A Novel Monetary Incentive for Commercial P2P Streaming

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ABSTRACT: *Today P2P faces two important challenges: design of mechanisms to encourage users' collaboration in multimedia live streaming services; design of reliable algorithms with QoS provision, to encourage multimedia providers employ the P2P topology in commercial streaming services. We believe that these two challenges are tightly-related and there is much to be done with respect. This paper proposes a novel monetary incentive for P2P multimedia streaming. The incentive model classifies the users in groups according to the perceived video quality. We apply the model to a streaming system's billing model in order to evaluate its feasibility and visualize its quantitative effect on the users' motivation and the provider's profit. We conclude that monetary incentive can boost up users' cooperation, loyalty and enhance the overall system integrity and performance. Moreover the model defines the constraints for the provider's cost and profit when the system is leveraged on the cloud. Considering those constraints, a multimedia content provider can adapt the billing model of his streaming service and achieve desirable discount-profit trade-off. This will moreover contribute to better promotion of the service, across the users on the Internet.*

Keywords: Incentive, P2P, Cloud, Streaming, Discount, Multimedia, Billing

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1. Introduction

P2P brought an alternative to the client-server content distribution. It introduced an application level routing among the users– called *overlay*–based on dynamically formed connections. Users may join and leave the overlay without restriction. The important momentum of P2P was recognized in systems with heavy server load, caused by users' overwhelming demand operations. A typical example is bottleneck caused by increased bandwidth demand in a streaming system. This kind of server independent cost-efficient overlay, engaged numerous users to a cooperative way of contents share and retrieval.

Despite the increasing support and innovations in P2P systems, bypassing the server role impacts the traffic control and security. Yet mechanisms to encourage users collaboration and avoid malicious behavior, are an ongoing challenge for multimedia live streaming systems. Moreover, the P2P algorithms should guarantee continuous quality of service (QoS) in the case of a system scale.

We organize this paper in two parts. First we briefly introduce P2P and show the tight relation of the multi-tree overlay topology with the users' behavior in the system. Today it is challenging to establish an incentive mechanism for a commercial live streaming system. We follow up some of the existing studies that address uncooperative and malicious behavior in P2P streaming systems.

In the second part we describe an example system for multimedia streaming that uses the P2P topology. We apply the incentive model in terms of monetary discount to the billing model of the system. So far the increasing offer of the cloud providers facilitates a specific type of infrastructure that liberates a client's service from irrelevant features–*pay for what you use*. The dedicated underlying infrastructure spread across continents to improve the system's QoS and the users' experience. We believe cloud is a good asset with favorable price offers and flexible infrastructure to leverage commercial P2P-assisted multimedia streaming services.

As of the above reasons, the described system relies on cloud infrastructure to host the multimedia service and uses P2P to redistribute the video among the users. We define the constraints for the provider's revenue that bound the feasibility of the billing model. Furthermore we present an analytical bounds for the provider's infrastructure cost in the established P2P-Cloud scenario.

Finally by analytical case study we sketch the effect of the incentive model to the global discount the provider has to provide and analyze how it affects his revenue. In a conclusion, a monetary remuneration tided to the billing model of a streaming service, can be beneficial incentive for both the provider and the participants in the multimedia streaming system, provided it complies to the established constraints. This approach can be further adapted to meet the requirements of other billing models.

2. P2P Live Streaming

In this section we describe the concept of P2P and how it applies for multimedia streaming applications. Latter we focus on a multi-tree P2P topology and describe the relation between the user behavior and the overlay.

2.1 Overview of P2P

P2P represents a cooperative model of interconnected users called *peers*. The integrity of P2P relies on the overlay network formed among the users and depends on the aggregate bandwidth in the system. When it appeared, the initial goal of P2P was to support scenarios with voluntary participation, where the users share their resources (ex. upload bandwidth, computing capacity) among each other. P2P inspired research in algorithms for overlay construction that aim on fair bandwidth distribution across the users in the overlay.

The P2P concept found an immediate application in file sharing systems, cooperative on-line games and multimedia streaming– live and on-demand with the appearance of Internet TV and content delivery networks (CDN). BitTorrent[1], CoolStreaming[2], PPTV[3] and SopCast[4] are only several pioneer applications that gained popularity among the file sharing and streaming applications. Unlike the client-server model where the contents are fetched from the server once per every client, in P2P a content can be redistributed repeatedly among the users. This is a fundamental difference that helps P2P enhance the system performance and avoid server bottleneck.

Although widely accepted and increasingly used, P2P faces an important drawback–the inability to prevent abusive and uncooperative users to join the overlay. Several P2P applications still fail to detect such behavior. Furthermore, as highly dynamic process, P2P streaming suffers of instability due to peer churn, since the users can join and leave the network voluntarily. This limits the exploitation of P2P for commercial multimedia streaming applications on the Internet. Livestation[5] with its premium subscription, BBC's iPlayer1.0[6] (being P2P-based until 2008), BitTorrent Live [7], Octoshape[8] and Zattoo[9] are few examples of commercial P2P-assisted live streaming services.

[1]http://www.bittorrent.com
[2]http://www.coolstreaming.us
[3]http://www.pptv.com
[4]http://www.sopcast.com
[5]http://www.livestation.com
[6]http://www.bbc.co.uk/iplayer/tv
[7]http://live.bittorrent.com/
[8]http://www.octoshape.com/
[9]http://zattoo.com/

Rodriguez et al. [1] observe the issues regarding commercialization of P2P algorithms. They point out the necessity to explore incentive models based on economic savings, access to premium content or community-based alternatives.

It is challenging to establish an accurate billing model in a P2P-based system. The system continuously change as new peers arrive and depart. Moreover uncooperative and malicious users impact severely the overall integrity of the system. Therefore - incentive mechanisms are necessary to motivate such users to actively participate in the system.

2.2 P2P streaming topologies

In the literature, the P2P overlay topology is classified in two general categories: multi-tree (tree as its subcategory) and data-driven randomized (also called mesh).

2.2.1 Mesh

This approach organizes the users in a randomly formed mesh, where the video is sliced in chunks and sent to the users. Since the system we use in the paper bases on a multi-tree topology, we omit from further details about mesh topology. For through description, Liu et. al, [2] present a comparative analysis of the two overlays employed in a streaming scenario.

2.2.2 Multi-tree

For the system described in the paper, we base on a multi-tree overlay [3] to show the topology setup effect on the QoS of the streaming system. We choose multi-tree over mesh mostly because of the possibility to intervene in the topology creation, unlike the mesh, which is randomly created. Moreover the billing model explained latter bases on three levels of QoS expressed as sub-stream multiples. Multi-tree environment shows more convenient for this type of multi-layer quality representation.

In a multi-tree overlay, the users take part in multiple d-ary sub-trees. The streaming server is the root of the tree. He divides the video with streaming rate r in m sub-streams and disseminates them deeper in the sub-trees. The sub-trees are formed in a breath-first manner, upon client's arrival. Figure 1 depicts a typical multi-tree overlay with a server as a root of the streaming content and two separate sub-trees. The tree has a depth h = 3 and degree d = 2.

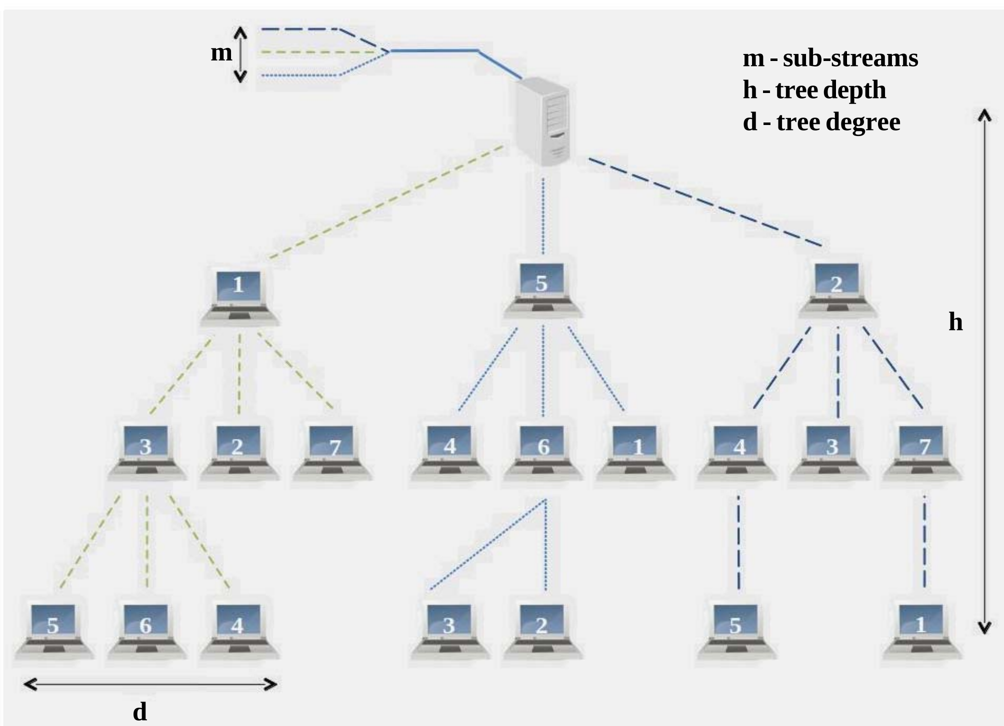

Figure 1. SplitStream [3] overlay topology

The tree degree defines node's maximum number of children, while the tree depth is the maximum number of traverses from the root to the furtherest leaf. Since the tree is formed in a breath first manner, higher tree degree results in wider sub-trees and connects more users at higher tree levels (close to the root). Bigger depth, in contrast, increases the number of steps a streaming content traverse on his way to the leafs, hence increases the delay at lower levels.

Therefore by adjusting the multi-tree topology, the provider can either reduce the bandwidth demand by reducing the tree degree while maintaining the delay sustainable, or scale the infrastructure to increase the bandwidth supply and decrease the user's perceived video delay. The previous analysis states for a valid $f_i \geq r_i$ pre-condition, i.e. the peer should contribute at least as much forward bandwidth f_i as he amount he receives r_i. The contrary will provoke elapsed brunches in the multi-tree environment. Therefore the streaming provider should account in advance the amount of peers' bandwidth for share in order to build an optimal overlay topology.

2.3 Behavior in P2P systems

We focus on the influence of both cooperative and uncooperative users in the system based on their position in the streaming trees. To remind, P2P relies on collaborative network of users that are expected to contribute, which in practice, is not always the case. Cooperative users share determined upload bandwidth with other users in the system, unlike the uncooperative also called *free riders*, who enjoy the streaming but don't forward the video to the other users in the tree. Malicious peers join the system exclusively to harm its integrity and decrease the QoS.

2.3.1 Cooperative users

In a multi-tree overlay these users improve overlay construction and contribute to more balanced sub-trees. Moreover they foster system's performance increasing shared bandwidth reserves. According to the multi-tree constraints in SplitStream [3], to achieve a feasible overlay a client contributes upload bandwidth at least as the amount he downloads. For a well-balanced overlay, authors suggest to connect each user as inner node in only one sub-tree, and as leaf in the rest, Figure 1. Sweha et al. on the other hand [4], suggest connecting the users in minimum number of sub-trees. From those, they appear as inner nodes only in a number of sub-trees corresponding to their upload bandwidth.

Imagine cooperative users with high upload bandwidth. Following the above recommendation, a provider can put them on a higher level in a number of sub-trees equivalent to the amount of their upload bandwidth. This opens proportional number of connections for additional high level users. As a conclusion, in a multi-tree P2P scenario, cooperative users make significant contribution if placed higher in the sub-trees.

In a mesh overlay, due to its dynamic nature, a cooperative users increase the availability of the streaming content to the peers across the entire overlay. They also improve the overlay integrity by forming a more stable connections among the peers.

2.3.2 Uncooperative users

In a voluntary system as P2P, the presence of uncooperative users is inevitable as a result of the optional bandwidth share and a peer's will to increase for free their personal welfare. For a multi-tree overlay, this generates elapsed branches in the sub-trees where the user appears as inner node, leaving his successors to be orphans. Higher level free riders make big impact to the overlay integrity as they leave empty connections and hence provoke sub-trees misbalance. Uncooperative users should be always connected at a lower tree level to reduce the impact on the tree expansion and to avoid system's resource consumption. Hosting selfish users in mesh overlay impacts to the same extent, since the peers would lack the resources of the selfish peer and thus experience a lower video quality. The selfish node on the other hand, benefits of the available bandwidth of the peers he connects to.

2.3.3 Malicious users

Unlike self interested users, malicious ones are even worse candidates who threaten the system integrity. They exploit the system by harming other peers and prevent them to enjoy the streaming. They do this by performing various actions such as: presenting false identities, data drop and data pollution, collusion attacks with other peers, assigning false reputations, etc. It is yet a challenging task to detect and deal these users even for a commonly used P2P streaming systems.

3. Incentive Mechanisms in P2P

For best user experience, P2P live streaming needs a sufficient amount of bandwidth in the system and topology's integrity.

Therefore the presence of incentive mechanisms is crucial to deal with negative behavior and generate more productive and user-friendly environment. The literature offers plenty of information on incentives for sharing in P2P. In essence, the aim is to motivate users to participate actively in the distribution of data streams by using their spare upload bandwidth. The authors in [5], divide incentive mechanisms applied to P2P media streaming into four groups: reciprocal, reputation-based, game-theoretic and taxation-based.

3.1 Reciprocal mechanisms

Base on the tit-for-tat strategy and it is mostly used in file sharing systems. Peers only exchange resources with neighbors with similar upload rates. Occasionally, they allocate their own upload capacity by assigning slots - first to those users with more transfer rate. In this scheme, free riders are alienated as they don't reach friendly relationships with their neighbors.

In [6] there is an interesting instance where a tit-for-tat mechanism is combined with multiple layered video encoding. Layered videos provide better quality when more layers are received, thus, by using a tit-for-tat strategy, users who transmit more layers receive more back and get a better video quality as a result. Ngan [7] proposes a mechanism similar to tit-for-tat aimed for P2P streaming services. He suggests temporal reconstruction of the overlay to distinguish nodes with selfish behavior and avoid free riders. This however increases overhead any time the tree is reconstructed.

3.2 Game-Theory

Bases on game theory approach to imple-ment strategic play among the participants in the streaming system. Every peer (strategic player) tries to optimize his play, that is, maximize the amount of data received while minimizing the amount of data transmitted. Lin et. al [8] provides a game-theoretic framework to model player's behavior and design incentive strategies for P2P live streaming.

3.3 Taxation

All the previous mechanisms tend to reward users based solely on their contribution. However, those peers with less capabilities in terms of bandwidth can be, in some cases, punished for the lack of resources rather than for the lack of willingness to participate. Chu [9] motivates users to contribute with the entire available bandwidth, i.e., users with high upload bandwidth get encouraged to participate with more bandwidth than they need to receive the whole stream, in order to compensate for the "*less fortunates*". This altruistic approach aims to achieve a sort of social welfare in the system where, ideally, more users are allowed to receive media in good conditions. Yang et. al, in [10] incorporate taxation based incentive mechanism into QoS aware neighbor selection algorithm.

3.4 Reputation-based mechanisms

Deal with providing a global rating for every user in the system. This score improves with the user's contribution. Users consult the reputation of the possible receivers and choose content suppliers. A reputation is an indirect-reciprocity mechanism. This means, as opposed to the reciprocal systems based on mutual relation of two peers, reputation is global. The main drawback of reputation for media streaming is that it can take time to build up. However, [11] uses a reputation history to improve on his reciprocal system, allowing users to perform informed choices when they select future candidates. This history bases on the previous interactions among the users.

In his study, Li [12], claims that reputation and credit-based incentive mechanisms although successful in a file-sharing P2P applications, are unlikely to work in a streaming scenarios due to limited time framework. As an open issue, he encourages further investigation for incentive models and price establishment in P2P streaming.

Apart from the described incentives, the literature offers models based on combinations of some of the above tech-niques. One example is the approach to introduce the social network data into game-theory approach as incentive in file-sharing [13].

An example of a commercial service on the Internet is to classify the clients in premium and basic membership based on subscriptions. Premium users usually pay monthly/yearly price and enjoy certain privileges such as - commercial-free, complete access to all services. Basic users on the other hand, are charged per content or have restricted access of contents and receive commercials during the streaming.

We registered no commercial streaming systems however, that uses QoS of video in their billing models. In the next section we present a case study for a billing model based on QoS which applies a discount-based incentive.

4. Novel Monetary-based Incentive

The trend of using cloud infrastructure to leverage multi-media services has increased in the last years. In a recent study [14] we showed that using cloud-based P2P streaming, increases overall system performance and improves QoS for the participants in the multimedia streaming service.

Deploying a P2P streaming service in a centrally controlled system opens as many possibilities for the streaming content providers, as for the users. The *easy-to-use* and *on-demand* cloud infrastructure saves for provider the cost of underutilized on-premise resources. This traces the way for innovative and user-oriented granular price classification to define a good billing model for streaming service in the cloud.

4.1An example for multimedia streaming system

In this section we base on our previously proposed multime-dia streaming system [15] to illustrate what are the provider's cost constraints to establish a commercial P2P service. We also describe discount incentive model based on money and discuss its application on the system. This system relays on cloud infrastructure for better QoS and service-scale in case of overload.

Figure 2 depicts the system topology. There is the server of the streaming content in the cloud and a P2P multi-tree topology formed among the clients. Before sending to the clients, the video is divided in sub-streams (three in this case) and disseminated in three different sub-trees. The streaming content provider can contract cloud instances in different geographic zones and connect each client in his closest sub-tree. This decreases video delay and facilitates scalability, since once the sub-tree is saturated (no more forward BW for upcoming clients), the system can be scaled on-time in the closest geographic zone.

4.1.1 Billing model

The billing model of the system consists of three types of subscriptions–*gold*, *silver* and *bronze* defined according to the QoS a client signs up for. Since we discussed previously that the video is divided into various sub-streams, gold clients receive all sub-streams which result in maximum perceived video quality with almost no delay; silver clients consequently receive less streams and experience some delay; and bronze–few streams with more delay. Gold clients get connected to all sub-trees at higher levels, while silver and bronze go to lower levels. Clients can choose a subscription type and connect to the service at the scheduled streaming time, provided they have enough download bandwidth to receive the requested sub-streams. Each client

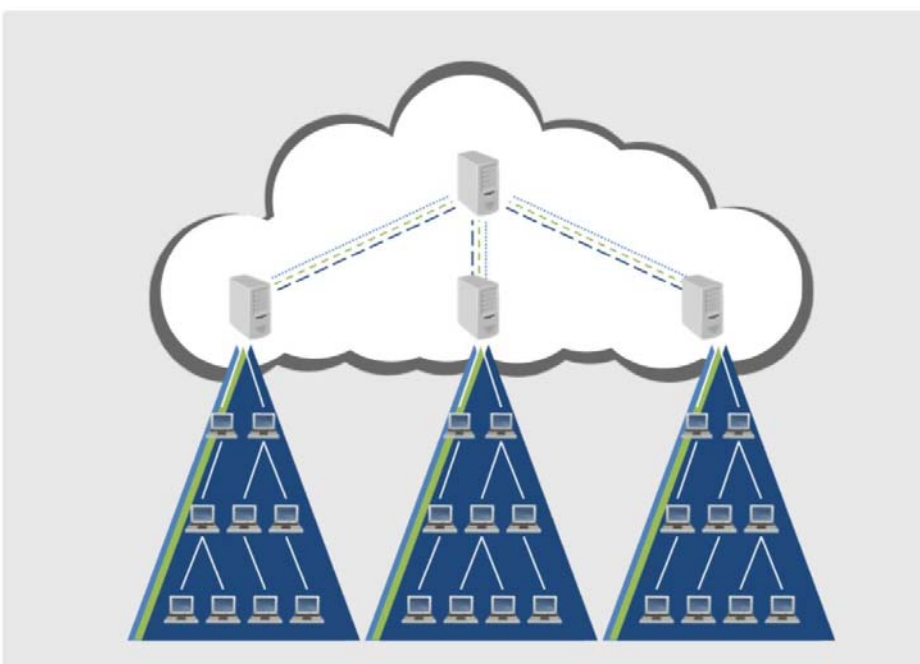

Figure 2. P2P-Cloud architecture with multi-tree overlay

declares if he will participate in the P2P network and the amount of upload bandwidth to offer to other clients. After the end of the streaming, peers are rewarded with discount from the initially payed price–an amount proportional to the shared bandwidth. The system encourages gratis clients to connect provided they contribute with their upload bandwidth. In exchange, they can watch the video for free. The system uses the multi-tree overlay topology to organize peers in the number of trees according to the quality they want and the price they pay. Heterogeneous peers can be connected at appropriate tree level according to the amount of bandwidth they declare to forward.

4.1.2 Peer churn and malicious users

The multi-tree organization resolves the single tree inefficiency to deal with peer churn. Since one user is connected to several trees, should a churn appears, the affected users from the elapsed branches will suffer decreased video quality in short time interval, but not an interruption. Moreover the invested money will stimulate the users to stay until the end of the streaming session. Furthermore, we believe that a commercial system reduces/eliminates the malicious behavior because all users pay the video price in advance (according to the price model they choose). This way, should malicious users connect, they will anyway have to pay the entire video price beforehand. This makes the pricing model unappealing to malicious users who would pay a subscription price, only to make a harm to the system. Users who announce more free bandwidth that they eventually contribute, will receive only the discount pro-portional to the amount of the contributed BW. The provider can also detect such users and reconnect them on a lower level in the trees - possibly as leafs. The children nodes from the elapsed brunches (the victims of the "*fake*" contribution) can be reconnected to other trees before they suffer a lower video quality.

The key driver in this system is the monetary incentive model. That stimulates cooperative behavior and motivates clients to offer by their selfs a spare upload capacity in form of a service to other users. Next, we analyze the incentive model and establish the provider's infrastructure cost. Later we apply the profit and cost analysis to the system discussed in this section.

4.2 Applying the incentive to the streaming system

In a P2P system where users pay a subscription price, the idea behind a discount-based incentive lies in establishing a remuneration policy to motive increased participation and collaboration among the users. The discount applies over the initial price proportionally to the amount of the shared bandwidth. For feasibility of the model, we set up a precondition for the provider–a positive revenue.

4.2.1 Provider's revenue

$P(R)$ is money the provider receives form the users for watching a streaming content such as: football match, live-concert, a keynote presentation, a pressconference etc. The revenue is tightly-coupled to the established billing model in the streaming service. It depends on the total number of users N_i and the price associated to stream the video P_i. T_v denotes the video duration.

4.2.2 Provider's discount

$P(D)$ is a monetary remuneration D_i the provider offers to the users for sharing their bandwidth. We denote a user's total forward bandwidth as f and T_f the time to forward the video to other users. Here $T_f \leq T_r$ to denote peer's sudden departure or fail.

Supposing all users will share their bandwidth, we can establish the general constraints for a discount-based model:

$$P(R) - P(D) = \sum_i N_i (P_i\ T_v - D_i\ f\ T_f) \geq 0 \qquad (1)$$

It may be challenging for the provider to establish pricediscount (P_i / D_i) trade-off, such that the above condition states. This discount incentive reward the users for being cooperative and partially returns them the invested money. From our point of view, a remunerative price model is a promising solution for commercial P2P based streaming.

The equation 1 although defined for a general discount based model, can be adapted for the billing model of this system, by defining more variables per price packet, instead of having a unique price per video content. For example, $N_i = P_g + P_s + P_b$, where P_g, P_s and P_b is the subscription price for gold, silver and bronze packet. With appropriate adaptation it can be applied to any discount based model.

4.2.3 Cloud cost

The multimedia contents on the Internet can be either previously stored and streamed to the clients at a certain time (VoD, IPTV), or shown as being emitted - live event streaming. In a cloud scenario, the video can be encoded in a streaming media server on premise or on the same cloud instance. The provider decide to use the cloud, he may add up charges for extended hosting services and tools such as: load-balancers, optimized utilization of instances use across data centers (in case of Amazon[10]), monitoring, etc. These additional services are nonessential for our profit-cost tradeoff analysis, so will be omitted in the provider cost calculus. To achieve a general price definition for a live streaming service on the cloud, we abstract from the video source location and define cost constraints per streaming event. From here, the total provider's cost depends on the cost per cloud instance and the data transfer cost to forward the video from the publisher to the directly connected users.

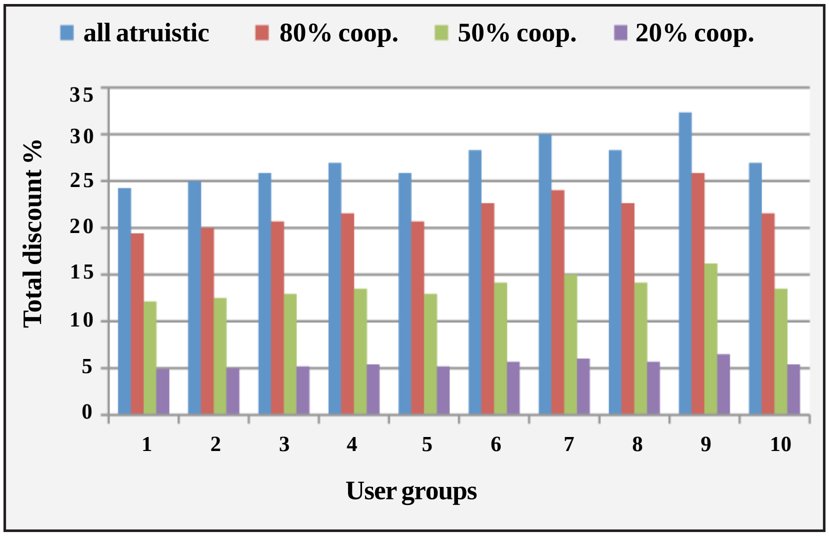

Figure 3. Three compositions of gold, silver and bronze users combined in ten groups and respective discount change for different levels of user cooperation

4.2.4 Instance cost

$C(I)$ Live streaming, unlike video ondemand, has a time frame limit. To take advantage of the flexible cloud service, a provider may rent an on-demand instance. Cloud providers today charge for the compute instances based on the user/service requirements. For example Amazon EC2 classify on-demand instances on: standard - small, medium, large, extra large; micro; high-memory; high-CPU; clustercompute; cluster-GPU and high-I/O.

4.2.5 Transfer cost

$C(T)$ is a price for the output traffic from the instance to the clients. What defines this cost, is the instance capacity $u(I)$ together with the video duration T_v.

Following is the provider's cost to stream a video during T_v, on a cloud instance with bandwidth capacity $u(I)$ that costs C_i, while the data transfer cost is C_t, across n instances:

$$P_c = C(I) + C(T) = (C_i + C_t\, u(I))\, T_v\, n \tag{2}$$

The cost depends on the number of cloud's direct connections. In a scenario where all clients are connected to the provider in a star topology, the provider's transfer cost increases linearly with the number of clients. P2P topology instead, decreases the number of direct connections by organizing peers in overlay network. In such case less clients are connected directly to the cloud, which reduces provider's transfer cost.

Finally we conclude that adjusting cost and revenue to abide to the condition $P(R) - P(D) - P_c > 0$, (equation 1, 2), represents a model for a discount based incentive for the participating peers in the streaming system and essential constraint for a provider of multimedia streaming service.

[10]http://aws.amazon.com

To calculate price-discount variables for the discussed billing model, we developed a Web tool *TVProviderCostCalculator*[11], based on the provider's cost and revenue equations. Although ti follows the model of the use case streaming system, it is general enough to address similar economicoriented business models.

4.3 Example case study

In this part we use statistically inferred values from a previously studied life streaming events, in order to see the feasibility and the effect of the incentive model in a real system. To achieve this, we use our previous knowledge and expertize of working with video systems on the one hand, and use the data presented in the papers [9] and [16] on the other. The authors use live event traces to assign initial parameters to their experiments. To model the fraction of gold, silver and bronze users in the system, we set up several example cases, Table 2. Similarly as registered in the life events described in
the papers, we choose a total of 1500 users to be participating in the streaming system.

For a previous related research [14], we used video encoded with 500*Kbps*. According to the authors in [17], the video streaming quality has improved along the last years and today it can easily reach a quality of more then 1.5 Mbps. We chose ten different group combinations for number of gold, silver and bronze users, Table 2 and set up a price per streaming content (3; 2.5 and 2 Euros consequently), Table 1. Depending on the price they pay, the users watch the video in different qualities. They are connected to various sub-trees to receive the appropriate number of stripes, as described in the Section II.

Gold price	**Low f.BW**
3 euro	500Kbps
Silver price	**High f.BW**
2.5 euro	1Mpbs
Bronze price	**Average f.BW**
2 euro	750 Kbps
Gold quality	**Discount (high)**
20 stripes	50%
Silver quality	**Discount (low)**
18 stripes	30%
Bronze quality	**Video quality**
15 stripes	1.5Mbps

Table 1. Parameters

G	Gold	Silver	Bronze
1	1500	0	0
2	1000	500	0
3	1000	0	500
4	500	500	500
5	500	1000	0
6	500	0	1000
7	0	500	1000
8	0	1000	500
9	0	0	1500
10	0	1500	0

Table 2. Subscriptions

For the first evaluation, we suppose all 1500 users are homogeneous - they contribute with average forwarding bandwidth of 750*Kbps*. We assign 50% discount, off the price they pay per GB received. The discount is set per GB of shared transfer (BW unit a user sends to other users). This means that for each GB the user contributes, the provider rewards him with half of the price that the user initially payed. We want to see, how the users' cooperation affects the provider's revenue taking into consideration the maximum possible discount to be gained by one user (provided he cooperates with this entire free BW).

Figure 3 depicts the % change (*y* axis) of the total discount for the ten groups of users (*x* axis), in the case of four levels of users' cooperation: 100% cooperative (altruistic), 80%, 50%, 20% - cooperative. From the values we note that the total discount the content provider has to return to the cooperative users, is biggest in the case when all the users are altruistic and decreases with the level of cooperation. We note that even in the case where all users participate, the total discount does not exceed 35% of the provider's total revenue. This is is due to the average BW we assigned to the users 750*Kbps* and the video duration of one hour. We conclude that the current discount, can contribute to increased motivation of the users to cooperate and contribute in the system. Considering that a user can get back half of the initially payed price, can motivate them to contribute more BW and this will potentially improve the global system's integrity.

For the following evaluation, we divided the users in two groups - *high capacity* and *low capacity* users depending on their forwarding bandwidth, Table 2. Then we assigned different discounts 50% and 30% for high and low capacity users respectively. With this we wanted to capture the total discount change as a function of the users' capacity, for the same contribution levels as in the previous case.We observe on Figure 4, the total discount change in the case when 20% of the users are high capacity - 1*Mbps*. This is the most common case of user's profiles on the Internet as stated in [9]. The common measurements have shown only 20% of the participants in P2P streaming events to be high capacity. As we see in this case, the total discount decreases and reaches maximum 20% of the total revenue, only for the case of the user group 9. This appears as a result of the increased number of bronze users in that group. These users bring lower profit to the provider while enjoying the same discount as the gold and silver users who pay higher subscription. To avoid profit loss due to the increased presence of cheaper subscriptions, the provider can always adjust the discount to be variable according to the user profiles and their outgoing BW capacity.

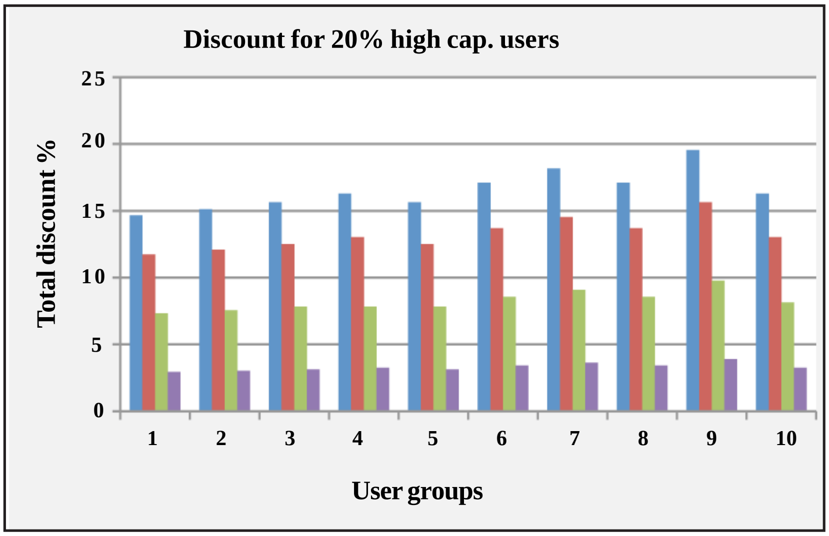

Figure 4. Three compositions of gold, silver and bronze users combined in ten groups and their respective discount change for different levels of cooperation, in the case of 20% high capacity users

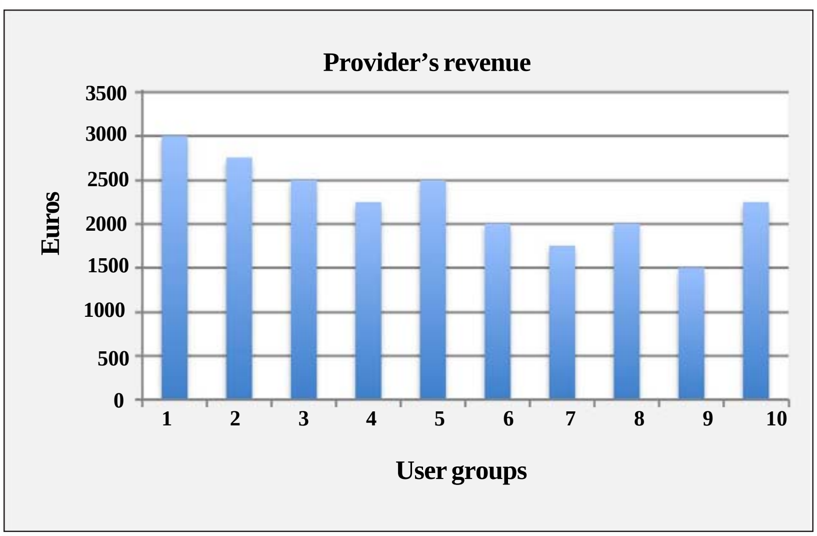

Figure 5. Provider's revenue change for one hour of HD video, in function of the user groups, for different cooperation levels

Finally, Figure 5 as per illustration, shows the total provider's revenue (in Euros) for the ten user groups groups. Note the revenue values for one hour streaming with high quality video of 1.5*Mbps*. The graph shows high revenue across all groups and shows that using P2P to leverage streaming, is a good deal for the provider's profit. Applying discount remuneration, doesdn't affect the profit to a hight extent, but contributes to the incentive model and motivates the users for increased collaboration. We should note that this example is only to illustrate the outcome of the billing model when common values for bandwidth and prices are considered in the evaluation. It confirms the feasibility of the monetary approach in a multimedia system under the determined bounds. Finally it should serve as illustration of the incentive model and help the multimedia content providers understand the benefit of the P2P technology and the promising potential of applying it in commercial streaming systems.

5. Conclusions and Future Work

In this paper we initially observed the characteristics of P2P and the challenges it faces for increased adoption in commercial live streaming systems. We sketched the influence of the uncooperative and malicious users to the overall system topology. The P2P dynamic nature increases the system's vulnerability in the presence of uncooperative users, as they impact the system's integrity and the users' perceived QoS. In continuation we presented a billing model with incentive based on monetary discount. The model establishes the constraints for users' satisfaction and provider's revenue in a cloud-hosted P2P service. We concluded that the discount as a potential incentive in P2P-based streaming systems can contribute to increased shared bandwidth, better system's performance and improved user's QoE. Moreover, implemented as a multitree overlay under the supervision of a central authority, the discount incentive increases the users' trust and can contribute to decreased or eliminated malicious behavior, controlling better the peers' churn.

Finally we made an analysis for different groups of peer's compositions for four cooperation levels–starting from all cooperative users to only 20% cooperative. We concluded that appropriately chosen discount and price values can boost up users to participate and this causes low effect on the global provider's revenue. To sum up, economic-oriented live streaming today faces a slow tendency in adopting P2P for large-scale systems. Up to our knowledge, we are the first to present an example for a billing model based on monetary discount incentive. We believe that this kind of approach can increasingly integrate the P2P technology in a commercially deployed streaming systems.

As future work, we plan to formalize the incentive model and perform more extensive analysis to qualify the benefit of the described billing model both from multimedia provider and user point of view. Moreover we plan to work on the implementation of the QoS algorithm for automatic allocation of the users in the multi-tree overlay. Our final goal is to implement the system in a real-life scenario and quantify its efficiency by evaluating the users' QoE.

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