Business Model Evaluation for an Advanced Multimedia Service Portfolio

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Abstract. In this paper we analyze quantitatively a business model for the collaborative provision of an advanced mobile data service portfolio composed of three multimedia services: Video on Demand, Internet Protocol Television and User Generated Content. We provide a description of the provision system considering the relation occurring between tecnical aspects and business aspects for each agent providing the basic multimedia service. Such a techno-business analysis is then projected into a mathematical model dealing with the problem of the definition of incentives between the different agents involved in a collaborative service provision. Through the implementation of this model we aim at shaping the behaviour of each of the contributing agents modifying the level of profitability that the Service Portfolio yields to each of them.

Keywords: Service Platforms, Business Models, Multi Follower, Stochastic Programming, Video on Demand, IPTV, User Generated Content.

1 Introduction

Advanced data services are customizable and oriented towards the on-demand and real time delivery. Typically they are bundled in Service Portfolios. Thus it is important to develop and provide such services in a flexible way. Services Portfolios are composed of different enablers and basic services provided by a constellation of actors. Most of the reseach carried out so far has been oriented towards the technical aspects of such a service provision, while the quantitative evaluation of business modeling aspects is still in an early phase.

The aim of this paper is to provide a proof of the concept for the economic evaluation of collaborative provision of a data service focused, for the time being, on the aspects of economic viability and risk management. We will focus on the case of the provision of a service composed by the bundle of three different services given by Internet TV (IPTV), Video on Demand (VoD) and User Generated Content (UGC). The composed service is used in a particular business scene, such as a concert.

We will analyze how the architecture of such a service delivery system is composed, in order to emphasize the elements which are technically relevant

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w.r.t. a business model. At the same time, considerations about the economic values will be introduced in order to consider a quantitative revenue and risk management model. Then the model is applied for fine tuning, via the use of a revenue sharing scheme, the decisions of the service providers about the amount of service to supply to the service portfolio to be bundled. Such model, has been tested in earlier work [1] for different configurations of the sharing scheme resulting in a feasible service portfolio provision.

In this paper we describe an implementation to select of the optimal sharing scheme in order to make the service portfolio feasible and to deliver the highest possible return on costs to the agent assuming the role of aggregator. The approach is based on an *aggregator centric business model*, described in [8], where an actor takes the double role of Service Aggregator, offering the service portfolio to the end user, and Portal Provider that visualizes the contents to the end user. In our approach we assume this actor to cover the further role of Platform Operator, offering the tools necessary for bundling the service portfolio. The analysis considers a general notion of platform, intended as an entity coordinating interactions between two or more distinct groups of stakeholders [8].

The rest of the paper is organized as follows. Section 2 describes three user scenarios where the service portfolios are invoked by the end user. The technical analysis of the provision of each basic service bundling the service portfolio is done in section 3 to understand the technical bottlenecks of such a provision. Section 4 describes how the technical constraints, together with business considerations, are mapped in a quantitative model related to the selection of a revenue sharing scheme amongst the service providers. Section 5 discusses the results of the implementation of the mathematical model. We conclude the paper and outline the future work in section 6.

2 Typical Business Scenes

The purpose of this section is to describe three user scenarios, in which the end user invokes the use of a Service Portfolio composed of the three multimedia services discussed above, in order to position our problem within a business point of view.

The first scenario depicts the end user at a concert. Using her device, the end user can have the concert broadcasted on enhanced TV while, at the same time, the end user can use the VoD service to retrieve material about the band and access to UGC directly on the device. In the second scenario the end user is a tourist using video guides requested as VoD together with UGC in order to read comments about places to visit, during the trips she may eventually want to relax watching IPTV or some desired VoD. A third service allows the users to interact with TV requesting VoD for changing the storyline of a movie, involving use of forums, chats and other UGC.

These services are provided collaboratively by a set of Service Providers that can decide to supply their component to a set of Service Portfolios. Their goal is to select an appropriate group of Service Portfolios that sounds as most profitable.

We consider the VoD provider to take the role of Platform Operator. Her work is to ensure that each Service Provider supplies a minimum amount of Megabits per second (Mbps). Such a coordination is achieved by a wise choice of the revenue sharing scheme between the contributing actors.

3 Technical Analysis of the Service Portfolio Provision

We assume that all the basic services are delivered by exploiting a high-bandwidth backbone network such as ATM or SONET [4]. This will allow us to neglect bottlenecks at the network level (in this case physical layer) and concentrate on possible constraints in the application layer of the system.

3.1 System Architecture Design

Video on Demand
In the general architecture of a VoD system we have thousands of local distribution networks, delivering audio and video content stored in Video Servers, connected by a high-bandwidth backbone network.

Video Servers are capable of storing and outputting a large number of movies simultaneously. Such a storage is done using different kind of supports characterized by a tradeoff between cost and number of users that can be served. A Video Server is composed by one or more high performance CPUs, a shared memory, a massive RAM cache for content which is supposed to be requested with more frequency, a variety of storage devices for holding the movies and some network hardware such as an optical interface (call it for example Network Interface) to a SONET or ATM backbone. These subsystems are connected by an extremely high speed bus (at least 1Gb/sec.). The CPUs are used for accepting user requests, locating movies, moving data between devices. Many of these operations are time critical, and thus they constitute a constraint for the number of services that can be produced in a given frame time.

We will assume that the VoD provider has constraints with respect to the number of services feasible for a given time unit, and such a constraint depends on the capacity of the server. The performance of the system is measured in Megabits per second (Mbps).

Internet Protocol Television
IPTV uses IP networks to deliver digital TV programming from a central location to a base of multiple subscribers. A large IPTV network works in the follwing way (see, for further discussion [6]). The Super-video Head End (SHE) receives video signals for national programming from a variety of sources and in different formats and encryption protocols. Its task consist in decripting the source format, converting it in a suitable data type and rebroadcasting it to regional Video Head ends Offices (VHO). When the VHO receives the packets, it aggregates such a content with the local content encoded and forwards it to the

Video Switching Office (VSO) which is the phone company's infrastructure for delivering video to users. In order to deliver IPTV to the end-user the carriers plan to use IP multicasting. With multicasting, a single copy of a program is transmitted through the network and replicated only where necessary. One of phone carriers' biggest IPTV challenges will be having enough bandwidth for both the potential growth in data-intensive high-definition programming and a growing number of customers (see e.g. [5]). To model the technical process necessary to deliver the IPTV service we will consider in a deeper detail the operations performed by each of the elements constituting the hardware architecture of an IPTV system.

User Generated Content

User Generated Content (UGC) refers to various kinds of media content, publicly available, that are produced and shared by end-users, whether is it a comment left on Amazon.com, a professional quality video uploaded to YouTube, or a student's profile on Facebook [7]. For capacity constraint purposes we will consider only the aspects of UGC including multimedia content, which is characterized by bottlenecks at the service provider side. We will approximate the architecture of a UGC system for multimedia content by considering it an extension of the VoD case, but allowing for the upload of multimedia content by the end-user.

3.2 System Architecture Approximation

The architecture of a system as the one described above is very complex and the elements involved in the provision of the services need to perform a large amount of operations. However, not all the operations are considered as critical for the provision of a Service Portfolio, since modern technology can efficiently perform most of them. For this reason we have restricted the analysis only to the operations that constitute a bottleneck in terms of capability to serve a continuously increasing number of end users. The approximation of the overall architecture follows the guidelines discussed in [2] and [3], and can be formalized through a UML class diagram, like the one showed in figure 1. The first element considered in the figure is a goal, which is a state a user tries to achieve or obtain. What is delivered to the end user is a Service Portfolio, i.e. a collection of services. Enabler is a functionality used by a service provider to create a service. Such enablers provide the SP capabilities and consume various resources, which constitute a constraint on the maximum level of basic service that can be provided to the Service Portfolio. Class diagrams provide an approximation of the system architecture for the different providers and highlight the importance of resources consumption in the service delivery process. To deliver a given service

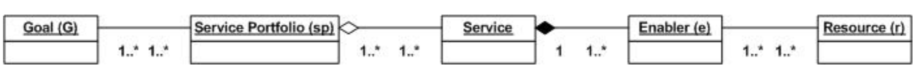

Fig. 1. A Generic Service Platform Model (source: Zoric, 2008)

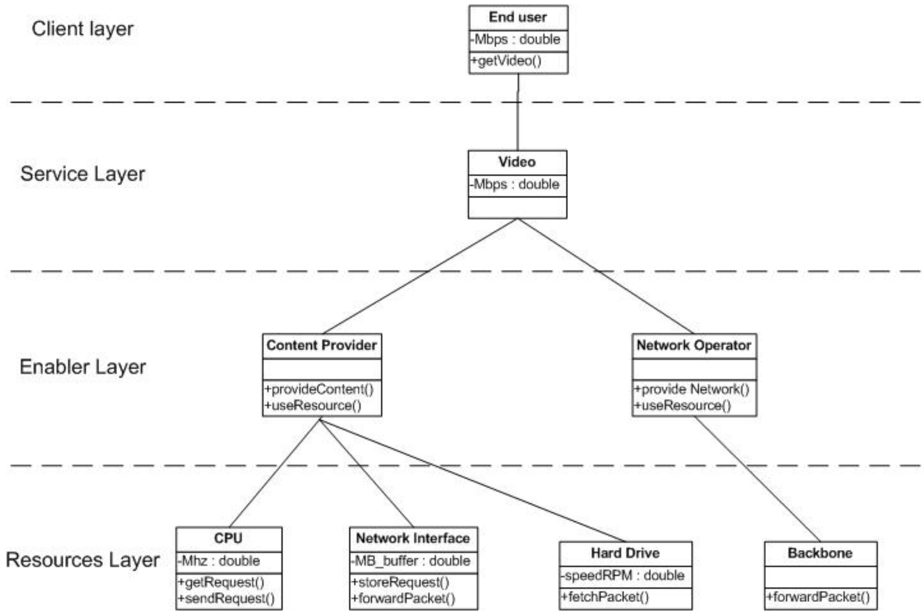

Fig. 2. Class diagram for the VoD case

(e.g. a video or some multimedia content) the server has to be able to provide a minimum amount of Mbps, which are a function of the number of operations that the server can perform.

Video on Demand

In figure 2 we identify the relations between the classes of objects describing the VoD system elements in a four layer architecture: Client Layer, Service Layer, Enabler Layer and Resources Layer. The Client Layer contains the class of objects sending the request for a service. The end user is characterized by the attribute defining the number of Mbps requested. At the Service Layer we have the video, which is characterized by a the actual number Mbps. The set of functionalities used to create the services, considered at the Enabler Layer is given by two enablers: content provider and network operator. These enablers provide the capabilities to build up a service ensuring a minimum amount of Mbps to each end user, in order to achieve a satisfactory experience. At the same time enablers consume resources, which are described in the Resources Layer. Let us examine with more detail the considerations introduced about the mapping between operations performed by the elements of the server and the Mbps delivered. We will consider, for the case of VoD, a table with four resource-consuming operations. The same considerations are applicable to IPTV and UGC cases. Namely, the service produced by the VoD provider is the result of the following main operations:

Operation	Performed by	Bounding measure
accepting download requests	CPU	Mhz
requesting data	CPU	Mhz
fetching data	Hard Drive	rpm
delivering data	Network Interface	MB

Given the power of each of these elements, there is an upper bound on the number of operations that they can perform in a particular frametime, bounding in the same way the number of Mbps that can be delivered.

Internet Protocol Television
The analysis considers the same four layers as previously done. In the Client Layer we have a group of end users sending a connection request to a set of different TV channels, which in our analysis are positioned in the Service Layer. The enablers involved in this delivery are the Content Provider (for the encoding and forwarding processes) and the Context Provider (for what concerns the context detection for local and customized content) on one side and the Network Operator (for the physical delivery of data) on the other side. What is done at the server side now is not so different from the Video on Demand case, except for the fact that the CPU has to handle the conversion of the source data obtained from an external antenna or satellite (receiving, decoding and re-encoding in a suitable format). The VHO performs the same operations as the SHE (receive and convert source), but it operates with local content. Moreover, it bundles the local content with the global one. The VSO has the task of demultiplexing the packets transporting data of different TV channels to different end users.

User Generated Content
As mentioned earlier, the UGC architecture resembles the one for the VoD, with the possibility for the end user to upload multimedia content to the server. In order to approximate the architecture of such a system we just take as a reference what is showed in figure 2, changing the class *Video* with the class *Content* and adding the operation `loadContent()` in the end user class and the operation `storePacket()` in the Hard Drive class. The operation `getRequest()` in the CPU class can be thought as well as a download request or an upload request. In the same way the operation `forwardPacket()` in the Network Interface class can be thought as a duplex connection: packets flow in both ways.

4 Modelling the Collaborative Service Provision

In this section we consider the model introduced in [1], which aims at achieving a collaborative provision of a data service via the choice of a revenue sharing scheme between the providers, taking as input statistcs on profitability of the service as well as preferences of the component providers in terms of risk tolerance and minimum accepted level of profitability.

The main building blocks of the model are *services* given by VoD, IPTV and UGC and indexed by $i = 1 : 3$ and *Service Portfolios* defined by the collection of services provided to the end user in the concert scenario, the tourist scenario and the interaction scenario which are indexed by $j = 1 : 3$. The relation between services and Service Portfolios is described by the coefficients λ_{ij} which measure the amount of Mbps that service provider i has to supply for delivery of the unit amount of Service Portfolio j. Thus, a Service Portfolio j can be described by vector

$$\lambda_j = (\lambda_{1j}, .., \lambda_{3j}) \tag{1}$$

which describes the amount of Mbps each service provider has to deliver to provide one unit of service portfolio j.

An end user requests a service portfolio j and generates a revenue v_j per unit sold. We can think v_j as a random variable; this means that the price level to be set in order to keep a given level of demand is uncertain. Randomness is thus due to uncertainty of user acceptance and demand.

A way to quantify the uncertainty attached to the revenue of each service portfolio is given by the computation of the risk level associated. In this framework we will consider risk as the non predictability of the unit revenues in order to have a certain level of demand, and this allows us to use standard deviation, one of the most established and wide used risk measures in finance, as a risk measure for the unit revenue. The economical concept underlying such a kind of analysis is that Component Providers want to choose how many Mbps to supply to each service portfolio in order to get the highest return on costs possible for a given level of risk. Increasing the level of risk accepted will result in a higher level of expected return on costs. We assume that the revenue obtained by a component provider is a share of the revenue generated by the sale of the Service Portfolio. Revenue is proportional to the percentage of Mbps provided to such bundle with respect to the amount of Mbps necessary to supply a enjoyable service to the end user.

The revenue v_j generated by a unit of Service Portfolio j is distributed among the actors who participate in the creation of the service portfolio using a vector of revenue shares

$$\gamma_j = (\gamma_{1j}, .., \gamma_{3j})$$

Determination of these revenue sharing coefficients is one of the objectives of the design of the business model for service provision.

Let us consider c_i as cost per unit of Megabit of service i sent per second and x_{ij} as the portion of provision capability (Mbps sent over total Mbps that the provider can supply) for service i dedicated to participation in provision of Service Portfolio j. We can define the expected return on total costs of the i-th provider as

$$\bar{r}_i(x_i, \gamma_j) = \sum_{j=1}^{4} \mu_{ij} x_{ij} = \sum_{j=1}^{3} x_{ij} \left(\gamma_{ij} E \frac{v_j}{c_i \lambda_{ij}} - 1 \right) + x_{i4} \left(E \frac{v_{i4}}{c_i} - 1 \right) \tag{2}$$

at the same way, we can define the standard deviation of the return on costs as

$$R(x_i) = \text{StDev}(r_i(x_i)) = \text{StDev}\left(\sum_{j=1}^{4} r_{ij}x_{ij}\right) \tag{3}$$

The problem of the i-th Service Provider is given by finding the best distribution of her service, in trems of Mbps supplied, amongst the Service Portfolios under a risk-performance point of view. Following the framework provided by [1] we define the problem of the i-th Service Provider as

$$\max_{x_i} \bar{r}_i(x_i, \gamma_j) \tag{4}$$

subject to constraints

$$\sum_{j=1}^{4} x_{ij} = 1,\ x_{ij} \geq 0 \tag{5}$$

$$R(x_i, \gamma_j) \leq \bar{R} \tag{6}$$

where we emphasize here the dependence of risk and return on the revenue sharing scheme γ_j. To provide a satisfactory experience to the end user, every component provider involved in the creation of the service portfolio has to provide a level of Mbps larger or equal to a given treshold. The solution of such a portfolio problem will be denoted by $x_i(\gamma_j)$ for all generic actors providing service i for the Services Portfolio j.

We assume that one of the Service Providers covers a further role of Service Aggregator. It is up to her to decide the correct revenue sharing scheme in order to compose the Service Portfolio. Formally such a provider faces the following optimization problem:

$$\max_{\gamma_j} \bar{r}_1(x_1(\gamma_j), \gamma_j) \tag{7}$$

subject to constraints

$$x_{ij}(\gamma_j) \geq {x_{ij}}^{\min} \text{ for all } i \in I_j \tag{8}$$

$$\gamma_j \in \mathit{\Gamma}_j \tag{9}$$

where the set $\mathit{\Gamma}_j$ can be defined, for example, by

$$\{\gamma_j | \gamma_{ij} \in [0,1], \sum_i \gamma_{ij} = 1\} \cap \{\gamma_j | p_i^* - \mathit{\Delta}^- \leq \frac{\gamma_{ij}}{\lambda_{ij}} Ev_j \leq p_i^* + \mathit{\Delta}^+\}$$

where p_i^* is a target for the price of the service i and $\mathit{\Delta}^+$ and $\mathit{\Delta}^-$ defines the tolerances within which she is willing to accept a different price, and

$$I_j = \{i : \lambda_{ij} > 0\}$$

The problem defined in (4)-(9) presents the structure of a stochastic bilevel multifollower model.

5 Numerical Implementation

The previous model has been tested in [1] computing the value of the objective function (7) corresponding to different values of the sharing scheme chosen for a platform service portfolio as shown in the following table.

Table 1. Values of the optimal expected return on costs of the Platform Operator (also VoD provider) as a function of the sharing scheme weights granted to the IPTV provider (first column) and the UGC provider (first row)

0	0,474	0,4795	0,485	0,4905	0,496	0,5015	0,507	0,5125	0,518
0,1765	0	0	0	0	0	0	0	0	0
0,182	0	0,2312	0,2239	0,2163	0,2083	0,2001	0,1917	0,1834	0,1760
0,1875	0	0,2239	0,2163	0,2083	0,2001	0,1917	0,1834	0,1760	0
0,193	0	0,2163	0,2083	0,2001	0,1917	0,1834	0,1760	0	0
0,1985	0	0,2083	0,2001	0,1917	0,1834	0,1760	0	0	0
0,204	0	0,2001	0,1917	0,1834	0,1760	0	0	0	0
0,2095	0	0,1917	0,1834	0,1760	0	0	0	0	0
0,215	0	0,1834	0,1760	0	0	0	0	0	0
0,2205	0	0,176	0	0	0	0	0	0	0

The model (4)-(9) has been successively implemented using the commercial software MATLAB with the aim of finding an optimal solution. We used anonymous data units in order to keep it similar to the original problem test. To find the optimal solution of the model considered at the beginning of the section we defined a function which takes as input the data necessary to run a set of mean-variance portfolio optimizations. In particular the input corresponds to the variance covariance matrix for the Portfolio Services revenues, the prices of the Portfolio Services, the costs for transmitting one Mbps of service as well as the risk bounds and the minimum level of basic service to provide to the service bundle in order to make the provision feasible. The output provided by the function is the amount of service supplied by each service provider to the service portfolio for a given sharing scheme. Such a function is used as constraint for the upper level optimization which attempts to find the optimal sharing scheme to provide the highest returns to the platform operator.

The result of the optimization gives an optimal sharing scheme vector of 34,15% to the VoD provider/Platform Operator 17,98% to the IPTV provider and 47,87% to the UGC provider, with both the IPTV provider and the UGC provider having expected returns at their minimum accepted level and risk measure value at their maximum accepted value. The optimal expected return of the Platform Operator (VoD provider) correspondent to the maximum risk level accepted by this provider is given by 23,51%.

6 Conclusions and Future Work

We have discussed the implementation of a model designed to coordinate the provision of services to bundle a Service Portfolio through the choice of a suitable revenue sharing scheme. The solution ensures that each service provider participates actively in the creation of a customized Service Portfolio and, at the same time, allows the Platform Operator to obtain the highest possible return. In the business model evaluated one agent takes the role of coordinator between the different providers, while other Platform Business Models (see e.g. [8] or [9]) with different coordination rules require different evaluation methods. The implementation considers Mbps as the relevant measure for the determination of the service provision level and it seems to be quite suited for multimedia contents, but such a measure could not be used in case of service providers not having bottlenecks linked to bandwidth.

Thus, the model is yet considered at an early stage and not fully operating in an industrial basis. A possible future extension of the evaluation framework can proceed in the direction of including different types of contribution models, in order not to restrict the analysis to multimedia bandwidth critical content. The model considers as well a set of parameters not always easy to estimate from market data, a way to simplify the constraints in order to allow for an easier evaluation of the parameters needed is considered a right step in the path of merging the academic and the industrial perspectives.

References

1. Gaivoronski, A.A., Zoric, J.: Business models for collaborative provision of advanced mobile data services: portfolio theory approach. Operations Research/Computer Science Interfaces Series, vol. 44, pp. 356–383. Springer, Heidelberg (2008)
2. Zoric, J.: Practical quantitative approach for estimating business contribution of enablers and service platforms. In: Proceedings of ICIN 2008 - Services, Enablers and Architectures supporting business models for a new open world, Bordeaux, France (2008)
3. Zoric, J., Strasunskas, D.: Techno-Business Assessment of Services and Service Platforms: Quantitative, Scenario-Based Analysis. ICT-Mobile Summit (2008)
4. Tanenbaum, A.: Computer Networks. Prentice Hall, Inc., Englewood Cliffs (2004)
5. Ortiz, S.: Phone companies get into the TV business. IEEE computer society (2006)
6. Cisco Wireline Video/IPTV Solution Design and Implementation Guide (2004)
7. IAB Platform Status Report. User Generated Content, Social Media and Advertising – An Overview. In: Interactive Advertising Boureau (2008)
8. Ballon, P., Walravens, N.: Competing Platform Models for Mobile Service Delivery: the Importance of Gatekeeper Roles. In: 7th International Conference on Mobile Business (ICMB 2008), Barcelona (2008)
9. Strasunskas, D. (ed.): Revised business analysis and models. SPICE project deliverable D1.7, IST-027617 (2008)