Enriched Network-aware Video Services over Internet Overlay Networks

www.envision-project.org

Deliverable D2.1

Final Specification of Use Cases, Requirements, Business Models and the System Architecture

Public report, Version 2, 2 November 2011

Authors

UCL	Eleni Mykoniati, David Griffin, Raul Landa, Miguel Rio
ALUD	Nico Schwan, Klaus Satzke
LaBRI	Toufik Ahmed, Ubaid Abbasi, Abbas Bradai, Samir Medjiah
FT	Jerome Royan, Pascal Rousset, Selim Ellouze, Bertrand Mathieu, Emile Stephan
TID	Oriol Ribera Prats, Adolfo Rosas, Ingacio Carretero, Armando Garcia, Arcadio Pando, Alvaro Saurín, Juan Carlos Valverde
LIVEU	Noam Amram, Bezalel Finkelstien

Reviewers Klaus Satzke, Raul Landa, Eleni Mykoniati

Abstract This deliverable is a key milestone for the ENVISION project. It presents the results of WP2 and sets the scene for the detailed technical work to be undertaken in the main technical workpackages. Three use-cases describing ENVISION-enabled media applications are introduced and refined: Web 3D Conference, Bicycle Race and Legacy Delivery Networks. Considering the overall problem domain of the project and from analysing the three use cases this deliverable goes on to derive and specify the requirements that capture the core features and design principles for multi-participant interactive applications that collaborate with the underlying ISPs identifying what is needed from the ENVISION theoretical solutions and developments. A set of business roles and scenarios are investigated and defined with two specific scenarios being examined in detail. A major contribution documented in this report is the ENVISION system architecture, defining the framework for the overall ENVISION solution. Finally, the results of an economic analysis is presented to assess the business feasibility of launching new services such as those identified in the ENVISION use cases.

Keywords Future Media Applications, Use Cases, Requirements, Business Roles, Business Scenarios, System Architecture, Economic Modelling

Project funded by the European Union under the
Information and Communication Technologies FP7 Cooperation Programme
Grant Agreement number 248565

EXECUTIVE SUMMARY

Future media applications will be increasingly dependent upon interactive, multi-sourced, real-time, high quality (HD/3D) video streams. Users will be more involved in content generation while services based upon centralised servers are becoming more distributed, and, as a consequence, highly distributed peer-to-peer based applications are foreseen as the basis of many future media applications. Such trends mean that application overlays can present unprecedented demands upon underlying networks in terms of the quantity of resources required to carry high quality media streams between unpredictable end-points. Rather than simply throwing bandwidth at the problem the ENVISION approach is to develop intelligent cross-layer techniques that, on the one hand, will mobilise network and user resources to provide network capacity where it is needed, and, on the other hand, will ensure that the applications adapt themselves and the content they are conveying to available network resources. The ENVISION solution advocates a two-way exchange of information between overlay applications and underlying ISPs, enabling the invocation and use of network services to improve QoE for the applications while reducing costs and improving efficiency for the network provider.

Three use-case describing ENVISION-enabled media applications are introduced in this report. Firstly, the *Web 3D Conference* is based around a virtual 3D world where, in addition to the usual interaction of avatars with one another and the virtual environment, participants may be involved in a virtual conference with real-time video interactions for presentations, questions and off-line discussions. The second use case is a micro-journalism based *Bicycle Race* where a mixture of professional and amateur content sources, all capturing different aspects of the race, is distributed over a wide geographical area. Consumers of the application may select one or more of the streams according to their preferences and choices which may change dynamically. Finally, a *Legacy Delivery Networks* use case is introduced to show how traditional content overlays, such as CDNs for stored content as well as live streams, may benefit from a closer collaboration with the underlying ISPs as provided by the ENVISION solutions.

Considering the overall problem domain of the project and from analysing the three use cases this report goes on to derive and specify the requirements that capture the core features and design principles for multi-participant interactive applications that collaborate with the underlying ISPs.

The next sections of the deliverable define the business environment applicable to the ENVISION solutions. This begins by identifying representative business scenarios. Firstly, a P2P business scenario is introduced where application logic is located solely in user equipment. The second scenario is still based around a P2P application assisted by a Service Provider contributing a small part of the required infrastructure with the ISPs offering a more comprehensive range of network services, including content adaptation, multicast distribution and QoS-based traffic prioritisation.

A major contribution documented in this report is the ENVISION system architecture developed to meet the requirements raised by the use cases and enabling the identified business scenarios. The architecture identifies nine high level blocks and the framework presented in this report forms a reference model for the overall ENVISION solution.

The final section of the report presents the results of an economic analysis to assess the business feasibility of launching new services such as those identified in the ENVISION use cases. The methodology employed was to design and build a time-sequential business simulator using a dynamic systems approach based on new product diffusion models to evaluate economic models of two sided markets. The modelling and simulation work resulted in a series of business guidelines providing insights to the path from technological research topics to feasible business realities. A significant conclusion based on the results of the modelling work is that the ENVISION-enabled technologies being researched are vital and could enable a new ecosystem for future Internet services.

TABLE OF CONTENTS

1. INTRODUCTION

This deliverable is a key milestone for the ENVISION project. It presents the results of WP2 and sets the scene for the detailed technical work to be undertaken in the main technical workpackages. WP2 was tasked with investigating existing ideas and new emerging trends for future networked media applications; building representative use cases to be used as a reference by the subsequent development and evaluation tasks of the project; analysing the use cases to produce technical and business level requirements from the perspectives of the users, application/service and network providers; identifying alternative business models regarding their potential and their impact on the business and technical interactions between the involved stakeholders; defining the overall cross-layer architecture and high-level design of the ENVISION functionality.

The report begins in ***Section 2*** by describing the ***problem to be solved*** by the project, introducing the ***essence of the solution*** and outlining the ***major research challenges***. The problem formulation is based around the observation of trends in media applications: media applications will be increasingly dependent upon real-time video; these video-based applications will become more interactive compared to simple retrieval of pre-recorded content; they will be multi-sourced; and consist of high quality (HD/3D) streams. A second dimension to the trend is that users are participating more in content generation and processing rather than simply acting as consumers; that services based upon centralised servers are becoming more distributed; and that highly distributed peer-to-peer based applications are the natural extension. These trends mean that application overlays can present unprecedented demands upon the underlying networks in terms of the quantity of resources required to carry high quality media streams between unpredictable end-points.

Three ***use-cases*** describing ENVISION-enabled media applications are introduced and refined in ***Section 3***. Firstly, the *Web 3D Conference* is based around a virtual 3D world where, in addition to the usual interaction of avatars with one another and the virtual environment, participants may be involved in a virtual conference with real-time video interactions for presentations, questions and off-line discussions.

The second use case is a micro-journalism based *Bicycle Race* where a mixture of professional and amateur content sources, all capturing different aspects of the race, is distributed over a wide geographical area. Consumers of the application may select one or more of the streams according to their preferences and choices which may change dynamically. The use case is challenging from several perspectives: the popularity of any one stream is difficult to predict; there may be a high churn rate of consumers between streams; professional sources, who may also be mobile, following the race on motorbikes, wish to inject high quality audio-visual streams through limited bandwidth mobile networks.

Finally, the *Legacy Delivery Networks* use case is introduced to show how traditional content overlays, such as CDNs for stored content as well as live streams, may benefit from a closer collaboration with the underlying ISPs through the ENVISION defined CINA interface.

Considering the overall problem domain of the project and from analysing the three use cases this deliverable goes on, in ***Section 4***, to derive and specify the ***requirements*** that capture the core features and design principles for multi-participant interactive applications that collaborate with the underlying ISPs through the CINA interface. User, Application and Network Provider requirements are identified followed by System requirements identifying what is needed from the ENVISION theoretical solutions and developments. The requirements were defined to be applicable to a wide range of use cases, irrespectively of particular business models, application-specific requirements and infrastructure restrictions. The requirements as defined in this report are a key input to the technical workpackages (WP3, WP4 and WP5), specifying the scope and constraints of the network services and network optimisation targets, the CINA interface functionality, the requirements for overlay data management, content distribution optimisation, content adaptation and caching.

The next sections of the deliverable define the business environment applicable to the ENVISION solutions. This begins, in ***Section 5***, by identifying the set of ***business roles*** (User, Network Provider, Service Provider, Content Provider, Advertiser, etc.) and goes on to define a set of representative ***business scenarios***, in ***Section 6***, where these roles are mapped to business actors and their interactions are investigated and defined. Two specific scenarios are examined in detail. Firstly, a P2P business scenario is introduced where the application logic is located solely in user equipment. The application does not rely on additional resources provided by a Service Provider, but some service-layer capabilities such as caching/super-peer functions may be provided by the ISP. The second scenario is still based around a P2P application, but with a Service Provider contributing a small part of the required infrastructure, e.g. authentication or resource management functions. In this scenario the ISP offers a more comprehensive range of network services, including content adaptation, multicast distribution and QoS-based traffic prioritisation.

A major contribution documented in this report is the ***ENVISION system architecture***, presented in ***Section 7***, which was developed to meet the requirements raised by the use cases and enabling the identified business scenarios. The scope of the functionality covered by the architecture is limited to these blocks relevant to the cooperation between overlay applications and underlying ISPs, for optimising the overlay and the network and for involving the end users in the applications. The architecture identifies nine high level blocks: End-user Application Management; at the overlay layer there are four blocks formed by Overlay AAA, Services Control, Data Management and Overlay Management; and at the network layer four blocks consisting of Network AAA, Network Data Management, Network Services Control and Network Management. The architecture is an important framework for the technical work to be undertaken in the technical workpackages, highlighting the major functional blocks in the network and overlay layers as well as user terminals, their relationships and interactions. The high-level architecture is implementation independent in the sense that it does not prescribe how the functions will be implemented, whether they will be distributed or centralised. The refinement and decomposition of the blocks into specific software modules is a task of the individual workpackages, but the framework as presented in this report represents a significant step, providing a reference model for the overall ENVISION solution.

The final section of the report, ***Section 8***, is a significant result in its own right. This section presents the results of an ***economic analysis*** to assess the business feasibility of launching new services such as those identified in the ENVISION use cases. The most challenging use cases from the business perspective were simulated as brand new services competing with well-established players. A dynamic systems approach based on *new product diffusion models* involved the construction of economic models of two sided markets. The methodology employed was to design, build and execute a number of economic scenarios in a time-sequential business simulator. In the simulation models the decisions of the business agents in any period are based on the actual network size and the dynamic relationships between agents in the preceding period providing a dynamic feedback loop between the two sides of the market. The modelling and simulation work has resulted in a series of business guidelines providing insights to the path from technological research topics to feasible business realities. A significant conclusion based on the results of the modelling work is that the ENVISION-enabled technologies being researched are vital and could enable a new ecosystem for future Internet services.

2. OVERVIEW OF THE ENVISION PROJECT

2.1 Problem Formulation

Future networked media environments will differ significantly from today's applications in two important dimensions. They will be high-quality, multi-sensory, multi-viewpoint and multi-streamed, relying on HD and 3D video which will place unprecedented demands on networks for high capacity, low-latency, low-loss communications paths. Advanced media applications will also be more interactive and distributed, putting the users at the centre of a massively multi-participant communications environment where they can interact in real-time with other user and provider resources, to provide and access a seamless mixture of live, archived and background material. In addition to meeting the capacity and quality challenges, future networks also need to provide mechanisms for the highly dynamic discovery of distributed content and other participants and to support the communications between unpredictable and arbitrarily large meshes of network endpoints, distributed around the entire globe.

High-definition, highly interactive networked media applications pose major challenges to network operators. Multi-sourced content means higher quantities of data throughout the network, putting additional pressure at the network edge for unprecedented upload capacity in access networks. If the entire burden of supporting high volumes of HD/3D multi-media streams is pushed to the ISPs with highly concurrent unicast flows this would require operators to upgrade the capacity of their infrastructure by several orders of magnitude. Rather than simply throwing bandwidth at the problem the ENVISION approach is to develop intelligent cross-layer techniques that, on the one hand, will mobilise network and user resources to provide network capacity where it is needed, and, on the other hand, will ensure that the applications adapt themselves and the content they are conveying to available network resources, considering core network capacity as well as the heterogeneity of access network and end-device capabilities.

Meeting these challenges requires a previously unseen amount of cooperation between application providers, users and the communications networks that will transport the application data. Applications need to be able to accommodate unpredictably large numbers of participants in a cost-effective way, while still maintaining high responsiveness to deliver a high Quality of Experience to the participants. Content, which itself is changing dynamically in scale and context according to user participation and behaviour, needs to be adapted to network capacity and capabilities, and networks need to be aware of the nature and needs of the content it is transporting.

ENVISION aims to enable this cross-layer optimisation by:

- increasing the degree of cooperation between ISPs and the networked applications they are conveying;
- optimising application overlay networks to make best use of the capabilities of the underlying networks and the participant end users;
- providing the means by which service providers can access and mobilise specialised network resources to achieve efficient distribution of highly demanding content streams;
- enabling dynamic adaptation of the content to meet the abilities of the underlying networks.

2.2 Future Networked Media Environments

Network-based applications and services have mostly followed the client-server model in the past. To a great extent most content has been centrally created and various communications networks have been involved as a distribution means to get information from the single source of the content to many consumers. This has been the model of the printed press, radio and television, theatre and cinema, music performance and the distribution of recordings and it has been replicated in the Internet.

In recent years there has been a trend for more user participation in the Internet-based services that they use. There has been an explosion of user generated, tailored and recommended content and social networking is beginning to replace traditional communications technologies such as email and websites. However, even though information is being created, modified, edited and consumed by a large number of distributed participants, almost all of these services still rely on servers that house and operate the applications on behalf of service providers in large data centres at strategic locations around the Internet. Typical examples of popular applications that only exist for, by and because of significant user participation are Facebook, YouTube, Flickr, Digg, eBay, Second Life and Wikipedia. All of these depend on the client-server model with servers that need to be adequately dimensioned and carefully positioned to ensure an adequate Quality of Experience for their users.

The next generation of applications will continue the trend of user-centricity where users are not just seen as consumers of a product or service but are active participants in providing, operating, or even being the application itself. The traditional model of media streams being produced centrally and then distributed through a largely passive network to passive consumers may still have a role but more advanced, interesting and attractive future applications will be characterised by having many sources from many viewpoints that need to be navigated, dynamically mixed and tailored to suit the needs, tastes and quirks of individual users according to their context. It will be hard to meet the requirements of these future applications with current hierarchical content distribution networks, as this hierarchical model is not well adapted to serve dynamic content from multiple sources especially considering the needs of low-latency live content streams.

In addition to being more distributed and interactive, future media applications will demand much more from the communications network than they do today. For example, new immersive, collaborative environments will require three-dimensional, multi-sensory user participation which demands high capacity, low latency communications channels to exchange a range of information in a large variety of formats. This ever increasing pressure on the network is amply demonstrated by the following trends:

- The increase in demand for HD (and beyond) quality from consumers on the one hand, and from manufacturers of consumer devices such as plasma screens on the other.
- Emerging standards for high-quality video content e.g. H.264 level 5, with typical resolutions of 2K x 1K or 4K x 2K, requiring bitrates of up to 240Mbps.
- With the standards for ultra HD coming from Japan and 3DTV following not far behind the amount of bandwidth that the networks will require to deliver will become 10 to 100-fold higher than today's capacity.
- Web 2.0 goes video and live. With the rapid deployment of wired and wireless broadband Internet access for any user, a largely reversed traffic load pattern with a vast number of ingress points for media content has to be handled by the operator networks.
- Modern wireless technologies (currently HSPA, with LTE and WiMAX in the near future) are being deployed widely, increasing mobile uplink and downlink bandwidth available for mass contribution and consumption of high-quality streaming media from anywhere.

2.3 Research Challenges and Issues

Because applications will be more participatory and interactive, their fundamental way of working is heavily dependent on user behaviour. This implies that it isn’t just the content that is housed in diverse locations but that the logic of the application itself will also be distributed. This means that today’s model of centralised or replicated servers in large data centres is likely to be replaced by a highly distributed model where processes run in user equipment and interwork with one another and with the providers' servers to form the participatory, multi-sourced communications applications we envision. The application level interaction between participants, the discovery and processing of information/media sources and the distribution of tailored content are all performed by the same network of participants, acting as peers at both the application logic and the content distribution levels.

Figure 2-1 shows the application participants forming an overlay network on top of the Internet. The overlay consists of nodes provided by one or more of a service provider (SP), the users themselves and, optionally, the ISPs. The application is formed by the collection and interconnection of all of these nodes with the content as well as application logic/behaviour being distributed amongst them. There will be separate instances of the overlay for each application. Different applications may be more or less dependent on SP nodes. At one extreme there may be no SP nodes at all, with the SP acting simply as the developer and provider of P2P software that is run by the users.

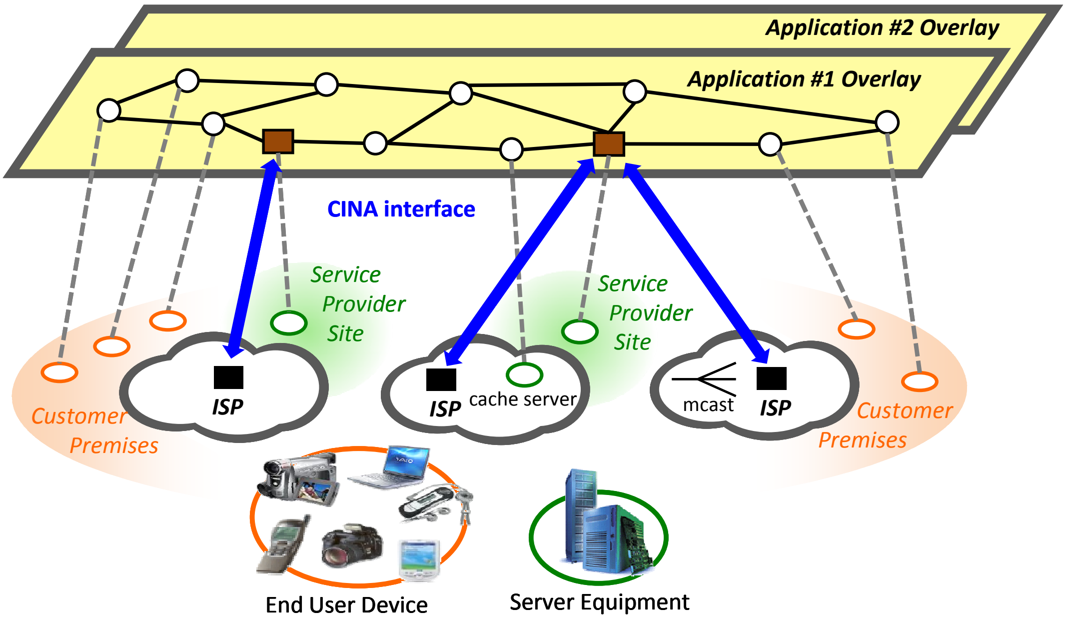


Figure 2-1: The CINA interface and its relationship with overlay applications, ISPs and service providers

The following sections outline the research challenges and issues that need to be addressed to enable the future media applications to run over the Internet providing adequate Quality of Experience (QoE) for the users and cost-efficiency for the involved business parties.

2.3.1 Fostering Cooperation between the Application and the Network

Application-layer networks are global overlays running on top of the Internet and it is essential that the participants have a high QoE considering the highly demanding nature of interactive multi-participatory communications including HD and 3D video. Today's media overlay applications are mainly in the field of file transfer, because live media streaming applications offer a limited QoE. This means that future overlays need to be aware of the underlying networks' capabilities (and weaknesses) and to be able to influence how their data is transported across the application-layer network using the facilities of the underlying ISP networks. This is a challenging task considering the inter-domain nature of applications with participation of users around the entire world.

The ALTO initiative investigates how overlay networks and ISPs can cooperate to optimise file-based traffic being generated by P2P applications and transported over the ISP's infrastructure. The ISP is able to indicate a preference for which peers should exchange data to avoid over-utilisation of its network or the unnecessary loading of high-cost resources such as inter-provider links. The P2P network benefits by avoiding congested parts of the network, resulting in higher average throughput.

The overlay-ISP interaction in ALTO is of limited functionality for future media services. The ISP provides information to the overlay on its preference for the ranking of peers according to the list/traffic matrix supplied by the overlay. However, live and on-demand multimedia services cannot be deployed efficiently without relying on network services. Examples of valuable services to effectively increase the capacity are multicasting, caching, fallback to lower bitrates by transcoding and quality adaptation. Increase in quality requires access to bandwidth reservation, traffic differentiation, mobility management, identity authentication, authorisation and geo-location. These network capabilities – today hidden in the walled gardens of network providers – are required to implement efficient network-aware services. To achieve efficient cross-layer integration, these network capabilities need to be made available by network providers to service developers and integrators. A major research theme of the project, therefore, is to ***expand and enhance the overlay-ISP interaction, by developing a comprehensive, media-aware open and standardised interface between the ISPs and the application overlay called CINA – Collaboration Interface between Networks and Applications***.

Since some information are critical for network operators and that they do not want to reveal them (such as internal detailed topology or BGP policies), the CINA interface is designed having in mind the agreements between the applications and the ISP and is adaptable to allow any kind of agreed information to be exchanged.

Furthermore, via the CINA interface, the network operators can also get information from the overlay so that they can optimise the traffic in their networks, mobilise resources and adapt to the overlay applications, eventually transparently; what is not covered by ALTO. Typically, the application could inform the ISP about its traffic demand: information related to users (e.g. user location and estimated traffic matrix) or information related to content (quantity of sources, their bitrate, adaptive coding, etc.).

This information exchanged between the application and the ISP goes then further than information reflecting the preferences and policies of the involved business entities as it is currently defined in the ALTO working group.

Our CINA interface goes further than ALTO also in the way that it enables future networked media applications to make use of advanced network services in a dynamic and flexible way to achieve a cost-efficient delivery of high QoE for their users. It is known that ISP could offer information to applications such as the location of users or some few user profile information but in our approach, we go further via the offering of advanced network services. For example, such possible network services can be: (1) multicasting: possibly with hybrid application layer and native IP multicast since the applications will usually be spread over several ISPs, or the use of high fan-out nodes, located in the network; (2) caching: via the use of specialised nodes, provided either by ISPs or third party entities, to optimise the delivery and save bandwidth in the network; (3) bandwidth on demand: to enable the delivery towards end-users over multiple access networks simultaneously, and provide bandwidth on demand over aggregated access networks; (4) dynamic QoS mapping: invocation and mapping of application QoS requirements network capabilities, end-users devices and access networks; (5) ad/text insertion: in order to offer added-value services that might be monetised by network operators, (6) content adaptation: the presence of heterogeneous end-users devices and network infrastructures will require multiple versions of the same resource that can be efficiently generated using content adaptation.

2.3.2 Optimising the Overlay Application

The scope of the overlay-ISP interaction in ALTO is limited to the viewpoint of a single ISP and the peers located on its domain. Given that our applications are global in coverage, and require end-to-end traffic optimisation involving several hops in different networks, it is necessary to collect information from many underlying networks. There are several problems associated with collecting and using this information: data from one network may conflict with that provided by another; the quantity and quality of the information may differ from ISP to ISP and some may not offer any information at all. The ***harmonisation of the information gleaned from the ISPs, the aggregation of the information collected from different ISPs, its auditing and augmentation with additional data collected by the overlay*** and its subsequent use for the global optimisation of the application is one of the major research challenges of this project.

Interaction with the underlying network provides essential information to a number of application functions that need to be optimised in order to support the future networked media environments.

In high volume applications where users are interested only in part of the available content, and this interest changes quickly over time (e.g. the micro-journalism use case), the application must provide the ***interest management*** techniques to determine which of the content sources need to be distributed and to which groups of users, so that the QoE remains high and within the capabilities of the given application and network resources. Selecting the appropriate subset of sources, needs to be optimised to best match, not only the interest of the participants, but also the capabilities of their access means and the underlying network conditions, while minimising the impact on the overlay topology.

The ***distribution of the content*** from a given source to a large and dynamic group of participants is a challenge in itself. Intelligent algorithms need to be in place to determine which application resources (e.g. caching servers, NAT traversal gateways etc.) need to be involved, how to best interconnect the participants and distribute the load and the content to achieve the best QoE given the available resources. The related topology creation and data scheduling algorithms need to be optimised depending on the requirements of the particular application for throughput, delay, loss and responsiveness to application-layer interactions. Resiliency is also an important objective, in particular in overlay applications where users participate in the distribution of the content but may dynamically change their participation to a particular stream, or the application altogether and leave the overlay with high churn. ***Caching*** techniques for content that remains popular over a period of time, are also of particular interest as they can significantly reduce the amount of resources required to distribute this content.

Finally, ***robust and efficient control data management*** techniques are required to enable the coordination of the media application through a control layer operating across a widely distributed set of nodes. Dynamically changing information regarding users and content sources participating in the application needs to be distributed efficiently and consistently to a large number of nodes. This is further complicated by the dynamics of participants' changing interest in content sources that are constantly joining and leaving as well as new network and application resources becoming available. Data management may be distributed uniformly to a number of overlay nodes, or the application space may split to distinct areas of responsibility. The protocols electing the nodes to participate in the infrastructure, assigning data to nodes or forming and inter-connecting the areas of responsibility, replicating the data and handling churn will be investigated.

The project will investigate appropriate optimisation techniques building on top of the CINA interface to accommodate the requirements of such advanced media applications.

2.3.3 Supporting Heterogeneous Access Means

Until now digital coding and encoding have been designed following the client/server paradigm but now applications will have to deal with the fact that the content may come from several sources and terminal devices with different capabilities, residing in networks that offer different services. Applications will have to adapt and select "quality layers" with a brand new set of constraints and circumstances. Another major research topic of the project is, therefore, the ***adaptation of content***

to the capabilities of the core and access networks, user devices and user preferences. This includes the encoding of media streams and other forms of content for transmission from the originator to the application; processing and mixing of media sources in the distributed application to produce derived content - adding value, customising and tailoring the data/media; encoding and distributing the derived content to the consumer(s). Content adaptation therefore has two dimensions: personalising and tailoring the content for the subjective viewpoint of the user(s); and encoding content in a flexible way to match the capabilities of the network (application-layer overlay as well as the ISP's layer-3 network).

Content adaptation for network-aware multi-participatory interactive applications presents several challenges. Intelligent techniques are required to dynamically select the content sources and corresponding quality levels to be transmitted to each recipient, following the application layer interactions and responding to the changes in network conditions. These techniques need to maximise the delivered QoE, be responsive to changes in the environment while minimising the impact on the overlay topology and reconfiguration. The content distribution algorithms need to be enhanced to treat differently the data packets depending on their layered codec priority.

2.3.4 Mobilising Network and Service Infrastructure Resources

The distribution of high-volume content like 3D HD video to a large number of recipients requires a huge amount of bandwidth, storage, processing and other service infrastructure resources. Optimisation techniques at the application and network layers will reduce the required resources to a minimum but this is still a significant amount of resources to accommodate the needs of advanced media applications if they rely only on traditional means.

Pre-provisioning and advance payment for bandwidth or other resources is considered highly inefficient for new applications that may need to accommodate an arbitrarily large set of end users, with unpredictable topological distributions and traffic profiles. It is therefore essential that the applications ***take advantage of the resources of the end users themselves*** wherever and to the extent that this is possible; user bandwidth, processing power and storage resources differ significantly depending on their terminal device (STB, PC, mobile phone, etc.) and their physical access network (ADSL, FTTH, Wi-Fi, WiMAX, 3G, etc.). To achieve this, applications need to provide incentives to their end users. Even assuming the full cooperation of end users the demand for resources may still exceed supply. This is very likely to be the case in mobile environments where upload capacity, storage and processing power of end devices might be very limited.

An alternative to be investigated in the project is the active participation of the ISP in the application overlay. ***An ISP may directly benefit from strategically contributing resources to the overlay***. Providing a node for caching content, for example, may result in reducing the load in the ISP's inter-domain links. It is expected, however, that the resources required by the application may exceed those that the ISP finds beneficial to contribute voluntarily. We envision, therefore, that ***an ISP may also offer service infrastructure nodes and associated bandwidth resources to the overlay, for a price***. The ISP is in an advantageous position to offer such resources compared to other third party service infrastructure providers, for several reasons. Firstly, the ISP can provide service infrastructure with associated network level guarantees. Secondly, provided that it has an appropriate prior agreement with its customers, the ISP can also mobilise the resources of its customers, through controlling their set-top boxes, for example, and offer them to the application to act as content caches or bandwidth multipliers. In the latter case a multiplication effect is provided by the users' STBs downloading only part of the content and uploading it as many times as possible.

3. USE CASES

Following are the three use cases that have been identified as being of the most relevance in describing different aspects of usage of the CINA interface and functionality. These use-cases are:

- ***Web 3D Conference***, highlighting:
  - Dynamic nature of streaming media
  - DRM and other Data Security issues
  - Multi-terminal profiles for media contribution and consumption
- ***Bicycle Race***, highlighting:
  - Mobility of Sources/Geographical diversity of contribution
  - Cross-network continuity of different kinds of data (streaming media, metadata)
  - Metadata generation/search
  - Media transcoding and re-purposing
- ***Distribution Network (DN) Legacy Case***, highlighting:
  - Media storage (e.g. caching) when dealing in both live and offline material

In each use case, we provide at least one scenario that emphasises the functionality being researched.

3.1 Use Case 1: “Web 3D Conference”

In their day to day lives, professionals might travel to many different locations for conferences or work meetings. The importance of these physical meetings can hardly be questioned. Human face-to-face interaction is, and will continue to be, the most effective form of communication. Simply put, live in-person meetings deliver the rich, potent experiences that virtual meetings can’t - asking if virtual meetings will ever replace live meetings is like asking if singles’ chat rooms will replace real dating. In addition to professional users, domestic users are trending in 3D virtual worlds ranging from SL, IMVU, and many others.

On the other hand, recent advances in technology are making virtual events a less expensive alternative to physical meetings, something that is seen to be an advantage in today’s tough economic and ecologically-aware times. To see just how valid a replacement this virtualisation is, we should ask the question: why do we have these meetings and events in the first place? Simply put, we meet to exchange information, and to “network” with others. Virtual meeting and event technologies can easily facilitate these two objectives, providing important savings by eliminating the costs of venue rental, accommodation and transportation, and by reducing the ecological footprint of such trips.

3.1.1 Introduction

A virtual meeting, such as a 3D virtual conference, can gather a large number of users who might communicate via voice, gestures and facial expression while simultaneously sharing multimedia information (video, sound, 3D models, text, slides etc).

This virtual meeting use case brings a few issues to light:

- **Content Dynamicity:** The virtual environment would contain static content such as the decor (the conference rooms with chairs, tables, screens, avatars), as well as dynamic data that should be frequently updated and synchronised to reach a sufficient level of consistency (position of an avatar, multimedia, dynamic items etc).

- **Optimisation/Efficiency:** From a P2P perspective, the presence of the attendees within the same delimited virtual space can greatly improve content sharing between participating peers: the users whose point of view is close to mine are in effect sources from whom I might download the content required for visualisation of the same event. Thus, the efficiency of the system can be greatly improved by organising the overlay with regards to the position of content within the virtual space.
- **Diversity of Consumption:** Not all attendees will be able to follow the conference live from their office, perhaps due to differing time zones. Some of them might access the conference from a low resources terminal (mobile phone, home TV with set top box), while others might want to attend the conference the following day in pre-recorded mode without any real interaction. Adaptation of content according to the peer capabilities and capacities in terms of network and graphic resources as well as pre-recording of the conference are real issues for this specific use case.

3.1.2 Scenario

Dr. Davis is a prominent researcher on P2P technologies, and this year, as usual, Dr. Davis will be delivering his key note at the PCC (P2P Computing Conference). The PCC conference allows him to present research work done at his laboratory, and gives him an opportunity to catch up on the latest P2P technologies, as well as meet his peers in the international P2P community. This year however, the PCC organisation committee has decided to hold a virtual conference in order to promote the theme of “decentralisation”. Each contributor and attendee will participate in and follow the conference from home, considerably reducing the global cost for organisers and attendees.

3.1.2.1 Step One: Virtual Conference Registration

Two months before the conference, Dr. Davis subscribes online to a premium account giving him many services such as:

- Efficient access to virtual spaces with low latency and fast download of high resolution content
- Live access to conferences on various screens such as a virtual reality “cave”, his personal computer, his TV connected to a set-top box, a tablet, or a mobile device (e.g. a smartphone)
- On-demand access to pre-recorded virtual lectures over a period of six months.
- A free virtual room for private meetings during the conference
- Access to the main room two weeks before the conference, allowing him to edit his slides with the co-authors, and to rehearse his presentation under real conditions

The online subscription and preference setup is done through a web interface, and the corresponding profile is record on a server.

3.1.2.2 Step Two: Talk Preparation

A week before the virtual conference starts Dr. Davis sends an appointment to the co-authors in order to review and complete the slides. The authors of the contribution each log in the main virtual room to share and edit the slides of the presentation in collaboration. Each co-author can select the avatar that will represent him in the virtual space from a set of default models that can be personalised, or the user can upload their own interoperable cloned avatar, modelled from a set of photographs. When the co-authors enter the virtual room, they are able to upload new content such as videos and slides, and can edit them in order to enhance the presentation. Once this has all been done, Dr. Davis talks to the co-authors to make sure that the presentation is all set, and finalises his speech according to the comments of the co-authors. Thanks to this virtual pre-talk, Dr. Davis is sure that the talk will match the co-authors point of view.

3.1.2.3 Step Three: Attending the Conference

On D-Day, Dr. Davis logs on to the virtual conference from his professional computer and sees that conference is already underway. Some attendees are already logged into the virtual environment and are participating in a discussion. They are visualising the virtual space. Some of them have already cached all the content required for a high or low definition visualisation of the scene according to the capacities of their terminals. Others have just connected to the conference, and are currently partially visualising the scene which is refined progressively as the missing content is downloaded.

To log on, Dr. Davis selects his arrival position within the virtual space by clicking on a hyperlink from the conference homepage (Exhibition hall, main session room, special session room, poster room). He logs into the distributed application overlay and receives metadata concerning the peers that are close to him within the virtual environment (IP, capacities, download rate, upload availability, valid responses rate etc.). Thanks to this information, Dr. Davis's terminal can begin the distributed download of the static content required for the visualisation of the conference.

As soon as Dr. Davis receives enough content from peers that are close in virtual space he begins navigating in the virtual space, changing the position of his embodied avatar. This movement is sent to the overlay application to inform other users of the new position at a rate of at least 40 times per second (a constraint that requires a high level of dynamicity on behalf the overlay application). In the same way, all users present within the scene update their states when modified (position, animation key frame). Accordingly, Dr. Davis and the other participants receive all the modified states of objects and avatars close to their viewpoint from the overlay application, also at the rate of 40 times a second, thus updating the position of avatars that are moving around the user's viewpoint for smooth visualisation.

During his virtual navigation, Dr. Davis meets some old acquaintances in the virtual reception hall and begins a discussion with them without disturbing his distant neighbours since his voice is spacialised and thus weakened according to the distance from the sound source. Indeed, his voice is multicast to neighbour peers, each client adapting the volume of his voice according to their relative virtual distance, and mixing it with other received voices and sounds.

As the first presentation is due to begin in a few minutes, Dr. Davis takes his place in the main conference room to follow the first presentation. To facilitate this, the overlay application is queried for any new avatars or objects that have to be downloaded according to the new viewpoint. The main conference room is populated with more than 500 avatars and Dr. Davis must sit on a virtual seat which is rather distant from the speaker. Fortunately, virtual screens positioned within the virtual conference room and on which the slides are "projected" can be displayed as a window on Dr. Davis's screen. By double clicking on the avatar of the speaker, Dr. Davis may display a window with the real live video of the speaker acquired from a webcam, and distributed in live through the overlay. The loudness of the speaker is not reduced within the virtual conference room to ensure that the entire audience hears him clearly. Once the talk is over, it's time for Q&A. Any attendee who wants to participate sends his question to the chairman, who selects one person from a list. The chairman has specific administrator rights during this session. The sound level of the selected person will not be reduced during his question in order to be audible by the entire audience.

3.1.2.4 Step Four: Give a Talk

It is time for Dr. Davis to give his talk on the new innovations developed by his research team. His avatar is now given access to the speaker zone since the chairman of the session entitles him. As soon as his avatar enters the speaker zone, its voice is amplified to be heard by everybody, exactly as if he was speaking into a real-life microphone. In this case, the voice is multicasted to all users present within the conference room. In a few clicks, Dr. Davis arranges his multimedia support material such as videos and slides on virtual panels visible by the entire audience. In the same way, this media is now multicasted to all attendees together with real video of Dr. Davis acquired by his webcam. Dr. Davis can now start his presentation, which, as expected, goes splendidly. As soon as he finishes his talk Dr. Davis moves his avatar outside the speaker zone to let the next talker take his place.

3.1.2.5 Step Five: Attending the Conference while Mobile

One of Dr. Davis's students, John, is not currently in the same time zone as that of the conference. It's getting late where John lives, so while he gets on the bus on his way home, he decides to connect to the conference from his mobile phone to follow a session which specifically interests him. The connection mechanism on John's device is identical to the one used for a terminal with more resources, except that when his peer receives the metadata of other peers close to it within the virtual environment, it will request content at a much lower resolution. If, for example, the video content is encoded with a scalable mechanism, John's device will demand only the base model with the first levels of refinement. Much in the same way, John's device will receive the modified states of virtual objects and avatars at a much lower rate of 10 times per second, which should be enough to follow the conference on a mobile phone.

Arriving at home, Dr. Davis connects to the virtual conference from his living room, and displays it on his new television. Dr. Davis is now able to attend the virtual conference and receive additional richness of media via his 5.1 sound system, 3D screen, and Xbox Kinect™ 3D webcam.

3.1.2.6 Step Six: Retrieving the Conference Talk on Demand

It is 10pm for Dr. Davis, and due to time differences, the conference is not yet finished. But since this is not a problem for Dr. Davis, he decides to go to bed. Thanks to his premium access, Dr. Davis arrives at work the next morning, and connects to the virtual conference in pre-recorded mode. Indeed, during the live event, all the states of objects and avatars are recorded and stored for later replay. Dr. Davis can navigate through the virtual space exactly as he would have been able to the day before. He can hear the talk as well as the questions session, has access to the different synchronised presentation support material such as slides and videos, and can see the real video of the speaker, the only visible difference being that he cannot interact with objects or avatars whose behaviour corresponds to that of the day before. When a user connects to the virtual conference at time ***t***, corresponding to the time ***t'*** of the day before, at each time ***t+n***, the overlay application will supply the state of the virtual world corresponding to time ***t'+n***. If Dr. Davis decides to ask the speaker some questions, his questions will be forwarded to the speaker, and he'll be able to receive the answers later once the speaker connects to the system. According to the premium access plan that Dr. Davis subscribed to, he'll be able to attend the virtual conference during six months.

3.2 Use Case 2: "Bicycle Race"

The Bicycle Race use case is part of the micro-journalism (MJ) family of applications. MJ applications generally have the following attributes:

- an event of interest to the public takes place at a site
- exposure of the event to the public involves integration of various sources such as Audio/Video inputs covering the event site from different positions and angles
- these Audio/Video inputs might be operated by professional crews as well as by a large number of the [non-professional] spectators, and may well be of different quality and format
- any media feeds generated at the event become accessible to the public in various ways like TV, Internet and more

The Bicycle Race case was selected to represent the MJ category since it introduces many challenges like **mobility of sources**, **wide geographical area**, and more as detailed below.

3.2.1 Introduction

A live sports event, such as a bicycle race, may span a large geographical region, including both urban and rural areas. The competitors and professional camera teams are constantly moving, while the spectators and potential amateur video sources are spread along the race track and have visual contact with the competitors only once or a few times during the race. Due to the wide geographic distribution, the available wireless/wired networks might very well be provided by different operators, necessitating selection and handover between different operator networks. Often there will be several networks available in one location, which would mean handover from one set of network links to another (possibly overlapping) set of network links. `The professional and amateur video feeds are made available to a large population of viewers, spread across the globe, accessing the video and other media through applications on their comp````uter terminals, TV sets, mobile phones etc. Some consumers might be commercial service providers like TV broadcasters however most consumers are assumed to be private users. In the next chapter, we elaborate on identified representative requirements/scenarios to be further studied in the technical WPs.

In each of the requirements/scenarios, we assume that:

- The bicycle race is underway
- There are already several professional and amateur streams being generated and numerous viewers receiving one or several of the streams, according to their preferences.

3.2.1.1 QoS Handling

Viewers may receive the available content at different quality levels, either because the service offerings and pricing models are differentiated for different types of viewers, or as a result of an incentives scheme where users that contribute more resources to the system receive better quality.

An example of viewers that have higher quality requirements are TV broadcasters that receive the content through the ENVISION application and re-distribute it to their customers through their dedicated network infrastructure, e.g. cable or satellite TV networks. At certain times during the event which may last hours, days or even weeks, the event is covered by such TV broadcast channels (news, or dedicated sport channels). For the related content consumers are willing to pay more to receive better quality.

In case such a viewer asking for higher quality content chooses to receive a different source, the ENVISION overlay application should adapt to increase the quality of the stream along the paths from the new video source to the high-priority viewer.

Quality differentiation in live video streaming may involve a number of different encoding and networking parameters, such as video resolution and SNR, latency between the video generation and the video viewing times, stream switching (zapping) delay, and reliability of a given quality level. The mechanisms available in ENVISION for providing quality differentiation include:

- increasing the level of redundancy with FEC schemes,
- modifying the overlay topology such that the prioritised source to consumer streams traverse shorter paths with lower propagation delays, or
- modifying data scheduling in the relaying nodes to allocate more forwarding capacity and give priority to the packets of these prioritised streams, etc.

Depending on the business models in place, additional resources might be allocated from third-parties and network providers to ensure the agreed level of quality is met.

3.2.1.2 Viewing Multiple Live and Recorded Video Streams

The application may support Picture-In-Picture and other related content processing features. Different groups of users will be able to follow two views of the race simultaneously when they wish, automatically receiving the stream in a content format suitable to their session context. This feature could be provided by the overlay application or outsourced to a third-party, who might wish to insert sequences of ads from time to time as part of their business model.

The application may support searching and viewing recorded content for past events that are considered highlights and might be of interest for a long time after they happened, e.g. a viewer who missed a mountain climb, a fall of a group of racers or an accident could ask for a playback of the scene. This feature implies some content storing infrastructure and an editor or a voting scheme for choosing the highly popular events to record and store for future access. This infrastructure might be implemented by the overlay application itself, or provided by a third-party provider.

Multiview functionality is very demanding in terms of resources. Terminals don't have always the bandwidth requested for receiving the multiview. Mobile terminal screens are usually too small for displaying multiview. An entity (peer, ISP, third party service provider) having caching resources provides a multiview service for terminals having limited bandwidth or resources.

3.2.1.3 Co-operating with the Network Provider to Optimise Resource Utilisation[1]

The bicycle race is underway and there are numerous streams being generated, adapted and viewed, generating a significant amount of traffic in the underlying ISPs.

An ISP monitors the use of its network, including the load on its own network and the load over any inter-domain links. The application overlay provides the underlying ISPs with an estimation of the traffic flowing between users. Some of the ISPs provide the application overlay with information on link costs, IP address priorities, etc.

One of the ISPs correlates high measured load on an inter-domain link to one of its provider ISPs with the information provided by the application overlay that identifies the same stream is being sent to many local IP addresses. The ISP concludes that it would benefit from utilising a multicast group for local distribution of the same data.

Alternatively, the application overlay identifies large number of receivers of a particular source being located in the same ISP and the upload capacities of the peers located in that ISP is insufficient to

[1] For the purpose of this document the resource considered is the use of IP multicast, while other resources being deployed dynamically could include high fan-out nodes, enhanced QoS, ISP-provided storage/processing nodes, etc.

deliver the stream at full quality. It decides that QoE would be improved if IP multicast were used rather than P2P swarming. The application overlay requests[2], via the CINA interface, that a multicast group should be established.

A multicast group is created by the ISP and the address is signalled to the application overlay via the CINA interface. The application overlay nominates the best peer to act as the single source for the geographical region of the ISP in question and instructs that peer to inject the stream to the multicast address. The downstream peers located in the same ISP are instructed by the application overlay to receive the identified stream on a named multicast address.

3.2.1.4 Linking the Application with Third-party Services

A third party offers "social space" functionality to the bicycle race viewers, allowing them to discuss the race, the racers, etc. A small column will appear near the video content in the application window with chat functionalities. The third party negotiates a small part of the chat column to insert ads to compensate the offered service.

A different third party provides the opportunity to get real-time extra information about the race, the racers, the nearby region, the weather, the coming races, the interesting monuments in the neighbourhood to visit, etc. That entity could be the source of the information, or it could be an aggregator node receiving information from other entities or looking for information elsewhere. Each viewer wishing to receive that information activates the option. The application downloads the information and distributes the data stream along with the application video content.

3.2.2 Scenario Step 1: Video Production

A new video producer (professional or amateur) joins the system as follows:

The producer switches on the camera, establishes access to the Internet and registers with their network provider. The producer logs into the distributed application overlay and provides some initial metadata (user identity, GPS coordinates, AV codecs, frame-rate, resolution). This information is stored by the application overlay and made available for search/discovery by the application overlay and/or the viewers.

The camera begins to record content and generate dynamic metadata (e.g. stream descriptor keywords, angle and field of view, focal point and possibly content descriptors, such as whether there are cyclists in view, which cyclists are visible, etc.). The dynamic metadata is uploaded to the distributed application overlay and made available for search/discovery by the application overlay and/or the viewers.

When there are interested viewers the application overlay signals to the user/terminal to begin distributing the stream and the terminal then uploads its AV stream[3] to the application overlay in addition to the metadata it is already providing.

3.2.3 Scenario Step 2: Video consumption

A consumer who wishes to watch the event connects to the application and provides profile metadata (terminal and network capabilities, etc.) as well as initial search criteria for video sources. The overlay application provides the consumer with a list of available videos according to the

[2] The request could be made by the Service Provider's servers in the case of some centralised SP-provided application functionality (which will make authentication, payments, etc. easier), but in the pure P2P case this request could be made by the peers in a distributed manner – payment and authentication needs more thought in this case (one possibility is that end users of ENVISION-enabled applications pay a premium to the ISPs for requesting multicast (and other) resources and the invocation only occurs when a sufficient number of peers have made a similar request – a sort of voting).

[3] This could be to uploading to a server, to seed a P2P-like swarm, inject the stream into a multicast tree, etc. depending on the detailed distribution mechanism.

selected initial criteria, by selecting the race, the overlay provides some details about the race and the currently available video sources[4].

Based on what is available, the consumer (by interacting with the application running in the user terminal) provides preferences for the sources it would like to receive (geographical location, angle of view, AV quality levels, follow a particular cyclist, follow the leader, receive critical footage of events such as accidents, etc.). The content search/discovery functions running in the overlay application finds the stream(s) that best match the consumer preferences and provides those streams to the user.

As stream metadata changes, or as content sources switch off and new content sources become available there may be better matches and these could be automatically[5] substituted for the current streams being sent to the user.

The user may change their preferences at any time and these will be signalled to the application overlay so that new matches to available content streams can be made.

If the closest matching AV sources are in a format which is incompatible with the viewers' terminal or network capabilities (wrong codec, bitrate too high, etc.) then the application overlay invokes the use of content adaptation functions[6] to generate a new version of the stream, if there is a sufficient number of viewers declaring a preference for that format.

[4] This step is optional. Another possibility is that the viewer simply declares her preferences regardless of the availability of streams and the application overlay makes the best match.

[5] Whether this is done automatically or not could be a declared user preference.

[6] There are two sub-cases here: A. the content adaptation functionality is available in the application overlay itself (in one peer, distributed over several peers, or located in the Service Provider's servers), and B. one or more of the ISPs offer content adaptation functionality to be invoked through the ENVISION interface.

3.3 Use Case 3: "Legacy Delivery Networks"

3.3.1 Introduction

The usage pattern of the Internet has shifted significantly. According to [Bauer2009] nowadays users upload four times more than in the past, traffic grows at a 50% CAGR yearly, and end user expectations on the access network become more demanding as resource intensive Internet services popularise. According to a real data analysis conducted at TID in the frame of ENVISION, roughly 10% of Spanish users account for the 50% of the total access network traffic.

Flat rates, high elasticity in residential Internet access, non-stop traffic increase, and increased user expectations all force operators to launch new value added platforms (such as ENVISION) with two clear objectives: to enable new business ecosystems lead by partners capable of delivering services massively adopted by users, and secondly, to reduce the network costs of new multimedia services significantly.

The DN case describes how a typical ISP might use the CINA interface in order to provide cutting edge content, while remaining competitive when compared to other ISPs. The scenarios used, will show how a wide range of functionality from the CINA interface would be put into day-to-day use.

3.3.2 Overview

Legacy overlays such as stored-content CDNs (and live ones) provide value on top of the raw network enabling a new business ecosystem with content, service, and application providers, and provide a more effective way to deliver consumables to end users.

In order to improve readability, rather than using specific "stored content", "live streams", or "application" terms, the more generic "consumable" – which refers to any of them - is employed in this use case description. Similarly, content, service or application providers are referred to generically as "providers".

Given that the distribution network serving such consumables are beyond stored content, supporting the distribution of live streams, applications and other consumables, the term DN is used to refer to this particular distribution network.

A DN is an overlay service where providers decide to provision stored or live consumables which are later consumed by users in a way such that the network resources employed are optimal.

Consumables in a DN follow a life cycle consisting of the following phases: ***reservation***, ***ingestion***, ***publishing***, ***consumption***, and ***removal***.

- The ***reservation phase*** happens each time a new consumable is to be distributed in the DN. The provider reserves the right resources in the DN by calling a reservation API providing descriptive information about the properties of the consumable, expected QoE, websites where it will be embedded, territory limitations, adaptation rights, availability schedule, providers channels, consumable tags, etc. According to the above, the DN then instructs the provider on the ingestion point and delivers a snippet of HTML code known as Consumable Snippet or CS. The CS contains a consumable identifier and relevant DN metainfo used by the DN at consumption time to balance network resources VS expected QoE.
- During the ***ingestion phase***, the provider uploads the stored consumable -or provides the live source descriptor from where to pull the live content.
- During the ***publishing phase***, the provider inserts the Consumable Snippet –CS- in the suitable website, news feeds, Internet platforms, and any other canvases where the consumable is to be displayed. Publishing happens automatically as well via the DN managed channels each time a new consumable is provisioned. The DN notifies then the end users subscribed to the specific

provider channel via email, RSS, Twitter, and blog posts by providing them the title and link to the provider's website where consumable can be found.

- During the ***consumption phase***, users visit web pages where the CS (consumable snippet) is embedded; the browser then fetches the consumable from the DN. The DN triggers a complex decision algorithm to decide the most optimal server from where the browser can obtain the consumable. The decision algorithm levers on the meta-information supplied during the reservation phase of the consumable, the context of the user (location, timeframe), and the updated map of resource occupation periodically updated by the monitoring information.

At any moment end users can rank the consumables, subscribe to the provider channels created and managed by the DN (via RSS or Twitter for instance), recommend consumables to friends, endorse content in their social profiles (via Facebook for instance), and invite other friends to join the visualisation in the same instant of the clip where he is at.

During consumption, the DN has the ability to insert clickable advertisements to end users for pre, during, and post consumption. The decision on the specific advertisement to serve depends either on the CP, or on the business owner of the DN depending on the agreement with the CP.

3.3.3 User Story

SuperbTV Inc. is under pressure to increase its operating profits by increasing advertiser revenues, as well as reducing the operating costs at the same time. In order to cut operating expenses, SuperbTV has decided to switch from the conventional CDN provider to a lower priced DN which will represent a cost cut in its operations, e.g. by offering a unique flexible pricing scheme more adapted to its business model with its advertisers and brands (therefore less risky), value added features to boost visualisations, and extensive reporting.

An ENVISION-based DN can now provide the following benefits to SuperbTV:

- Delivering stored and live consumables in superb quality to end users in a highly efficient way such that the cost per GB is the smallest amongst competitors with a pre-agreed QoE.
- Support for very large files such as Full HD movies and non-stop live transmissions
- Automatic transcoding and content adaptation performed by ENVISION without the hassle of uploading a myriad of formats, resolutions and frame rates with the capability to limit the supported conversions
- Extensive reporting and logging for tracking of consumption times, resolutions, access networks, real QoE delivered, URL property problems etc.
- Geotargeting content to limit access to users from inside from a specific region
- Structured pricing propositions and detailed daily reports: pay per impression, pay per click, and ad-funded free accounts for small publishers
- Option for generating revenues by one click advertising inclusions with pre-established ad-networks
- Word-of-Mouth marketing by allowing users to recommend the content to their social network
- Raise instant awareness amongst users when new content is published via DN hosted channels

4. REQUIREMENTS

This section presents the requirements that are derived from the analysis of the use cases presented in chapter 3. These requirements are meant to capture the core features and design principles for multi-participant interactive applications that collaborate with the underlying ISPs through the CINA interface and are applicable to a wide range of use cases, irrespectively of any particular business models, application-specific requirements and infrastructure restrictions. The requirements regarding the specification of the interface itself, and the development of any particular technique at the application and network layers are addressed separately in the corresponding sections of D3.1, D4.1 and D5.1.

4.1 User, Application and Network Provider Requirements

1) The application should allow users to submit user generated content which may be live or pre-recorded, depending on the application.
2) The application should allow users to interact with one another and to distribute their content to as many other users who wish to consume it.
3) The application should allow the users to create and consume content through various access devices, including desktop computers, smart phones, PDAs, TV sets, etc.
4) The delivered service quality to the end user should be tuned according to user context, preferences, terminal capabilities and network conditions, as specified in a user profile and associated metadata.
5) The application must support without major disruptions frequent changes in consumer interest to particular content objects.
6) The application must scale to support large number of users creating and consuming high volumes of content located in unpredictable locations without excessive capital and operational costs.
7) The application that wishes to collaborate with the underlying ISPs should be free to choose how to make use of the offered information and network services in order to improve the quality for its customers and/or reduce the application capital and operational costs.
8) ISPs that wish to collaborate with the overlay applications should be free to choose which network information and services it will provide and under which conditions, in order to increase its revenue, improve the quality for its customers and/or reduce the network capital and operational costs within the restrictions of its infrastructure.
9) ISPs that wish to collaborate with the overlay applications should be free to choose how to make use of the offered information by applications in order to improve quality for its customers, better provision/configure its network and/or reduce operational costs.

4.2 System Requirements

1) The application should be able to make use of participant resources for content distribution, content adaptation and other supporting functions to enhance scalability and allow for cost-efficient application deployment.
2) The application should have the capability to ingest content with multiple data rates (bitrates) in a single layer coding, a scalable coding, or multiple description coding etc.
3) The application should adapt the content at the source before transmitting, or select a particular adaptation node (adaptation gateway) to perform this task.

4) Content adaptation may be undertakes at two epochs: at the service invocation phase and/or at the service delivery phase.
5) The creation of the overlay topology and the scheduling of data over the overlay links should be efficient and tailored to the optimisation objectives of the particular application, taking into account the relevant costs, resource utilisation and user satisfaction parameters.
6) The creation of the overlay topology and the scheduling of data should take into account the relevant importance of data for the decoding process, taking into account distortion and redundancy settings set by the encoding and forward error correction processes.
7) The management of metadata describing an application's participants, available content, offered resources etc. should scale efficiently with the number of items being described.
8) The application should be able to discover whether the ISP that corresponds to a specific node's IP address supports a CINA interface, how to connect to it and the particular capabilities, network information and network services that it offers.
9) The application should be able to communicate with the ISP to retrieve information about the network performance and the ISP preferences in order to improve the performance and efficiency of the application.
10) When the information provided by the ISPs does not cover the entire end-to-end path, or when it is not accurate enough, the application should be able to complement it with passive and active monitoring at the overlay layer.
11) The application should be able to create a consolidated view of the network performance and the preferences of the ISPs end-to-end, by combining the information it retrieves from the ISPs and the overlay monitoring processes, resolving any possible conflicts and inconsistencies.
12) The ISPs should be able to express their preferences and associated traffic treatment policies regarding traffic to/from particular local and remote end points, at particular times, for particular traffic volumes, etc., in alignment with their business objectives, cost models and operation practices.
13) The application should be able to gather information regarding the application traffic patterns at particular locations and provide it to the ISP to allow for a better optimisation of the network resources and offered services.
14) The ISP should be able to provide access to a set of network services including multicast, caching servers, high capacity servers, etc. in order to increase its income and/or control the traffic at particular inter- and intra-domain links, depending on the network conditions and the ISP's policies and optimisation objectives.
15) The application should be able to make use of the network services offered by the ISP in a flexible way, allowing the dynamic negotiation and invocation of resources when and where they are required, within the limits defined a-priori by the ISP.
16) The application must be able to assess the benefit of invoking a particular network service in terms of cost savings, improvements in the application performance and/or the satisfaction of its customers' QoE.
17) The ISP should be able to authenticate the application overlay nodes, authorise them for the subset of the offered capabilities according to the corresponding business agreements, and gather accounting information as necessary by the associated charging models.
18) Network layer optimisation algorithms should be able to estimate the gain in network performance from collaborating with applications using parameters such as:
    - Link and path metrics, including utilisation, packet loss, and queuing delay,

- Frequency, duration and severity of congestion events,
- Impact of load and congestion on the usage cost per resource, e.g. interdomain links, etc.

19) Overlay layer optimisation algorithms should be able to estimate the gain in application performance using resource utilisation and QoE parameters associated with the particular media it conveys, including parameters such as:

- Delay from the source to content consumers for live or interactive media,
- Content resolution, frame rate and distortion levels that can be received reliably by content consumers (given the constraints of their terminal),
- Application availability for new arrivals under heavy demand conditions, etc.

5. CATALOGUE OF BUSINESS ROLES

The use cases of chapter 3 have been analysed and broken down in a set of business roles in the industry required for the mentioned use cases to occur. The main business roles are later associated to different business entities depending on the business scenarios and interactions described in chapter 6.

Figure 5-1 depicts the roles described below, and the interactions between them.

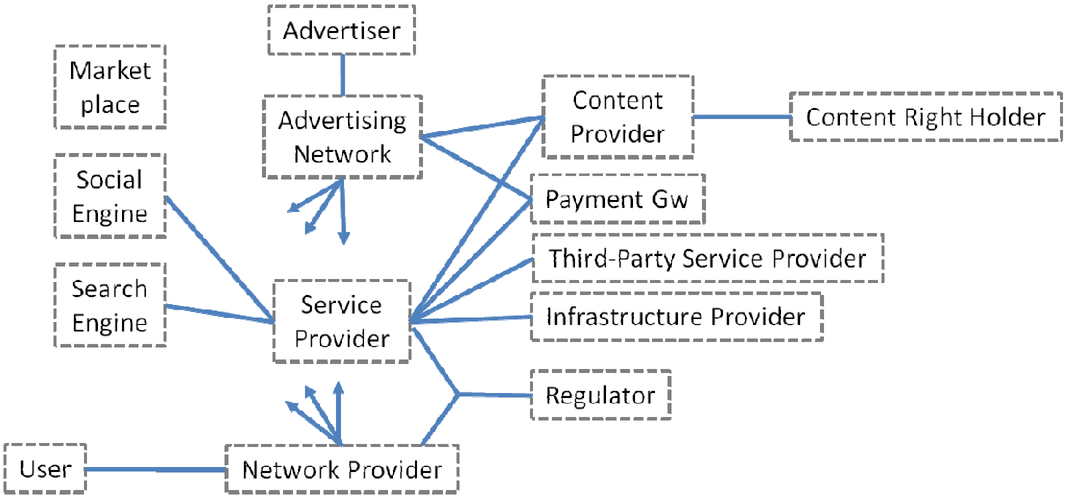


Figure 5-1: Business Roles

A business role defines a set of functions implemented by a business entity together with a set of interactions with other business roles. The main business roles relevant to ENVISION are:

- *User* – the participant in a networked media application. Users can have different roles within the context of a particular application, e.g. in a tele-conference application, a user can be the speaker of a conference session, the chairperson of a session, or a simple attendee.
- *Producer* – A conventional user or professional organisation that creates content and licenses it to *Content Rights Holders* or final under creative commons or similar license schemes. Examples: Alicia Keys, Paulo Coelho, end users clips, etc..
- *Service Provider* – the provider of the networked media application. The entity that implements this role interacts with the users, and manages the service (L4 and above) resources required to ensure that the application provides satisfying Quality of Experience to the users, in a cost-effective way for the service provider. It generates advertising inventory such as dedicated advertisement spaces in the screen of the end user. Examples: Skype, Gmail, etc.
- *Net*work Provider – the provider of the networking (L3 and below) infrastructure over which the networked media application operates, multi layer resources name resolution and addressing (such as DNS resolution and IP pool administration). This role interacts with the users to carry their traffic, and optionally with the service provider and/or directly with the users, to adjust the networking resources provided to the application. Network providers can be further distinguished into *Acc*ess Network Providers and Core Network Providers. It has the banking details of the users and charges them on a timely basis. It may generate advertisement space such as for instance in the form of advertisement block time after certain period of time of using the services. Examples: Orange, Telefonica, etc.

An ISP implements at minimum the role of the network provider. Thanks to its full access to the network infrastructure, an ISP is in an advantageous position to provide service infrastructure and other supporting functions to service providers. We model these additional roles as follows:

- *Infrastructure Provider* – the provider of dumb storage, hosting, processing resources, large amount of content processing and transformation, prepare content and data for distribution. Instead of pre-provisioning a sufficient pool of resources, a service provider uses the resources offered by an Infrastructure Provider, taking advantage of the flexibility of the associated SLAs. Examples of Infrastructure Providers are data centres, cloud computing providers, and GRIDs. Examples of companies developing these roles are like Amazon EC2 and Microsoft Azure.
- *Third-Party Service Provider* – the provider of a service other than the final networked media application and possibly associated with a pool of service and network resources. A service provider is expected to use third-party service providers to a certain extent, determined by its particular business strategy. Third-party service providers can be limited to supporting functions, e.g. content adaptation, NAT traversal, etc., or they can be functions more fundamental for the delivery of the final networked media application, such as CDNs. Examples of companies working in this roles are Amazon EC2 and Microsoft Azure.

Note that the Infrastructure Provider and third-party service provider roles are equally applicable to ISPs as to any other business entity that does not implement the role of network provider.

Finally, we have identified the following business roles with a significant impact on the cash flows or user experience in the ENVISION business environment:

- *Content Provider* – provider of media to be offered to users, through the networked media application. The content provider interacts with the service provider who makes the content available to the users. Example business entities in the role of content provider are film and TV programme production companies, networked game companies, or the users themselves. Examples of this companies working in this roles are for instance Buenavista International, United International Artist.
- *Content Rights Holders* – The provider of licenses to end users or content providers for viewing or distributing stored content. Examples of companies acting with these roles are 20th Century Fox, Universal, Music Business Group in UK, or SGAE in Spain.
- *Advertiser* – the provider of advertisement media to be interleaved with the content offered to the users. The advertiser plans, defines, executes, controls, reports, and pays ad campaigns that are delivered to end users in the form of ads via the ad network. The service provider might use information about the service and the users to target the advertisement to interested users. Examples: Dove, BMW, etc.
- *Advertising Network* – Aggregates advertising inventory space and re-sells it to advertisers with different business model schemes (PPC, PPM,…). Examples: Google Ad Sense.
- *Regulator* – an organisation responsible for monitoring and ensuring that network and service providers meet the industry standards with respect to services offered to users and to fair competition rules. Government regulatory bodies are typical Regulators. Might monitor as well the operators KPIs and quality parameters to ensure citizens satisfaction.
- *Search & Directory Engine* –cross service content indexing and caching content where users actively search for content. For instance Google Search, Torrentz, and Pirate Bay.
- *Social Engine* – popular landing page of users where any service can be triggered from. Provides end users with community related features such as community news updates, status publication, presence information, address book, content recommendation, cross service social functions (for instance providing access to the address book of the user according to privacy restrictions). ENVISION services might be often launched from the social engine pages. Generates advertising inventory.

- *Marketplace* (content retailers, B2B, and auctions) which connect buyers and suppliers and enable Internet transactions between them as well as bundled services such as advertisers on behalf of Service Providers or other users for goods or services which do not take title on. Provides functions such as: price fixation, sales transaction processing and co-ordination (auction for instance), payment clearance, transaction quality assurance, stock management, auction service.
- *Payment Gateway* – A trusted site by the end user that collects the payment details and charges the user for content or services served by the service providers, or social engine.

6. BUSINESS SCENARIOS AND INTERACTIONS

This section elaborates on the high-level business scenarios and interactions that are considered most representative of the applications and the problems addressed by the ENVISION project. The business roles of concern have been selected from chapter 5, therefore the application participants as users and as contributors of resources to the application, the network providers, and the service providers.

6.1 Scenarios Scope

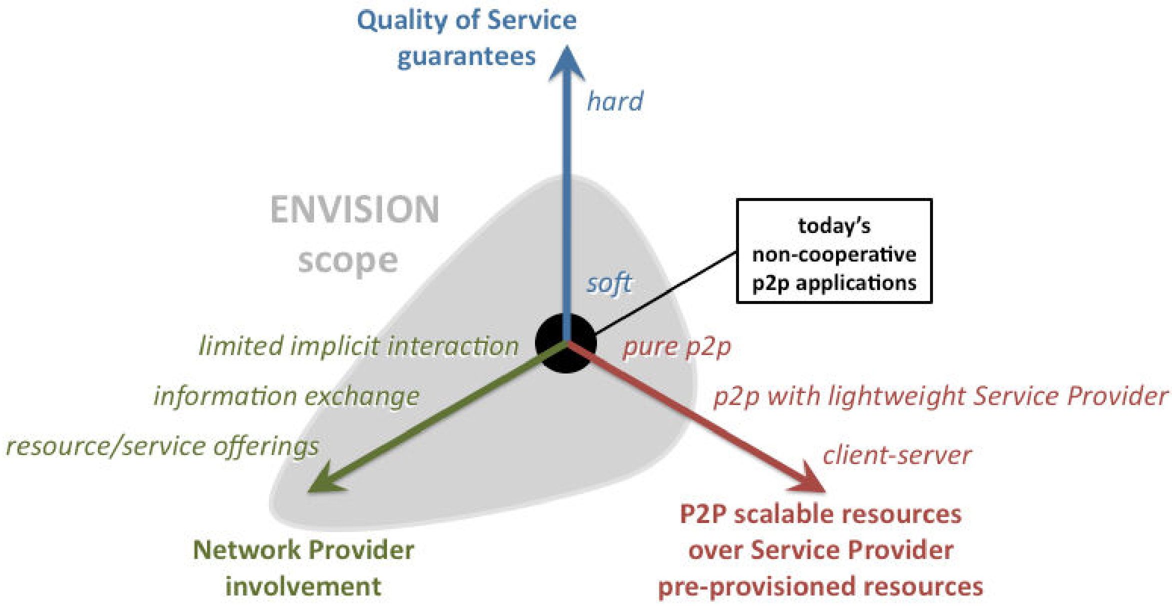


Figure 6-1: ENVISION Scope over the Basic Business Environment Spectrum

There are three fundamental dimensions that define the spectrum of the possible business scenarios, also depicted in Figure 6-1:

- *Quality of Service guarantees*: Different applications provide very different levels of performance guarantees to their users. Internet access is by default best-effort, while enterprise networks interconnected over the Internet typically require hard resource reservation to guarantee a certain level of throughput.

  The only way to provide hard guarantees is resource over-provisioning for subscription-based services. However, the future networked media applications ENVISION is targeting will be multi-participant open environments, where demand will be impossible to predict in volume and in geographical distribution, and access should not be limited by the restrictions of a-priori resource provisioning. Therefore, the scope of the applications considered in ENVISION does not cover applications that provide hard QoS guarantees to their users.

- *Service Provider resources*: At one extreme there are the pure peer-to-peer models, which assume that no resources are contributed to the overlay application by a service provider, and no central authority is responsible for the overlay application. At the other extreme lie the client-server applications, where all the resources building the overlay application are provided by a service provider which has complete control of the application. Between these two extremes, there are a number of alternative paradigms, where the service provider and the application participants both contribute resources to a certain degree. The Skype call service is an example of a lightweight service provider which contributes resources only for the presence part of the service and a limited number of NAT gateways and super nodes, and everything else is contributed by the application participants.

The future networked media applications considered in ENVISION cannot be supported in a scalable way relying solely in infrastructure resources provisioned by the service provider; engagement of participant resources is considered essential. For this reason the client-server model and other service provider paradigms that heavily rely on pre-provisioned resources are considered out of scope.

- *Network Provider involvement*: In today's Internet, network providers interact with the overlay applications only implicitly, by the congestion control mechanisms of TCP, or through the controversial tactic of Deep Packet Inspection and bandwidth throttling. One can imagine however that the network providers and the applications have incentives to explicitly interact and co-operate in different levels, ranging from mere exchange of information about the network capabilities and dynamic conditions and the application demand distribution and quality requirements, to more tight collaboration, where the network provider might volunteer resources and network services that can be beneficial for both the application and the network, or offer such services at a certain fee to the application.

  While a number of proposals in the past (e.g. Parlay, IMS) have explored interfaces with the network providers for invoking resources and services, they all focused in services with hard or statistical QoS guarantees always assuming a service provider entity and no incentive for the network provider other than receiving cash payments. More recent proposals like ALTO and P4P are investigating interfaces to exchange information with the application, without any considerations of more active involvement from the network providers. ENVISION will investigate the full range of possible degrees of involvement of a network provider.

6.2 Scenario 1: Pure Peer-to-Peer & Mutually Beneficial Resource/Service Offerings by the Network Provider

In this scenario the application is the collection of the participant resources and any additional resources or services that the network provider and possibly third-party service providers are willing to provide to the application for free or on an advertisement-based revenue scheme. The difference with today's peer-to-peer applications lies in the explicit co-operation between the peer-to-peer application and the network provider, to exchange information and to invoke resources and services to their mutual benefit.

This scenario is based on a virtual world access application like Google Earth. For simplicity we eliminate the option of users interacting with each other, allowing only for navigating the virtual world and progressively retrieving the available content.

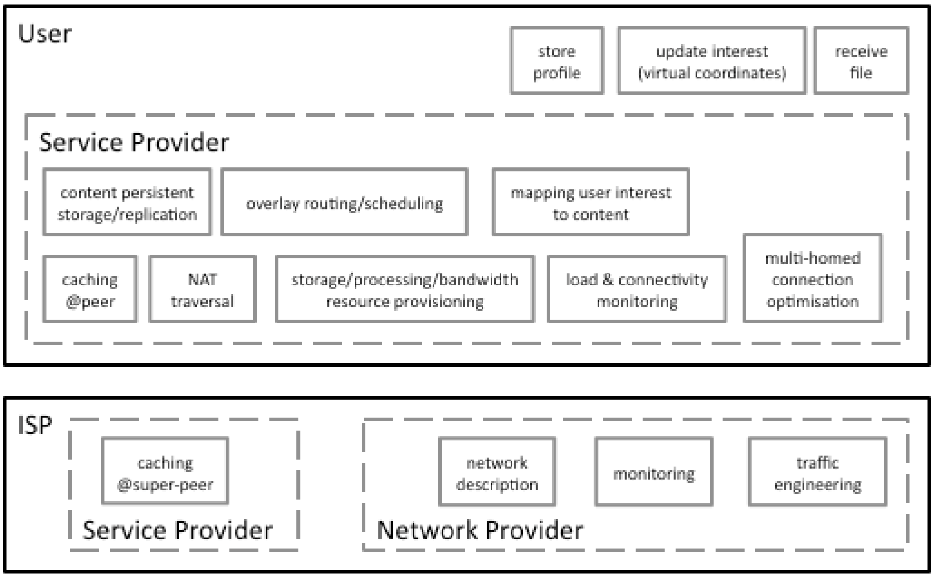


Figure 6-2: Peer-to-Peer and Thin ISP Business Scenario

The users run the application, through which they communicate with other users to discover and retrieve the available static content. The application supports the necessary functions to persistently store the content under churn conditions, to provide the content discovery infrastructure, and to optimise the content retrieval, through efficient allocation of resources, content caching and content distribution mechanisms. To this end, the users, or an elected subset of the users, communicate with the ISP to retrieve information about the network conditions and to provide information about the application traffic demand.

The ISP provides static and dynamic information about the network, and uses the traffic demand information from the application to improve the performance of the traffic engineering functions. The ISP may choose to transparently contribute caching super-peers to the application, to improve the traffic distribution on its network.

6.3 Scenario 2: Lightweight Service Provider & Full Range of Resource/Service Offerings by the Network Provider

A service provider entity is assumed, contributing a small part of the required infrastructure resources mainly for the required supporting and coordination functions, e.g. authentication, authorisation and accounting, or resource management functions. The participant users contribute their upload bandwidth, storage and processing resources to improve the scalability of the application. When more resources are required to maintain a good level of quality, in addition to mutually beneficial offerings, other possibly expensive and specialised resources and services are offered by the network provider, on the basis of a charging model agreed between the network and the service providers.

Consider an application where the content is provided both by a content provider, and by the users generating live video with their cameras distributed across a focal point, which defines the viewpoint of the video feeds. Other users in the role of content consumers receive the video feed(s) best matching their static profile and their dynamic selection of viewpoint.

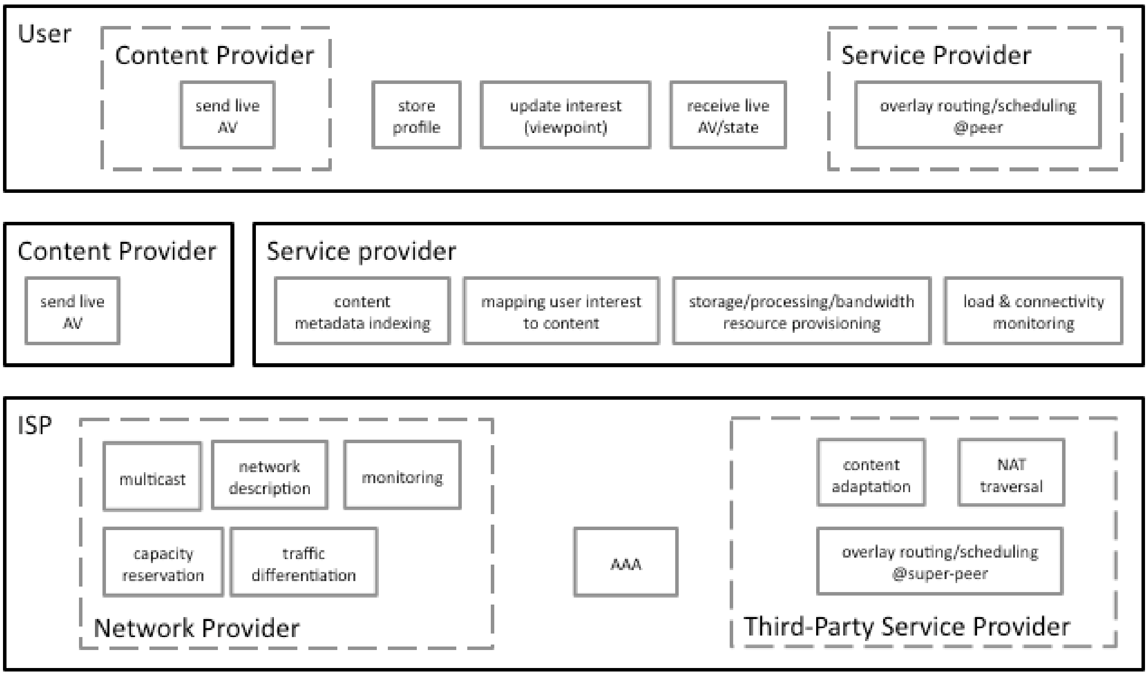


Figure 6-3: Service Provider and Thick ISP Business Scenario

The service provider keeps track of the available content sources and the interest of the content consumers, and coordinates the allocation of user and ISP provided resources based on the current content demand and monitoring information on server load and network state.

The ISP enables the use of multicast addresses, traffic differentiation and capacity reservation by the service provider based on the terms and conditions captured in the corresponding SLA and enforced through the AAA function in the ISP. In addition to these L3 (network provider) functions, the ISP provides third-party services to the service provider, namely content adaptation servers, NAT traversal gateways for the users, and super-peers participating in the content distribution overlay.

Finally, the users also participate in the content distribution overlay, offering their upload bandwidth to re-distribute the content they receive to other users acting as content consumers.

The resources contributed by the users are considered part of the service provider, as this comes with the application user agreement (as in the case of Skype for example), and there is no explicit SLA for making use of these resources. In the case of the resources contributed by the ISP however, there is an explicit agreement authorising the service provider to use these resources, hence the ISP acts in the role of third-party service provider.

7. ENVISION SYSTEM ARCHITECTURE

7.1 High Level Architecture

7.1.1 Overview

In this section, we describe the overall functional architecture of our system (Figure 7-1). As it is a functional architecture, we do not specify if the building blocks are centralised or distributed (being on specific nodes or end-users node themselves), nor we give recommendations about how implementing them (grouping some blocks together in the same server or distributing them), etc. The architecture is rather defined to understand the functional blocks that are required, for achieving which role, which interfaces between them, etc. It was designed to meet the requirements for the expected cooperation between the entities taking part in the content distribution, the end-users, the overlay and the underlying network. A set of fundamental functionalities for this cooperation was identified and the interfaces between them properly defined. As for the underlying network, being composed of Autonomous Systems (AS) each on its own, we identified a network level with a managing functionality for the overlay under the charge of the willing-to-cooperate ISP. The cooperation was identified as providing information and services and processing requests reciprocally. Such a level of cooperation demands security mechanisms for Authentication, authorisation and accounting facilities. At the overlay level, this cooperation requires an information sharing functionality. The end-users are traditionally represented while the new services that offer opportunities for QoE enhancement such as content adaptation and that could be provided by any entity e.g., third party service provider enforce their place in the architecture. Finally, the major functionality resides with the overlay management end-to-end functionality. The interfaces were defined after studying meticulously the interactions between these functionalities delimited into blocks in the architecture.

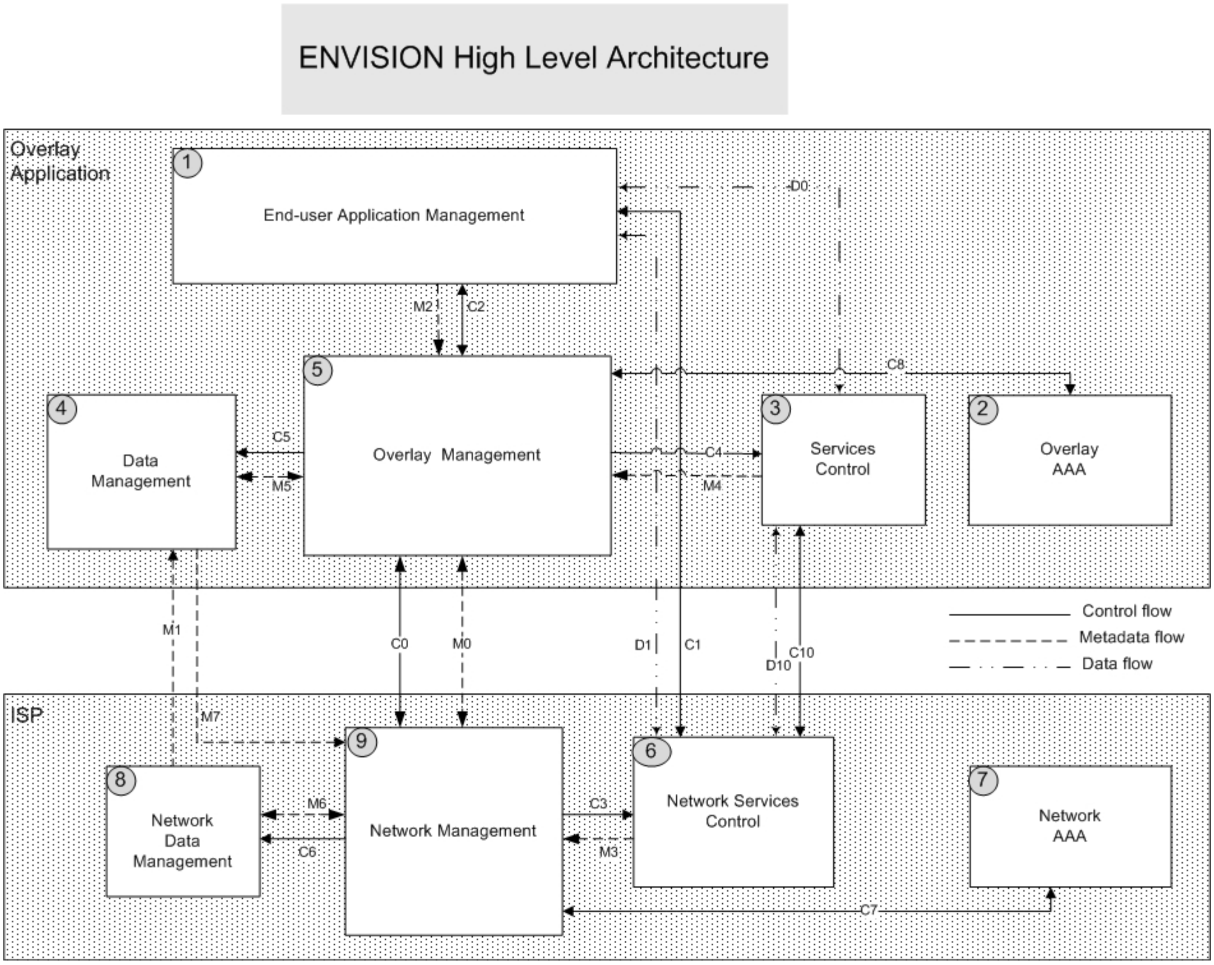


Figure 7-1: High Level Architecture Overview

7.2 Functional Blocks

7.2.1 End-user Application Management (1)

The End-user Application Management is the entity providing the functionalities for the user-side. It implements the procedures allowing the end user application to:

- Connect to the overlay application
- Exchange information and negotiate with the Overlay Management functional entity about:
  - The content of interest
  - The end-user terminal capacities
  - The user preferences and interests
  - The user resource contribution to the overlay (adaptation of content, storage,…)
  - The connection quality (delay, loss-rate,…)
- Manage the transmission and reception of the content
- Control the terminal connectivity (P2P, multicast, multipath,…)

This entity is implemented within the user terminal and interacts with the Overlay Management through interfaces C2 and M2. Interface M2 is used for carrying metadata information while C2 is used for the command primitives.

7.2.2 Overlay AAA (2)

The Overlay AAA is the functional entity that performs the authentication, authorisation and accounting functions of the application users and under some business scenarios of third-party providers on behalf of the application.

In the context of the content distribution applications considered in ENVISION, the application users may act as content consumers or content providers and different AAA procedures may apply in these two cases. Further, in the context of the scalable multi-participant applications, the application resources may be provided by a combination of application provider, user, third-party provider and network provider resources. The Overlay AAA functions undertake the authentication, authorisation and accounting required at each of the above cases.

The Overlay AAA functionality can be summarised as follows:

- user AAA functions:
    - profile management for the users registered with the application
    - authentication of content consumer and content provider terminals accessing the application from ad-hoc locations, or server sites against a set of predefined credentials, or using ad-hoc authentication means, e.g. assigning a unique identifier based on the terminal public IP address
    - authorisation of authenticated users to act as content producers based on predefined profiles and application access rights
    - authorisation of authenticated users to consume content generated by any producer, or following specific DRM restrictions associated with each available content item
    - tracking of the application resources spent for the distribution of the content produced per content consumer to allow for calculating associated billing information
    - tracking of the content consumed and the application resources spent per content consumer to allow for calculating associated billing information
- resource provider AAA functions:
    - profile management for the third-party providers and the users that have registered with the application their availability to provide application resources
    - authentication of user terminals accessing the application from ad-hoc locations, or server sites against a set of predefined credentials, or using ad-hoc authentication means
    - authorisation of authenticated users and third-party providers to provide resources to the application that may entail replicating content subject to DRM
    - tracking of the resources provided to the application per user or third-party provider, to allow for the calculation of credits in case of reciprocation incentive schemes for the users, or to verify billing by third-party providers

The Overlay AAA function runs at the application layer and interfaces with:

- the Overlay Management function for AAA and profile management

7.2.3 Services Control (3)

The Services Control functional entity controls and executes all the supporting services required for the processing and distribution of the content. Examples of such services include:

- content persistent storage

- content caching
- content uploading and relaying
- content adaptation to lower bitrate formats to allow access by heterogeneous access means
- content personalisation and ad-insertion
- active and passive overlay network monitoring
- application-specific processing e.g. serialisation and conflict resolution for shared editing applications, multi-player game session consistency coordination, etc.

Depending on the particular business scenarios, these services can be provided by a combination of different business entities: the application provider itself using dedicated application infrastructure, third-party infrastructure providers e.g. cloud services, or the application participants themselves.

Depending on the type of content processing and distribution service, the Services Control functional entity may be responsible for allocating user requests to service nodes, for communicating with the user and other service elements involved in the data path or being controlled by the Overlay Management entity which federates the user requests and the distribution requirements before requesting services from the SC entity which control the service execution and data forwarding, for executing the service and finally for gathering and reporting data regarding the performance and the quality of the services.

The Services Control function runs at the application layer and interfaces with:

- the Overlay Management function for issuing notifications regarding the operation of the services and for receiving authorised user requests and instructions to change the operation parameters of the services
- the End-user Application Management function to exchange data plane messages
- the Network Services Control to exchange control and data plane messages

7.2.4 Data Management (4)

The Data Management functional entity is responsible for managing network and application related information, required for the operation of the application itself and for the optimisation of its mechanisms against the network conditions. Examples of such information include:

- network information
  - information regarding the capabilities, network service offerings and conditions, etc. of the ISPs where the application users or the application infrastructure nodes are located
  - network performance information like delay and loss statistics across the domains of the underlying ISPs or end-to-end across the overlay network
- application resource information
  - information regarding the capabilities and application supporting services and related conditions of third-party providers and the application participants
  - information regarding which content item is available at which service node
  - supporting service performance information like message overhead and QoE gain associated with particular service nodes
- content information
  - metadata regarding any unique content item available through the application, e.g. the original source format, the content producer, the contained information, etc.

- metadata regarding the interest of application users to content, any particular restrictions or preferences regarding the content format etc.

The Data Management functional entity ensures the persistent storage of all the required information, allows for registering information as well as actively gathers information from other entities, and provides mechanisms for sophisticated and efficient access to the collected data.

The Data Management function runs at the application layer and interfaces with:

- the Overlay Management function for registering and providing data regarding the operation of the application and for controlling the information required by and exported to external business entities
- the Network Data Management function for retrieving data regarding the capabilities of the ISP and network performance information
- the Network Management function for providing data regarding the requirements and traffic demand of the application

7.2.5 Overlay Management (5)

The Overlay Management functional entity is responsible for interacting with the users, the network providers and the third-party providers to control and optimise the application operation.

The Overlay Management functions control the amount of resources and the types of supporting network and application services required for the optimum operation of the application. Depending on the user demand, the Overlay Management will decide to activate/deactivate resources, to invoke network and application services from the ISP and/or from the third-party providers, to increase the incentives provided to the users to contribute their own resources to the system, etc. The objective of the Overlay Management function is to optimise the balance between the QoE experienced by the users and the cost associated with resource and service consumption.

The Overlay Management functions also ensure that a given set of active resources and services are used in an optimum way. This entails controlling at a high-level how to distribute these resources between different functional entities at the application, different overlay networks dedicated to the distribution of different content items, or different locations.

The Overlay Management function runs at the application layer and interfaces with:

- the End-user Application Management function to receive and respond to requests for accessing the application and specific content items
- the Overlay AAA function for AAA and profile management
- the Data Management function for registering and providing data regarding the operation of the application and for controlling the information required by and exported to external business entities
- the Services Control function for receiving notifications regarding the operation of the services and for forwarding authorised user requests and sending instructions to change the operation parameters of the services
- the Network Management function for issuing requests for the use of network services, responding to requests from the network regarding the traffic generated by the application and exchanging associated information

7.2.6 Network AAA (7)

The Network AAA is the functional entity that offers the authentication, authorisation and accounting services. It resides in the network part and is responsible for holding information related to:

- Overlay applications for:
    - Authenticating overlay applications aiming at using the developed interface to communicate with the network
    - Providing authorisation agreements for the overlay application to access the network information and services
    - Managing security procedures for information exchange
    - Managing overlay applications profiles
    - Handling charging information
- Network services
    - Managing services profile
    - Handling Services accounting information

This functional entity is hosted and managed by the underlying network. It interfaces with:

- Network Management (9) through C7 for AAA and profile management purposes.

7.2.7 Network Data Management (8)

The Network Data Management functional entity is a subsystem responsible of collecting and managing network and overlay related information. It provides functions for:

- Data collection, filtering and storage
- Managing access levels for the network and overlay functional entities
- Updating storage, filtering and management policies
- Data management (e.g. keeping track of relevant information)
- Data thresholds monitoring and notifications support

The Network Data Management is hosted at the underlying network. It interfaces with the following entities:

- The Network Management (9) through M6 for data exchange and C6 for policies update purposes.
- The Data Management (4) for exporting network related information.

7.2.8 Network Services Control (6)

The Network Services Control (NSC) is the functional entity responsible for the implementation of mechanisms and procedures executing policy-based network services. NSC provides the following functionalities in the network:

- Resource allocation for upstream and downstream traffic
- Multicast support and management
- Network status monitoring

- Caching services support
- Transcoding and stream adaptation services support
- Policing of incoming and outgoing traffic
- Services execution monitoring
- Unicast and multicast admission control

The NSC resides at the underlying network. It is proper for each network bringing together a number of functionalities supported by the hosting network, e.g. multicast, caching…

NSC interfaces with the Network Management through:

- M3 interface for exporting collected information
- C3 interface for policies configuration purposes

7.2.9 Network Management (9)

The network management (NM) is the first contact point for an overlay application within an operator’s network for any expected cooperation through the CINA interface. It is functional entity in charge of the coordination of the whole set of actions provided by the network. It implements the system intelligence at the network level for processing, deciding and controlling. There are different tasks assigned to the NM entity:

- Data collection from the overlay DM entity, the NSC entity and the NDM entity
- Data analysing and processing
- Management algorithms execution
- Overlay messages processing
- AAA mechanisms support
- NDM entity control
- NSC entity control
- Providing data to NDM
- Interconnection function

The management algorithms implemented within the NM entity represent the intelligent procedures that define the actions to be undertaken for optimising the system. The decisions are defined depending on the network and the overlay contexts materialised through the data provided by the overlay, by the monitoring mechanisms at the NSC and the stored data at the NDM. The NM entity is hosted and controlled by the network operators as it is responsible for the network management. In addition it is expected to support AAA procedures.

7.3 Interfaces

This section details how the previously described functional entities are connected to each other. The protocols and communication procedures are not defined yet. However, you will find a description of the data exchanged between the entities and the direction of the connection. The system interfaces can be divided into three main types:

- Metadata interfaces
- Control interfaces
- Data interfaces

7.3.1 Metadata Interfaces

The metadata interfaces are intended to provide a connection between two functional entities in order to forward descriptive information about the context, condition or characteristics of a function, an entity or a system.

7.3.1.1 M0: Network Management <=> Overlay Management

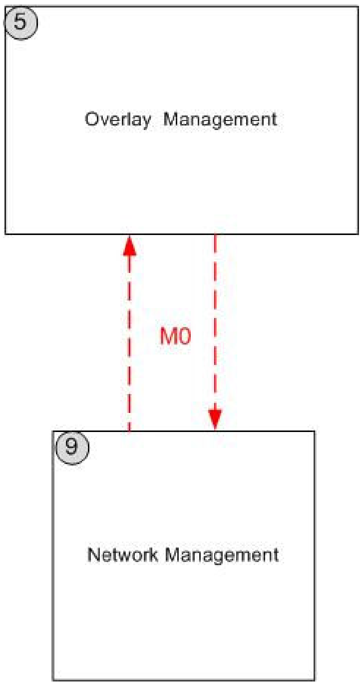


Figure 7-2: M0 interface

The M0 interface connects The Overlay Management functional entity to the network Management one. It is used to convey information directly between both entities in both directions. Additionally security procedures could be applied to this interface as it connects entities belonging to independent systems. This kind of procedures could be negotiated during the first handshake or even later in the process.

7.3.1.1.1 OM to NM

The information provided by the OM to NM through this metadata interface could be classified as follows:

- Pre-authentication information: This allows the OM entity to provide the NM with initial information about the overlay application until the AAA procedures went through successfully and a connection is established with the Data Management entity. A non-exhaustive set of information that could be communicated to the NM could contain the number of users, the streaming technology, the content characteristics, the overlay state, etc.
- Delay stringent information: The interface could be used to transport information of importance that can't stand further delay. A typical example of this kind of information is partial failure of the overlay connections within the network.
- Backup information: Typically when the NM fails to establish a connection with the DM entity, the M0 interface could be used as a backup interface until the problem is solved.

7.3.1.1.2 NM to OM

The M0 is used by the NM to provide symmetrical information to those described within the previous section 7.3.1.1.1. For the backup scenario, the interface is used when the connection between the

Network Data Management entity and the Data management entity fails. In this case, the NM takes over to provide the expected data to the OM.

7.3.1.2 M1: Network Data Management => Data Management

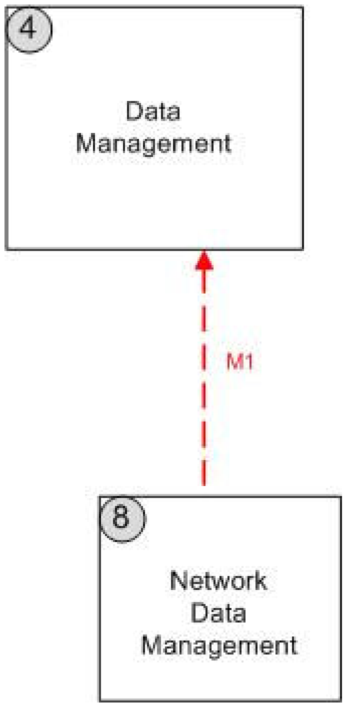


Figure 7-3: M1 interface

The M1 interface links the Network Data Management entity to the Data Management entity. It is a one-direction link used to transport data describing the network context. Like the M0 interface, M1 is a link between functional entities in separate sub-systems, thus requiring extra procedures relevant to the security matters including authentication, confidentiality, integrity, etc. Information conveyed through M1 is divided into two main categories:

- Authorisation information: This information indicates to the DM entity the minimum authorisation level required to get access to the corresponding data. As the DM is an entity accessible to different separate subsystems, the authorisation information provides means to protect data confidentiality.
- Network information: This data provides a description about the network context. It can be divided into different categories:
    - Network services: it provides information about the services made available by the network to the overlay (e.g. multicast, adaptation...)
    - Network topology:
        - Network topology at the granularity the ISP wants: e.g. know bandwidth, delay between access routers of its network, etc.
        - Number of hops between access routers
        - Loss packet ratio
        - Peering agreement with others ISPs (AS Number)
        - Cost for links between access routers

- Network state: this data provides information about the network dynamic state. A non-exhaustive set of information includes link loads, equipment charges, etc.

7.3.1.3 M2: End-User Application Management => Overlay Management

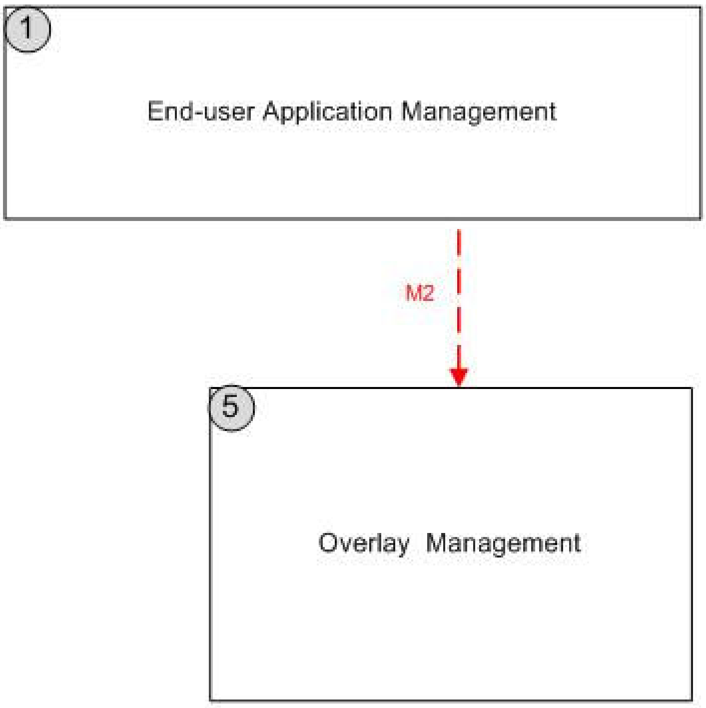


Figure 7-4: M2 interface

The M2 metadata interface links the End-user application management to the Overlay Management. It is a one-direction link used to convey data describing the terminal characteristics, the client preferences and the content characteristics.

7.3.1.4 M3: Network Services Control => Network Management

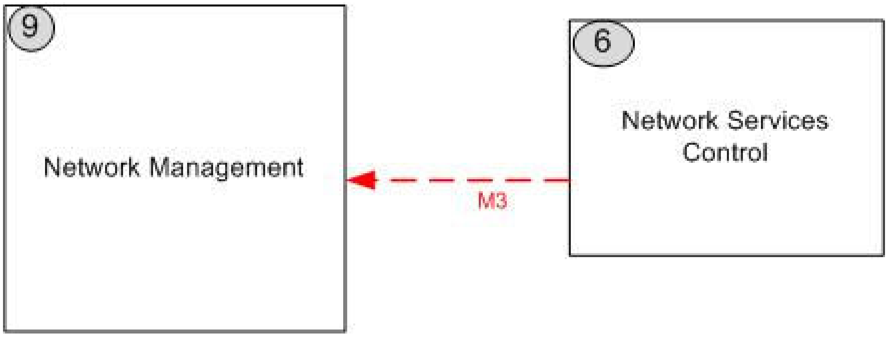


Figure 7-5: M3 interface

The M3 metadata interface connects the Network Management and the Network Service Control entities. It is a one-direction link used to convey data describing the network and the services context. This interface is intra-operator meaning some features related to security or authorisations are not necessary. M3 conveys the following categories of information:

- Network state: This data is collected by the monitoring process executed at the NSC. It provides information about the network real-time state.

- Services availability: it contains information about the available services in the network (e.g. multicast, caching, etc.). It provides also a description of each service, including for example domain of usage, supported number of users, etc.
- Services states: this information allows the NM entity to get a feedback about the executed services state.

7.3.1.5 M4: Services Control => Overlay Management

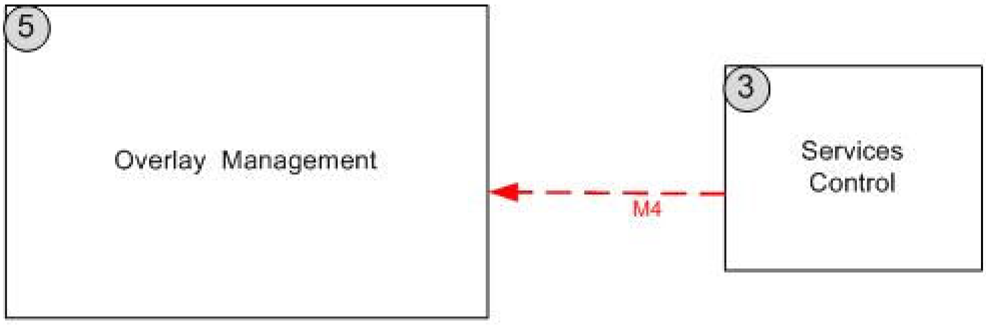


Figure 7-6: M4 interface

The M4 metadata interface is a one-directional interface from the Services Control to the Overlay Management functional entity. Depending on the business model, this interface may be internal to the application provider, between the application provider and the application users, or between the application provider and third-party service providers. M4 conveys the following types of information:

- Statistical performance data regarding the execution of the services
- Notifications when the load or other metrics at a particular resource or service node reach a high or an low threshold set by the Overlay Management through C4
- Updates regarding the availability of the services at particular times and locations

7.3.1.6 M5: Overlay Management <=> Data Management

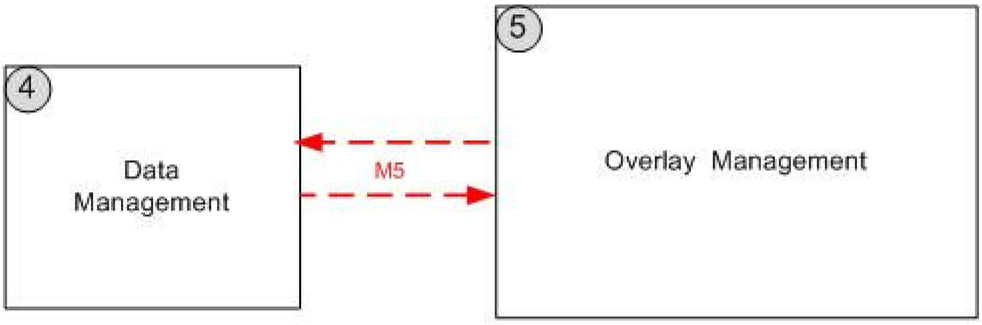


Figure 7-7: M5 interface

The M5 metadata interface is a bi-directional interface between the Overlay Management and the Data Management functional entities. In the typical business scenario, this interface is internal to the application provider. However, it is not impossible to consider a case where the data management functionality is also outsourced to a third-party provider, given that security considerations are addressed appropriately.

7.3.1.6.1 Overlay Management to Data Management

The Overlay Management registers data with the Data Management function. These data may include:

- Performance statistics from the execution of the services
- Availability of resources and service nodes
- Activation/deactivation of application users
- Creation or withdrawal of content items with associated metadata, and subsequent metadata updates
- Updates regarding the interest of each application user to particular content and their restrictions and preferences for accessing this content
- Availability of content at particular formats and at particular locations

7.3.1.6.2 Data Management to Overlay Management

The Overlay Management retrieves data from the Data Management function. These data may include:

- All the information registered by the overlay management function, filtered, combined and aggregated with any applicable rules, e.g. number of users interested at a particular content item accessing the application from a particular location
- Information regarding the capabilities and the network services offered by the ISPs
- Network performance information e.g. delay, loss, throughput at particular ISPs or end-to-end across the overlay links

7.3.1.7 M6: Network Management <=> Network Data Management

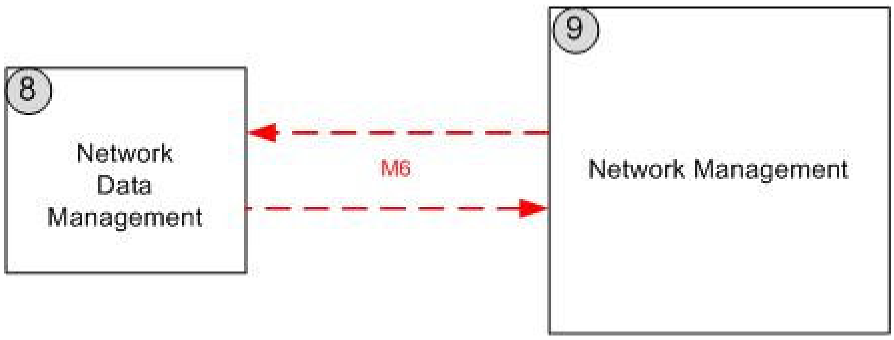


Figure 7-8: M6 interface

The M6 interface links the Network Management entity to the Network Data Management entity. It is used to transport data in both directions. It allows both entities to share information about the network and the overlay contexts. Like the M3 interface, M6 is an intra-operator interface not requiring excessive security and checking mechanisms.

7.3.1.7.1 NM to NDM

M6 allows the NM entity to send different types of information to NDM:

- Network state: this information originally provided by the NSC is processed and filtered at the NM entity. It is then associated to an authorisation level and sent to NDM
- Network services availability and states: like the network state information, it is processed at the NM before to be conditioned and sent to NDM

- Overlay context: this information is originally provided by the DM entity. It is processed and analysed at the NM level to help the decision process then it is filtered to be sent to DM. This allows the NM to store relevant data about the application overlays and have a base experience for prediction processes for example.
- NM logs: this information contains a description of the NM entity execution. It includes information about the decisions made by the NM management algorithms, the information taken into account, etc. It includes also the logs about the overlay application connections made with the NM.

7.3.1.7.2 NDM to NM

The NDM entity provides NM entity with information it holds through M6. There is no restriction or access level for NM. It can obtain the whole set of information:

- Network context: all the information relative to the network topology, state and services
- Overlay context: all the information relative to the overlay topology and state
- NM logs

7.3.1.8 M7: Data Management => Network Management

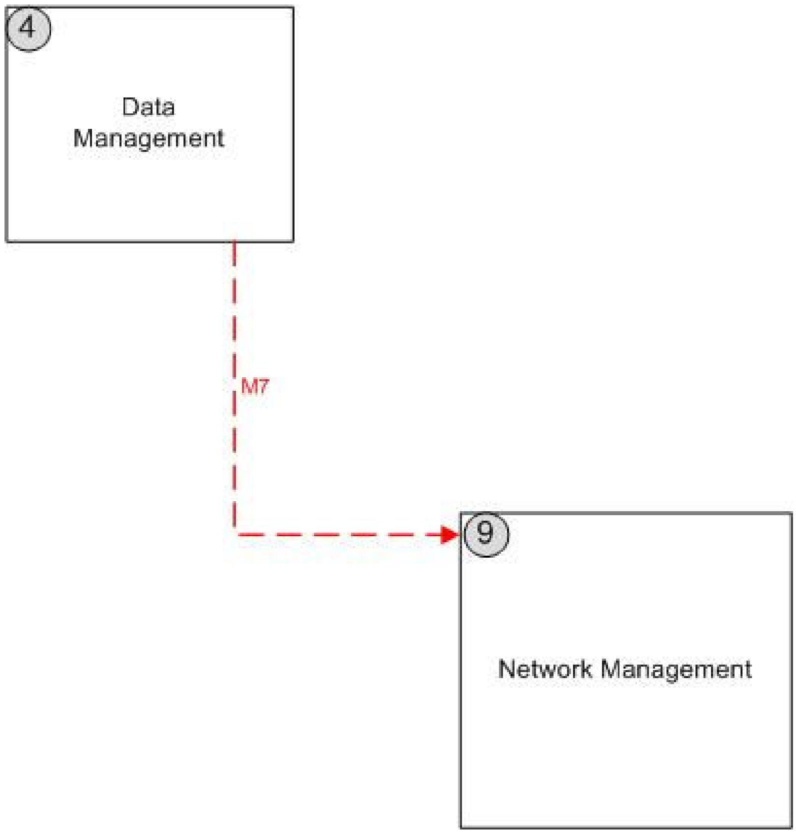


Figure 7-9: M7 interface

M7 interface links the DM entity to the NM entity. It is one direction link used to convey data providing information about the application overlay to the network. The interface is secured using adequate procedures as it is a cross-subsystem connection. The data that is downloaded from the DM to the NM can be classified into different categories:

- Stream characteristics: to provide information about the data distributed by the overlay application (e.g. encoding standard, bitrate, etc.) and its delay constraints (conversational, live, VoD, etc.)

- Distribution context: to provide information about the distribution scheme at the overlay. Such information could be subdivided as well:
  - Topology: to provide a description of the overlay topology (e.g. multicast, peer-to-peer, client-server, etc.). In case of a combination, the topology could be detailed in subdomains
  - Audience: to describe the nature and number of the overlay clients by providing their types of connectivity, their repartition, etc.
- Distribution feedback: to provide information about the application clients QoE.

7.3.2 Control Interfaces

Control interfaces are offer connections between the system functional entities to transport information relative to the configuration and the execution of the functions provided by those entities, e.g. signalling messages, command primitives, control procedures, etc. Practically control interfaces could use the same media as the metadata interfaces. By media we mean any protocol or link used to convey the information relative to an interface. However functionally, they target a different usage.

7.3.2.1 C0: Overlay Management <=> Network Management

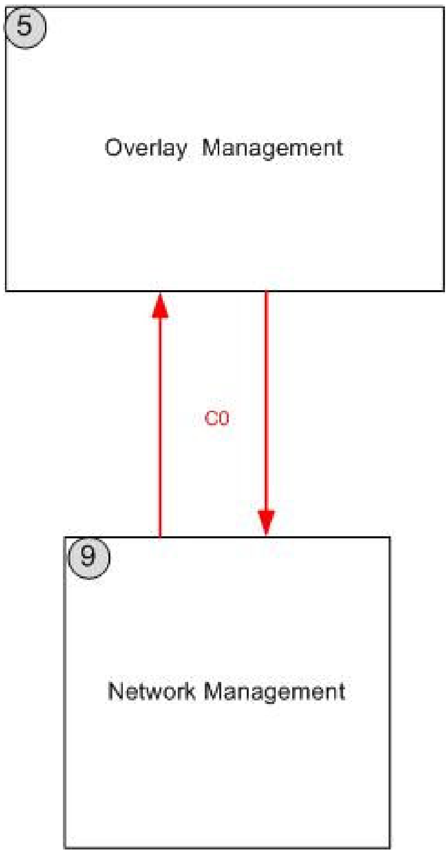


Figure 7-10: C0 interface

The C0 interface connects the Overlay Management functional entity to the Network Management one. It is used to convey messages directly between both entities in both directions as depicted in Figure 7-10. Additionally security procedures could be applied to this interface as it connects entities belonging to independent systems. This kind of procedures could be negotiated during the first handshake or even later in the process.

7.3.2.1.1 OM to NM

This interface is used for different types of procedures:

- Authentication procedure: the overlay applications use the C0 interface to send a connection request with NM entity. The information and the mechanisms required for the authentication of the overlay applications are out of the scope of this document. The NM relies on the Network AAA functional entity to process the authentication of overlay applications and load their profile.
- Control procedures: allows the OM to send requests for negotiating the session parameters with the NM. Parameters relative to other sessions are negotiated through this phase as well, e.g. sessions between DM and NM. Those procedures could be called even session establishment if there is need to renegotiate parameters.
- Transaction procedures: allows the OM to send request to negotiate with the NM any transaction relative to the stream distribution. An example of transaction procedures are network services execution (e.g. enabling multicast), specific resource allocation, etc.

7.3.2.1.2 NM to OM

The C0 is also used by the NM to execute the same procedures as those described within the previous section 7.3.2.1.1. Symmetrically:

- The network sends authentication information to the overlay application in order to fulfil the handshake mechanism.
- The parameters are negotiated between both parties through the control procedures.
- Transaction procedures are used to answer the processed overlay application requests and send network requests to the overlay application if there is a need to.

7.3.2.2 C1: End-User Application Management <=> Network Services Control

The C1 interface connects the End-user Application Management entity and the Network Services Control entity. This interface is used for conveying configuration procedures between both entities in both directions. When it happens that the end-user application is using a network service, e.g. multicast, an exchange of messages is required to establish successfully the multicast session between the network equipment and the end-user device. This signalling is forwarded through the C1 control interface.

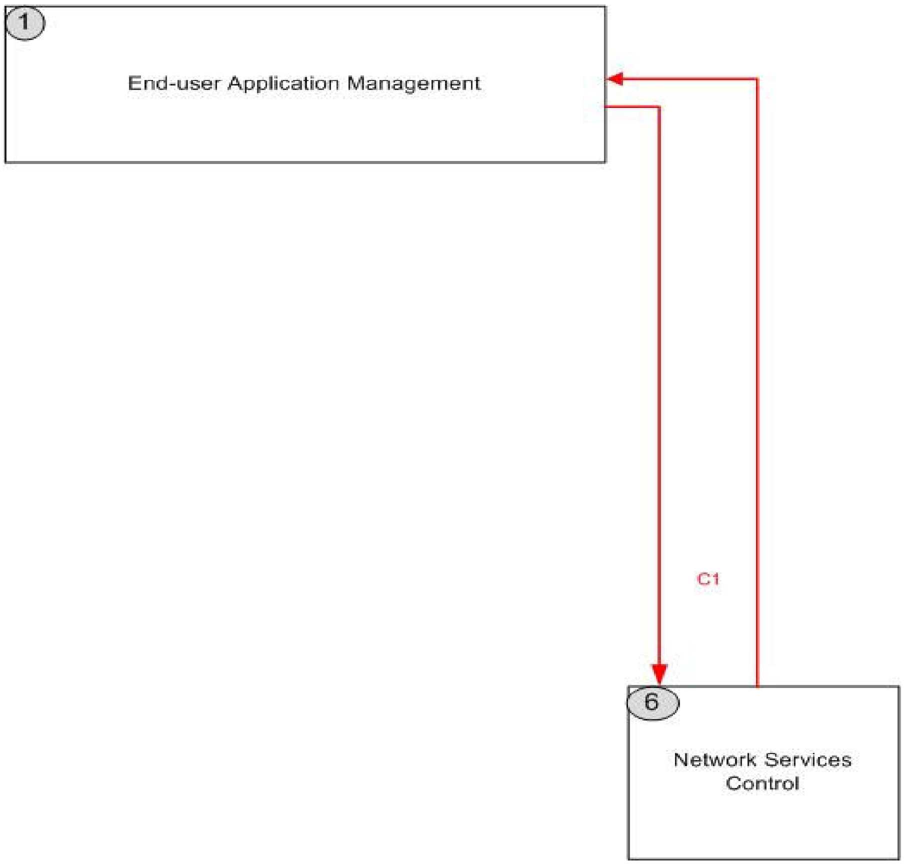


Figure 7-11: C1 interface

7.3.2.3 C2: End-User Application Management <=> Overlay Management

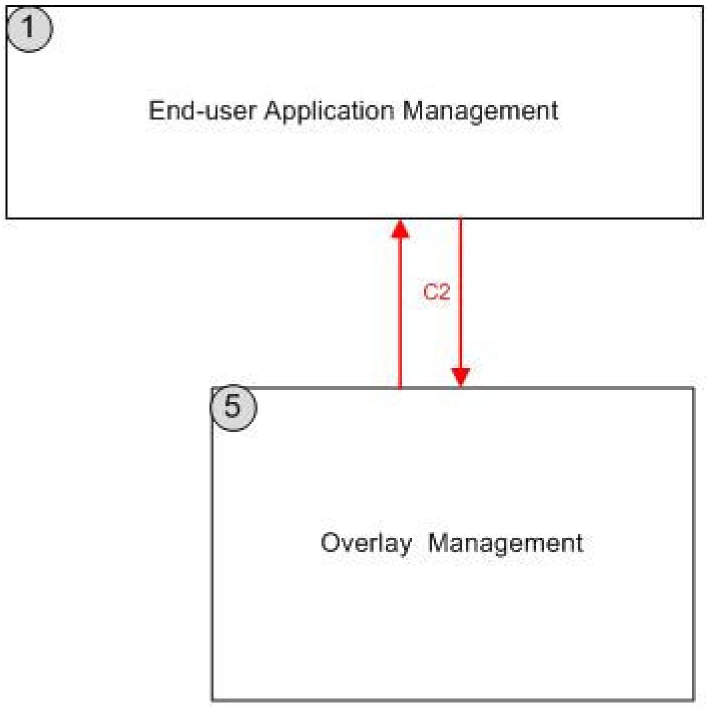


Figure 7-12: C2 interface

The C2 interface links the EAM entity to the OM one. It is used for forwarding control procedures in both directions. It allows the OM to communicate to the EAM the set of actions to be executed to meet the decisions made by the overlay including

- Content upload configuration: to define the uploaded content characteristics (bitrate, quality, FEC mechanisms, etc)
- Overlay connectivity : to define the terminal connectivity to the overlay (e.g. P2P, multicast, etc)
- Terminal status : to define the terminal status in the overlay (e.g. switching to super-peer)
- The distribution protocol procedures : the classic procedures used by the application for defining the content distribution (e.g. the list of peers, …)

The EAM uses the C2 interface for communicating to the OM the primitives matching its requirements (e.g. switching to a different content, requesting another list of peers, etc).

7.3.2.4 C3: Network Management => Network Services Control

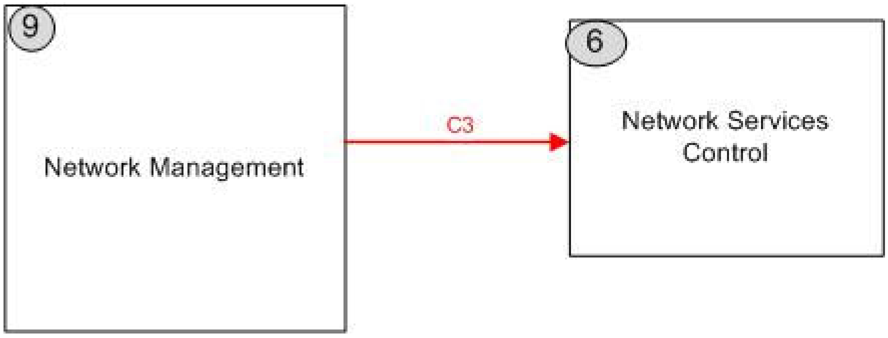


Figure 7-13: C3 interface

The C3 interface links the NM entity to the NSC one. This interface allows NM to forward control primitives to the NSC in order to configure the network services execution. These procedures could be divided into different categories:

- NSC configuration: allows the NM to configure the NSC functions, e.g. the periodicity of the monitoring reports, the thresholds for alert notifications, etc.
- Network administration: to send new policies defined by the HN to the NSC relative to the traffic management, e.g. adding new routes
- Service control: allows the NM to send primitives to configure the service execution (e.g. setting up a multicast tree for a subdomain)
- Enquiry primitives: allow the NM to send request to the NSC for a specific task, e.g. enquiring about a cache server load or a peering link load, etc.

7.3.2.5 C4: Overlay Management => Services Control

The C4 control interface is a one-directional interface from the Services Control to the Overlay Management functional entity. Depending on the business model, this interface may be internal to the application provider, between the application provider and the application users, or between the application provider and third-party service providers.

The Overlay Management function, responding to changes in demand by the application users and to changes in the network conditions, it communicates with the Services Control function in order to:

- forward authorised user requests that require invocation or modification on the operation of a particular service

- activate or deactivate resources and service nodes allocated to a particular service at a particular location
- modify the parameters of operation of the Services Control function to adjust to the current user demand and network conditions, e.g. dedicate more resources to the distribution of a given content item or a given location
- modify the thresholds for notifications sent back to Overlay Management regarding the load levels and the performance of the services

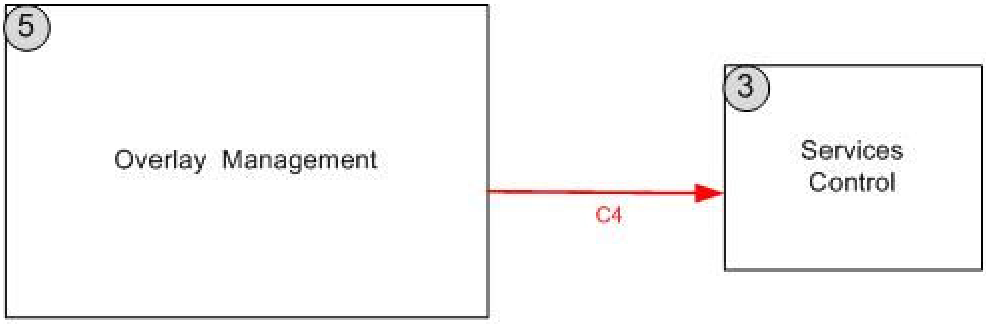


Figure 7-14: C4 interface

7.3.2.6 C5: Overlay Management => Data Management

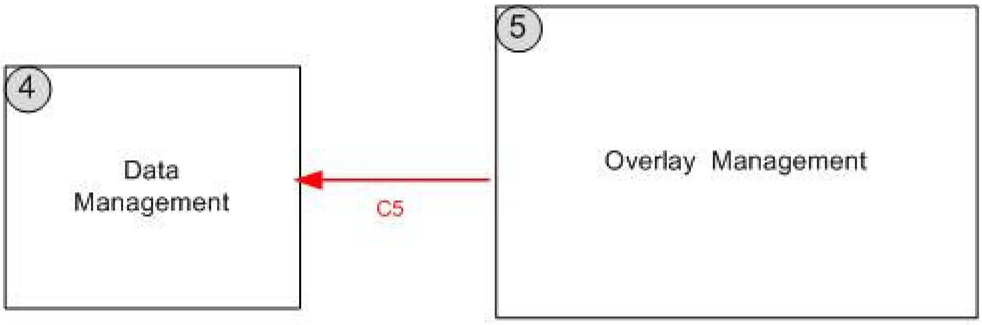


Figure 7-15: C5 interface

The C5 control interface is a one-directional interface from the Services Control to the Overlay Management functional entity. In the typical business scenario, this interface is internal to the application provider. However, it is not impossible to consider a case where the data management functionality is also outsourced to a third-party provider, given that security considerations are addressed appropriately.

The Overlay Management function communicates with the Data Management function in order to:

- activate or deactivate resources and service nodes allocated to data management to ensure the efficient operation following the growth of the application and associated data management needs
- determine the locations, frequency and granularity of network performance information gathered by the Data Management function
- determine the restrictions to application information that can be exposed by the Data Management function to external business entities

7.3.2.7 C6: Network Management => Network Data Management

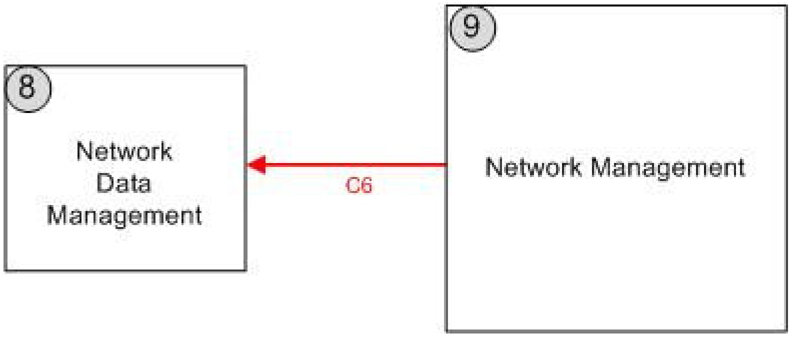


Figure 7-16: C6 interface

The C6 interface links the NM entity to the NDM entity. It allows the NM to control NDM. The main procedures supported over this interface are:

- Data access control: allows the NM to define the data the NDM is allowed to provide to NM entities through interface M1.
- Data processing and storage policies: allows the NM to define the policies for the data processing and storage by NDM, e.g. logs Time-To-Live (TTL).
- Data retrieve: provides mechanisms to allow the NM to send requests to the NDM to retrieve data

7.3.2.8 C7: Network AAA <=> Network Management

The C7 control interface is a bi-directional interface between the Network Management and the Overlay AAA functional entities. It is used to convey the control primitives for executing the security procedures relative to the authentication of the application, the encryption of the data, etc.

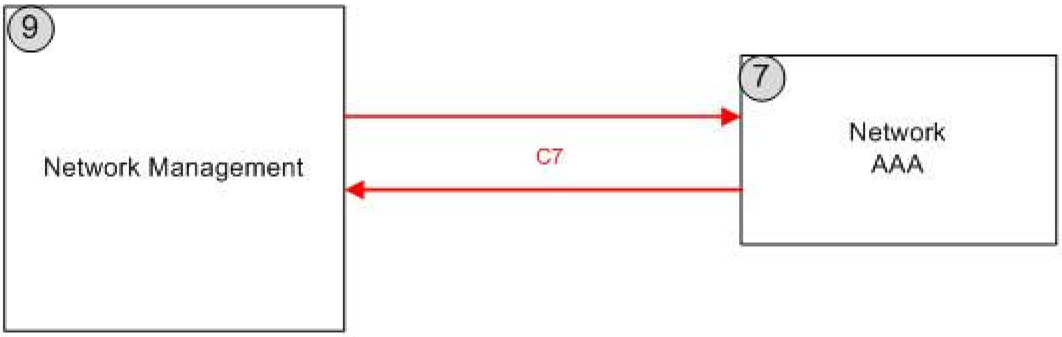


Figure 7-17: C7 interface

7.3.2.9 C8: Overlay AAA <=> Overlay Management

The C8 control interface is a bi-directional interface between the Overlay Management and the Overlay AAA functional entities. In the typical business scenario, this interface is internal to the application provider.

7.3.2.9.1 Overlay Management to Overlay AAA

The Overlay Management function communicates with the Overlay AAA function in order to:

- add, remove and update the profiles of the application users and third-party providers
- authenticate users and third-party provider service nodes
- authorise users to distribute their content using the application, or to consume available content

- authorise users and third-party providers to provide resources for processing and distributing particular content items

7.3.2.9.2 Overlay AAA to Overlay Management

The Overlay AAA function communicates with the Overlay Management function in order to:

- track and possibly limit the application resources spent for the processing and distribution of content per content consumer and content provider
- track and possibly limit the resources used per third-party provider or application user acting as a resource provider

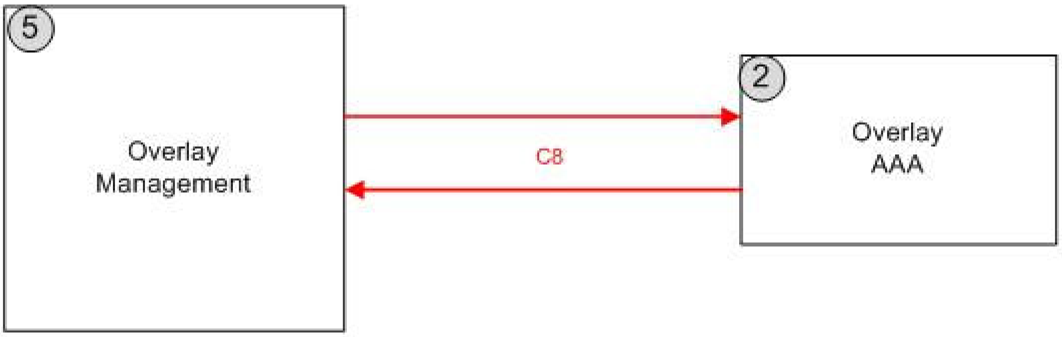


Figure 7-18: C8 interface

7.3.2.10 C10: Services Control <=> Network Services Control

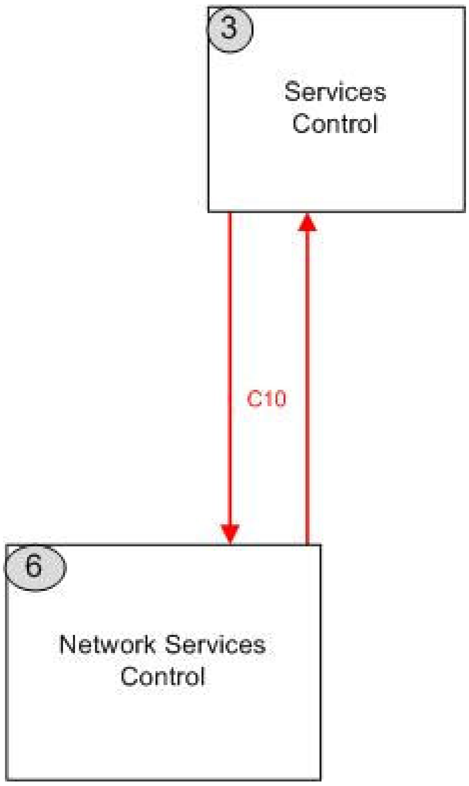


Figure 7-19: C10 interface

The C10 interface connects the Services Control entity and the Network Services Control entity. This interface is used for conveying configuration procedures between both entities in both directions. When it happens that the SC entity executes a service taking part into the overlay distribution topology and is using a network service, e.g. multicast, an exchange of messages is required to establish successfully the multicast session between the network equipment and the device hosting the overlay service. This signalling is forwarded through the C10 control interface.

7.3.3 Data interfaces

7.3.3.1 D0: End-User Application Management <=> Services Control

The D0 connects the End-user Application Management to the SC entity. It is used for conveying the data distributed within the overlay between the end-user device and equipments or terminals offering services being exploited by the overlay.

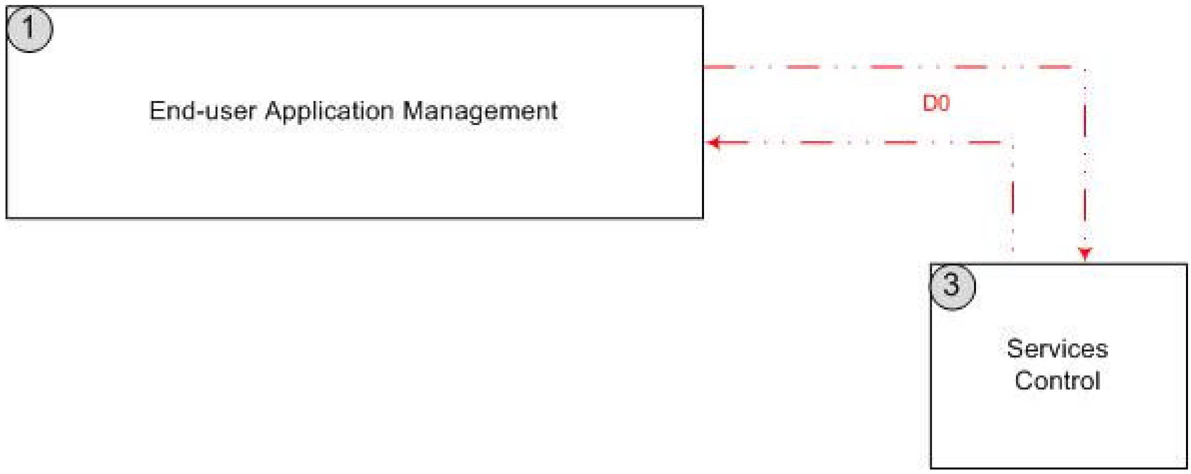


Figure 7-20: D0 interface

7.3.3.2 D1: End-User Application Management <=> Network Services Control

The D1 interface provides a connection between the NSC entity and the EAM one. It is used for conveying the data distributed within the overlay between the end-user device and its access network(s).

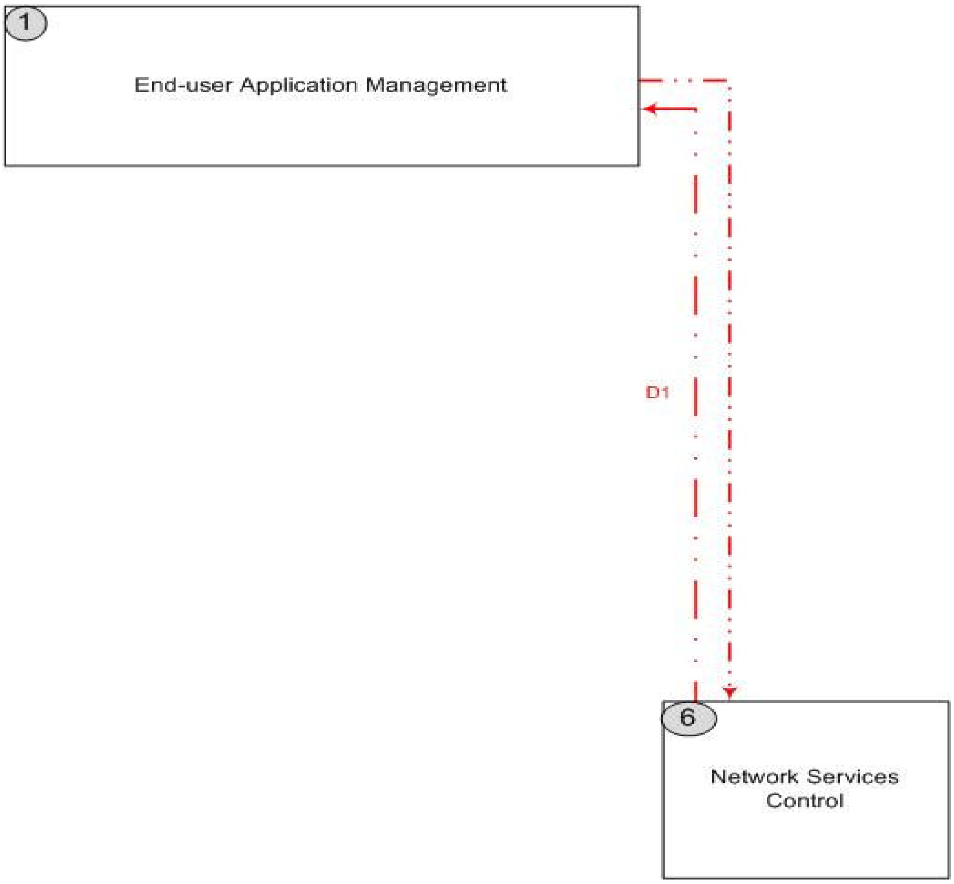


Figure 7-21: D1 interface

7.3.3.3 D10: Services Control <=> Network Services Control

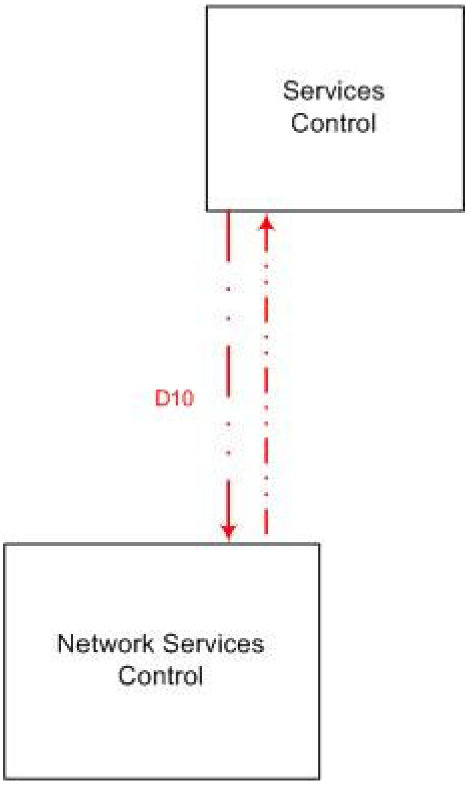


Figure 7-22: D10 interface

The D10 interface provides a connection between the NSC entity and the SC one. It is used for conveying the data between the device hosting an overlay service taking part into the data distribution within the overlay and its access network(s).

7.4 Interaction with multiple ISPs

7.4.1 Multi-ISPs architecture

The following figure shows the ENVISION high level architecture with two ISPs and the interfaces between each ISP and the overlay functional blocks. Facultative interfaces between the Network Services Control functional entity and some overlay functional entities were not depicted for better readability.

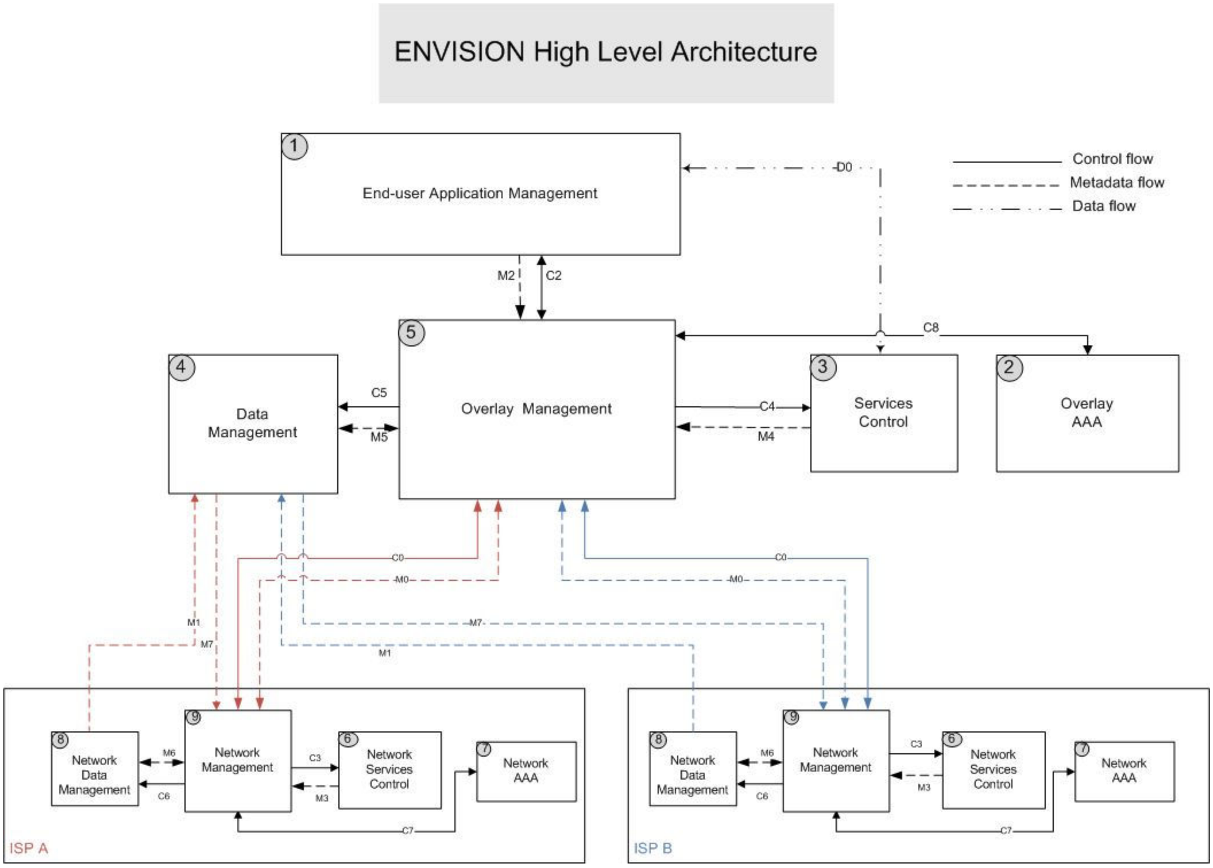


Figure 7-23: High Level architecture multi-ISPs

In Figure 7-23, the interfaces M1, M7, M0 and C0 representing the ENVISION interface are depicted for each interface between ISP A and the overlay and similarly between ISP B and the overlay. The Overlay Management functional block is the entity responsible for managing the interactions with the different underlying ISPs, e.g. ISP A and ISP B in the figure. It negotiates the collaboration scheme with each ISP and defines the procedures engaged in the collaboration process.

It could be the case that an ISP is not willing or able to provide any service to the overlay, i.e. the ISP is going to collaborate with overlay only by means of exchanging information. In this special case, information, procedures and command primitives related to the network services discovery and invocation are disabled for the interfaces M0 and C0 with the corresponding ISP.

7.4.2 Managing non-collaborative ISPs

It is expected that some ISPs are not capable of collaborating with the overlays through the CINA interface by exchanging information or providing network services. In this case, it is the responsibility of the Overlay Management functional entity to run specific procedures for overcoming this problem. Depending on the scenario, different actions could be decided by the overlay.

To better illustrate the overlay initiatives, we consider the representative scenario of Figure 7-24. The figure shows an overlay with presence over 6 Autonomous Systems (AS) of different levels: 3 Tier 2 networks (ISP 2 and 4 and AS Transit) capable of offering transit service for the Tier 3 networks. Among these networks, ISPs 1 to 5 are ISPs providing connectivity to end-users or business customers. The networks shaded in red are not willing to collaborate with the overlay application through the CINA interface while the others shaded in green are.

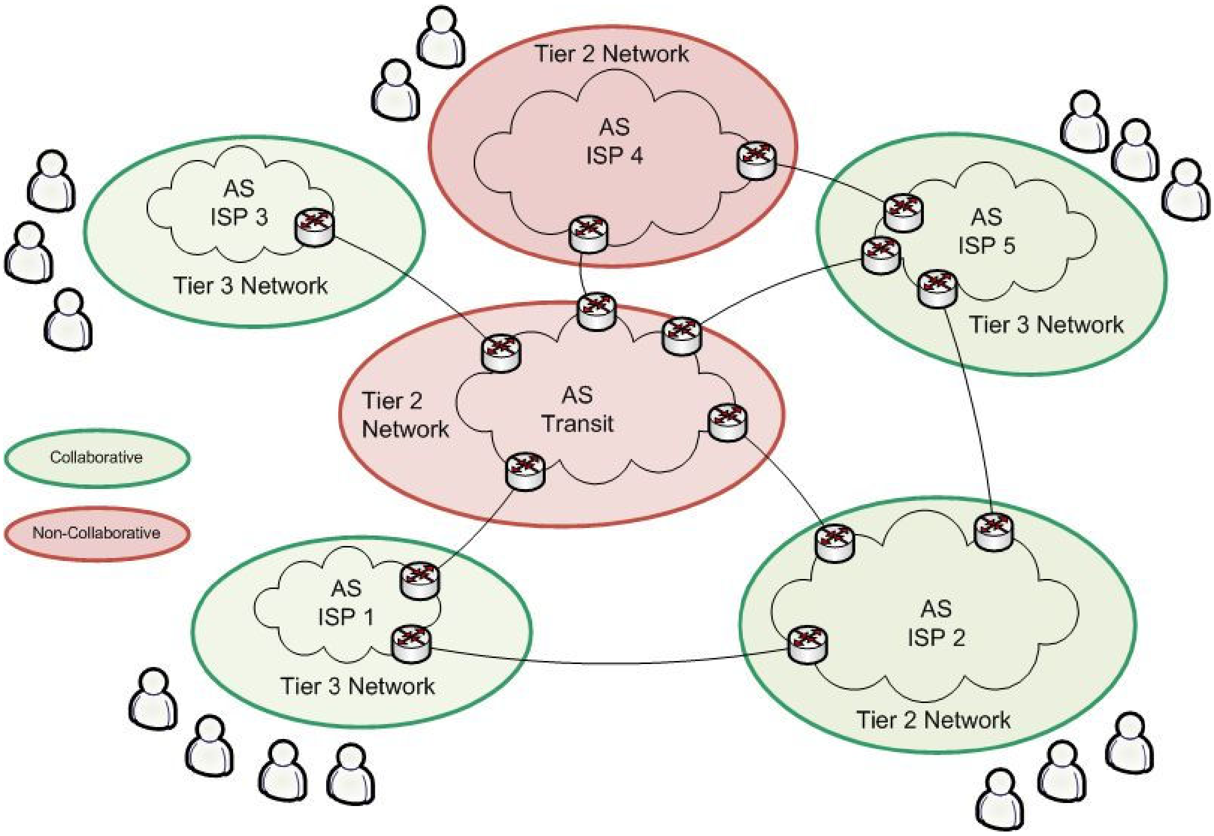


Figure 7-24: Multi-ISPs overlay with collaborative and non-collaborative ISPs

In this scenario, the overlay collects information from ISP 1, 2, 3 and 5 where it does have clients. It collects information about the peering between the different networks from the information provided by the collaborative ISPs. In order to proceed with a consolidated overlay view, the application takes further measures to deal with non-collaborative networks.

- Empiric measurements: the application executes when possible different end-to-end measurements between non-collaborative ISPs and collaborative ones to estimate the link quality of the available routes to those ISPs.
- Peering policies consultation: the application could analyse the peering policies and route recommendations made by ISPs to infer information about the noon-collaborative ISPs.
- Available network consultation: the application could probe end-users to seek if they have the possibility to connect to other networks.

Depending on the collected information, the application could make relevant decisions such as:

- Network choice advice: when different networks are available for the end-user to choose, the application could recommend the collaborative ones to choose or to switch to.

- Traffic routing: whenever possible, the application could define specific destinations and routes to be used for the content distribution.
- Service invocation: whenever possible, the application could decide to request services in order to rectify the lack of collaboration of certain ISPs or networks and enhance the overall QoE of the application users.

8. ECONOMIC MODEL

This section presents the results of the economic analysis conducted in order to identify and validate feasible revenue flows and the business strategies to ensure the profitability of ENVISION-enabled services. In order to conduct the analysis, an economic model of two sided markets has been constructed. Logistic and Bass models where initially evaluated as possible candidates, but discarded because of the missing -or seldom accepted- methodology on how to incorporate competing services.

A Two sided market is a relatively new concept in the study of Economics. In microeconomics, the most relevant papers about this concept are [ARMS05, TIRO03, ROSO05, RYSM04, WRIG04]. In such a market, two groups of agents interact with each other via a common network platform, the value in participating in the network for agents in one group, depends on the number of participants from the other group.

Two sided markets model have been ported to the ENVISION domain as depicted in Figure 8-1.

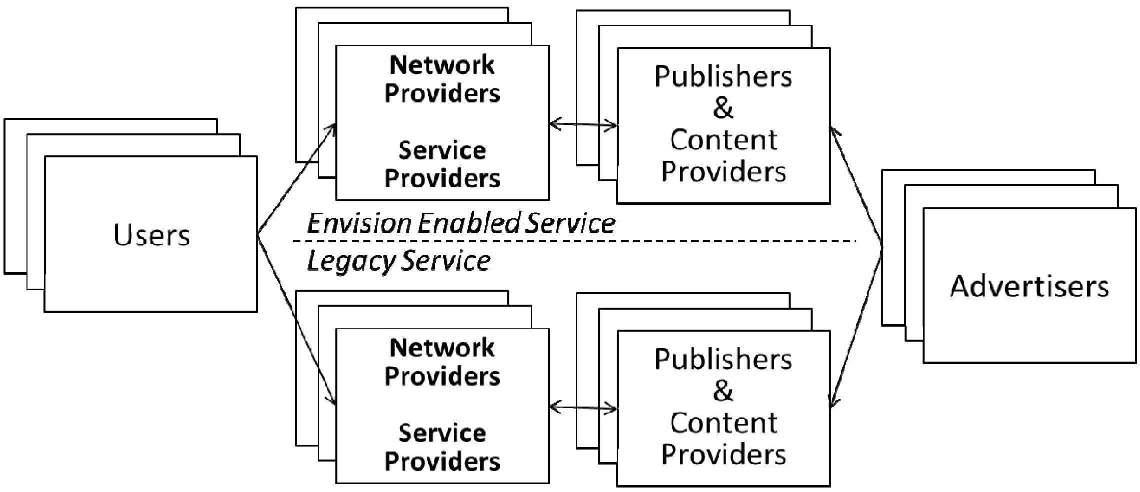


Figure 8-1: Two sided markets model in ENVISION

The two most challenging use cases from a business perspective – Web 3D Conference and Bicycle Race – have been simulated as brand new services competing with well-established players using two sided markets. The Web 3D conference application use case, has been analysed in comparison to Second Life and the Bicycle Race application has been compared to Facebook (not a competitor but a substitute preventing the adoption of new entrants). The use cases' economic feasibility has been assessed, and evaluated to the extent that the ENVISION-enabled technologies being researched are vital and could truly enable a new ecosystem of future Internet services to come.

In addition, a sensitivity analysis has been conducted to, in the first place, provide strategic guidance to business planners regarding the market and actor behaviours that play a critical role in determining business feasibility, and secondarily, to identify the business requirements/guidelines to facilitate feasibility and sustainability of the envisioned overlay services.

The economic research conducted in ENVISION has been focused on providing market insights to the project's researchers as well as potential business owners of future innovative services leveraging on ENVISION-enabled applications. The research aims to quantify the complex dynamics of two sided competitive markets foremost in Internet and Telco services.

Strategic recommendations, revenue streams, type of expenditure, and feasible business models have been identified and documented in the following sections. State of the art economic analysis techniques have been adopted, implemented, and evaluated to provide as much knowledge and guidance as exists today in order to guide the research and business planning of ENVISION-enabled services. Although it may be argued that the selected parameter values may differ, e.g. the absolute quantity of forecasted users and publishers, the underlying market trends identified, quantified and used below for business model estimation are indicative of the interest of publishers and the community of users.

8.1 Economic Model and Analysis Methodology

8.1.1 Introduction: Dynamic versus Static analysis

The approach of this work (similarly to [SUN06, TSE02] differs from the usual models in network economics and two sided market literature, which use static equilibrium models [TIRO03]. These models rely on the “fulfilled expectation” concept, which may not be realistic. The differences in the modelling approach also lead to different perspectives and insights.

Conceptually, the theory of two-sided markets is related to the theories of network externalities and of multi-product pricing. From the former, it borrows the notion that there are non-internalised externalities among end-users. From the latter, it borrows the focus on the price structure and the idea that price structures are less likely to be distorted by market power than price levels. The multi-product pricing literature, however, does not allow for externalities in the consumption of different products.

As a starting point to the analysis, it is important to distinguish between usage and membership fees. The platforms’ usage or variable charges have an impact on the willingness to trade for both sides, and thereby on their net surpluses from potential interactions. On the other hand, the membership or fixed platform charges condition the end-users’ presence on the platform. The design of the detailed structure of variable and fixed charges is relevant only if the two sides do not negotiate away the corresponding usage and membership externalities [TIRO03].

Though the assumption of “fulfilled expectation” or “perfect foresight” model is a convenient way of modelling network effects in a static equilibrium model, there are examples in the video games industry and others where it appears to be incorrect. [SUN06] presents several examples of incorrect expectations, not only by ordinary consumers, but also by professionals such as industry analysts, or corporate senior executives, among others. If professional forecasters and executives could are incapable of forming correct expectations, it is unrealistic to assume that ordinary customers would perform any better. Therefore, rather than focusing on the analytical determination of equilibrium outcomes, the present work focuses on the sequential modelling of agent decisions. It is assumed that agents make their decisions on what they have seen in the market, rather than what they expect to see in it. In our model, agents will make adoption decisions on the basis of the actual size of the network, rather than on its expected future size.

We cast the model as a dynamical system where the decisions of an agent in the current period is based on the actual network size in the preceding period. Thus, the positive feedback loop across the two sides of the market is modelled in an explicit and sequential way. The long-term behaviour of the dynamical system, or its steady state (if it exists) is analogous to the equilibrium concept in the static modelling approach.

Because of the reliance on the “fulfilled expectation” assumption, most works in the relevant literature explain the *chicken-and-egg* and *winner-takes-all* phenomena in terms of varying agent expectations on the size of the relevant network platforms. For example, if agents share a widespread belief that no other agents will join a given network, they will be reluctant to do so themselves, and no agents will join that network in the end. Therefore, expectation management is one of the most important strategy recommendations arising from this modelling approach.

On the other hand, dynamic approaches do not rely on expectation. Instead, it is assumed that agents make their decisions based on what they have seen in the market. They follow a sequential adoption process in which some people may join the network early and some people may join late. These timing adoption dynamics are not a result of agent heterogeneity, but of random factors such as incomplete information, technical constraints, and adoption inertia.

The use of dynamic approaches provides a different set of insights, when compared with the fulfilled expectation models. Fist, the *winner takes all* phenomenon is explained by the tendency of participants to single homing, in contrast to the fulfilled expectation models which attribute its cause to varying participant expectations. As a result, instead of advising network service providers to manage expectations, it suggests taking actions to change the behaviour of participants and caution in entering a single-homing market at all.

Introducing a two sided market framework into the traditionally one sided diffusion model has important implications. One is the possible presence of the *chicken-egg-problem,* an inherent characteristic of two sided markets. To attract some business participants to join a network, it is necessary to attract enough user participants first; but to attract some user participants, there must be enough publisher participants on the market. In reality, such *chicken-egg-problem* has killed many new products/networks in its infancy. Unfortunately, the one sided Bass diffusion models fail to capture this important feature of two sided markets.

The assumption of a sequential adoption process allows the incorporation of diffusion parameters in the model. Advertising, marketing and promotion, time costs, number of average sessions, learning curve, barriers to entry and other factors that affect the diffusion speed of a network can be thus considered. For an independent two sided network, such factors do not determine whether the network can overcome the *chicken-egg problem* but affect only the growth rate of the network. For competing networks, these factors determine which network will capture a higher market share in a multi-homing scenario. It is interesting to note that in a static approach, adoption is a “one shot” simultaneous move by al the agents and diffusion effects can only be considered by incorporating them into the expectation of agents.

Finally, a dynamic approach enables us to examine the entire diffusion process instead of the steady state or equilibrium results only. As a trivial example, when participants tend to multi-homing and two competing (and equal) networks start with unequal sizes, the steady states of participant adoption for the two networks converge to each other.

In summary, a time-sequential modelling approach was preferred to one based on equilibrium solution concepts because:

- It is possible to arrive at very different conclusions depending on whether the network attracts primarily single homing or multi-homing participants, and this distinction can be naturally introduced in the sequential model.
- The sequential model provides increased flexibility with regards to the point on the dynamic path the empirical data is observed.
- Equilibrium or steady state results may have little practical significance, because the system may be unlikely to converge to them in reality. Rather, a dynamic approach can be fit to the observed adoption dynamics and extrapolated if necessary.

8.1.2 Analysis Methodology

The dynamic system approach employed in this work is similar to that of [SUN06]. Both works are derived from *the new product diffusion models* in the marketing literature [BASS69, FARI81, HORS90, MULL79, MAHA90]. Though not explicitly specified, these models actually involve network effects in the form of contagion effects and word-of-mouth. For example, the classical Bass model [BASS69] can be formulated as follows:

Equation 1

$$\Delta y_t = \left[p + \frac{q}{m} N_t\right][m - N_t]$$

Where N(t) is the cumulative number of adopters at time t, m is the potential number of adopters, and p and q are parameters that affect the speed of adoption. In the first bracket on the right-hand side, the word-of-mouth effect or contagion is modelled by the term $\frac{q}{m} N_t$: increases in the installed adopter base N(t) will increase the number of new adopters for q>0 and m>0. The second bracket models the *market boundary effect:* a larger installed base will reduce the pool of potential adopters, which will in turn lower the rate of growth of the number of current adopters. Both can be interpreted as indirect network effects, although the first represents a positive effect (bandwagon effect) while the second represents a negative effect (congestion effect).

Since there are two groups of participants for each two sided network, both the model in this work and that in [SUN06] involve at least two state variables for an independent two sided network, and at least four in a basic competition scenario. This requires a system with at least two or four differential equations to describe the adoption dynamics, as compared to Bass models which typically have only one differential equation[7].

Typically, Bass models involve only one type of adopters (mostly consumers or users) which may differ from each other in terms of the propensity to adopt. In our case, however, we are dealing with two groups of agents who are functionally different (users and publishers who have different roles in the network). Therefore, while the Bass models involve only one-sided network with only within-group network effects, the models in this work are all based on two sided networks with cross-group network effects.

Another important distinction between this model and that of [SUN06] is the incorporation of competition dynamics in the adoption process. Bass models normally assume superiority of the new technology over its predecessor, thus trivialising a normally complex dynamic market scenario. The next figure (Figure 8-2), explains the rationale of our proposed modelling approach.

Reference	Time evolution	Same side effect	Cross side effect	Switching Behavior	competition	Optimization of agents	Study situtations of winner-takes-all
Bass model	✓	🚩	🚩	🚩	🚩	🚩	🚩
Ming chun Sun	✓	🚩	✓	✓	✓	🚩	✓
Kai Chen	✓	🚩	✓	✓	✓	🚩	✓
E. Tse	✓	🚩	✓	🚩	✓	🚩	🚩
Rochet- Tirole	🚩	✓	✓	🚩	✓	✓	🚩
Kumar R (and others)	✓	✓	✓	🚩	✓	🚩	🚩
Envision Market Simulator	✓	✓	✓	✓	✓	🚩	✓

Rocher – Tirole optimize in a static way. Dynamic Systems don´t optimize, but describe and solve the market in a consistent way, so it´s relatively easy guess optimal marketing policies.

Figure 8-2

7 Some extensions of the Bass model also involve systems of differential equations and some cross-group network effects.

8.1.3 Economic Model

8.1.3.1 Market Structure

By definition, there are two sides in this market that interact through a common network platform. In addition, there is a third party who creates and maintains network services - the *network platform owner or sponsor.*

As shown in Figure 8-1, in this concrete two sided market, the greater the number of users that use the service, the greater the incentive to publish works using it - and vice-versa. The behaviour of both users and publishers is influenced by the number of sessions in the system: more sessions result in more users (a *contagion effect*), and more sessions result in more publishers (an *attraction effect*).

The platform regulates the market flows, and of course, the advertisement business.

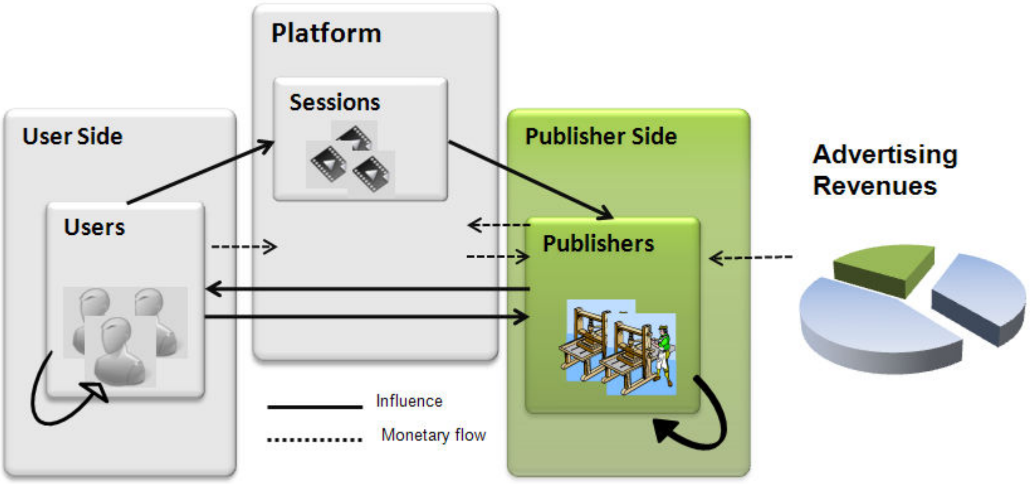


Figure 8-3

8.1.3.2 Model Setting

Assume two competing networks and infinite numbers of potential participants exist in the market. In the model, the notation will be as follows:

Y_{it} number of existing users in platform i at moment t.

Z_{it} number of existing publishers in platform i at moment t.

User participants take advantage from joining the platforms by deriving a benefit that is defined as follows:

v **functional value** answers to how much time it would take to the user to perform the common functionality without using the platform. It is measured in seconds and related to one session.

pv **usability effort** answers to how much time it takes for the user to perform the functionality in the platform? It is measured in seconds per session.

$v - pv$ **usability effort** is, therefore is session value per user.

θ_i the average monthly quantity of sessions per user.

In order to represent the net benefit (NB) of the sessions in a platform, we introduce the following equation:

Equation 2

$$NB(y,i) = \theta_i y_i (v - pv)$$

Where is easy to derive the main condition of a platform to survive: the net benefit has to be greater than zero, as it can be seen in Figure 8-4:

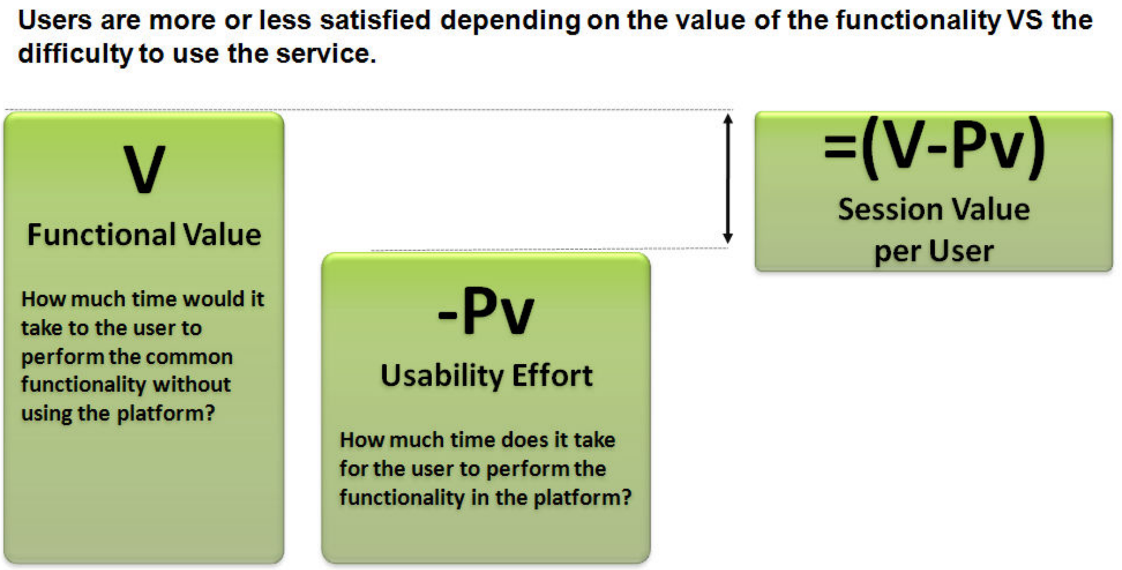


Figure 8-4

Similarly, publishers get a monetary profit from the sessions. In the model this concept has been taken into account:

- IP **Publisher incomes** refers to how much a publisher earns per each session in terms of average CPM, CPC advertising revenue per session and content royalties.
- r **session costs** refers to how much a publisher pays to the platform per session.
- $IP - r$ **publisher operating profit per session**.
- θ_i average monthly quantity of sessions per user

The net profit of the publisher is represented by the following equation:

Equation 3

$$NP(z,i) = \theta_i y_i (IP - r)$$

In this case, the first condition to attract publishers is to have IP-r>0, as represented in Figure 8-5.

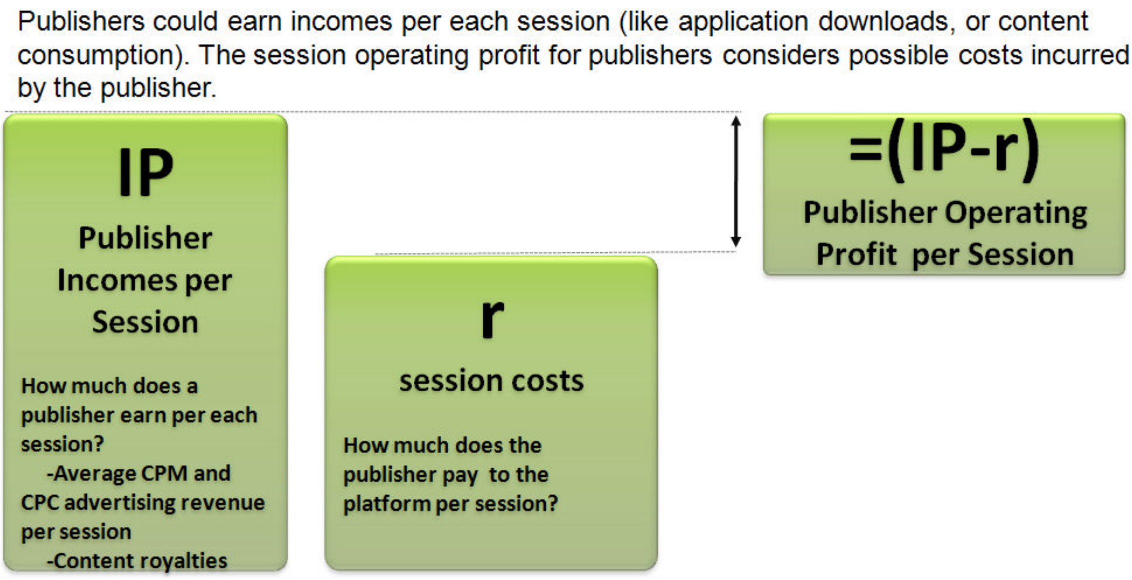


Figure 8-5

Another relevant term to define the demand-supply of an Economic product is the price and the relative price. In the model, both concepts are depending on the user and publisher levels. It is said that is a non-constant elasticity context where the user-publisher response to price (or fee) increases with the market level at time t. This is explained more deeply in the next section.

8.1.3.3 Same Side Network Effect

Before setting all the model equations, it is recommendable to begin by understanding their derivation.

Firstly, the focus is on the **same side effect**. This effect could be defined as the impact on the demand of a market side generated by this same market side. As an example, for users, one could think of word-of-mouth effects, contagion effects and viral marketing. In the case of publishers, this could be thought as the effect of the size of the market side (the more publishers that are present in a platform the more new publishers will wish to enter popular platforms).

Taking into account the model has two platforms (represented by the subscript), with the same side effect could be represented as the following system of equations:

Equation 4

$$\Delta y_{1t} = \alpha_{01}\alpha_{b1}[y_{1t}\theta_1(v_1 - p_1^F)] - \alpha_{11}y_{1t}p_1^f$$

$$\Delta y_{2t} = \alpha_{02}\alpha_{b2}[y_{2t}\theta_2(v_2 - p_2^F)] - \alpha_{12}y_{2t}p_2^f$$

$$\Delta z_{1t} = \gamma_{a1}\gamma_{b1}z_{1t} - \gamma_{11}\gamma_{b1}z_{1t}f_1$$

$$\Delta z_{2t} = \gamma_{a2}\gamma_{b2}z_{2t} - \gamma_{12}\gamma_{b2}z_{2t}f_2$$

Defining these parameters:

- α_{0i} diffusion parameter: velocity with which the users in period "t" adjust to increases/decreases of net benefit of the sessions in platform i.
- α_{bi} first time user convertibility parameter: % of newcomers that join the service once they can overcome of initial learning curve, user investment in equipment, etc
- α_{1i} price sensitivity parameter: quantifies the decrease in users (depending on platform user level) given an increase in the fixed price.

γ_{4i} publisher traction: a diffusion parameter representing the velocity of publisher contagion - how many new publishers join the platform in a given month per each existing publisher in the platform.

γ_{6i} entry barriers factor: % of newcomer that drop in once the pass the barrier because of required upfront fees, investments, learning curves, content adaptation or other obstacles.

γ_{1i} fixed fee sensitivity parameter: quantifies the decrease in publishers (depending on platform publisher level) given an increase in the fixed fee.

p_i^f price charged to users by the platform

f_i fixed fee charged to publishers by the platform

8.1.3.4 Cross Side Network Effect

This effect could be considered as the increase/decrease in the demand of one side of the market due to the increase/decrease in the demand of the other side of the market. For instance, if a network achieves more publishers, this increase will affect the users, stimulating the entries to the platform. Conversely, if the number of users increases, more publishers will perceive the market as a valuable opportunity to generate sales and will thus join the platform.

Now, the model will represent these terms as in the following equation.

Equation 5

$$\Delta y_{1t} = \alpha_{41} z_{1t}$$

$$\Delta y_{2t} = \alpha_{42} z_{2t}$$

$$\Delta z_{1t} = \gamma_{01}\gamma_{61}[y_{1t}\theta_1(IP_1 - r_1)]$$

$$\Delta z_{2t} = \gamma_{01}\gamma_{62}[y_{2t}\theta_2(IP_2 - r_2)],$$

Where:

α_{4i} publisher traction: how many users will join the platform in a given month per each publisher active in the platform.

γ_{0i} market attraction: how many new publishers would join the platform in a given month driven by the operating profit of the existing publishers. It is measured in terms of publishers/€.

γ_{6i} entry barriers factor: defined as the percentage in newcomer drops after the barrier because of required upfront fees, investments, learning curves, content adaptation or other factors.

8.1.3.5 Switching Effect

This effect is closely related to the concepts of single homing and multi homing. Single homing is a market situation in which users or publishers only can operate in one platform. In this kind of markets, there is a “switching” factor that gradually drives agents to a single platform, potentially the one with better economic conditions.

Multi homing markets, in the other hand, allow users and publishers to be in several markets at the same time, and there is no switching factor. Since all agents could be in some or all platforms, they are not required to commit to a single one. Figure 8-6 shows the flow diagram of this kind of dynamic system allowing for switching in all agents (single homing model for users and publishers):

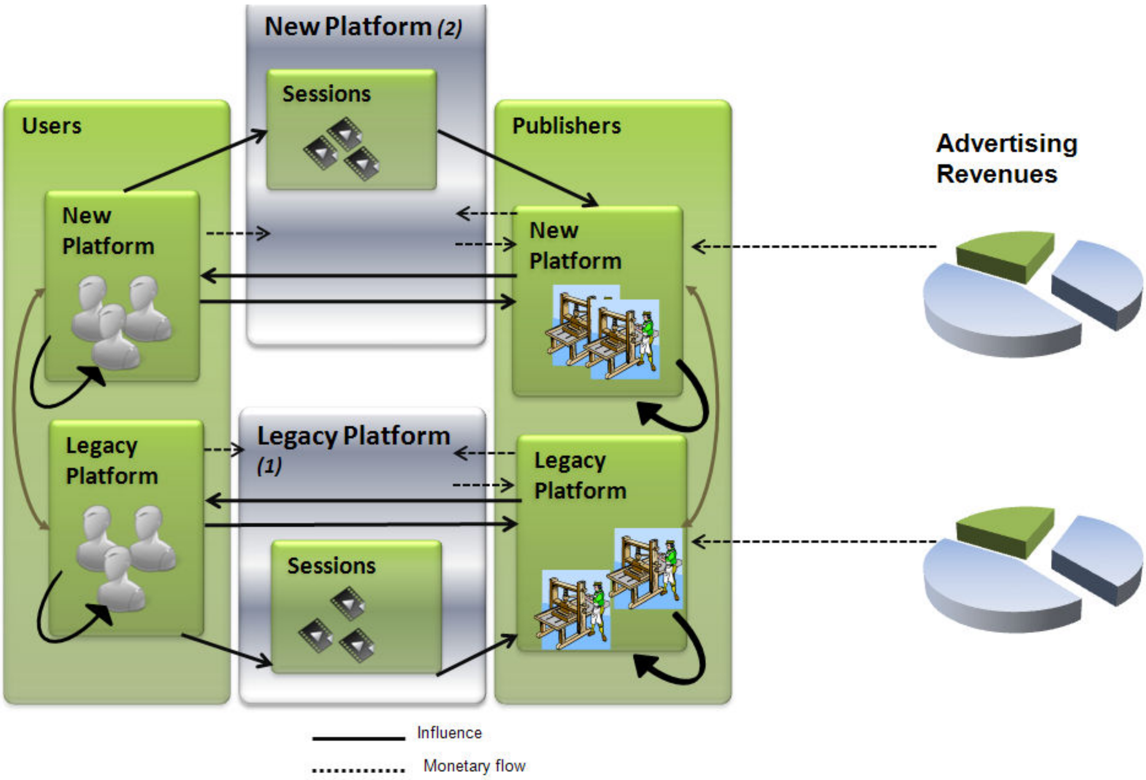


Figure 8-6

In this example, where there are two available platforms, we can foresee the following scenarios:

- Both sides multi homing (there is properly not switching term, both users and publishers can be in both platforms at the same time). In this case, the model can predict the two platforms to survive, in a state of non-fierce competition.
- One side multi homing and other single homing. (In this case, the single homing side needs some switching parameter in the model). Developing the model in this situation, where in one side the agents have to decide one of the two platforms, the model is prone to forecast a winner takes all dynamic.
- Two sides single homing. (In this case all state equations need some switching term). Again, the model is predisposed to the selection of a single platform as a winner-takes-it-all.

Only switching terms are included in the following equations:

Equation 6

$$\Delta y_{1t} = \alpha_{21}[\alpha_{61}[y_{1t}\theta_1(v_1 - p_1^F)] - \alpha_{62}[y_{2t}\theta_2(v_2 - p_2^F)]] + \alpha_{31}y_{1t}\left(\frac{p_2^f - p_1^f}{p_1^f}\right) + \alpha_{51}(z_{1t} - z_{2t})$$

$$\Delta y_{2t} = \alpha_{22}[\alpha_{62}y_{2t}\theta_2(v_2 - p_2^F) - \alpha_{61}y_{1t}\theta_1(v_1 - p_1^F)] + \alpha_{32}y_{2t}\left(\frac{p_2^f - p_1^f}{p_1^f}\right) + \alpha_{52}(z_{2t} - z_{1t})$$

$$z_{1t} = +\gamma_{21}[\gamma_{61}y_{1t}\theta_1(IP_1 - r_1) - \gamma_{62}y_{2t}\theta_2(IP_2 - r_2)] + \gamma_{31}\gamma_{61}z_{1t}\left(\frac{f_2 - f_1}{f_1}\right) + \gamma_{51}(\gamma_{61}z_{1t} - \gamma_{62}z_{2t})$$

$$\Delta z_{2t} = +\gamma_{22}[\gamma_{62}y_{2t}\theta_2(IP_2 - r_2) - \gamma_{61}y_{1t}\theta_1(IP_1 - r_1)] + \gamma_{32}\gamma_{62}z_{2t}\left(\frac{f_1 - f_2}{f_1}\right) + \gamma_{52}(\gamma_{62}z_{2t} - \gamma_{61}z_{1t})$$

As it can be seen in Equation 6, switching terms are similar to cross side effect and same side effect, but only including a parameter to discriminate the monthly velocity of diffusion from one platform to the other:

- α_{2i} **functional churn factor user.** This factor measures the monthly movement of users between platforms, given that net benefit of one platform is greater than that of the competition. Logically, a sufficiently high parameter value joined to a sufficiently high net benefit of one platform versus its competition is key to understand the winner takes all dynamics.
- α_{3i} **price churn factor user.** This factor measures the increase in users in one platform by agents making comparisons with competition prices. (The term in the model that compares prices is $\frac{p_2^f - p_1^f}{p_1^f}$ and $\frac{p_1^f - p_2^f}{p_1^f}$, taking as basis price p1.
- α_{5i} **publishers churn factor.** This factor measures the increase in users due to the entry of new publishers from the other platform.
- γ_{2i} **publishers profit churn factor.** This factor measures the entry of publishers into the platform due to the increase of publisher benefit in comparison with the competition.
- γ_{3i} **Publisher fee churn factor.** This factor measures the publisher switch among platforms by comparing the fixed fee values. This comparison is made in the model with this terms $\frac{f_2 - f_1}{f_1}$, $\frac{f_1 - f_2}{f_1}$ related to f1.
- γ_{5i} **publisher imitation churn factor.** This is a parameter that measures the increase in publishers in one platform due to the increase of publishers in this platform in comparison with the other.

8.1.3.6 The Dynamic System

Once the model was conveniently explained, it was developed according to the system equations (see Equation 7):

Equation 7

$$\Delta y_{1t} = \alpha_{01}\alpha_{61}[y_{1t}\theta_1(v_1 - p_1^y)] - \alpha_{11}y_{1t}p_1^f + \alpha_{21}[\alpha_{61}[y_{1t}\theta_1(v_1 - p_1^y)] - \alpha_{62}[y_{2t}\theta_2(v_2 - p_2^y)]] + \alpha_{31}y_{1t}\left(\frac{p_2^f - p_1^f}{p_1^f}\right) + \alpha_{41}z_{1t} + \alpha_{51}(z_{1t} - z_{2t})$$

$$\Delta y_{2t} = \alpha_{02}\alpha_{62}[y_{2t}\theta_2(v_2 - p_2^y)] - \alpha_{12}y_{2t}p_2^f + \alpha_{22}[\alpha_{62}y_{2t}\theta_2(v_2 - p_2^y) - \alpha_{61}y_{1t}\theta_1(v_1 - p_1^y)] + \alpha_{32}y_{2t}\left(\frac{p_1^f - p_2^f}{p_1^f}\right) + \alpha_{42}z_{2t} + \alpha_{52}(z_{2t} - z_{1t})$$

$$\Delta z_{1t} = \gamma_{01}\gamma_{61}[y_{1t}\theta_1(IP_1 - r_1)] - \gamma_{11}\gamma_{61}z_{1t}f_1 + \gamma_{21}[\gamma_{61}y_{1t}\theta_1(IP_1 - r_1) - \gamma_{62}y_{2t}\theta_2(IP_2 - r_2)] + \gamma_{31}\gamma_{61}z_{1t}\left(\frac{f_2 - f_1}{f_1}\right) + \gamma_{41}\gamma_{61}z_{1t} + \gamma_{51}(\gamma_{61}z_{1t} - \gamma_{62}z_{2t})$$

$$\Delta z_{2t} = \gamma_{01}\gamma_{62}[y_{2t}\theta_2(IP_2 - r_2)] - \gamma_{12}\gamma_{62}z_{2t}f_2 + \gamma_{22}[\gamma_{62}y_{2t}\theta_2(IP_2 - r_2) - \gamma_{61}y_{1t}\theta_1(IP_1 - r_1)] + \gamma_{32}\gamma_{62}z_{2t}\left(\frac{f_1 - f_2}{f_1}\right) + \gamma_{42}\gamma_{62}z_{2t} + \gamma_{52}(\gamma_{62}z_{2t} - \gamma_{61}z_{1t})$$

The dynamic system in Equation 7 has a unique equilibrium by equilibrium, which can be found trivially by imposing the fixed point conditions on the difference equations. Under those circumstances ($\Delta y_{1t} = 0, \Delta y_{2t} = 0, \Delta z_{1t} = 0, \Delta z_{2t} = 0$), and since the system is linear, and neither under- nor over-determined, the equilibrium points are ($y_i = 0, z_i = 0$). We now characterise the stability of this point.

8.1.3.6.1 Instability

To proof instability, is needed to show that at least one of the eigenvalues of the linear dynamic system Equation 7 is strictly positive. Analytic demonstration is out the scope of this document. But, for technical details the nearest reference to understand this model's operations is [SUN06].

In a four state dynamic system, the coefficient matrix determinant will derive in a four degree equation. Solving it, the eigenvalues will be positive and negative values. So the **equilibrium of the system must be unstable.**

The instability of the system equilibrium can be intuitively imagined. Assume the two networks starts at the equilibrium (0,0,0,0). If, for any reason, publishers become greater than zero (i.e. 1) in platform number 1 it will cause users in platform 1 to increase and platform 2 to continue in zero. So this, will generate a loop where platform publishers will continue increasing and in platform 2, in zero.

The positive feedback loop will drive the system to diverge from its equilibrium, showing this instability. By the way, another conclusion that could be took into account is:

If both sides of the market are multi homing, and the initial size of the two platforms in the market is above their corresponding saddle path, they will survive conjointly.

If at least one of the sides of the market is single homing, the probability of survival or coexistence of all the platforms is low due to the "chicken-egg" problem.

8.1.3.6.2 Unlocking the "Lock-in" Phenomenon.

The Chicken-egg problem is one of the first issues to analyse once this market model is detected in a sector.

In fact, the finding that only one network is likely to survive in a two sided market (where at least one of the side of the market is single homing) sends strong messages to business owners: *avoid entering in winner takes all services.*

Knowing the relative position of a network as compared to the competing network will help the business owner to understand whether its service locates in a sustainable growth region. Since it is impossible to draw a complete phase diagram for the 4 x 4 dynamic system in Equation 7 It is possible to solve this equilibrium system in a reduced form, depending only of initial values from competition.

Since it is complex to represent the phase diagram -because of the four dimensions of the model-, then a two dimension simplification is taken. One of the dimensions is for studying the values that allows publisher to growth or to shrink under every possible solution of competition including the starting conditions. In the same way is it possible to study the values that enable user adoption to growth or to shrink under the publisher equilibrium and the possible values of competition. A simulation tool for aiding in the visualisation of these aspects has been built in the simulator leveraging on [TSE02].

Figure 8-7 visually shows this tool for assessing the recommended starting conditions for the new service either to coexist, or to beat the competing platform.

The green area is used to reflect safe starting conditions that lead to profitable market conditions, whilst the red colour indicates the opposite. There are no absolute values regarding the probability of winning or to losing based on these values, so the recommendation is to be cautious.

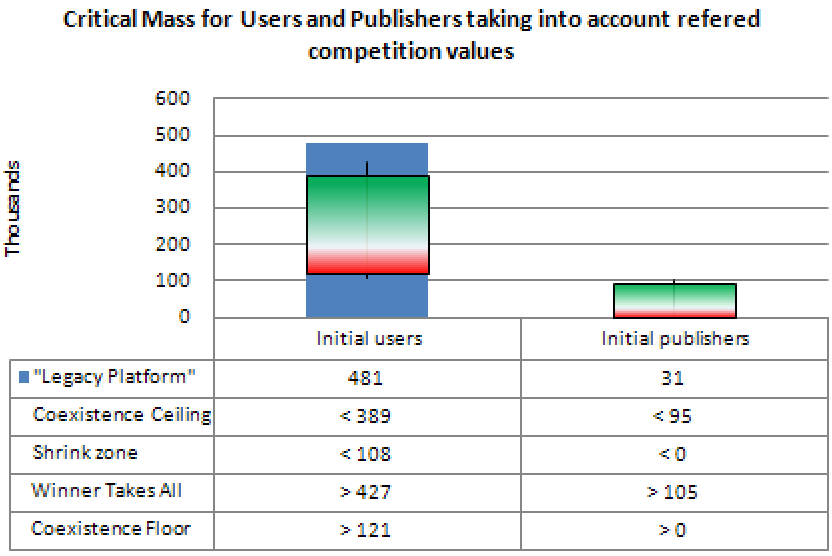


Figure 8-7

Launch Strategy Tool

	"Legacy Platform"	Coexistence Ceiling	Shrink zone	Winner Takes All	Coexistence Floor
Initial users	481	< 389	< 108	> 427	> 121
Initial publishers	31	< 95	< 0	> 105	> 0

Assuming that platform 1 is incumbent, and 2 is the new service, the next operations are developed in detail:

Equation 8

$$\Delta y_{1t} = \alpha_{01}\alpha_{61}[y_{1t}\theta_1(v_1 - p_1^v)] - \alpha_{11}y_{1t}p_1^f + \alpha_{21}[\alpha_{61}[y_{1t}\theta_1(v_1 - p_1^v)] - \alpha_{62}[y_{2t}\theta_2(v_2 - p_2^v)]] + \alpha_{31}y_{1t}\left(\frac{p_2^f - p_1^f}{p_1^f}\right) + \alpha_{41}z_{1t} + \alpha_{51}(z_{1t} - z_{2t})$$

Equation 9

$$a1 = \alpha_{01}\alpha_{61}\theta_1(v_1 - p_1^v),\ a2 = \alpha_{11}p_1^f,\ a3 = \alpha_{21}\alpha_{61}\theta_1(v_1 - p_1^v),\ a4 = \alpha_{21}\alpha_{62}\theta_2(v_2 - p_2^v),$$
$$a5 = \alpha_{31}\left(\frac{p_2^f - p_1^f}{p_1^f}\right)100,\ a6 = \alpha_{41} + \alpha_{51},\ a7 = \alpha_{51}$$

Equation 10

$$\Delta y_{1t} = (a1 - a2 + a3 + a5)y_{1t} - a4y_{2t} + a6z_{1t} - a7z_{2t}$$

The model can be expressed by Equation 8, Equation 9 or Equation 10. Equation 8 is the original model, Equation 9 is modified to reflect the grouping of parameters, and Equation 10 is a simplification for greater readability. Firstly, each system equation is simplified in notation terms from Equation 8 to Equation 10. The next question is dealt with in the same fashion:

Equation 11

$$\Delta y_{2t} = \alpha_{02}\alpha_{62}[y_{2t}\theta_2(v_2 - p_2^v)] - \alpha_{12}y_{2t}p_2^f + \alpha_{22}[\alpha_{62}y_{2t}\theta_2(v_2 - p_2^v) - \alpha_{61}y_{1t}\theta_1(v_1 - p_1^v)] + \alpha_{32}y_{2t}\left(\frac{p_1^f - p_2^f}{p_2^f}\right) + \alpha_{42}z_{2t} + \alpha_{52}(z_{2t} - z_{1t})$$

Equation 12

$$a8 = \alpha_{02}\alpha_{62}\theta_2(v_2 - p_2^v), a9 = \alpha_{12}p_2^f, \quad a10 = \alpha_{22}\alpha_{62}\theta_2(v_2 - p_2^v), \quad a11 = \alpha_{22}\alpha_{61}\theta_1(v_1 - p_1^v),$$
$$a12 = \alpha_{32}\left(\frac{p_1^f - p_2^f}{p_2^f}\right)100, a13 = \alpha_{42} + \alpha_{52}, a14 = \alpha_{52}$$

Equation 13

$$\Delta y_{2t} = (a8 - a9 + a10 + a12)y_{2t} - a11y_{1t} + a13z_{2t} - a14z_{1t}$$

Equation 14

$$\Delta z_{1t} = \gamma_{01}\gamma_{61}[y_{1t}\theta_1(IP_1 - r_1)] - \gamma_{11}\gamma_{61}z_{1t}f_1 + \gamma_{21}[\gamma_{61}y_{1t}\theta_1(IP_1 - r_1) - \gamma_{62}y_{2t}\theta_2(IP_2 - r_2)] + \gamma_{31}\gamma_{61}z_{1t}\left(\frac{f_2 - f_1}{f_1}\right) + \gamma_{41}\gamma_{61}z_{1t} + \gamma_{51}(\gamma_{61}z_{1t} - \gamma_{62}z_{2t})$$

Equation 15

$$b1 = \gamma_{01}\gamma_{61}\theta_1(IP_1 - r_1), b2 = \gamma_{11}\gamma_{61}f_1, b3 = \gamma_{21}\gamma_{61}\theta_1(IP_1 - r_1), b4 = \gamma_{21}\gamma_{62}\theta_2(IP_2 - r_2),$$
$$b5 = \gamma_{31}\gamma_{61}\left(\frac{f_2 - f_1}{f_1}\right)100, b6 = \gamma_{41}\gamma_{61}, b7 = \gamma_{51}\gamma_{61}, b8 = \gamma_{51}\gamma_{62}$$

Equation 16

$$\Delta z_{1t} = (b1 + b3)y_{1t} - b4y_{2t} + (b5 - b2 + b6 + b7)z_{1t} - b8z_{2t}$$

Equation 17

$$\Delta z_{2t} = \gamma_{01}\gamma_{62}[y_{2t}\theta_2(IP_2 - r_2)] - \gamma_{12}\gamma_{62}z_{2t}f_2 + \gamma_{22}[\gamma_{62}y_{2t}\theta_2(IP_2 - r_2) - \gamma_{61}y_{1t}\theta_1(IP_1 - r_1)] + \gamma_{32}\gamma_{62}z_{2t}\left(\frac{f_1 - f_2}{f_2}\right) + \gamma_{42}\gamma_{62}z_{2t} + \gamma_{52}(\gamma_{62}z_{2t} - \gamma_{61}z_{1t})$$

Equation 18

$$b9 = \gamma_{01}\gamma_{62}\theta_2(IP_2 - r_2), \; b10 = \gamma_{12}\gamma_{62}f_2, b11 = \gamma_{22}\gamma_{62}\theta_2(IP_2 - r_2), \; b12 = \gamma_{22}\gamma_{61}\theta_1(IP_1 - r_1),$$
$$b13 = \gamma_{32}\gamma_{62}\left(\frac{f_1 - f_2}{f_2}\right)100, b14 = \gamma_{42}\gamma_{62}, b15 = \gamma_{52}\gamma_{62}, b16 = \gamma_{52}\gamma_{61}$$

Equation 19

$$\Delta z_{2t} = (b9 + b11)y_{2t} - b12y_{1t} + (b13 - b10 + b14 + b15)z_{2t} - b16z_{1t}$$

So, using Equation 10,

$$\Delta y_{1t} = \underbrace{(a1 - a2 + a3 + a5)}_{A}y_{1t} + \underbrace{a4}_{B}y_{2t} + \underbrace{a6}_{C}z_{1t} - \underbrace{a7}_{D}z_{2t}$$

Equation 13,

$$\Delta y_{2t} = \underbrace{(a8 - a9 + a10 + a12)}_{E}y_{2t} - \underbrace{a11}_{F}y_{1t} + \underbrace{a13}_{G}z_{2t} - \underbrace{a14}_{H}z_{1t}$$

Equation 16,

$$\Delta z_{1t} = \underbrace{(b1 + b3)}_{I}y_{1t} - \underbrace{b4}_{J}y_{2t} + \underbrace{(b5 - b2 + b6 + b7)}_{K}z_{1t} - \underbrace{b8}_{L}z_{2t}$$

and Equation 19

$$\Delta z_{1t} = \underbrace{(b1 + b3)}_{M}y_{1t} - \underbrace{b4}_{N}y_{2t} + \underbrace{(b5 - b2 + b6 + b7)}_{O}z_{1t} - \underbrace{b8}_{P}z_{2t}$$

this system can be reduced to:

$$\Delta y_{1t} = Ay_{1t} - By_{2t} + Cz_{1t} - Dz_{2t} \quad (1)$$
$$\Delta y_{2t} = Ey_{2t} - Fy_{1t} + Gz_{2t} - Hz_{1t} \quad (2)$$
$$\Delta z_{1t} = Iy_{1t} - Jy_{2t} + Kz_{1t} - Lz_{2t} \quad (3)$$
$$\Delta z_{2t} = My_{2t} - Ny_{1t} + Oz_{2t} - Pz_{1t} \quad (4)$$

Evaluating under the equilibrium point (all the differenced terms get value zero) and substituting (3) into (1), is obtained:

$$z_{2t} = \frac{Iy_{1t} - Jy_{2t} + Kz_{1t}}{L}$$

And

$$y_{2t} = \frac{(LA - DI)y_{1t} + (LC - DK)z_{1t}}{LA - DJ}$$

And using (4) and (2)

$$z_{2t} = -\frac{M}{O}y_{2t} - \frac{N}{O}y_{1t} + \frac{P}{O}z_{1t}$$

$$y_{2t} = \frac{(-GN + OF)y_{1t} + (-GP + HO)z_{1t}}{OE - GM}$$

The system highlights two important limits for users and publishers: the initial bootstrap limits of floor and ceiling for users and publishers based on the current values of users and publishers of competition.

All these values are dependent on the structural parameters of the model, so, solution of these initial points will differ according to market hypotheses.

8.2 Scenario Analysis

8.2.1 Bootstrap Conditions

In order to forecast the results, an initial configuration of the quantity of users and publishers in legacy platforms of both services is needed before it is possible to determine the minimum quantity of users and publishers to, technically, survive.

Model parameterization (data in thousands)	data
Initial users legacy services	486
Initial users new services	?
Initial publishers legacy services	0,37
Initial publishers new services	?
Market sizes (data in thousands)	
users legacy services	5000
users new services	5000
publishers legacy services	3
publishers new services	3

Table 8-1 Bootstrap parameterisation of Web 3D conference vs. Second Life (legacy)

Model parameterization (data in thousands)	data
Initial users legacy services	53
Initial users new services	?
Initial publishers legacy services	0,09
Initial publishers new services	?
Market sizes (data in thousands)	
users legacy services	500
users new services	500
publishers legacy services	2
publishers new services	2

Table 8-2 Bootstrap parameterisation of Bicycle race vs. Facebook (legacy)

Considering Web 3D conference applications, Second Life has around 370 publishers and 486 000 active users ("economic participants") according to the figures provided by the directory of development companies published by SL in [BM-4].

In Bicycle race services, a starting point could be to estimate, based in widely-available market knowledge, the current market conditions, according to figures researched on well known Facebook events. Doing so, in the next table, Table 8-3, it is quantified so that approximately 53 000 followers per month pay attention to the largest 90 events in Spain.

Type	Quantity per month	Followers on Facebook
Big concert	4	2000
Medium concert	20	200
High profile Sport event	16	2000
Low profile sport event	40	200
Other events	10	100

Table 8-3 Current followers of events in Spain

So, this numbers have been taken into account to develop the initial bootstrapping conditions revealed on Table 8-2.

8.2.2 Survival Analysis

A specific tool has been built that derives the initial conditions that Web 3D conference, Bicycle race and Legacy services would require to be prone to get better market performance in the medium term. This is very important due to the fact that it is based in the model parameterisation and the current initial data of Second Life, Facebook and BitTorrent (direct competitors of those).

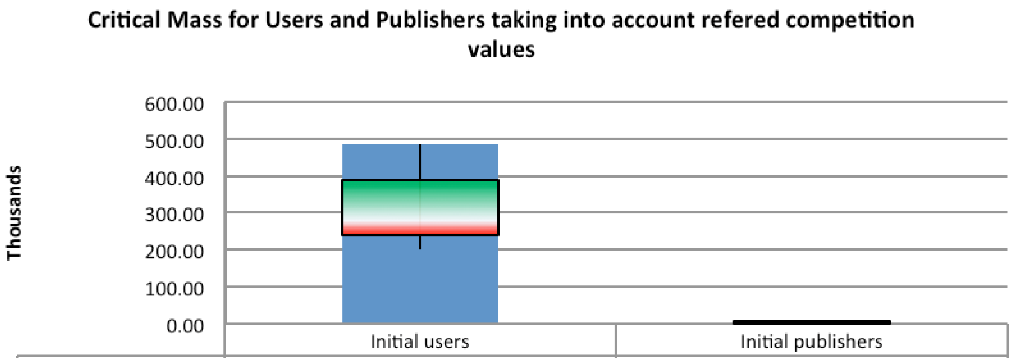
The resulting survival chart is a kind of semaphore that is used to indicate probability of success under different market conditions. Since Two Sided Markets are very exigent with the initial starting quantity in users and publishers, it is important to study, conditional to competition information, how many users and publishers would be necessary to coexist.

The more placed in the green zone, the more win probability in the market, or at least coexist.

The survival analysis has been used twice in order to evaluate to what extent the ENVISION technologies help in the survival or win strategy of the studied overlay applications built on top:

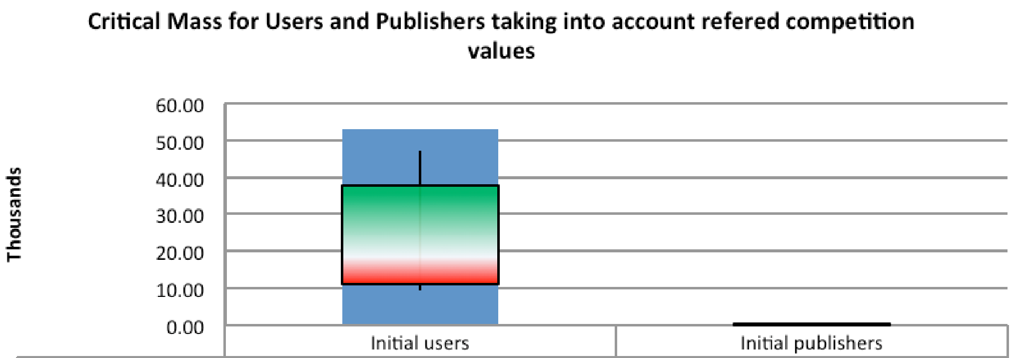
- First, simulating non ENVISION-enabled applications, delivering the first block of results
- Second, simulating ENVISION-enabled applications, resulting in the second block.

One of the objectives has been to quantify the shift in the required starting market conditions when using ENVISION technology assumed to be appreciated by users and publishers in the terms estimated in the parameter estimation chapter.



	Initial users	Initial publishers
"Legacy Platform"	486.00	0.37
Coexistence Ceiling	388.77	5.64
Shrink zone	199.40	0.00
Winner Takes All	485.96	7.05
Coexistence Floor	239.27	0.00

Figure 8-8: Survival Analysis Tool. Web 3D conference without ENVISION

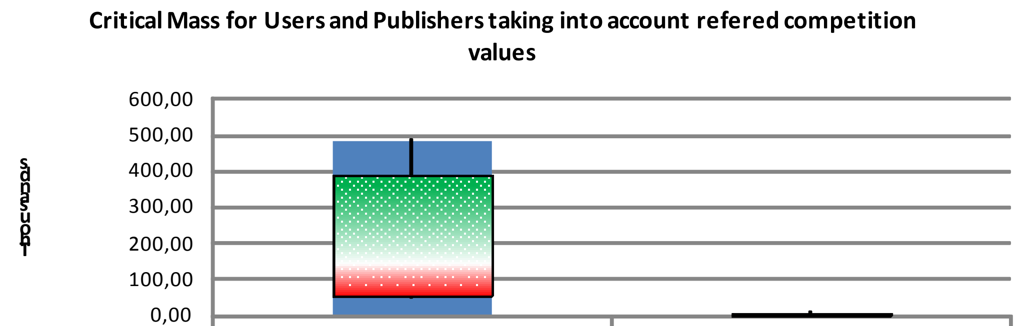


	Initial users	Initial publishers
"Legacy Platform"	53.00	0.09
Coexistence Ceiling	37.63	0.18
Shrink zone	9.28	0.01
Winner Takes All	47.04	0.22
Coexistence Floor	11.14	0.01

Figure 8-9: Survival Analysis Tool. Bicycle race without ENVISION

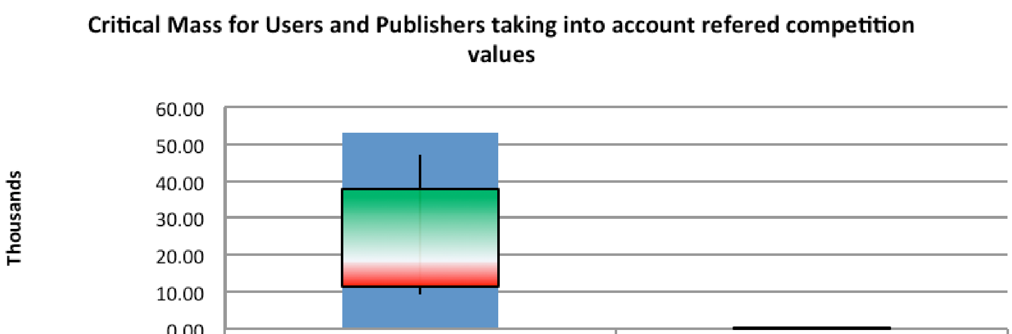
With respect to the Web 3D conference in the above survival chart, if it was introduced into the market using conventional (and similar to Second Life) technology, initial requires would be quite exigent. In fact, survival tool assess that it would require a minimum of about 250 000 users to start operating the service with minimal survival probability in addition to 5000 publishers to be able to coexist. Below this figures, the service without ENVISION would die.

A specific micro-journalism service without using ENVISION would require when competing with Facebook around 20 000 users and about 50 events.



	Initial users	Initial publishers
"Legacy Platform"	486,00	0,37
Coexistence Ceiling	388,77	6,13
Shrink zone	48,16	0,00
Winner Takes All	485,96	7,67
Coexistence Floor	57,80	0,00

Figure 8-10: Survival tool. Web 3D conference with ENVISION



	Initial users	Initial publishers
"Legacy Platform"	53.00	0.09
Coexistence Ceiling	37.63	0.17
Shrink zone	9.31	0.01
Winner Takes All	47.04	0.22
Coexistence Floor	11.18	0.01

Figure 8-11: Survival tool. Bicycle Race WITH ENVISION

When enabling ENVISION into the services, the starting market conditions are significantly less exigent, due to the capacity of the ENVISION-enabled new technology to compete with the legacy platforms. The factors that power the survival of ENVISION enabled services is described in detail in Appendix A – Scenario Modelling. The main ones – as indicated in 8.2.6.1 – are the shortening of the session duration thanks to the underlying speed and responsiveness of the overlay (QU-1), and the expected increase in the amount of sessions/user/month given the novelty of the new applications (Q-M1).

In the case of Web 3D conference, this tool requires, at least 150 000 users in the first months far better than the 250 000 users required without ENVISION. It is important to remark that in publishers the solution is similar to the latter scenario. In this case, it appears to be more sensate to bet first on gathering users to have an acceptable critical mass which later boosts publishers in.

With Bicycle race happens similarly. A 25% less of starting users are required for the platform to survive, around 15 000 in comparison with the 20 000 of the non ENVISION-enabled one.

From this diagnostic, it seems reasonable in order to provide a minimum guarantee of coexistence with competitors, to require the following starting market conditions (achieved via viral campaigns, media campaigns, etc):

- Web 3D conference. Initial users: 170 000 Initial publishers: 50
- Bicycle race. Initial users: 15 000 initial publishers: 50

8.2.3 Stage One: ENVISION-less Forecast

Leveraging on the previous defined conditions, the core of simulations follow three stages. The objective of the next sections is to develop a complete simulation exercise that obtains all the possible information about this market experiments.

Remark 1: Phase one analysis

In this phase, a first forecast is run without taking into account the "technological shock" that ENVISION could incorporate to the businesses.

The goal is to have a contrast between the business feasibility of a non ENVISION-enabled business, and an ENVISION-enabled one in order to identify the strategic shift.

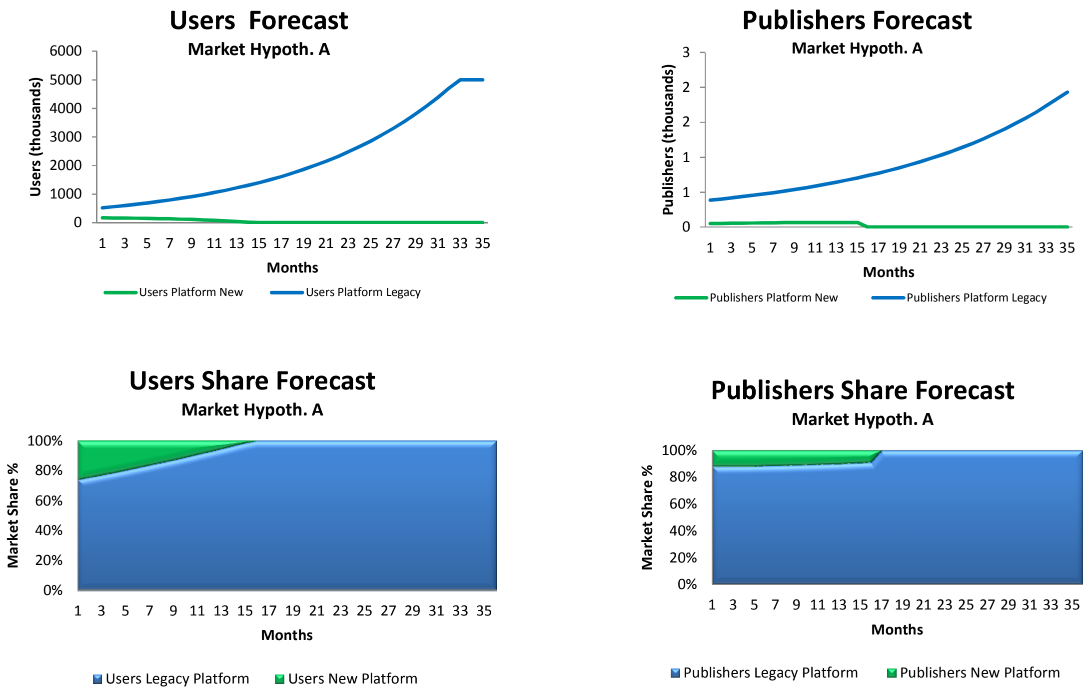


Figure 8-12: First Forecast of two sided markets for Web 3D conference vs. Second Life without ENVISION

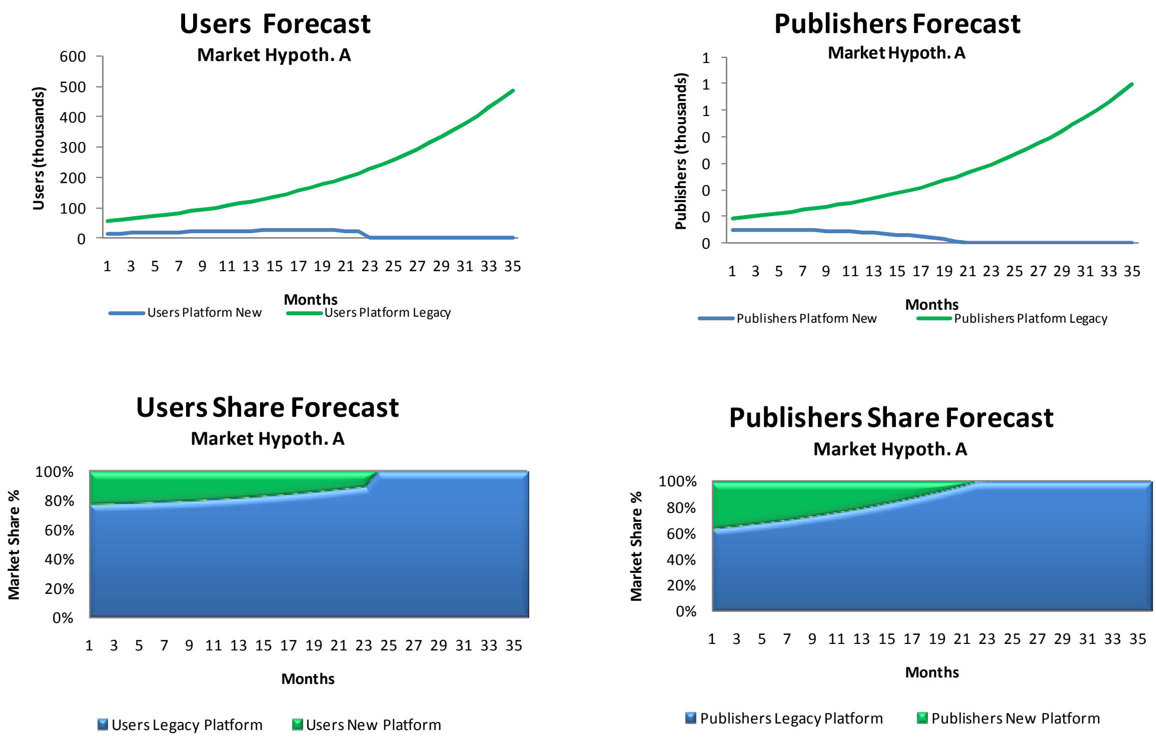


Figure 8-13: First forecast of two sided markets for the Bicycle race vs. Facebook without ENVISION

As it is showed in Figure 8-10 and in Figure 8-11, Web 3D conference and Bicycle race services won't survive in a face-off with Second Life if and Facebook, respectively, the underlying technology is similar, (in terms of the parameters in section 3.1).

Initial users and publishers of Web 3D conference and bicycle race are neither sufficient to compete with Second Life and other competitors, and make unfeasible this service to get any stable and positive market share in users and publishers. In less than one year, users and publishers would decline towards zero and, in fact, they would never overpass substantially the initial quantity.

8.2.4 Stage Two: ENVISION-enabled Forecast

This stage forecasts the user publisher adoption rates given the legacy platform competitor, both with ENVISION-less and ENVISION-enabled services.

As already proven in the initial market conditions required to run the services, introducing ENVISION-enabled technology into the new platform is a guarantee to achieve better results in such a competitive market according to the market parameterisations. The main differences between Second Life, Facebook and Web 3D conference, Bicycle race enabled with ENVISION technology have been quantified in this way:

- Sessions per user (greater in ENVISION-enabled services leveraging on the hypothesis that greater speeds, responsiveness, and lower cost will imply that users are more satisfied and make more use of ENVISION-enabled services)
- Entry barriers (bigger in ENVISION-enabled due to the unknown applications by the general public and the developers)
- Saved hours per session (greater in ENVISION-enabled due to the ease oriented of this new technology)
- Hours per session (Bigger in ENVISION-enabled due to new and attractive applications, responsiveness, features, etc.)

- Think time (even entry barriers are bigger, the quality of sessions are notoriously better than in Second Life given the better network responsiveness expected)
- ARPU (it is a kind of indirect ARPU in *freemium* consumers that is bigger in ENVISION-enabled).

In the mathematical dynamic system simulations, both ENVISION-less and ENVISION-enabled new services have been compared with the respective legacy platform, and a contrast analysis is presented ahead. Forecasts with ENVISION-less services are called “forecast without shock”, and ENVISION-enabled ones, “forecast with shock”.

The results are reflected in Figure 8-12 and Figure 8-13 under the label “New Platform”. Solid lines show the forecast of the ENVISION-less new services, whilst dashed lines correspond to the forecast of ENVISION-enabled services.

The resulting figures clearly highlight that the ENVISION-less service would have an unfeasible forecast, whilst the ENVISION-enabled ones would survive and become fruitful.

The graphs also show the churn between the legacy platform and the new ENVISION-enabled platform. As it can be seen in this graphs, in the long term (3 years from launch), the Web 3D conference, ENVISION-enabled technology would “steal” around 500 000 users to Second Life and over 50 publishers. In Bicycle race case, in long term, ENVISION could steal 15 000 users to Facebook, and near 30 publishers.

The forecast of the ENVISION-enabled Web 3D conference could receive near to 1,8 million users (1,3M could be fresh users and 500K from competition) and 720 publishers (50 of them are from Second Life platform and the rest are coming for fresh). In the Bicycle race case, the ENVISION-enabled service could gain around 100 000 users and more than 350 publishers in three years.

It is important to highlight how small users achieve in Figure 8-13. This is due to the slow word-of-mouth resulting from the estimated parameters because of the inner nature of the service itself. Therefore, a strong business case would only result after five or more years operating the service, or by finding out the twist in the business model or service concept that would achieve a strong word-of-mouth.

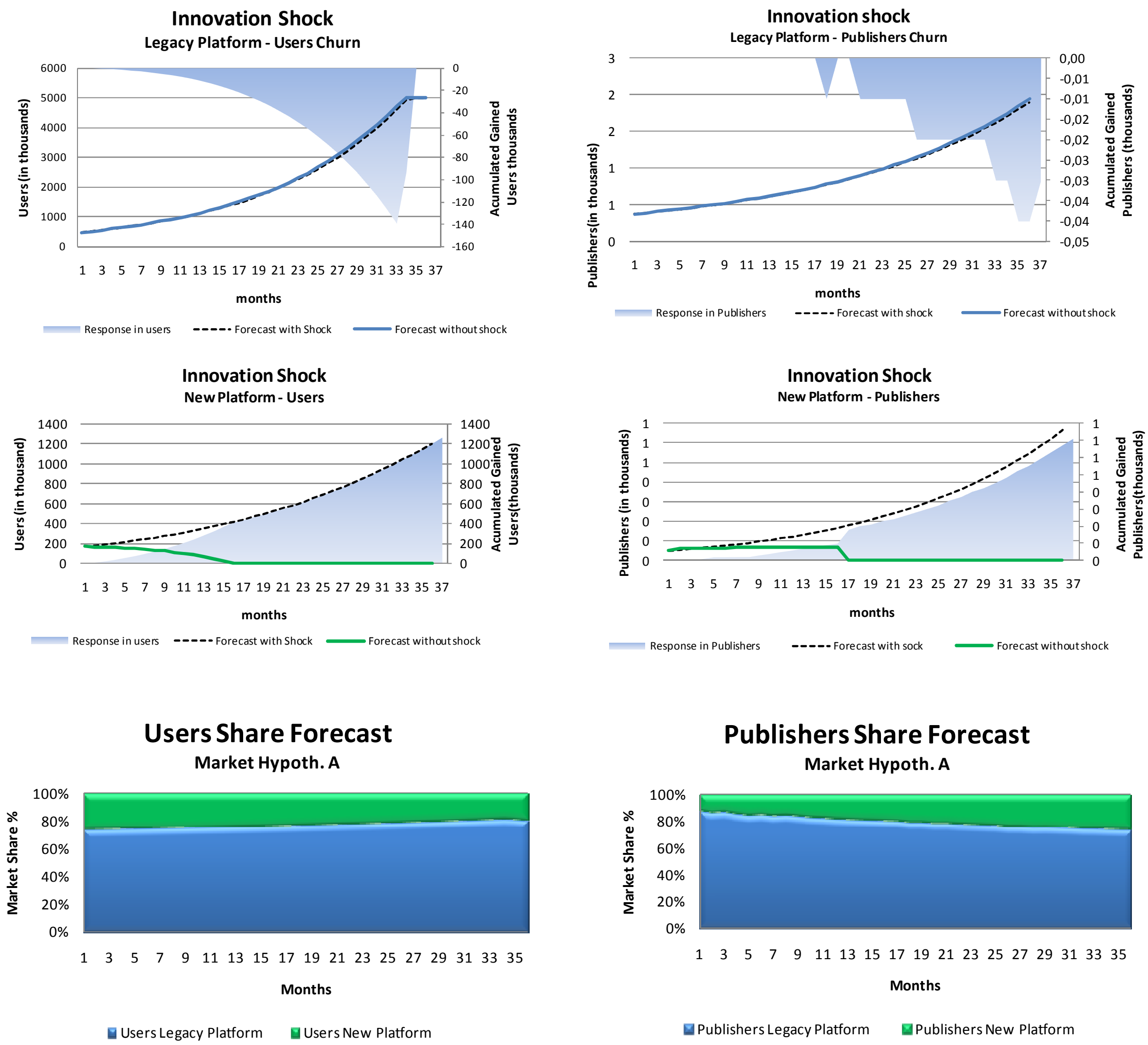


Figure 8-14: Market forecast with and without ENVISION-enabled Web 3D conference use case

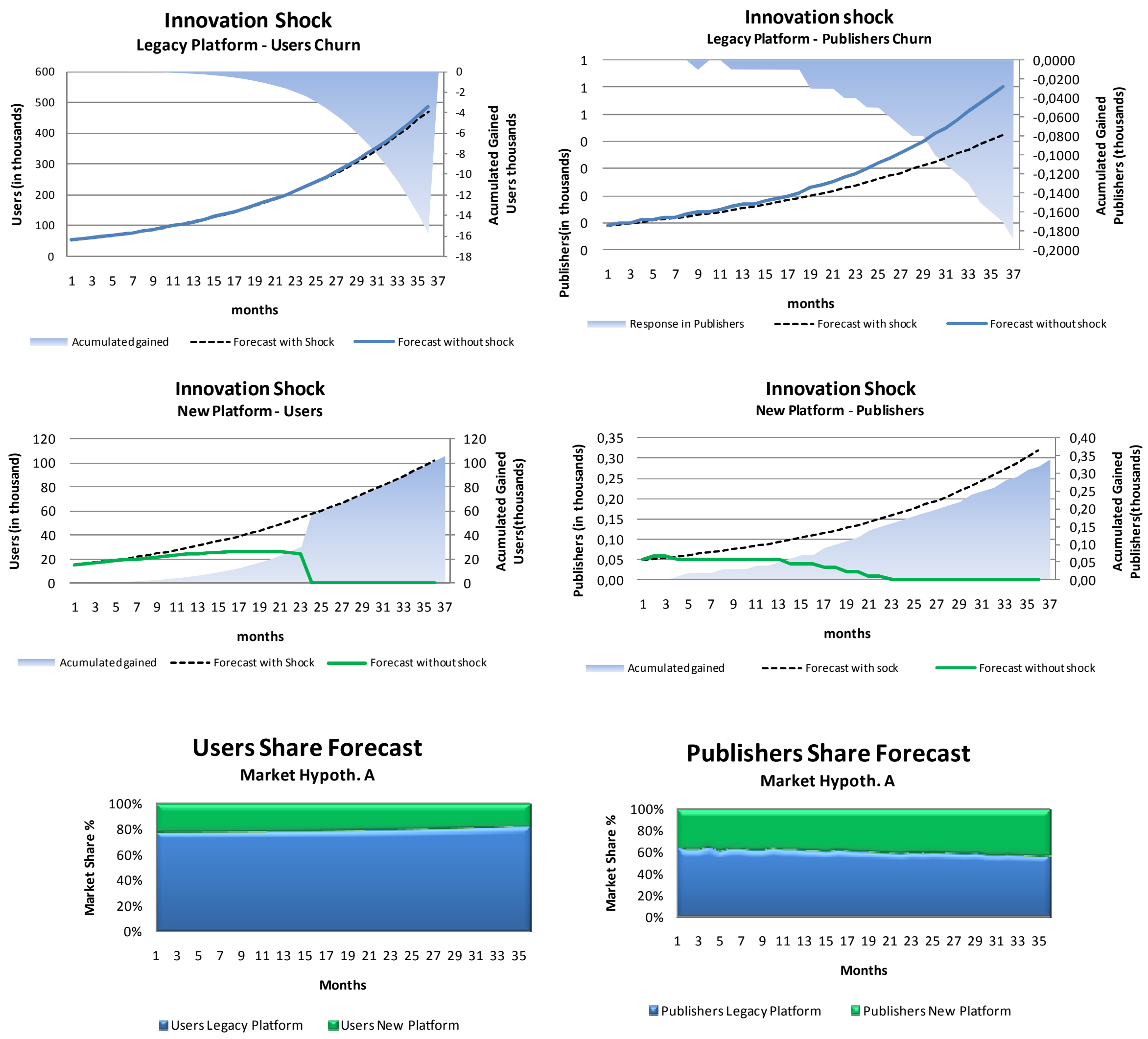


Figure 8-15: Market forecast with and without ENVISION-enabled Bicycle race use case

8.2.5 Stage Three: Economic Results

The following charts display the incomes, and an estimation of the OPEX and CAPEX required to run the services in order to estimate the operating profit function. Advertising and R&D budget required to run the services have not been taken into account.

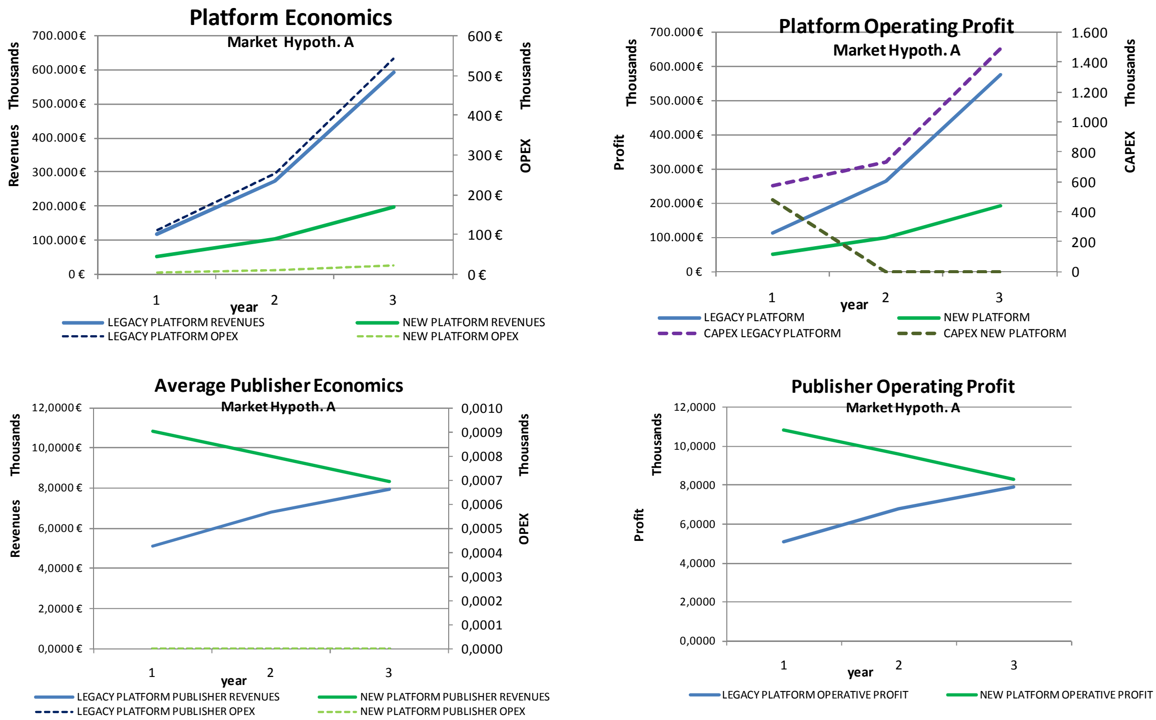


Figure 8-16: Economic Results under the ENVISION-enabled Web 3D conference use case

In Figure 8-14 it can be observed that both platform achieve increasing profits (together with increasing costs).

According to this information, it is possible for Web 3D conference to earn around 200 M€ in profits in the third year. It is important to remark that the ENVISION-enabled new service has a better performance in costs due to the actual lower concurrent sessions and the possibility of maintaining the initial investment while the competition's CAPEX is continuously growing due to the concurrent sessions growth.

Publisher economics are reflected as a per publisher basis, reflecting the average publisher. The figure illustrates that during the first two years, the publisher of ENVISION-enabled Web 3D conference would be generating 10K€ monthly. The ENVISION Web 3D conference network is thought to give more advantages to their publishers (inline to attract the more of them), but since publishers growth faster than total incomes, publishers receive less every year.

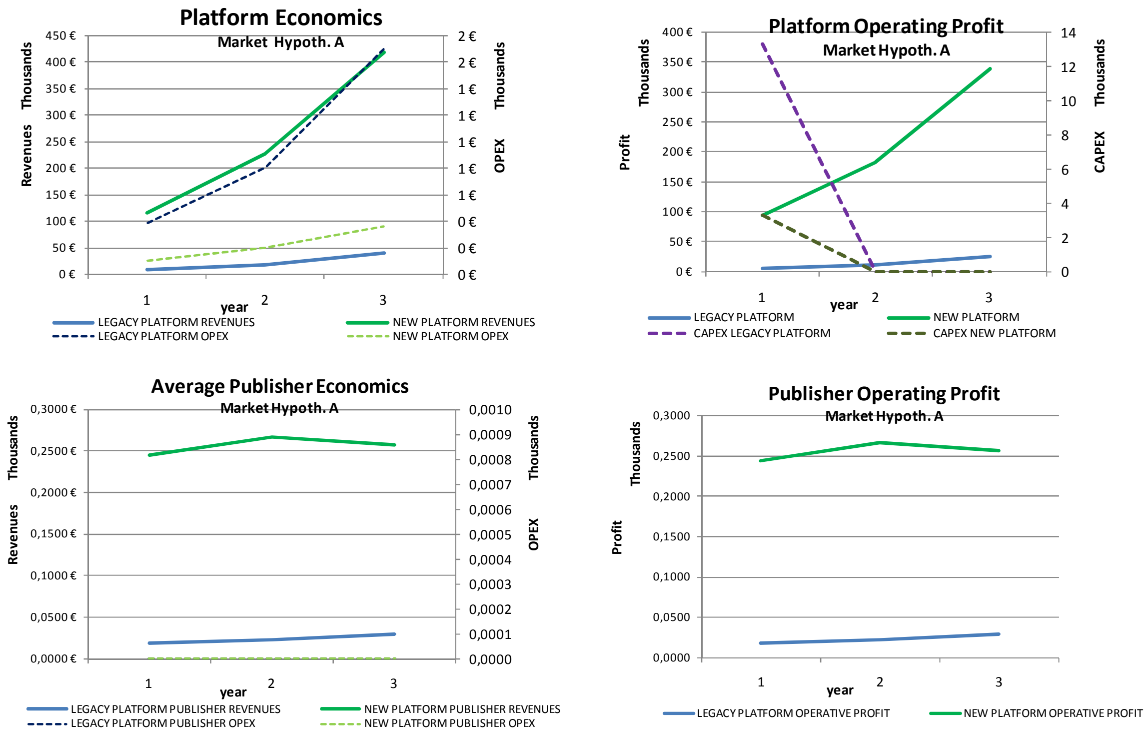


Figure 8-17: Economic Results under ENVISION-enabled Bicycle Race user case

In Figure 8-15 it can be observed that the ENVISION-enabled service revenues reach the 400K€ the third year whilst the legacy platform (Facebook) grows very mildly. Profits grow accordingly for the ENVISION-enabled platform.

Publisher economics are too small because of the small amount of users achieved according to the forecast of Figure 8-13 therefore, in case of considering to launch this service, a low profile mode should be adopted unless improvement to the concept are introduced resulting in greater word-of-mouth actions.

8.2.6 Stage Four: Sensitivity Analysis/Strategic Recommendations

Last simulations are reserved to understand which are the most sensitive aspects of the analysed services. Therefore, providing guidance on the strategic moves that a business owner could take based along the service operation leveraging on this key business information.

Remark 3: Phase three analysis.

In this phase, the dynamic system is used to simulate sequentially different combinations in order to understand how to implement additional policies to continue growing. The following charts are divided in two sections:

Direct actions

This is the response of the main KPIs of the model to different changes in the more actionable variables related to prices, customer and publisher satisfaction and technology.

It could be used to support and take decisions in two ways. What could be the optimal values to apply a policy of this item? What are the most essential drivers in the new service?

Indirect actions

This is referred to investigate what if scenarios in the model diffusion parameters. By "model diffusion parameters" could be understood this parameters that govern users and publishers behaviour, so are a consequence of the nature of service itself and harder to change. The causality chain could be:

Direct action (policy action)➔ Indirect action (market dynamics) ➔ CHANGE OF BEHAVIOUR

The market dynamics could be altered with the present policies to avoid churn, to encourage word-of-mouth among users, to reject competition with an aggressive and near to target advertising campaign.

8.2.6.1 Direct Actions

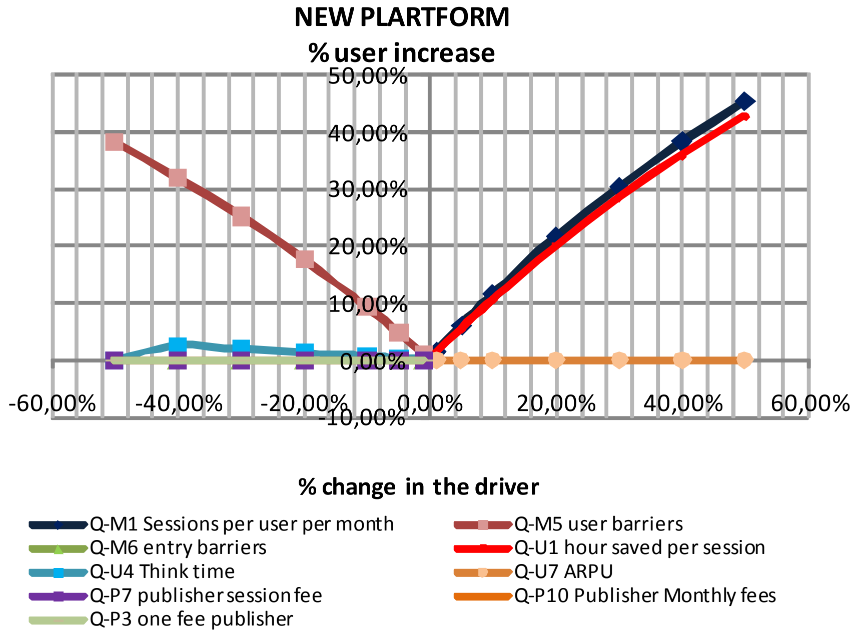
In order to understand how to manage the Technologic and Economic **competitive advantages** of ENVISION versus another platform, in the following a simulation exercise has been carried.

The main objective has been to study the behaviour in the Economic System, simulating the increase of different policies in a range of percentages in order to gauge the sensitivity response.

Basically, the tactical levers could be:

- ***Technological levers***:
  - Decrease user barriers
  - Increase user hour saved per session
  - Decrease entry barriers
  - Decrease think time
  - Increase sessions per user per month
- ***Commercial levers***:
  - Publisher session fee
  - One time fee publisher
  - ARPU
  - Publisher monthly fees
  - Increase sessions per user per month

This study has been implemented in users and publishers, revenues and OPEX. It is relevant to note that this simulation has been performed under the scenarios where ENVISION was used. So, this results are interesting in order to guide the research, and exploitation of ENVISION enablers.



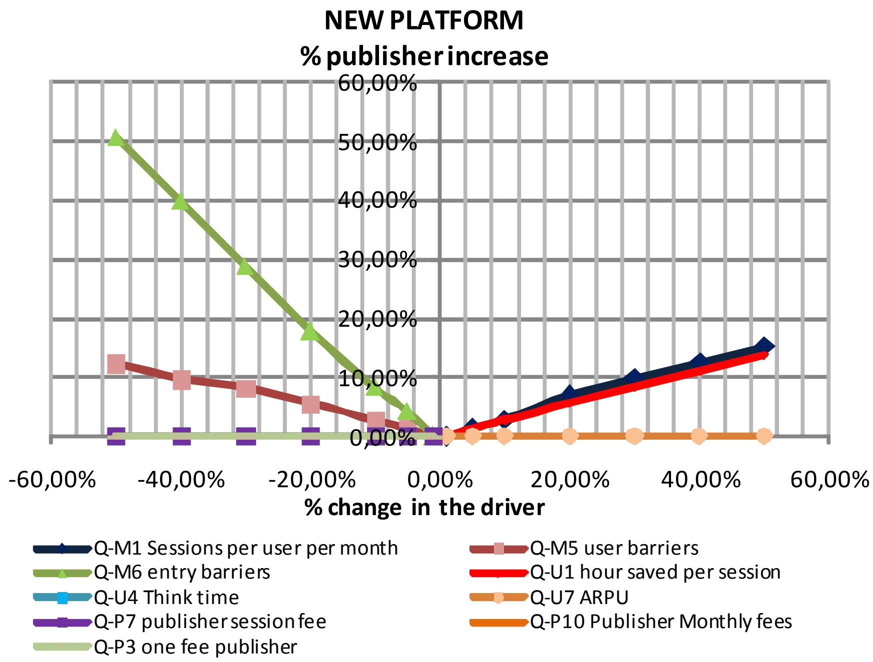


Figure 8-18: Web 3D conference Sensitivity Chart

In Figure 8-16 it is possible to note that functional forms of market responses are non linear type. The main implication is that under this bootstrapping market conditions there could be saturation points. This saturation points remark that the more the driver changes, the variable response (users and publishers) don't follow this line when it arrives to the saturation point.

In Web 3D conference kind of services, there levers providing strong end user adoption are:

- Q-U1 Hour saved per session
- Q-M1 Session per user per month

- Q-M5 user barriers

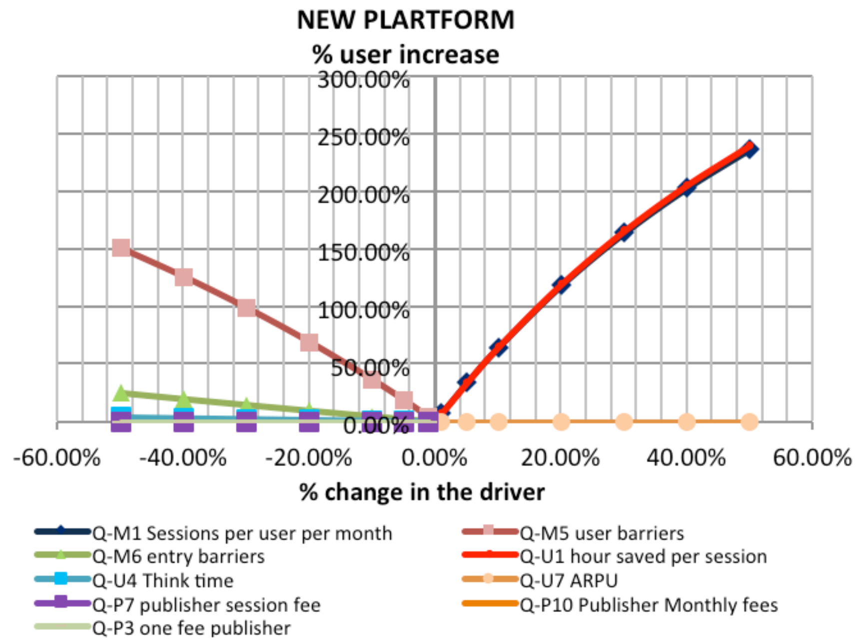
Therefore, it is advisable to continue technological development focusing in increasing the functional gap between ENVISION-enabled services and plain services existing in the market, as well as increase the number of monthly sessions by improving end user satisfaction and true value delivery. This could result as a compound strategy of marketing and technologic developments.

About Q-M1, there is a caveat to do, increasing sessions per user per month has a big impact on costs, variable OPEX (very related to investments derived from session demands forecasts) tend to increase expenses faster than entry barriers and hour saved per session policies do.

It is interesting to note user barriers like another important variable. A better education and simplicity in Web 3D conference kind of services would provide increasing returns.

In the Web 3D conference publisher case, it seems that similar strategies are prone to develop this market, however:

- There are more quickly saturation points (in the main variables of users, additional increases further than a 10% do not have big repercussions on publishers)
- But a remark in QM-6 (entry barriers) has to be done. The more effort on facilitating the migration of content, open APIs, easiness of development, etc, the more additional publishers, even more publishers than current ENVISION technology provides itself.



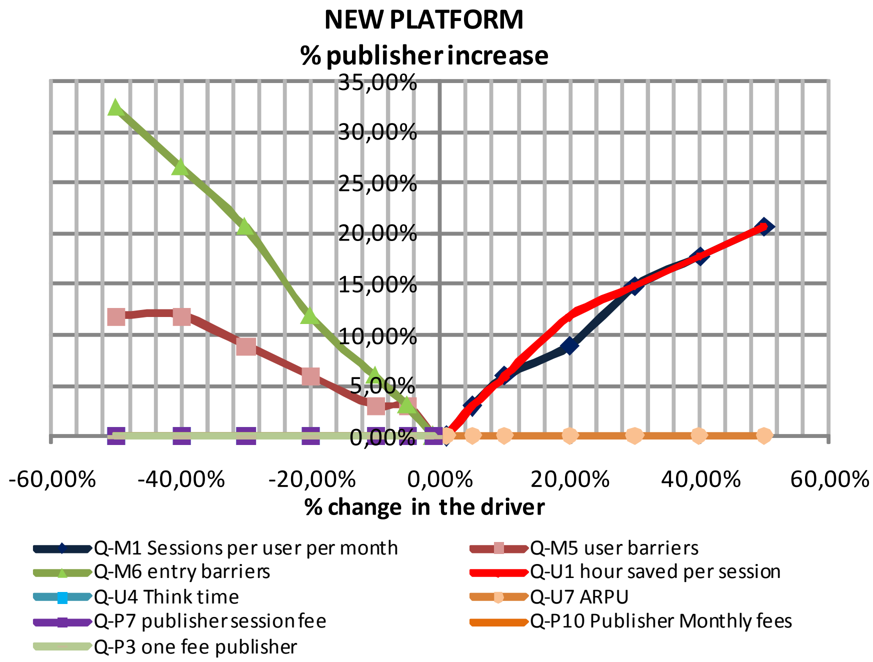


Figure 8-19: Bicycle race Sensitivity Chart

In the Bicycle race, in the same fashion that in Web 3D conference, there are same three main milestones:

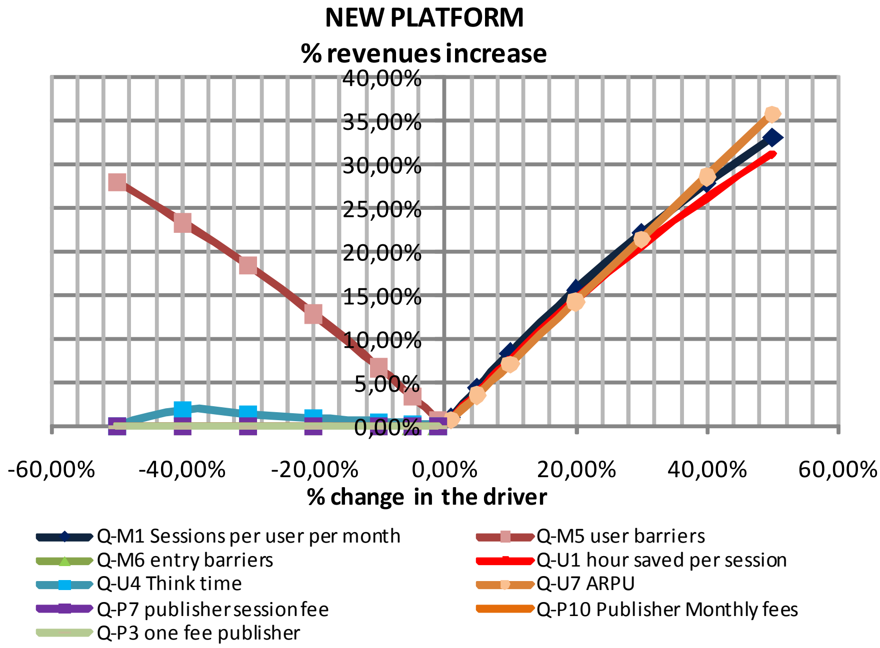
- Q-U1 Hour saved per session
- Q-M1 Session per user per month
- Q-M5 user barriers

Similarly, it is advisable to continue technological development focusing in increasing the functional gap between ENVISION-enabled services and plain services existing in the market, as well as increase the number of monthly sessions by improving end user satisfaction and true value delivery. This could result as a compound strategy of marketing and technologic developments.

User barriers again should be reduced at any cost, for instance by better education, and simplicity in new services, and resulting in increased returns.

In the publisher side, in this use case, it seems that similar strategies are prone to develop this market, however:

- The quantitative impact on publishers of the policies is less impressive due the low percentage of response that achieves the additional increases in policy variables.
- Considering QM-6 (entry barriers), the more effort on facilitating the migration of content, open APIs, easiness of development, etc, the more provide additional publishers, even more publishers than current ENVISION-enabled technology gets by itself. In fact, there is less evidence about a saturation point in this variable, so it could be used as a way to improve publisher activity.



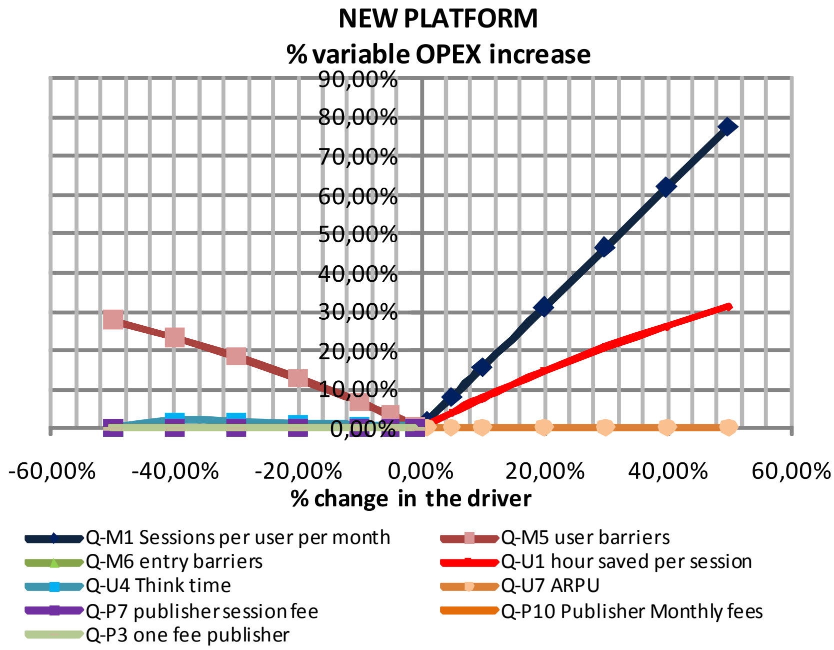


Figure 8-20: Web 3D conference Sensitivity chart platform Economics

As it can be observed in Figure 8-18, the key drivers are very similar to Figure 8-16, however, Q-U7 (ARPU) could be added as one of the most determinant variables in revenues.

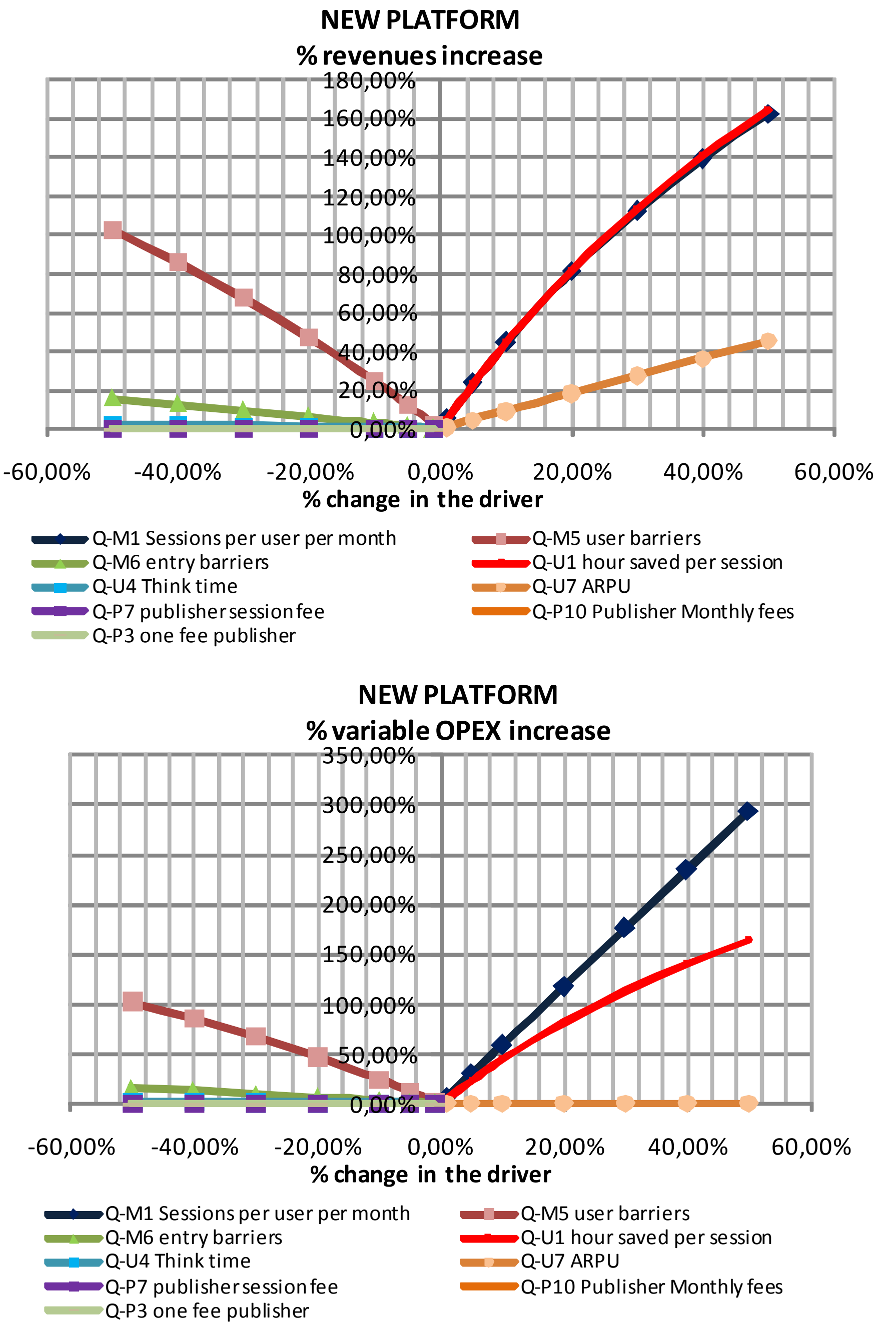
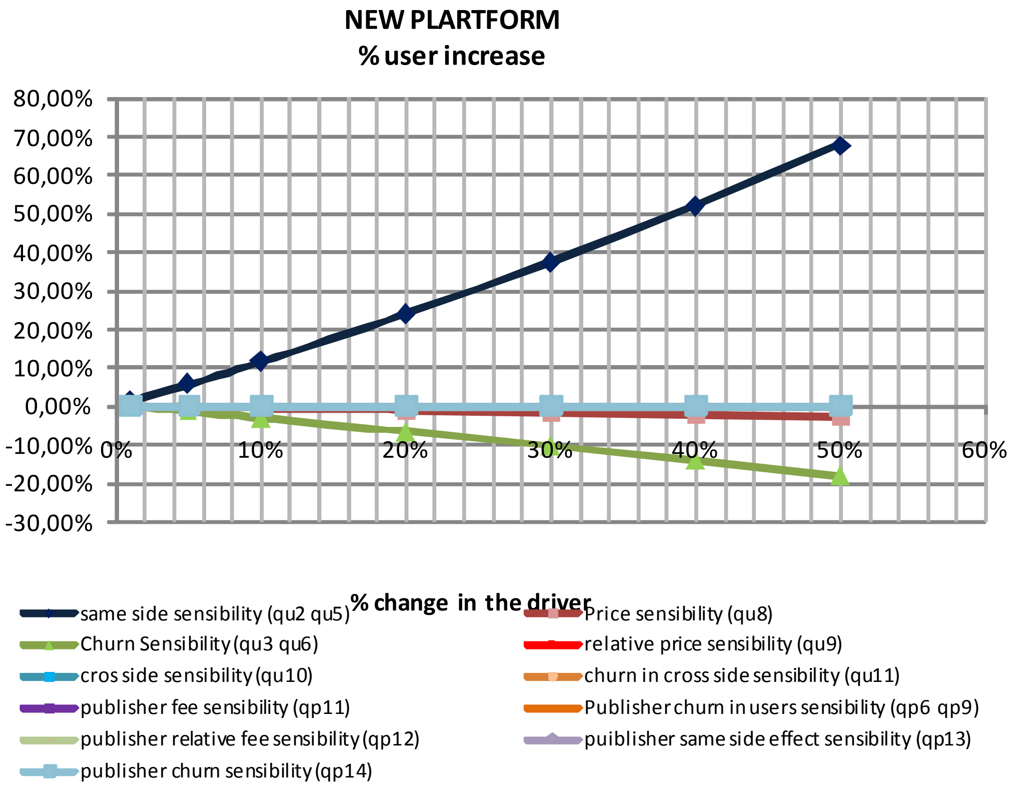


Figure 8-21: Bicycle race sensitivity chart platform Economics

In Figure 8-19 can be appreciated the drivers in platform economics. One of the most important cost inductors is the increase in sessions per user. In fact in the segment analysed appears to have a linear behaviour (no saturation points). This is dangerous in order to increase benefits. Therefore, it could be more interesting -to get more revenues and to control OPEX – to develop more policies towards an increase in the "hour saved per session", in concordance with Q-U1.

8.2.6.2 Indirect Policies

As it has been explained in "remark 3", in this phase, it has been studied the possibility to trigger better results due to the indirect implications of policies that affect market dynamics. This are more subtle to correlate with ENVISION technology, or exploitation efforts, and depending on the use case, not always possible to alter.



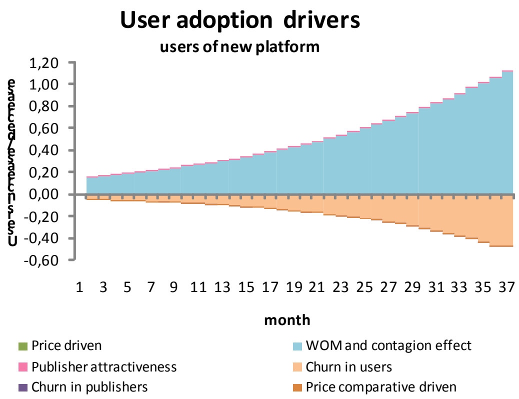
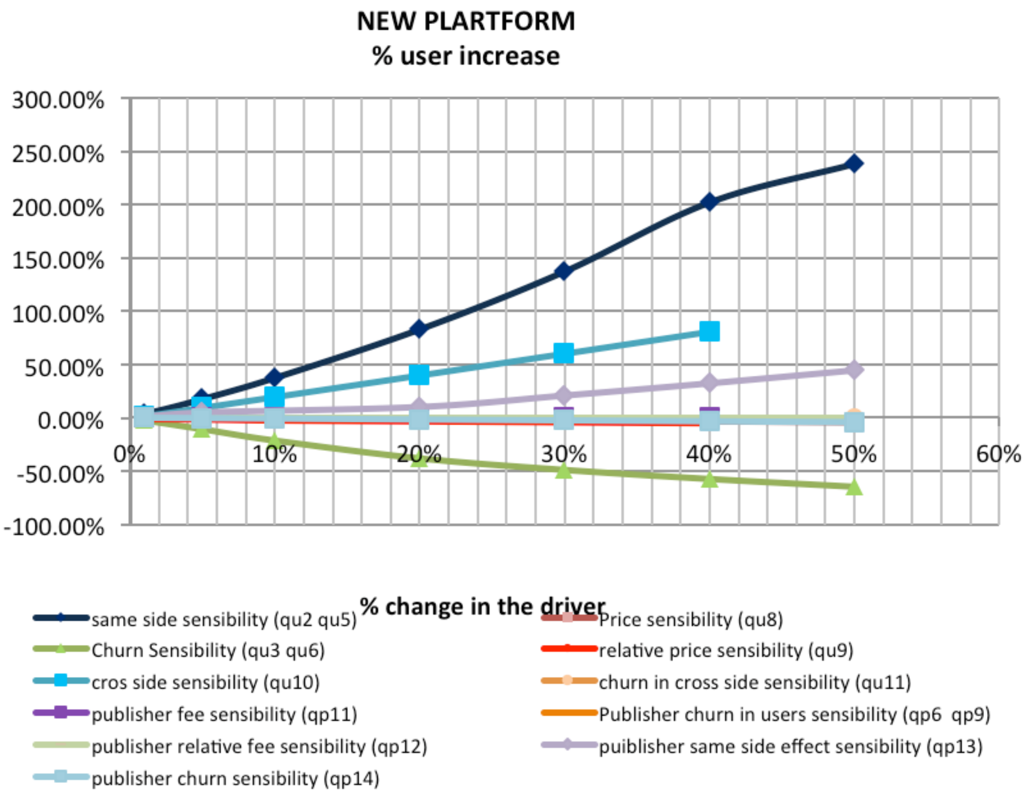


Figure 8-22: Indirect user policies (Web 3D conference)



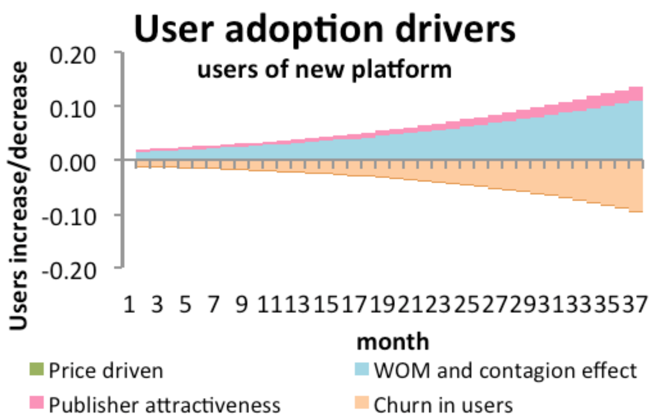
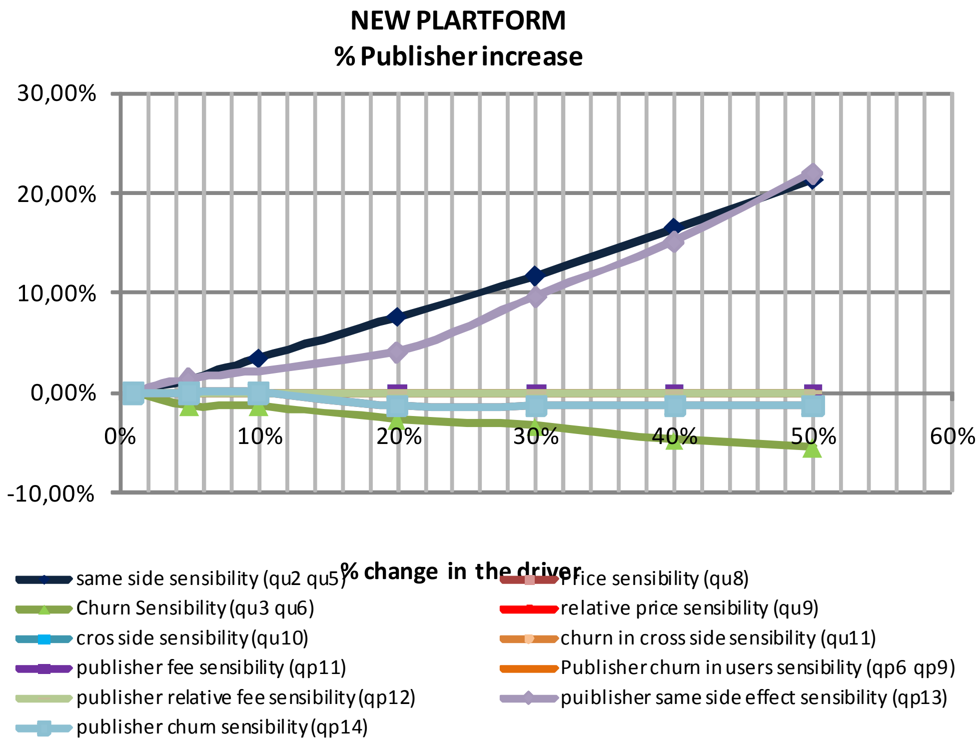


Figure 8-23: Indirect User Policies (Bicycle race)

Figure 8-20 and Figure 8-21 represent the main dynamics that drive users in Web 3D conference and Bicycle Race. Word-of-mouth policies (sensitivity to same side effect) are the most relevant in this two market model. However, in Bicycle race show more importance due to the high effectively that could be this kind of policies in trigger more and more users in proportion to the effort.

One of the reasons that allows this effect to be stronger is the contention in the churn sensitivity effect. An increase of 1% in churn variables results in less that 1% in effective departures from the platform.



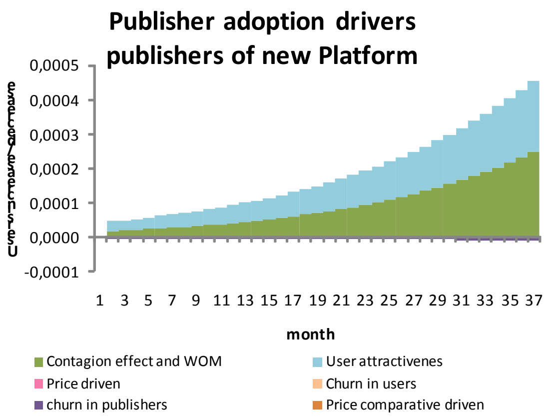
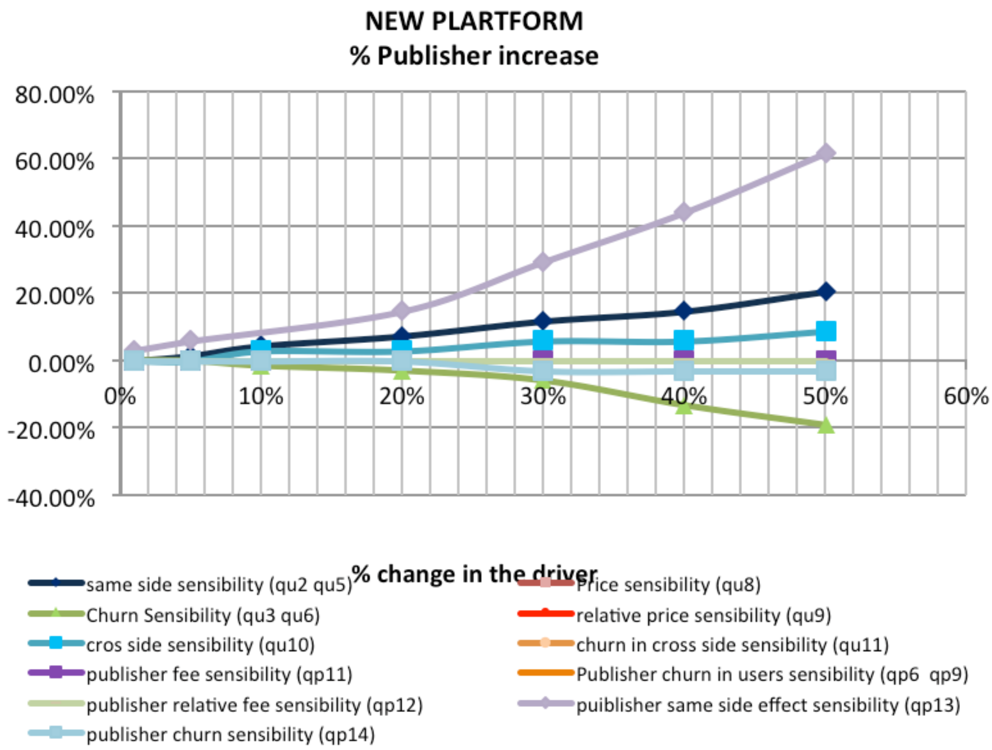


Figure 8-24: Indirect Publisher policies (Web 3D conference)



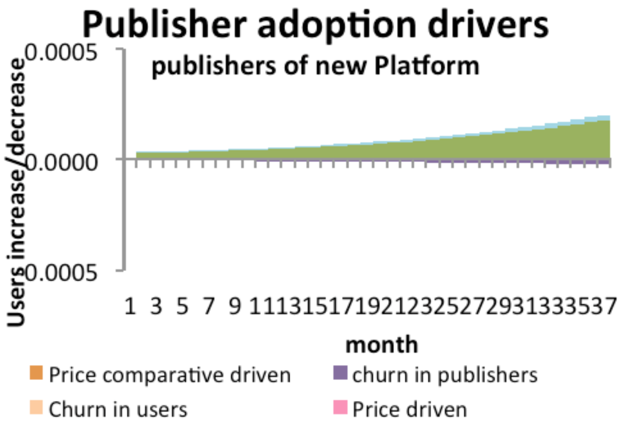


Figure 8-25: Indirect Publisher policies (Bicycle race)

Figure 8-22 and Figure 8-23, representing publisher dynamics, show that in Web 3D conference case ENVISION-enabled, all of them have decreasing returns (in order that the proportion of the increase of the driver, never will be outperformed by the increase in users or publishers). In this side of the market it appears to be relevant both same side effect, users and publisher. So, this indicates the sensitivity of publishers to users behaviour more than in the reverse side. This is interesting in order to incorporate more policies relative to exigencies of high quality to publishers. This is a traditional piece of advice in strategy texts about two sided markets. In this case appears to be convenient, providing that a good word-of-mouth of users have big influences on publishers growth.

In bicycle race case, the more relevant effect is the publisher same side, indicating that if contagion effect between publisher is boosted, the returns in more publisher and, given the dilemma, users is the most effective.

8.3 Conclusions from the Economic Modelling Analysis

In this section an economic analysis has been conducted in order to assess the business feasibility of launching new services such as the ones described in the use cases. Because the economic feasibility of ENVISION applications rely heavily on a combination of network, and non network related aspects, a compilation of business guidelines for the ENVISION research have been complicated in order to provide guidance and insights to help the governance of the technological research to become business feasible:

- Applications using the ENVISION interfaces should not be understood as final content. Each application should be understood as an intermediary agent which provide access to final third party content providers/publishers, and even third party advertisers. Therefore, ENVISION applications should be understood as platforms. For instance, in the Web 3D conference, the application would be the core logic coordinating ENVISION end user interactions and flows to more or less extent. In addition, the Web 3D conference would have to coordinate the ENVISION end user flows with a catalogue of lands, objects, rich advertisements, properties, or live media flows that could be created, provisioned and administrated by third party providers out of the ENVISION-enabled network reach.

  An example of how this could apply to the technological research would be at the time of designing or implementing the ENVISION interfaces; those may be aware that some peers of a collaboration flow –for instance- could be placed out of the ENVISION-enabled network, and therefore with less reliable and versatile network conditions.

- The ENVISION-enabled technologies should be aware that future applications will probably require the possibility of selling premium content from third parties beyond the applications to end users, for instance pre-generated video clips by the brand manager of a sports event in the micro-journalism case.

  An example of technological implication could be that underlying technologies should be flexible enough to enable different degrees of network resource quality at the moment of negotiating a collaboration amongst several peers for instance.

- Along the parameter estimation conducted in the economic analysis, the following differential business features -that could make ENVISION a truly business enabler- have been identified, and are suggested to be considered during the research:

  - ENVISION-enabled services should result in services with **greater sessions per user** in comparison with a similar non ENVISION enabled service. The reasoning behind is the wow factor, greater functionality, and usability perceived by the end users when using ENVISION-enabled applications.

  - **Greater entry barriers** for services enabled with ENVISION due to unknown features and novel applications by the end users and the developers. Therefore, the resulting technologies should try to become as backward compatible as possible with existing interfaces and content formats.

  - **Greater time savings for the end user** when using ENVISION-enabled services. Therefore, resulting technologies should enable novel features and very low response time to applications with the goal of delivering significant time savings for the end users when using ENVISION-enabled services versus non enable ones.

  - **Greater hours per session** in ENVISION-enabled services delivering end users a shift in satisfaction with the service and its richness perceived as attractive applications.

  - **Lower response times** resulting in small interaction think time for the end user and perceived as highly usable and fast services.

In conclusion, the modelling and simulation work resented in this section has resulted in a series of business guidelines providing insights to the path from technological research topics to feasible business realities. A significant conclusion based on the results of the modelling work is that the ENVISION-enabled technologies being researched are vital and could enable a new ecosystem for future Internet services.

9. CONCLUSIONS

This report is a key milestone for the ENVISION project. It sets the scene for the detailed technical work to be undertaken in the main technical workpackages.

The report began by describing the problem to be solved by the project, introducing the essence of the solution and outlining the major research challenges. Three use-case describing ENVISION-enabled media applications were introduced and refined: *Web 3D Conference, Bicycle Race* and *Legacy Delivery Networks*.

Considering the overall problem domain of the project and by analysing the three use cases this deliverable proceeded to derive and specify the requirements that capture the core features and design principles for multi-participant interactive applications that collaborate with the underlying ISPs through the CINA interface. The requirements were defined to be applicable to a wide range of use cases, irrespectively of particular business models, application-specific requirements and infrastructure restrictions. The requirements as defined in this report are a key input to the technical workpackages (WP3, WP4 and WP5), specifying the scope and constraints of the network services and network optimisation targets, the CINA interface functionality, the requirements for overlay data management, content distribution optimisation, content adaptation and caching.

This document went on to define the business environment applicable to the ENVISION solutions by identifying a set of business roles and representative business scenarios where those roles are mapped to business actors and their interactions

A major contribution presented in this report was the ENVISION system architecture developed to meet the requirements raised by the use cases and enabling the identified business scenarios. The architecture identified the nine high level blocks that form the framework for the technical work, highlighting the major functions in the network and overlay layers as well as user terminals, their relationships and interactions. The framework, as presented in this report provides a reference model for the overall ENVISION solution being developed in the main technical workpackages of the project.

The final part of the report presents the results of an economic analysis to assess the business feasibility of launching new services such as those identified in the ENVISION use cases. The most challenging use cases from the business perspective were simulated as brand new services competing with well-established players. The modelling and simulation work resulted in a series of business guidelines providing insights to the path from technological research topics to feasible business realities. A significant conclusion based on the results of the modelling work is that the ENVISION-enabled technologies being researched are vital and could enable a new ecosystem for future Internet services.

10. REFERENCES

[ALTO] https://datatracker.ietf.org/wg/alto/

[ARMS05] Armstrong, *Competition in two-sided markets.* MIMEO, University College London, 2005.

[BASS69] Bass, *A new product growth for model consumer durables***.** Management Science, 15, 215-227.1969.

[BM-1] http://lindenlab.com/pressroom/releases/22_09_09

[BM-2] http://mba.tuck.dartmouth.edu/pages/faculty/koen.pauwels/pdf/word_of_mouth2006 1216.pdf

[BM-3] https://marketplace.secondlife.com/listing_guidelines

[BM-4] http://solutionproviders.secondlife.com/

[BM-5] https://jira.secondlife.com/secure/IssueNavigator.jspa?mode=hide

[BM-6] http://secondlife.com/land/privatepricing.php?lang=en-US

[BM-7] Nelson Linden, The Second Life Economy in Q3 2010, Linden Research, Inc, http://blogs.secondlife.com/community/features/blog/2010/10/28/the-second-life-economy-in-q3-2010, San Francisco, 2010

[EASY08] EasyNet Global Services, *Face to Phase: The convergence of business travel and virtual meetings.* Europe, 2008.

[FARI81] Farivar, Tigert et al., *The Bass new product growth model: A sensitivity analysis for a high technology product***.** Journal of Marketing, 45, Fall 81-90. 1981.

[GART07] Gartner, *Dataquest Insight: Videoconferencing Products and Services Market Forecast. Worldwide.*, 2007-2013.

[HORS90] Horsky, *A diffusion model incorporating product benefits, price, income and information.* Marketing Science, 9, 342-365**.**1990.

[INFO10] Informa Telecom & Media, *Converging Media - Digital content Strategies*: Volume 9, Issue 5, March, 2010.

[MAHA90] Mahajan, Muller & Bass, *New Product diffusion models in marketing: A review and directions for research***.** Journal of Marketing, 54 , 1-26**.** 1990.

[MULL79] Mahajan, Muller, *Innovation diffusion and new product growth models in marketing*, Journal of Marketing, Vol 43, 55-68 1979.

[OECD] OECD*, Digital Broadband Content: Music.* [Online], 2005. http://www.oecd.org/dataoecd/13/2/34995041.pdf.

[ROSO05] Roson, *Two sided-markets: A tentative survey*. Journal of Network Economics, 4, 142-160.2005.

[RYSM04] Rysman, *Competition between networks: A study of the market for yellow pages***.** Review of Economic Studies, 71, 483-512.2004.

[SUN06] Sun, Mingchun*, Dynamic Network Platform Competition in two Sided Markets***.** 2006, Stanford University, PhD dissertation.

[TIRO03] Tirole, Rochet, et al., *Platform competition in two- sided markets.* IDEI Working Papers 152, Institut d'Économie Industrielle (IDEI), Toulouse 2003.

[TSE02] Tse, *Grabber-holder Dynamics and Network Effects in Technology Innovation*. Journal of. Economic Dynamics and Control, 26, 1721-1738. 2002.

[WRIG04] Wright, *One-sided logic in two-sided markets*. Review of Network Economics, 3(1), 44-64. 2004.

11. APPENDIX A – SCENARIO MODELLING

In this chapter, the specific parameterisations of the simulator are defined in order to reflect the market conditions per each use case. The parameterisation has been achieved by judgemental analysis of each use case. The questions below are estimations of hypothesis about three different market behaviours, one per each use case. Each of them has three different values: the value for the legacy platform, the one for a new platform without ENVISION, and the one for an ENVISION-enabled new platform.

As mentioned in the methodology, the legacy platform corresponds to well established players in the market today that could somehow compete as a substitute or alternate of the new ENVISION-enabled services being analysed. However, a step beyond simple comparison with existing platforms has been taken. A comparative analysis has been conducted in order to estimate the market shifts hypothetically gained by a new service using ENVISION, or without it. “New platform” stands for a new service similar to the one described in the use cases implemented with nowadays technology without ENVISION, whilst “ENVISION-enabled” stands for the same overlay application using the ENVISION technology.

At this stage of the research -when there are not yet any measurable results- it is unfeasible to quantify with precision the effects of specific areas of research in ENVISION with the estimated market shifts employed in the parameter estimation for “ENVISION-enabled” services. Therefore, a qualitative approach has been used creating reasonable hypothesis that result in a set of recommended requirements.

The use case Web 3D conference is one of the examples of innovative services that could be delivered leveraging on ENVISION infrastructure. The current competitor in the market –the “Legacy Platform” is Second Life. The “New Platform” stands for a Web 3D conference developed with existing technology today, and the “ENVISION-enabled”, a similar one but relying on ENVISION technologies.

The use case “Bicycle Race” is the other example of innovative services. This service falls in the area of micro-journalism family of applications, providing exceptional usability for events that require fast and rich interaction far beyond what typical generic social networks provide. This simulation provides market insights on how ENVISION can turn an unfeasible micro-journalism application (from now denoted as *MJ-client*) competing with Facebook into a sustainable business. The “legacy platform” is assumed to be a generic social network style of application like Facebook, and the “new platform” an MJ-client developed with existing technology today, and the “ENVISION-enabled”, a similar one but relying on ENVISION technologies.

11.1 Overall Market Parameters

Given the disruptive nature of future enabled ENVISION services, readily available historical business data was not always available. Therefore, the values of the simulation parameters were required to be hypothesised based on the judgements of expert consultants from Telefonica I+D. Depending on the area of expertise, and previous experience, experts were targeted to aid the estimation of specific parameters where available data was not in place. Data that was readily available is identified with appropriate references in analysis in the following subsections.

A straightforward estimation of parameters, as described in the methodology (section 8.1.2), was unable to answer because of the complex units, and multiple implications of a single parameter. For instance, estimating “b” in the formula $a=b\cdot(c+d)$, in some instances, was more complex than estimating $b\cdot c$ or $b\cdot d$. Therefore, a set of high level questions were carefully formulated in order to facilitate comprehension of the factorisation of some of the critical parameters by the selected experts in their business field. These aspects are dealt with in detail in the commentary against each question, below.

11.1.1 User Sessions

The following questions deal with the core nature of how the service provided by the platform is used, therefore, what kind of "sessions" users perform in the service.

QUESTION M-1: Could you provide us a size of the average number of sessions per user in a month?

Q-M1	Legacy Platform	New Platform	ENVISION-enabled	% difference
Web 3D conference	1,6	1,6	2,5	50,00%
Bicycle race	1	1,5	1,5	0,00%

Comments: Web 3D conference kind of applications compete with a legacy platform such as Second Life. The legacy platform values are extracted from the SL stats reported by LindenLabs in [BM-1]. A new services being launched without ENVISION would not be expected to vary in the number of sessions per month. However, when enabled by ENVISION it would be reasonable to expect higher number of sessions driven by a higher richness of the overlay applications, as well as higher user experience due to better QoS, less packet loss, etc.

Bicycle Race, given the lack of specific micro-journalism functionality in social networks, it is hypothesised that a user would only publish content once every two events, therefore, one session per month. With a generic MJ-client, a substantial functional improvement would be achieved, therefore increasing the monthly sessions on average 1.5 events per month. However, if ENVISION-enabled, it is not expected that users will go more frequently to concert halls or sport events, therefore the value remains the same.

QUESTION M-2: could you provide us a size of the average duration per session in minutes?

Q-M2	Legacy Platform	New Platform	ENVISION-enabled	% difference
Web 3D conference	100	100	80	-20,00%
Bicycle race	5	10	20	100,00%

Comments: **Web 3D** In the Web 3D conference kind of applications, the values reported by LindenLabs in [BM-1] are taken for the value of the mean time per visit. Since the latency, and resolution will be higher in the Web 3D conference use case implemented on top of ENVISION, and assuming the same usage, an estimated reduction on the session duration of 20% for the same functionality is assumed.

Bicycle race. Users of legacy SN such as Facebook, are hypothesised to employ close to 5 minutes (Q-M2) for taking some pictures, commenting on the status, maybe visiting the fan page of the event and reading some comments from other attendants. When using a plain MJ specific client, engagement should be higher since the app is designed for the specific purpose of sports and music events, therefore, an average user should use it at least twice, 10 minutes. The underlying technology provided by ENVISION would enable better functionality, usability, and cost, therefore, a reasonable hypothesis would be to duplicate the consumption up to 20 minutes.

11.1.2 Capacity Planning

Usually, a service is used more during specific periods called peak times.

QUESTION M-3: How many hours in a month could be designed as peak-hour?

Q-M3	Legacy Platform	New Platform	ENVISION-enabled	% difference
Web 3D conference	40	40	40	0,00%
Bicycle race	48	48	48	0,00%

Comments: In the Web 3D conference kind of applications, the load profile reflects that the peak timeframes on any of the platforms is expected to be approximately of 40 hours per month (Friday and Saturday night time).

However, on music and sport events, we estimate that on average, each month there will be 48 hours of peak slot corresponding to four weeks, each of them having one peak evening during the week, in addition to Friday and Saturday evenings.

QUESTION M-4: Could you forecast the monthly percentage of sessions will be in peaks due the current behaviour of the market?

Q-M4	Legacy Platform	New Platform	ENVISION-enabled	% difference
Web 3D conference	60%	50%	50%	0,00%
Bicycle race	80%	80%	80%	0,00%

Comments: In Web 3D conference kind of applications, platforms should have an uneven percentage of sessions given the smaller amount of users –early adopters- of the Web 3D conference platform in the initial stages.

In Bicycle race, events will tend to be concentrated in peak slots, therefore having more concentration than in the previous use case.

11.1.3 Disengagement Ratio

In every service there is a drop from new users that sign in, to those users usually using the service (called active users). This might be due to the learning curve, miss-expectations, curiosity, etc. This is called the "disengagement ratio".

QUESTION M-5: Approximately how many (in %) new users drop and do not become active users for the mentioned reasons?

Q-M5	Legacy Platform	New Platform	ENVISION-enabled	% difference
Web 3D conference	20%	35%	35%	0,00%
Bicycle race	5%	35%	35%	0,00%

Comments: In the Web 3D conference kind of applications, the Second Life competing platform is assumed to have a moderate ration, whilst new services tend to have a higher deactivation ratio given the novelty of the client software to be installed in a PC or mobile and less knowledge by the end users.

Users of the bicycle race type of services using Facebook (the legacy platform) are expected to have very low disengagement ratio given to the popularity of the SN. However, the alternate purpose specific services developed with or without ENVISION are expected to have a drop-out ratio similar to the previous case.

11.1.4 Entry Barriers

QUESTION M-6: Approximately how many (in %) new publishers decide not to join/leave the platform because of the entry/exit barriers?

Q-M6	Legacy Platform	New Platform	ENVISION-enabled	% difference
Web 3D conference	20%	35%	40%	15,00%
Bicycle race	10%	20%	18%	-10,00%

Comments: In the Web 3D conference kind of applications, publishers do have "entry barriers" analogous to the "disengagement ratio" of the end users in their initial experience. Learning curves of their production lines, incompatible content originally meant for the legacy platform, missed expectations, and other reasons difficult the entry of new publishers. This model assumes that the exit barriers are symmetric to the entry barriers, thus, the higher the entry barrier, the higher the exit barrier. The question Q-M6 captures this figures measured in % of publishers that desist of publishing once they showed firm interest in the platform. Similarly to what happens to users with the disengagement ration, the Second Life competing platform is assumed to have a lower entry barrier ratio than the ENVISION Web 3D conference given the maturity of the sl client (used by publishers to publish new content) to be installed in the PC, and the better knowledge by the community of publishers of the precise service provided.

However, in the bicycle race micro-journalism type of services, of every 100 publishers that would have interest in publishing in Facebook, a 10% is estimated to resign. If this platform is a plain new micro-journalism service, a 20% is estimated to resign given of the lack of market reputation, lack of knowledge of the interfaces, etc. This drop out is considered to be slightly less in ENVISION-enabled micro-journalism because the significant benefits achieved with ENVISION compensate the natural entry barrier when using a different platform than well established SN, therefore the drop out is estimated to be a 18% of interested publishers.

11.2 User Behaviour

This section of the parameterisation defines the main attributes of the degree of attractiveness of potential users depending on the functionality provided by the service (perceived value), the amount of existing users (same sided network effect), usability (cost of usage), ARPU (average revenue per user), and availability of publishers (cross-sided network effect).

11.2.1 Functionality & Same Sided Network Effect

QUESTION U-1: How many hours do subscribers safe when using the service instead of using a combination of previous ones (YouTube, Facebook, Twitter and alike)?

Q-U1	Legacy Platform	New Platform	ENVISION-enabled	% difference
Web 3D conference	5	5	8,3	66,00%
Bicycle race	1,83	1,96	1,96	0,00%

Comments: **Web 3D** In the Web 3D conference kind of applications, the functionality perceived by a user has been measured in the terms of how many hours –on average- would a new user save in a typical session of the service, in comparison to use a combination of third party services -excluding the competitor one- to achieve the same functionality. Examples of third party service would be combinations of web conference, phone calls, SMS, Facebook, Twitter, Flickr, etc, that would deliver an equivalent functionality.

The estimated values for the Web 3D conference use case compared with SL about session value in terms of hours saved per session when using conventional existing services has been estimated to triple the average session mean time of 100 minutes of SL according to [BM-1], in the case of the ENVISION Web 3D conference, it is estimated that ENVISION-enabled applications in this field would deliver hypothetic savings of 66% leveraging on the rich set of functionalities such as distributed caching, monitoring, QoS, higher quality, greater speed, and less jitter not feasible to be implemented nowadays by most applications due to the high implementation cost, operational expenses, or unavailability.

In the Bicycle race In the estimation of this user time value, it has been taken into account the average time to record an event, sync it with the PC (uploading videos via mobile phone and email applications is rare), perform the content adaptation, share with other fans, as well to retrieve and view the videos from other fans. Per each event, this process is estimated to take about 2 hours (excluding attendance to the concert). When using a plain SN, this process is estimated to take about 10 minutes in total, therefore 1.83 hour time savings (excluding attendance to the concert). When using a MJ-client, this is estimated to take only 2 minutes, therefore 1.96 hours saved. In the worst case, ENVISION enablers would not deliver significant better functionality (however other remarkable benefits are accounted in other aspects).

Situation*: Imagine that both the new service and the competing service have 1 000 subscribers each. An upgrade in only one of the two platforms will deliver more functionality increasing subscribers time savings in a 10%. The satisfaction of existing subscribers would bring new users by word-of-mouth. In addition, some users from the non upgraded service driven by the greater time savings would join as well.*

QUESTION U-2: How many new users out of 1 000 would come attracted by the word-of-mouth of greatly satisfied subscribers if the raise happened in the legacy, new, or new ENVISION-enabled platform?

Q-U2	Legacy Platform	New Platform	ENVISION-enabled	% difference
Web 3D conference	20	10	20	100,00%
Bicycle race	16	20	24	20,00%

Comments: **Web 3D** In the Web 3D conference kind of applications, new users are attracted by the word-of-mouth of existing users in the platform is captured in Q-U2 and it's measured in new users attracted monthly per each thousand existing users. It is hypothesised that ENVISION-enabled applications would become more appealing to end users leveraging on the innovative underlying technologies. More appealing applications should generate double word-of-mouth effects amongst end users.

The research conducted by [BM-2] concludes in that social networks achieve a 0.5% increase per each 1% increment in the word-of-mouth actions. Given that a 10% rise in the functionality is not equivalent to the raise of word-of-mouth actions, it is estimated in first place that both platforms have a similar reaction by user satisfaction after the increase in functionality in a way that one user out of 20 will trigger word-of-mouth recommendation of the service to the community. This means that in a service with 1000 users (as asked in the question) per each 10% rise in functionality, 50 users trigger a word-of-mouth actions, therefore the word-of-mouth actions increase a 5% per each 10% increase in functionality in a service with 1000 users. According to the [BM-2] report this 5% word-of-mouth increase would presumably translate to 2.5% increase on the existing users, thus resulting in 25 new users coming to the platform. Given that the report does not distinguish between users coming from the competing websites and fresh users not belonging to any of those, the 25 users are split into 20 newcomers and 5 former users of the competing platform (see next question).

In the bicycle race use case the figures shift significantly in comparison with the previous since the shift in the Facebook legacy platform is not expected to generate the same “wow” factor because of the cross application generic nature of Facebook, therefore the word-of-mouth actions are expected to be less than when the shift occurs in vertical applications. The specific micro-journalism service without ENVISION is expected to behave according to the previous calculations. When incorporating ENVISION, the attracted new users is expected to be higher because of the novelty of the functionalities shown, however, the shift with the non ENVISION service is not expected to be as differential as with the Web 3D conference gap is.

QUESTION U-3: How many additional former users out of 1 000 of the non upgraded platform would become new users of the upgraded platform if the raise happened in the legacy, new, or new ENVISION-enabled platform?

Q-U3	Legacy Platform	New Platform	ENVISION-enabled	% difference
Web 3D conference	1	5	5	0,00%
Bicycle race	1	5	6	20,00%

Comments: In comparison with the previous question, the legacy platform here captivates users from the competing alternatives with less efficiency since purpose specific services de per se will be more customer driven, and therefore, hard to assume that the switching from legacy to purpose specific applications will be symmetrical.

Therefore, if the raise happened in the legacy SN, the amount of users migrating from the purpose specific service to the legacy platform is reduced to 1.

In addition, it is reasonable to expect that the popularity of ENVISION-enabled micro-journalism applications will be increased thanks to word-of-mouth recommendations based on a 10% increase in functionality and a richer feature set in the overlay applications.

11.2.2 User Experience & Same Sided Network Effect

Usability effects on the adoption and retention of existing users, are gauged in questions Q-U4, Q-U5, and Q-U6. Given that usability is becoming a significant competitive lever, the present parameterisation hypothesises that a 10% better usability will impact three times more in the market than a 10% functionality improvement.

QUESTION U-4: In a typical session, how many "think time" does a subscriber employ in minutes?

Q-U4	Legacy Platform	New Platform	ENVISION-enabled	% difference
Web 3D conference	1	1	0,5	-50,00%
Bicycle race	0,5	0,25	0,20	-20%

Comments: In the Web 3D conference kind of applications, It is assumed that usability in Web 3D conference will be better than in SL kind of services because what is called "think time" (the time employed by the user to reach the functionality of a typical session which depends on the number of clicks, menu complexity, etc) is greatly improved by lower response time, and packet loss for instance by ENVISION-enabled services.

It is estimated that the SL "think time" is about 1% of the mean session duration, therefore 1 minute, and a 0.5% of the expected average session duration, therefore 0,5 minutes if the application is ENVISION-enabled.

Bicycle race. As a starting hypothesis, it is estimated that conducting the standard MJ use case on top of Facebook –rich ENVISION features not even possible to perform on top of it- will have a higher think time proportion than in other use cases due to the non MJ UI design of Facebook. Therefore, it is estimated that a 10% of the session duration in Facebook is attributable to "think time", when using a non ENVISION-enabled client, it is assumed that given the MJ UI specific purpose design, the think time could drop a 50%, and if enabled with ENVISION, an additional 20% drop would be expected.

Situation: *An upgrade in only one of the two platforms (1 000 subscribers each) will improve the usability reducing the "think time" in a 10%. The satisfaction of existing subscribers would bring new users by word-of-mouth. In addition, some users from the non upgraded service driven by the greater time savings would join as well.*

QUESTION U-5: How many new users (out of 1 000) would join attracted by the word-of-mouth of the newly satisfied subscribers if the raise happened in the legacy, new, or new ENVISION-enabled platform?

Q-U5	Legacy Platform	New Platform	ENVISION-enabled	% difference
Web 3D conference	60	30	60,0	-50,00%
Bicycle race	48	60	72	20,00%

Comments: In both services, and as mentioned above, the attraction of new users generated by word-of-mouth in front of a satisfaction raise driven by usability improvements (Q-U5) is three times the attraction generated by the an equivalent raise in functionality (Q-U2).

QUESTION U-6: How many new users (out of 1 000) from the non upgraded service would join if the raise happened in the legacy, new, or new ENVISION-enabled platform?

Q-U6	Legacy Platform	New Platform	ENVISION-enabled	% difference
Web 3D conference	3	15	15	0,00%
Bicycle race	3	15	18	20,00%

Comments: In both services, as mentioned above, the attraction of churners generated by word-of-mouth in front of a satisfaction raise driven by usability improvements, is three times the attraction generated by the an equivalent Q-U3.

11.2.3 ARPU effects

ARPU is understood in this section as the total of direct and indirect revenues obtained by the platform from the end users. As Internet applications nowadays are mostly free, the ARPUs estimated in this section are to be generated via freemium models, where certain premium users would pay for some extra functionality as Spotify model does for instance. An interesting consequence of this, is that price sensitivity would not be that high given that a raise in the ARPU could be driven either by a better communication of the premium benefits to end users –for instance- and not a direct raise on the monthly tariffs of all users (as conventional monthly ARPU has been understood usually in the industry).

QUESTION U-7: What could be the monthly ARPU (av. revenue per user in € per month)?

Q-U7	Legacy Platform	New Platform	ENVISION-enabled	% difference
Web 3D conference	9,37	9,37	13,11	40,00%
Bicycle race	0,0067	0,30	0,33	10,00%

Comments: According to [BM-6], Second Life legacy platform in Web 3D conference kind of services generates incomes from selling and maintaining different kinds of lands as priced in Table 11-1. Lands are sold primarily to content providers/publishers that create venues where users gather. Table 11-2 estimates the indirect monthly ARPU generated in SL per each user. A non ENVISION Web 3D conference kind of service would be expected to reach a similar indirect ARPU as the SL does, however, new services deployed on top of ENVISION (higher resolution, less response time, greater collaboration capabilities, better user experience,…) would be expected to have a higher ARPU because of the better experience and usability by users.

SL Lands Q2 2010	Land Parcels (of 65000 m2)	Price per parcel (€)	Monthly maintenance per parcel (€)
Full Region (44%)	14 283	750 €	221 €
Homestead Region (36%)	11 686	281 €	94 €
Openspace Region (19%)	6 168	188 €	56 €
	Subtotal:	**15 155 481 €**	**4 602 640 €**

Table 11-1

ARPU Estimation Q2 2010	Column1
Land maintenance (€/month)	4.602.640 €
Active users	491 333
ARPU per user/month	9 €

Table 11-2

Bicycle race. In order to estimate a feasible freemium ARPU model, Facebook has been estimated to generate an indirect ARPU via CPC (cost per click) advertising revenues of 0,0067 €/month. This estimate is the result of assuming that a user will click an advertising once every 30 sessions, and the click will generate a CPC ad revenue of 0,20€ for the platform.

In a purpose specific MJ-client without ENVISION enabling technologies, it has been estimated that the value of communicating their experience to friends, as well as the plus of enjoyment at the venue should be worth 1% of the ticket entrances for the end user. Estimating an average of 20€ per ticket, this leads to 0,20€ per session, translated to monthly ARPU by multiplying the average number of sessions per user. If enabled with ENVISION, the enjoyment degree for the end user as well as the quality of the content shared with his community would be worth a 10% increase versus the non ENVISION version.

Situation*: Imagine that both the new service and competing service have 1 000 subscribers each, and only one of both increases a 10% the av. monthly fee. Some subscribers would leave the service, and others would decide to switch to the other service driven by lower monthly fees.*

QUESTION U-8: How many subscribers out of the 1 000 would quit using the service if the raise happened in the legacy, new, or new ENVISION-enabled platform?

Q-U8	Legacy Platform	New Platform	ENVISION-enabled	% difference
Web 3D conference	1	1	1	0,00%
Bicycle race	1	1	1	0,00%

Comments: In both cases, given that the ARPU is indirect and generated via a freemium model with small elasticity, the sensitivity is very small. It important to note, that increasing the mean indirect ARPU by 10% could require the platform to become very valuable to the extent that new premium subscriptions account for the average increase.

QUESTION U-9: How many subscribers out of the 1 000 ones would switch to the lower priced service if the raise happened in the legacy, new, or new ENVISION-enabled platform?

Q-U9	Legacy Platform	New Platform	ENVISION-enabled	% difference
Web 3D conference	1	1	0,8	-20,00%
Bicycle race	1	1	0,8	-20,00%

Comments: Similarly to the above, values could be low given the indirect nature of ARPU in freemium models.

11.2.4 Content Provider/Publisher Cross Sided Network Effect

In the Web 3D conference service, there is a group of content providers/publishers that feed the virtual world with objects to be sold. Second Life (SL) has a large group of content providers/publishers that provide value to the users of the platform. A new entrant must take into account the attraction that publishers generate on users.

In the bicycle race use case, publishers are the number of live events where users attend, without venues, or events, to attend the platform has no value at all.

Situation*: Imagine that both the new service and competing service have 1 000 subscribers each and suddenly only one of them achieves 100 new publishers. New fresh users would join the upgraded service, as well as attract existing subscribers from the non upgraded service.*

QUESTION U-10: How many fresh users out of 1000 would join by the sudden 100 publisher increase if the raise happened in the legacy, new, or ENVISION-enabled platform?

Q-U10	Legacy Platform	New Platform	ENVISION-enabled	% difference
Web 3D conference	0,88	0,88	0,88	0,00%
Bicycle race	400	680	816	20,00%

Comments: In the Web 3D conference kind of service, Second Life (the legacy platform) has the following KPIs extracted from [BM-7]:

	Q2 2009	Q2 2010	
Monthly repeated logins	742	806	('000)
Acc. User Hours in Q	126 000	109 000	('000)
Monthly Economic Participants	465	491	('000)
Exchange Rate L$/EUR	196	198	
€$ supply (money in the platf)	122 184	130 957	
€$ trading volume	29	29	
Marketplace sales in €	1 893 853	4 211 857	
Marketplace objects	*566 160*	1 259 119	
Land size in km2	1,9	2,11	

http://lindenlab.com/pressroom/releases/22_09_09
http://blogs.secondlife.com/community/features/blog/2010/09/10/second-life-economy-stable-in-q2-2010

The above table serves as a base calculation that results in a estimation for question Q-U10.

Publisher Driven User Adoption	
Y2Y Monthly Economic Participants churn	26 000
Est. Fraction of users driven by marketplace objects	50%
Est. Y2Y Monthly Economic Participants churn driven by publishers	13000
Est. Y2Y Monthly Economic Participants churn driven by publishers (% of total users)	2,6%
Est. publishers churn (est. 20 obj/publisher)	34 640
% of users driven per 100 publisher	0,008%
Est. New users attracted by 100 publishers from 1000 existing customers	0,8

Therefore, increasing in 100 publishers in an existing community of 1000 existing customers would bring 0,8 new users.

Regarding Web 3D conference service, given a rise of 100 additional music or sports event fan pages in Facebook, and assuming that there is a community of 1000 Facebook users of this kind of event pages, it is estimated that each additional fan page created could on average interest to 10 members of the existing community of 1000 users (because of the topic, place, date,…), and from the 10 members, 5 to be so interested to trigger 2 recommendations each, therefore triggering about 10 recommendations, but later only accepted by 1 person (assuming a 10% conversion ratio) per each new event page. Therefore, 100 events (publishers/content providers) would account for 100 new users out of 1000 existing ones (the disengagement ratio in Q-M5 is then applied to them to estimate the resulting new users finally joining).

Facebook users will hardly leave their legacy platform, therefore, are "multihoming" amongst the platforms, instead of telling the simulator that those are switching from one platform to another, this multihomed users will be added as well as new incoming users. In other words, users from the New Platform with and without ENVISION, do join the fan page of an event (hypothesising that given the zero cost, the publisher of the event will do create a fan page in addition to publishing the event in the new services). Therefore, inline with previous calculations where each additional fan page created in Facebook advertising the MJ specific application could on average interest to 10 members of the existing Facebook community (because of the topic, place, date,…), in this case 3 existing users of the alternate platform will accepted and become fan of the event page (a higher ratio of 33% due to the existing knowledge of micro-journalism). Considering the 100 new fan pages, then 300 Facebook users as well users of the new service would join the Facebook pages. Totally accounting for 400 new users (100 new users in the market, and 300 multihoming with the legacy platform Facebook).

This ratio is assumed to be higher in non ENVISION micro-journaling client thanks to the rich functionality, usability, and novelty, therefore, it is assumed that in the first years of usage, there will be a 70% higher than Facebook, and for the ENVISION-enabled one, an additional 20% higher thanks to the functionality, and usability increase.

QUESTION U-11: How many users would switch the service out of the 1 000 and join the arose one if the raise happened in the legacy, new, or new ENVISION-enabled platform?

Q-U11	Legacy Platform	New Platform	ENVISION-enabled	% difference
Web 3D conference	0,001	0,01	0,01	0,00%
Bicycle race	0	0	0	0,00%

Comments: Given the low attraction generated by publishers in the Web 3D conference service estimated in Q-U10, it is hypothesised that only 1 user out of 1000 of the SL legacy platform will switch and migrate to the new platform per each 10 000 publishers added the a new Web 3D conference platform either ENVISION-enabled or not. Because of the attractiveness of ENVISION-enabled platform, it is estimated that returning back to the less attractive and perceived as technologically obsolete SL legacy platform if the increase of publishers is ten times higher.

About the Bicycle Race, as mentioned before, none of the Facebook users will definitively quit and only use the MJ application regardless of the amount of publishers, and vice versa.

11.3 Publisher Behaviour

11.3.1 Session Revenues & Cross Sided Network Effects

Publishers may receive revenues from advertisers, as well as royalties from platform where the service runs. The platform may pay in the form of session based royalties (content consumptions, etc). The advertisers may pay in terms of CPM (cost per thousand impressions), CPC (pay per click), and CPA (pay per action) with precise values averaged per session.

QUESTION P-1: On average, how much does the publisher earn from the platform per each user session (like royalty style)?

Q-P1	Legacy Platform	New Platform	ENVISION-enabled	% difference
Web 3D conference	1,74	1,74	1,74	0,00%
Bicycle race	0,025	0,5	0,5	0,00%

Comments: In the Web 3D conference use case, Publishers/Content Providers in SL legacy platform obtain incomes by selling virtual objects to end users via the SL marketplace. From each purchase, the publisher gets the 95% of the sale, and the 5% is for the platform. The following table summarises the session revenues from sales of virtual objects in the marketplace where developers publish new creations according to data from [BM-1] [BM-2] and [BM-3]:

Average Revenue Per Session	Q2 2010
Market sales €/month	1.403.952,30 €
Publisher Share	1.333.754,69 €
Platform Share	70.197,62 €
Monthly sessions	806 333
Publisher sales/session	1,74 €

It is assumed that the Web 3D conference should achieve similar revenue per session by any other means such as advertisement, marketplace or any other source.

Regarding the Bicycle race use case, a micro-journalism specific application meant for live events such as the ones launched by Telefonica at O2 Priority generate revenue by selling premium online content prior during and after concerts. Therefore, the micro-journalism client should include the possibility of selling premium content to end users (either generated by the venue organiser, or created leveraging on the content created by the end users) with an estimated 0,50 € per event.

QUESTION P-2: On average, how much do external advertisers pay to the publisher in the following terms: CPA, CPC, CPM?

Q-P2	Legacy Platform	New Platform	ENVISION-enabled	% difference
Web 3D conference	0	0,025	0,025	0,00%
Bicycle race	0	0,0175	0,0175	0,00%

Comments: In the Web 3D conference use case, the content providers/publishers of Second Life are not enabled with advertising revenues. However, in the new platform, publishers could have incomes from third party advertisement agreements where the platform has the right to insert branded logos in the objects published by the developers. Advertisers would pay a CPM fee to the platform for inserting their logos in the objects, and the platform would share the 70% of the revenues with the publisher of the object. Let's take a virtual 3D model of a house. The publisher of the model –the developer- at the moment of designing the model, would allocate certain advertisement spaces on the house, that later on, each time the platform renders the house for users, advertisements are inserted by the platform. Inline with industry prices, the advertisers could pay a 0.50€ per each 1000 impressions to the platform, and the platform would give the 70% to the publisher/developer. All the exposures of all the objects in the Web 3D conference in a given month is called "inventory", however, it is not expected that there will be enough advertisers to cover the 100% of the inventory, therefore, only a 50% of the inventory is expected to actually be branded.

In the same advertising frame agreement, CPC agreements could also be established, with figures resembling the figures of the table below which on average could generate 0,025€ per session.

Average Revenue Per Session	Q2 2010
Publisher share (% of ad cost paid by the platform to the Publisher)	70%
Session duration (min)	100
Ad inventory per session (estim. 1 impressions/min)	100
Estimated ad sales load	50%
CPC	
Estimated click-through ratio	0,1%
Av. CPC (€)	0,20
CPC Platform Revenues per Session	0,010
CPC Publisher Revenues	**0,007**
CPM	
Av. CPM (€)	0,50
CPM Platform Revenues per Session	0,025
CPM Publisher Revenues	**0,018**

For the Bicycle race use case, the following advertising revenues has been estimated with feasible industry figures:

Average Revenue Per Session	Q2 2010
Session duration (min)	10
Ad inventory per session (estim. 5 impressions/min)	50
Estimated ad sales load	50%
CPC	
Estimated click-through ratio	0,10%
Average CPC (€)	0,2
CPC Ad rev/session (€)	*0,005*
CPM	
Av. CPM (€)	0,5
CPM Ad rev/session (€)	*0,0125*
Total Ad rev/session	**0,0175**

QUESTION P-3: Are publishers charged with a one time fee for start using the service? How much?

Q-P3	Legacy Platform	New Platform	ENVISION-enabled	% difference
Web 3D conference	0,000	0,000	0,000	0,00%
Bicycle race	0,000	0,000	0,000	0,00%
Legacy services				

Comments: In neither service, developers are charged an upfront fee when joining neither of both platforms.

QUESTION P-4: Are publishers charged by the platform on a session basis? How much?

Q-P4	Legacy Platform	New Platform	ENVISION-enabled	% difference
Web 3D conference	0,09	0,09	0,09	0,00%
Bicycle race	0	0	0	0,00%

Comments: **Web 3D** In the Web 3D conference kind of applications, publishers are charged the 5% of the sold goods by the platform in the marketplace. Therefore, extending the figures of question P-1:

Average Revenue Per Session		Q2 2010
Market sales €/month		1.403.952,30 €
	Publisher Share	1.333.754,69 €
	Platform Share	70.197,62 €
Monthly sessions		806 333
Publisher sales/session		1,74 €
Platform rev/session (Session cost for the publisher)		**0.09 €**

Bicycle race the values are void since publishers of events are not charged one time fees, nor per session.

Situation*: Imagine that both the new service and the competing service have 1 000 active users each. A policy change in only one of the two platforms will result in a 10% raise in the average revenues per session that publishers receive. The raise would trigger a wave of new publishers entering in the market, in addition to churners -a wave of publishers coming from the non risen service- driven by the greater revenues.*

QUESTION P-5: How many new publishers (out of 100) would enter the market and join the platform attracted by the higher incomes generated by the sessions of the 1 000 users if the raise happened in the legacy, new, or new ENVISION-enabled platform?

Q-P5	Legacy Platform	New Platform	ENVISION-enabled	% difference
Web 3D conference	0,01	0,01	0,02	100,00%
Bicycle race	0,01	0,01	0,02	100,00%

Comments: **Web 3D** In the Web 3D conference kind of applications, 10 users (1000 users evenly distributed amongst the 100 publishers) per each publisher considering 1,74€/session revenues, and an average of 1,6 sessions per month would represent roughly an increase of 2,7€ out of the total 27€ per month that generate the 10 users for the publisher. Therefore, not bringing significant new publishers, and therefore, setting a low value such as bringing 0.01 new publishers.

Because the ENVISION platform, is positioned has an overall better proposition to the end users, and has a longer growth roadmap, it is estimated that per each publisher that joins the competing service, two publishers join the ENVISION-enabled platform drive by the same conditions of 10% revenues increase. Therefore, the ENVISION-enabled Web 3D conference is configured as 0.02 new publishers. And similarly applies to the Bicycle race use case.

QUESTION P-6: How many publishers would join coming from the non risen service attracted by the higher session revenue over 1 000 users if the raise happened in the legacy, new, or new ENVISION-enabled platform?

Q-P6	Legacy Platform	New Platform	ENVISION-enabled	% difference
Web 3D conference	0,003	0,003	0,003	0,00%
Bicycle race	0,003	0,003	0,003	0,00%

Comments: In the Web 3D conference use case, it is expected that publishers churn between platform could be a third of the rate of the new publishers driven by a revenues shift because publishers have switching costs related with the cost of re-converting the content for the other platform and similarly for the Bicycle race use case.

11.3.2 Variable Session Costs Effects

QUESTION P-7: What is the fee that a publisher pays to the service per each user session? (€ per session)

Q-P7	Legacy Platform	New Platform	ENVISION-enabled	% difference
Web 3D conference	0,000	0,000	0,000	0,00%
Bicycle race	0,000	0,000	0,000	0,00%

Comments: In both services, session costs would not be charged to publishers, therefore those are set to zero.

QUESTION P-8: How many fresh new publishers (out of 100) would enter the market and join the service if the raise happened in the legacy, new, or new ENVISION-enabled platform?

Q-P8	Legacy Platform	New Platform	ENVISION-enabled	% difference
Web 3D conference	0,000	0,000	0,000	0,00%
Bicycle race	0,000	0,000	0,000	0,00%

Comments: In both services, since there are no session costs, no churn would happen, therefore those are set to zero.

QUESTION P-9: How many publishers (out of 100) of the non upgraded service would join the upgraded service if the raise happened in the legacy, new, or new ENVISION-enabled platform?

Q-P9	Legacy Platform	New Platform	ENVISION-enabled	% difference
Web 3D conference	0,000	0,000	0,000	0,00%
Bicycle race	0,000	0,000	0,000	0,00%

Comments: In both services, since there are no session costs, no churn would happen, therefore those are set to zero.

11.3.3 Fixed Monthly Fee Effect

QUESTION P-10: What is the average monthly fee per publisher (€ per month)?

Q-P10	Legacy Platform	New Platform	ENVISION-enabled	% difference
Web 3D conference	0,000	0,000	0,000	0,00%
Bicycle race	0,000	0,000	0,000	0,00%

Comments: In both services, since there are no fixed costs, no churn would happen, therefore those are set to zero.

Situation: *Imagine that both the new service and competing service have 100 publishers each, and only one of both increases a 10% the av. monthly fee. Some subscribers would leave the service, and others would decide to switch to the other service driven by lower monthly fees.*

QUESTION P-11: How many publishers out of the 100 would stop using the service if the raise happened in the legacy, new, or new ENVISION-enabled platform?

Q-P11	Legacy Platform	New Platform	ENVISION-enabled	% difference
Web 3D conference	0,000	0,000	0,000	0,00%
Bicycle race	0,000	0,000	0,000	0,00%

Comments: In both services, since there are no fixed costs, no churn would happen, therefore those are set to zero.

QUESTION P-12: How many publishers out of the 100 ones would switch to the non arose service if the raise happened in the legacy, new, or new ENVISION-enabled platform?

Q-P12	Legacy Platform	New Platform	ENVISION-enabled	% difference
Web 3D conference	0,000	0,000	0,000	0,00%
Bicycle race	0,000	0,000	0,000	0,00%

Comments: In both services, since there are no fixed costs, no churn would happen, therefore those are set to zero.

11.3.4 Publishers Same Side Network Effect

Situation: *Imagine that both the new service and competing service have 100 publishers each. Suddenly only one of the services raises its publishers to 150. The raise would trigger a wave of new publishers entering in the market, in addition to churners -a wave of publishers coming from the non risen service- driven by the greater expectations of users.*

QUESTION P-13: How many new publishers would enter the market and join the risen platform driven by imitation of the 50 new publishers out of 100 previous ones if the raise happened in the legacy, new, or new ENVISION-enabled platform?

Q-P13	Legacy Platform	New Platform	ENVISION-enabled	% difference
Web 3D	4	4	6	50,00%

conference				
Bicycle race	4	4	6	50,00%

Comments: It is hypothesised that 4 new publishers would join the SL legacy platform in front of a raise of 50 new publishers, and the newer ENVISION-enabled platform for Web 3D conference would attract a 50% more publishers. Similarly for the bicycle race use case.

QUESTION P-14: How many publishers out of 100 existing ones would switch to the competing service if the raise happened in the legacy, new, or new ENVISION-enabled platform?

Q-P14	Legacy Platform	New Platform	ENVISION-enabled	% difference
Web 3D conference	0,4	0,4	0,6	50,00%
Bicycle race	4	4	6	50,00%

Comments: **Web 3D** In the Web 3D conference kind of applications, the ratio is symmetric to the previous question, however, given that the cost of migration is high due to the 3D content adaptation costs, it is expected that only 1 out of 10 publishers will in fact migrate.

Bicycle race since event organisers are not bound to any specific platform since no investments in content are done, the values are in line with the values in Q-P13.