to reach its market maturity. To specify the services that will be provided, their market penetration over the study period and their tariffs should be initially defined. The TE tool can then calculate the annual revenues for the selected service set using the combination of tariff and market penetration. The next step is to perform a network planning of the proposed architecture scenario in order to evaluate, each year, the necessary number of network components along with their distribution over different flexibility points of the network. The costs of the network components are calculated using an integrated cost database. Architecture scenarios are used together with the cost database to calculate investments for each year. The price erosion of network components over time, significantly affecting the techno-economic analysis, is performed using the extended learning curve model [12]. Components' replacement due to their lifetime is also taken into account. In this study the TONIC model, a generalization of the logistic model, is used for demand forecasting. Such models are based on the diffusion theory, a methodological approach used for estimating the adoption of technological innovations or other products or services.

### 3. Results and Discussion

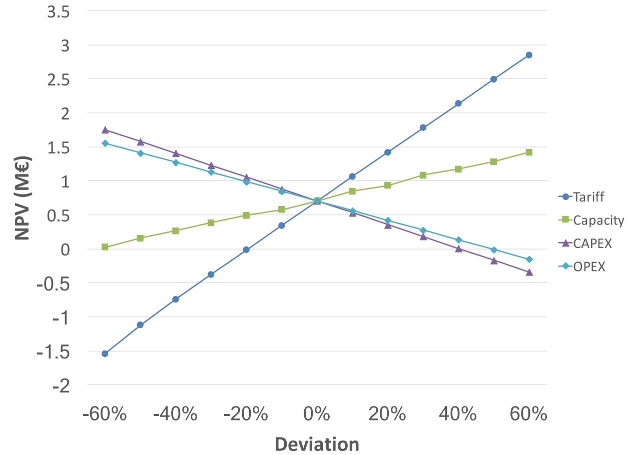
In this section, results derived from the techno economic analysis are presented and used in order to assess a potential investment for an IVS enabled 5G infrastructure in CE venues such as stadiums. The discount rate is assumed to be 10% while taxes are set to 20%. It is also assumed that three mobile operators, with market shares of 50%, 30% and 20% respectively, have an agreement to access the small cells operators' network.

Fig. 1(a) illustrates the demand for 5G. The demand is calculated using the TONIC model along with historical data for 4G networks. Taking into account market maturity and other market expectations the forecast is adjusted accordingly. It is expected that 5G demand will be below 5% for the first years after its introduction and will reach 40% in 2026.

For the base scenario (described so far), the net present value (NPV) was calculated to be 705k€ with a payback period of approximately 6.5 years and an Internal Rate of Return (IRR) equal to 27% for a study period of 10 years starting at 2020. To gain further understanding of these results and consider the uncertainties involved, several sensitivity analyses were performed. The parameters chosen for the sensitivity analysis were tariff, stadium capacity, CAPEX and OPEX. All the parameters are varied within an interval of ±60% of their initially assumed values.




(a)




(b)

Fig. 1. (a) 5G demand forecast [Source: inCITES] and (b) Economic results of the 5G investment

From Fig. 1(b), it can be deduced that the most crucial parameter affecting the NPV is the services tariff prices. A 60% increase in the monthly tariffs of Table 1 (e.g., bringing them to 1.6, 0.8 and 0.4€/month in the case of gold, silver and bronze subscriber respectively) results in improving the NPV by as much as 2 M€. On the other hand, if the NPV value is reduced by 20% (e.g., 0.8, 0.4 and 0.2€/month in the case of gold, silver and bronze subscriber respectively), then this leads to a marginally negative NPV.

The next crucial parameter under consideration is CAPEX namely the cost of the required network components. If CAPEX drops by half, then the project has an NPV of 1.58 M€, whereas if it increases by 50%, then the NPV becomes negative and equal to −170 k€. It should be pointed out that the quite strong dependency of NPV on CAPEX is further enhanced by the fact that 5G enabled radio nodes with improved performance and capabilities are not yet commercially available. Some variations in the assumed prices are therefore expected due to the increased uncertainty.

## 4. Conclusion

We carried out a techno-economic analysis for an IVS to assess the potential investment of emerging converged optical/wireless 5G networks leveraging on SDN and NFV technologies in a CE. We showed that such an investment is viable under specific assumptions related to demand and services' tariffs. Sensitivity analysis revealed that the most crucial parameters affecting NPV are service tariffs and CAPEX.

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