Optimal Price Distribution Strategy for Mobile Service Providers

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***Abstract*— Ubiquitous Multimedia Access has become a very common topic within the multimedia community during the last few years. Research centers and telecom providers address new, smart and efficient solutions for the ubiquitous access to multimedia data and in particular videos, from everywhere with mobile devices. But videos pose serious problems in terms of both amount of data transferred on the network and computational resources. In the mobile communication network, data-plan subscribers are tend to redistribute the video content to nonsubscribers at reasonable price. This kind of redistribution of video contents leads to a competition for the mobile service provider and it becomes very difficult to trace the route of content distribution from subscribers to the non-subscribers. Therefore the service provider needs to set a reasonable price for the data plan to prevent such unauthorized redistribution so that he can maximize his profit. In this paper, we do a survey on the optimal price distribution strategy for the service provider. For this we model the behavior between the subscribers and the secondary buyers as a no cooperative game and find the optimal price and quantity of video content for both groups of users.**

***Keywords*— Mobile communication, Mobile Service Provider, Pricing strategy, Ubiquitous Multimedia access, Video sharing.**

I. INTRODUCTION

Due to different possible communication interfaces that are available for mobile devices, we considerer that they can be in networks with different throughput characteristics, and also, they can be distributed through the Internet. The development of new wireless technologies and the advent of new mobile devices, new services and applications are necessary to supply the needs of the users of these devices. Video on-Demand services have become one of these services. The spread of both mobile devices and wireless network accessibility, Ubiquitous Multimedia Access (UMA) has become a very common topic within the multimedia community during the last few years. Research centers and telecom providers address new, smart and efficient solutions for the ubiquitous access to multimedia data and in particular videos, from everywhere with mobile devices (laptops, PDAs or last generation cellular phones). Possible applications of such technology include consumer entertainment and digital TV broadcasting, video conferencing, telemedicine and tele manipulation, military applications, and remote video surveillance. All these applications share several technological challenges.

On the one side, videos pose serious problems in terms of both amount of data transferred on the network and computational resources. On the other side, mobile devices and UMA scenario require accessibility through different and often limited wireless networks. The meaning of the term “mobile” is quite hazy and might assume different meanings, depending on the context: for example it could be an installation not constrained to remain in a fixed location, a moving device, a portable device (such as handhelds and laptops), or finally a battery-powered device. However, in multimedia the term “mobile” is generally related to the connectivity. Accordingly, here we assume that the reference mobile video surveillance system is provided with an ubiquitous wireless connectivity (either on the server, on the client or on both). Conversely the term “fixed” will be used to consider systems with wired connectivity [1].

Management and security of mobile networks and smart mobile devices became challenging when employees want to use their own devices for business purposes. The bring-your-own-device trend exasperates this challenge when we look at protecting the critical information needed to manage the organization and the network without sacrificing the privacy of employee's personal information and activities.

II. CHALLENGES IN MOBILE NETWORK

Today's mobile computing environment has redefined the way business is done, and challenged enterprise networks to deliver security and service levels exceeding any previous benchmark. Not only are today's users demanding mobile access, they bring and use their own devices. Enterprise networks have to provide that access transparently, securely, wired or wirelessly, at any campus or branch location in the enterprise, and from any external location as well.

The Bring Your Own Device (BYOD) phenomenon brings with it especially difficult security challenges because each type of mobile device is different and has unique vulnerabilities. At the same time, attackers are more numerous and sophisticated, and keep finding new ways to attack each type of device. In addition, today's multimedia and interactive applications present new ways of masking attacks, further increasing network vulnerability. And it's all growing — quickly. Today's networks have to allow access to a rapidly growing number of employees, partners, customers, patrons, and even casual visitors, and so they must have strong and flexible identity management systems to ensure appropriate access. At the same time they have to protect of business critical applications and intellectual property, and enable all types users to have access to sophisticated online applications designed to fulfill their particular business purposes.

All of this has to be provided with enhanced levels of performance that support wide and responsive distribution of today's sophisticated business and entertainment applications, ranging from simple order entry and account management, to VoIP telephony and interactive video training programs

III. CONTRIBUTION IN THE PAPER

According to a survey on the popularity of mobile devices [2], almost every person has at least one cell phone in developed countries. With such a high popularity and the convenient mobile-to-mobile communication technologies, it is possible for data-plan subscribers to redistribute the video content at minimal price in an unauthorized way. Compared to generic data, multimedia data can be easily retrieved and modified, which facilitates the redistribution of video content and allows the subscribers to redistribute the content sometimes for a higher price than their transmission cost. This redistribution activity exists only for a short period of time and is very difficult to track by the service owners. Therefore the better way to prevent this kind of copyright action is to set a price distribution strategy so that no primary subscriber will have the incentive to redistribute the video content to the second subscribers.

But there is a tendency that the mobile network service provider will be more interested in setting the video content price to maximize his own profit rather than protecting copyrights. In this paper a no-cooperative game theory is applied between the service provider & subscriber in such a way so that the service provider's can be represented as the total number of subscriptions times the content price. If the content price is high, mobile users have less incentive to subscribe to the data plan, which might result in less subscription. But on the other hand, the content price in the redistribution network may get higher due to less subscribers and more secondary buyers. In such a case, although a subscriber pays more for the video stream, he/she also gets more compensation by redistributing the data. Hence, setting the content price higher does not necessarily reduce the number of subscriptions, and it is not trivial to find the optimal price that maximizes the service provider's utility.

The service provider, the data-plan subscribers, and the secondary buyers who are interested in the video data interact with each other and influence each other's decisions and performance. In such a scenario, the game theory is a mathematical tool to model and analyzes the strategic interactions among rational decision makers. In this game theory model we add the service provider as a player to the game to analyze the optimal pricing for the service provider in the video streaming marketing network. Since the mobile users can change their decisions on subscribing or resubscribing, the content owner is interested in the number of subscribers that is stable over the time. Therefore, a robust equilibrium solution is desired for the service provider. Hence, we formulate the video streaming marketing phenomenon as an evolutionary game and derive the evolutionarily stable strategy for the mobile users [6].

IV. VIDEO STREAM REDISTRIBUTION NETWORK

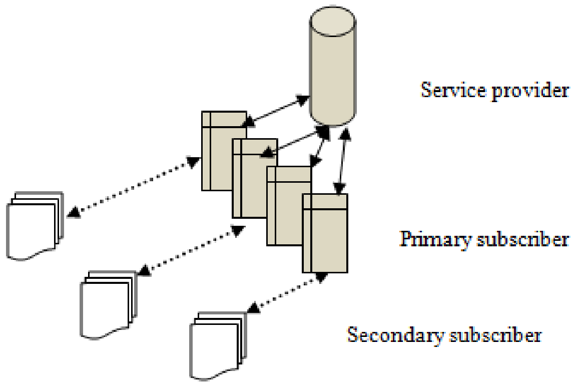

Fig 1: Video stream redistribution scenario

In the system diagram shown in Fig. 1, there are P_s subscribers in the network, who are trying to sell the video content to secondary subscribers S_s. Here, we assume that the content is redistributed through direct links between the primary subscribers and the secondary subscribers.

Given the current technology, such direct link can be Bluetooth or Wi-Fi. At the beginning, each primary subscriber sends his/her own price per unit transmission power, as well as the probing signal to secondary subscribers. The probing signal enables secondary subscribers to estimate the maximal achievable transmission rate. A secondary subscriber has to decide how much power he/she wants to buy from each primary subscriber. Since scalable video coding is widely used in mobile video streaming , secondary subscriber can purchase different coding layers of the video from different subscribers and combine these streams during the decoding process.

For video streaming services, two commonly used objective quality measurements are the video's peak SNR (PSNR) and the streaming delay. Here, we adopt the polynomial delay model as in [6]. The overall delay D_B at the secondary buyers' end is the network delay between the subscribers and the service provider plus the maximal processing time of the subscribers. Here, we assume the users for an ad hoc network, and the communication is through direct links. Therefore ,

$$D_B = D_q \frac{(N'+K)}{M} + \max_{i \in N'} D_p(i) \quad \text{(i)}$$

Where N' is the number of subscribers from whom the secondary buyers purchase the video stream and K is the number of subscribers within the coverage of the same base station, who are currently using the data service but cannot establish direct link to secondary buyers or are not willing to redistribute the video content. M is the maximal number of users that the network service provider can simultaneously afford. D_p (i) is the processing time of subscriber & the network delay between subscribers and the service provider is $D_q \frac{(N'+K)}{M}$.

V. GAME THEORITIC MODEL

Since the video-stream redistribution network is a dynamic system in which all users have high mobility that can join and leave anytime, it is very difficult to have a central authority to control the users' behavior. In addition, since this redistribution is unauthorized and illegal, to minimize their risk of being detected by the service provider, the participating users (subscribers and secondary buyers) have no incentives to trust one extra person and the central authority, and a distributed strategy is preferred.

Given the fact that there is only one secondary buyer, we propose a Stackelburg game model to analyze how the secondary buyer provide incentives for subscribers to redistribute the video stream and find the optimal price and quantity that the secondary buyer should offer. The ultimate goal of this model is to help the content owner to set an appropriate subscription fee such that the equilibrium of the game between the subscribers and the secondary buyers leads to negative payoffs. Thus, subscribers will have no incentive to redistribute the video. Before the game starts, each user, either a subscriber or the secondary buyer, will declare his/her presence to all other users within his/her transmission range.

(1)Game Stages: The first stage of the game is the subscribers' (leaders') move. For each subscriber, he/she will set his/her unit price P_i per unit transmission power, as well as his/her maximal transmission power $P_i^{(max)}$. Then, in the second stage of the game, the secondary subscriber (follower) will decide from whom to buy the video and how much power he/she wants the subscriber to transmit. The secondary subscriber then pays each subscriber accordingly at the price that the subscriber sets in stage 1.

(2)Utility function of the secondary buyer/follower: We first define the secondary subscriber's utility function and study his/her optimal action. The secondary buyer S_s gains rewards by successfully receiving the video with a certain quality. On the other hand, S_s has to pay for the power that the subscribers use for transmission.

(3)Utility functions of the subscribers: Each subscriber S_i can be viewed as a seller, who aims to earn the payment that covers his/her transmission cost and also to gain as much extra reward as possible. We introduce parameter , C_i i.e., the cost of power for relaying data, which is determined by the characteristics of the device that subscriber S_i uses. Hence, the utility of S_i can be defined as:

$$\pi S_i = (P_i - C_i)\, P_i$$

Where P_i is the power that subscriber i uses to transmit to the secondary buyer. Thus, subscriber S_i will choose price P_i that maximizes his/her utility πS_i .

The choice of the optimal price P_i is affected by not only the subscriber's own channel condition but also other subscribers' prices, since different subscribers non cooperatively play and they compete to be selected by the secondary subscriber. Thus, a higher price may not help a subscriber improve his/her payoff.

VI. CONCLUSION

The aforementioned video-stream redistribution game is a game with perfect information, and the secondary buyer has perfect information of each subscriber's action (the selected price). According to backward induction, a game with perfect information has at least one equilibrium. Therefore, the optimal strategies for both the secondary buyer and the subscribers exist and can be obtained by solving the optimal decision for each stage using backward induction.

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