Domain Decomposition Based Game Theory to Arrive Optimal Video Streaming Pricing Policies

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***Abstract*-- Mobile phones users with 3G networks and smart phones watch video programs by subscribing data plans from service providers. Data-plan subscribers redistribute video content to non subscribers which is become potential competitor for mobile service provider and is very difficult to trace given users' high mobility. Service provider needs to set reasonable price for data plan to prevent unauthorized redistribution behavior to protect or maximize his/her own profit. Existing work presented optimal price setting for service provider by investigating equilibrium between subscribers and secondary buyers in content-redistribution network. Behavior between subscribers and secondary buyers is modeled as non-cooperative game and find optimal price and quantity for both groups of users. This work investigated evolutionarily stable ratio of mobile users decided to subscribe to data plan. It improves quality of service for end users and profit on redistribution network. However, it could not address Domain overlapping. To address this issue, Proposal work plans to present a Domain Decomposition Based Game Theory to arrive optimality that making data owner more profitability compared to redistributors. To present an optimal video streaming pricing policy during content distribution and to maximize the data owner profit compared to secondary buyer, Domain overlapping due to content delivery between distributors should be minimized and to reduce the complexity of content delivery by distributor network to consumers, we go for the proposed system.**

***Keywords*— quality of service, equilibrium, 3G, game theory.**

I. INTRODUCTION

Major thrust is given to multimedia processing technologies as huge demand for video contents being delivered to end users. More frequently wireless and mobile devices are being used for multimedia access. Network service providers focused on developing solutions to access of multimedia data from everywhere using mobile devices. Mobile phone users watch video programs, subscribing data plans from network service providers and to retrieve and reproduce the video content. Scalable video coding is used in mobile video streaming.

Mobile network service provider interested in setting content price to maximize his/her own profit than protecting copyrights. Service provider's profit is represented as total number of subscriptions times the content price. If the content price is high the mobile users have less incentive to subscribe to the data plan which result in less subscription.

But content price in redistribution network get higher due to less subscribers and more secondary buyers. Subscriber pays more for video stream gets more compensation by redistributing data. Setting content price higher does not necessarily reduce the number of subscription and not trivial to find optimal price to maximizes service provider's utility. Service provider, data-plan subscribers, and secondary buyers interested in video data interact with each other and influence each other's decisions and performance.

The existing presented game theory to model analyze strategic interactions among rational decision makers of service provider, data plan subscriber and secondary buyers of video data. Model user dynamics in redistribution network as multiplayer non cooperative game. Obtain equilibrium price from all users having no incentives to deviate.

Equilibrium price serve as upper bound for the price set by network service provider to prevent copyright infringement. Due to the small coverage area and limited power of each mobile device subscriber only sell the content to secondary buyers within transmission range, distance between users; channel conditions dominate users' decisions. Robust equilibrium solution is desired for service provider. Formulated video streaming marketing phenomenon as an evolutionary game derives evolutionarily stable strategy (ESS) for mobile users.

But the existing system has the following disadvantages. Domain overlapping was not addressed. Complexity of content delivery increased between distributor networks. Delay rate of content distribution varies as secondary buyer try to maximize his network presence. The existing was unable to handle both the direct and inverse problem of redistribution network.

To overcome the above disadvantages we go for the proposed to present a Domain Decomposition Based Game Theory to arrive optimality making data owner more profitability compared to redistributors. Evaluate the application of decentralization optimization from game theory to the solution of direct and inverse problems of video streaming content delivery.

II. LITERATURE REVIEW

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]. Bit rate scalable media naturally combines with prioritization methods: It may be successfully combined with unequal error protection, selective retransmission, or hierarchical modulation schemes. The idea is to strongly protect the important part of the scalable media (the base layer) in order to overcome worst-case error scenarios and give less protection to the enhancement layer in order to overcome the most typical error situations. This approach results in graceful degradation of the play-able quality according to the channel condition [2].

The choice of error resilient and compression schemes generally requires a tradeoff, and it is difficult to achieve both strong error resiliency and good compression simultaneously. Note that the error resiliency schemes introduce some redundancy in the data. On the other hand, the compression schemes aim to remove various redundancies (e.g., spatial, temporal and statistical) from the data. The spatial, temporal, and statistical redundancies are typically removed by transforms (such as DCT) or predictive techniques (such as DPCM), inter-frame prediction (including motion compensation), and entropy coding, respectively [3]. Ad hoc routing protocols that make forwarding decisions based on the geographical position of a packet's destination. Other than the destination's position, each node need know only its own position and the position of its one-hop neighbors in order to forward packets. Since it is not necessary to maintain explicit routes, position-based routing does scale well even if the network is highly dynamic. This is a major advantage in a mobile ad hoc network where the topology may change frequently. The main prerequisite for position-based routing is that a sender can obtain the current position of the destination [4].

Multimedia in-network processing: is many applications of WMSNs, a single sensor node is not able to answer a posed question, but several sensor must collaborate to answer it. For instance, a sensor node with a camera monitoring a moving group of people, cannot count their exact number and determine their direction, but it needs the collaboration of nearby sensors in order to cover the whole extent of the group of people. Therefore, sensor nodes are required to store rich media, e.g., image, video, needed for their running applications, and also to retrieve such media from remote sensor nodes with short latency [5]. Coupled with the fact that the computation power and storage capacity of mobile devices have been improving at a fast pace, mobile clients can now communicate among themselves to share information rather than having to rely on their connection to the server for each request [6].

Tradeoff between achievable data rates and complexity is examined for adaptive and nonadaptive modulation, where adaptive modulation achieves an average data rate within 7–10 dB of the capacity derived herein (depending on the required error probability), while nonadaptive modulation exhibits a severe rate penalty [7]. We use nonoverlapped spectrum segments for multiple-level embedding to avoid interference among different levels, although overlapped embedding can also be used. A key issue in nonoverlapped embedding is to determine what part of the host signal to be used for each embedding level [8].

The scalable video coding (SVC) standard as an extension of H.264/AVC allows efficient, standard-based temporal, spatial, and quality scalability of video bit streams. Scalability of a video bit stream allows for media bit rate as well as for device capability adaptation. Moreover, adaptation of the bit rate of a video signal is a desirable key feature, if limitation in network resources, mostly characterized by throughput variations, varying delay or transmission errors, need to be considered [9]. Subjectively perceived video quality is a critical factor when adopting new mobile video applications. When video is used in mobile networks the most important requirements are related to low bit rates, frame rates and the screen size of mobile device. In two tests we investigated the effects of codecs and combinations of audio and video streams with low bitrates and different contents on the perceived video quality of mobile devices. The first test showed that the codec H.264 produced the most satisfying video quality, but the quality was not high enough for the presentation of textual information [10].

III. METHODOLOGY

Proposed to present a Domain Decomposition Based Game Theory to arrive optimality making data owner more profitability compared to redistributors. Evaluate the application of decentralization optimization from game theory to the solution of direct and inverse problems of video streaming content delivery. Analyze multi-criteria optimization with or without overlapping of video data content between providers. Perform well using adjoin set theory with redistributors to the data owners. Experimentation conducted with distribution of data content among video data content owners, corresponding redistributors and video content consumers.

System model comprises of five modules which is described as follows,

1) Service Provider and Data Plan Subscription
2) Redistribution of Data Content
3) Game Theory and Optimal Pricing Strategy
4) Domain Decomposition
5) Game Modeled Suboptimal Pricing

a) Service Provider and Data Plan Subscription

Mobile network service provider might be more interested in setting the content price to maximize profit. Service provider’s profit can be represented as total number of subscriptions times the content price. Higher content price provides mobile users with less incentive to subscribe to data plan result in less subscription.

High content price in the redistribution network gets higher due to fewer subscribers but induces more secondary buyers. Setting content price higher does not necessarily reduce number of subscriptions, find optimal price to maximize service provider's utility. Video data content pricing decision influenced each others of service provider, data-plan subscribers and secondary buyers.

b) Redistribution of Data Content

Video-stream redistribution network is dynamic system in which all users have high mobility that can join and leave at anytime. Trivial to have central authority that controls users' behavior. Furthermore, redistribution is unauthorized and illegal to minimize risk of being detected by service provider and participating users. Participating users (subscribers and secondary buyers) have no incentives to trust one extra person and the central authority and distributed strategy is preferred.

It provided Stackelburg game model to analyze how secondary buyer provides incentives for subscribers to redistribute video stream and find optimal price and quantity that secondary buyer should offer. This helps to provide content owner to set an appropriate subscription fee such that equilibrium of game between subscribers and secondary buyers leads to negative payoffs. Therefore, subscribers have no incentive to redistribute the video.

c) Game Theory and Optimal Pricing Strategy

Game theory is a mathematical tool to model and analyzes strategic interactions among rational decision makers. Initially, we model user dynamics in the redistribution network as multiplayer non cooperative game and get equilibrium price from all users having no incentives to deviate. Hence, equilibrium price serve as upper bound for the price set by network service provider to prevent copyright infringement.

Due to the small coverage area and the limited power of each mobile device, a subscriber can only sell the content to secondary buyers within his/her transmission range, and the distance between users and the channel conditions dominate users' decisions. Then, 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 (ESS) for the mobile users, which is the desired stable equilibrium for the service provider.

d) Domain Decomposition

Domain decomposition is introduced to solve a boundary value between data content owner, subscriber and secondary buyers by splitting into smaller boundary for data content price value on sub domains and iterating to coordinate solution between adjacent sub domains. One or few unknowns per sub domain is used to coordinate solution between sub domains of secondary buyer or redistribution contents globally.

Sub domains of redistribution are independent that makes domain decomposition suitable for further redistribution. Overlapping domain decomposition is done for secondary buyer sub domains overlap by more than the interface. In case of non-overlapping case, sub domains intersect only on their interface. Continuity of solution across sub domain interface is enforced by representing value of suboptimal price solution on all neighboring sub domains by the same unknown.

Non-overlapping domain decomposition is iterative sub structuring model that can be used to separate discretization on non overlapping sub domains. Meshes on sub domains do not match on the interface. Equality of the solution is enforced by Lagrange multipliers to preserve accuracy of suboptimal content pricing solution.

e) Game Modeled Suboptimal Pricing

Game model suboptimal price is done with each user (subscriber or secondary buyer) to declare the presence to all other users within the transmission range. Initial domain decomposition is done with overlapping region of subscription. Game starts with subscribers' (leaders') move and each subscriber set unit price per unit transmission power and maximal transmission power.

Next secondary buyer decides on from whom to buy video and how much power required for subscriber to transmit. Secondary buyer then pays each subscriber accordingly at the price the subscriber sets in initial stage. Suboptimal domain decomposed utility function of secondary buyer define secondary buyer's utility function and optimal action. Secondary buyer gains rewards by successfully receiving video with a certain quality and pay for the power that subscribers use for transmission.

It evaluates each domain's video rate-distortion and measure user defined constant for receiving reward in the domain of sub optimal pricing strategy. It improves PSNR of reconstructed video to appreciable dB to reduce stream quality loss. It Obtains maximal PSNR of the video for each domain users to get the price optimality in terms of data content delivery, subscribing to the service as price set by the content owner.

IV. RESULTS AND DISCUSSION

In this section, we will show the equilibrium of the videostream redistribution game under different scenarios, as well as the optimal price for the content owner. In our simulations, the secondary buyer is located at the origin (0,0), and the subscribers are initially uniformly distributed in a rectangle of size 100m by 100 m centered around the origin.

The pricing game is played 100 times, and each subscriber changes its location each time the game restarts. For each subscriber, the location change is normally distributed with zero mean and unit variance. The direction of each subscriber's location change follows the uniform distribution. For all users, the maximal transmit power is 100 mW, and the noise level is W. The processing delay of each subscriber is also a uniformly distributed random variable in milli seconds.

The performance of proposed Domain decomposition and has been compared to existing Optimal pricing protocol is evaluated by the following metrics.

- Range of transmission
- Time for content delivery
- Secondary buyer to data consumer ratio

Table 1 Range of Transmission

Data Owners	Domain Decomposition	Optimal Price Setting
1	25	65
2	45	115
3	55	175
4	75	225

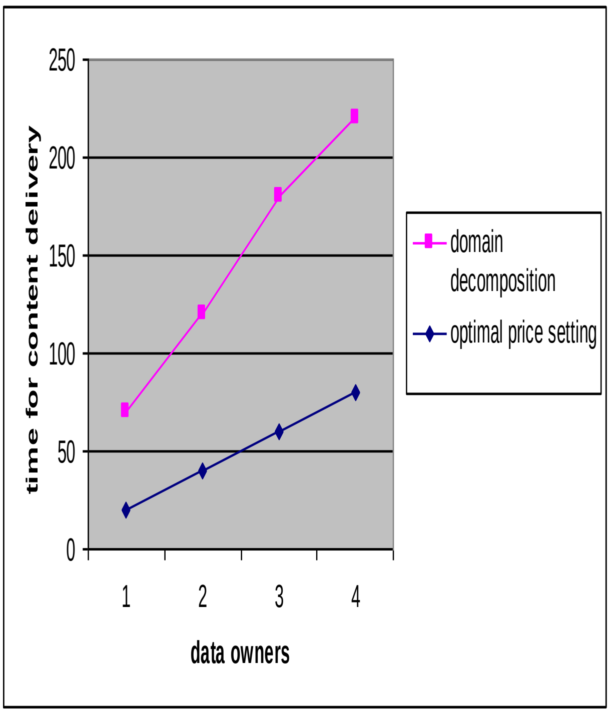

Figure 1 Time for content delivery

Fig. 1 describes the performance result of game theory in terms of Time for content delivery for different number of data owners. Time for content delivery is the time (ms) required to deliver the content to data consumer. In all the cases Proposed Domain decomposition outperforms Existing Optimized pricing protocol, paying the cost of a very high number of sent messages. The time increases even with the increase of data owners. The curve shows the result of game theory, in all the cases it paying the cost of a very high number of content deliveries. However it's Time for content delivery increases while increasing the number of data owners. Proposed Domain decomposition achieves 8 to 16% high in delivery ratio when compared with Existing Optimized pricing protocol.

Table 2 Secondary Buyer to Data Consumer Ratio

Data Owners	Domain Decomposition	Optimal Price Setting
1	60	150
2	45	120
3	40	90
4	30	70

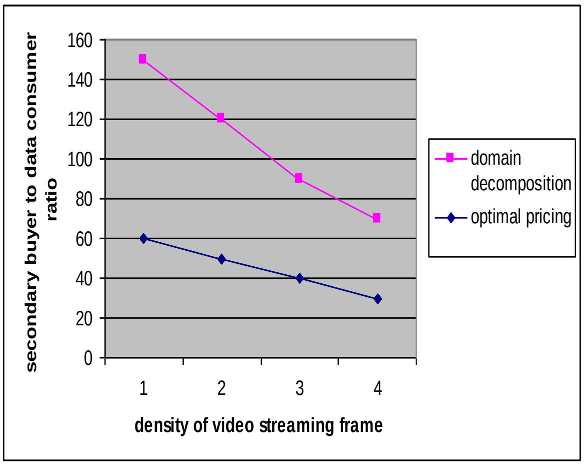

Figure 2 Secondary buyer to data consumer ratio

Fig. 2 shows the result of Secondary buyer to data consumer ratio. Secondary buyer to data consumer ratio is defined as the ratio between numbers of sub domain redistributors to data consumer in corresponding sub domain. Fig. 2 shows the Secondary buyer to data consumer ratio of game theory with respect to an increasing Density of video streaming frame. We notice that for the uppermost curve in Performance of Proposed Domain decomposition technique in terms of secondary buyer to consumer ratio attains 40% to 60% difference than Existing optimal pricing.

Table 3 Range of Transmission

Data Owners	Domain Decomposition	Optimal Price Setting
1	20	80

2	30	105
3	40	130
4	80	180

V. CONCLUSION

In this paper, we have investigated the Domain Decomposition Based Game Theory to Arrive Optimal Video Streaming Pricing Policies. We have first analyzed the equilibrium price of the video stream redistributed by the subscribers given the number of subscribers and secondary buyers. Consequently, the results provide a guideline for the content owner to prevent the redistribution behavior and to maximize the service provider's payoff. The redistribution behavior has been modeled as a Stackelburg game, and we have analyzed the optimal strategies of both subscribers and secondary buyers. From the simulation results, a secondary buyer will tend to buy more power from subscribers with better channel to maximize his/her utility. If the total number of the subscribers increases, a secondary buyer can obtain a larger utility value, and the payment to each subscriber is reduced due to a more severe competition among the subscribers. Also, when the mobile phone network is crowded, a secondary buyer tends to purchase the video stream from fewer subscribers, and the price for the streaming service can be higher. Nevertheless, the service provider should always offer high-quality video stream to prevent the illegal redistribution of video via such redistribution networks.

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