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Video Dissemination Protocol Over Hybrid WIFI Cellular Networks

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ABSTRACT
We study the issue of disseminating video clips to mobile users with a hybrid cellular and ad hoc network. In particular, we formulate the situation of optimally picking out the mobile devices that will assist as gateways through the cellular to the ad-hoc network, the ad-hoc routes through the gateways to person devices, and the layers to deliver on these ad hoc routes. We create a Mixed Integer Linear Program based algorithm, called POPT, to solve this optimization trouble. We then create a Linear Program (LP)-based algorithm, called MTS, for lower time difficulty. While the MTS algorithm achieves close-to-optimum video quality which is more efficient than POPT regarding time complexity, the MTS algorithm doesn't run in real time for hybrid networks with many more nodes. We propose a fresh video ads dissemination way for mobile terminals which utilizes both WiFi and cellular communities. In the suggested method, a file of video ad is actually divided into items and each node swaps the pieces with neighbor nodes using WiFi ad hoc communication so your usage of cell network is lowered. In order for making the method performs effectively for a large number of nodes, we propose an algorithm where portable nodes autonomously in addition to probabilistically decide their actions and not using a central control. As a result of simulations, we confirmed that our method reduces cell network usage by means of about 93% in comparison with a case that each nodes download video ads via cell network, and works efficiently in cases with a large number of nodes and high mobility.
Keywords:-Wireless Networks, Video Streaming, Quality Optimization, Resource Allocation

I. INTRODUCTION

Mobile devices, such as sensible phones and tablets, are getting increasingly popular, and continue to build record-high amount involving mobile data visitors. For example, a Cisco report indicates that cellular data traffic increases 39 times by simply 2015. Sixty six percent from the increase is because of video traffic [5]. However, existing cellular networks were suitable for unicast voice providers, and do definitely not natively support multicast as well as broadcast. Therefore, cellular networks are not suitable for large-scale video clip dissemination. This was validated with a measurement study, which signifies that each HSDPA cellular can only support as much as six mobile video clip users at 256 kbps [8]. Thus, disseminating videos to numerous mobile users over cellular networks may lead to network congestion as well as degraded user practical knowledge.

Cellular service vendors may partially handle the capacity problem by: (i) implementing more base stations, (ii) upgrading their own base stations, e.g., to assistance Multimedia Broadcast Multicast Companies (MBMS) [10], or perhaps (iii) building dedicated broadcast networks, like Digital Video Broadcast Handheld (DVB-H) [4]. Even so, these solutions incur substantial infrastructure costs and will not be compatible with current mobile devices. Hence, a far better solution is suitable. Since modern mobile devices are equipped with multiple network interfaces, cellular service providers may offload cellular video traffic a great auxiliary network. Since illustrated in Fig. 1, we look at a hybrid cellular and ad hoc network consisting of your base station and multiple mobile devices. Mobile devices relay video data among each other using ad hoc links, exploiting such a free mechanism of submitting alleviates bottlenecks as well as reduces cost for cellular service providers.

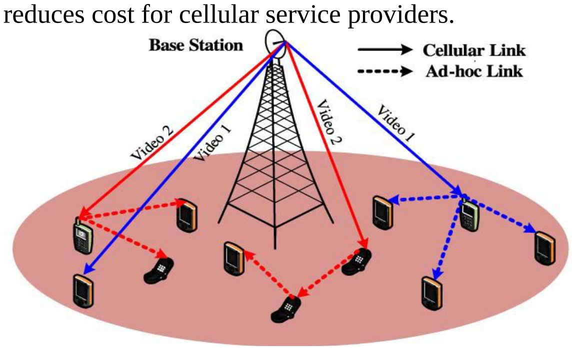

Fig. 1. A hybrid cellular and ad hoc network.

In this paper, we propose a for delivering video ads for many people users according for their contexts. Our method makes use of both cellular system and WiFi ad hoc communication between mobile terminals concurrently, aiming at reducing usage of cellular network while keeping high delivery ratio at end user terminals. We presume an urban natural environment with many end users. The users have mobile phones (terminals) capable regarding communication over cell phone network and ad-hoc method on WiFi. The terminals automatically pick some video advertisings, and set final target time of receiving each ad based on the context, which could be the schedules of the person, life patterns, and many others. We propose a means to allow terminals for the requested contents until the deadline, while reducing usage of cellular network. In this method, a content, which is some sort of file, is split into chunks and nodes trade the chunks over WiFi communication so that you can reduce usage regarding cellular network. To have high efficiency, scalability, along with robustness, we propose a simple probabilistic distributed algorithm by which each terminal decides his or her action autonomously with virtually no central control. To be able to evaluate our proposed method, we carried out experiments by simulations supposing urban environment. The results showed which our method reduced using cellular network simply by 93% while rewarding the deadline reduction, compared with true that all terminals download video ads through cellular network. We also noticed that higher terminal density ends up with greater reduction regarding cellular network usage.

II. RELATED WORK

Having an auxiliary ad hoc network to augment some sort of WiFi cellular network may be considered in before literature for boosting data transfer and also video dissemination.

A. Data Transfer over Hybrid Networks

We classify the previous approaches to speed up data transfer over the cellular network utilising an ad hoc multilevel into two organizations: unicast and multicast files transfers. In the former group [12], [15], data are unicast from a base station to cellular devices over a cellular network, and these devices relay the files to other cellular devices over a random network. In your latter group [6], [14], [2], [13], by way of multicast-enabled base programs, data are simultaneously sent to multiple mobile gadgets, which then propagate the results to other gadgets through multihop paths in an ad hoc multilevel. Although, multicast data transfer may improve system performance, current cellular networks simply employ multicast intended for disseminating short announcements (at most three months characters) [3], that is inapplicable for disseminating video lessons.

Unicast Data Transport. Luo et al. [12] design any hybrid network that works on the WiFi ad hoc multilevel to route cellular data via other cellular devices with higher cellular data rates. A pair of neighbor discovery as well as routing protocols, proactive and on-demand, usually is proposed. With your former protocol, all devices proactively conserve the states of his or her immediate neighbors. When a device wants to identify a route to the camp station, it issues any route discovery message with a neighbor with the very best cellular data fee. The message will be further relayed by the neighbor to it's highest rate neighbor until there's no neighbor with higher rate compared to the relayer or your hop count reduce is reached. The final relayer is the one which receives data from your cellular network as well as propagates data to the original requester. While using the on-demand protocol, devices will not maintain their neighbors' declares. A requester discovers a approach to the base station by flooding any route discovery message to any or all its neighbors in a given range. Devices with better data rates than that from the previous hops onward the message to the base station, which eventually selects the very best path to your requester. Simulation results show how the on-demand protocol typically incurs higher traffic overhead about the cellular network, as you move the proactive protocol takes in more energy. By way of simulations, Hsieh and Sivakumar [15] display that generic random protocols do not work well in hybrid cellular and WiFi random networks, and can lead to: 1) degraded general throughput, 2) illegal resource allocation, as well as 3) low strength to mobility. They propose two ways to improve the efficiency of random protocols. First, the camp station can run optimization algorithms for that WiFi ad hoc multilevel, for example, to develop optimized routes. Next, mobile devices attached to other access sites can offload traffic from your cellular network to help those access sites, so as to avoid network congestion round the base station.

Multicast Information Transfer, evaluate a hybrid network in which a cellular base station reduces its transmission range to obtain a higher files rate for cellular devices inside its range. Some mobile devices represent gateways and exchange data to cellular devices outside the range using a multihop ad hoc multilevel. The analysis as well as simulation results indicate that approximately 70 percent downlink ability improvement over natural cellular networks can be done. Lao and Cui [2] suggest a hybrid multilevel, in which every multicast group is either inside the cellular mode or inside the ad hoc mode. Initially, all multicast groups are usually in ad hoc mode, and when the bandwidth element a group exceeds the random network capacity, the camp station picks way up that group as well as switches it into your cellular mode. Park and Kasera [6] find the gateway node discovery problem, and model the random mobile product. Bhatia et al. [11] consider the random problem intended for multicast services, and also abstract ad hoc interference like a graph. They formulate a difficulty of finding your relay forest to increase the overall files rate, and that they propose an approximation protocol.Unlike the over works [12], [15], [6], [14], [2], we concentrate on delay sensitive live video distribution spanning a hybrid network.

B. Video Dissemination over Hybrid Networks

The situation of video dissemination above hybrid networks has become recently considered [7], [9], [11], [1]. Qin and Zimmermann [7] present an adaptive technique for live video distribution to look for the number of quality layers for being transmitted between two mobile phones. They also propose a method that helps cell nodes retrieve absent frames when nodes obtain reconnected after disconnections. Their particular solution, however, should be only applicable to personal links, while stay video distribution usually utilizes multihop paths. Hua etal. [9] formulate a great optimization problem in a very hybrid network to look for the cellular broadcast rate of every quality layer. Within the ad hoc circle, a flooding routing protocol is needed to discover neighbors plus a heuristic is applied to forward video data. Our work differs from Hua etal. [9] in many aspects: 1) we suggest a unified optimization problem that jointly finds the suitable gateway mobile products, ad hoc paths, and video version, 2) we contemplate existing cellular base stations that will not natively service multi-cast, and 3) we all employ Variable-Bit-Rate (VBR) streams.

III. LIVE VIDEO DISTRIBUTION IN HYBRID NETWORKS

We consider about a hybrid network (see Fig. 1), which includes a cellular base station and lots of mobile devices. The base station concurrently directs K videos to U mobile phones, where each portable device receives along with renders a video chosen by the user. Throughout this particular paper, we use node to make reference to both the basic station and mobile phones. All mobile devices have two network interfaces intended for cellular and ad hoc networks, respectively. Cellular devices can always acquire video data on the base station by way of cellular links. Unlike cellular networks, ad hoc connectivity is not guaranteed want. Typical ad hoc network includes a shorter range compared to cellular networks.

interference as any graph coloring issue. Solving this problem allows those to approximate the number of other mobile devices inside the transmission range of a specific routing

We consider a hybrid network (see Fig. 1), which includes a cellular base station and several mobile devices. The beds base station concurrently transports K videos to U mobile phones, where each cell device receives as well as renders a online video chosen by the user. Throughout that paper, we use node to reference both the basic statiDistributing live videos in a very hybrid network will be challenging because: (i) wireless cpa networks are dynamic with regards to connectivity, latency, as well as capacity, and (ii) online video data requires high throughput and lower latency. To overcome these challenges, most of us employ layered online video coding, such seeing that H. 264/SVC, in order to encode each online video into L cellular levels. Layer 1 is referred to as the base covering, which provides a simple video quality. Cellular levels 2, 3,..., L are enhancement cellular levels, which provide incremental high quality improvements. An enhancement layer is decodable in the event that all layers underneath it are obtained. With layered videos, we can dynamically adjust how many layers sent for you to each mobile unit. While the adjustments could be done very frequently, a subject user study reveals that frequent quality changes cause degraded viewer expertise. Therefore, we separate each video straight into multiple D-sec online video segments, where D is really a small integer. Quality changes are just allowed at limits of segments. We let S be the total number of segments of each and every video, and we let $t_{k,s,l}$ ($1 \leq k \leq K$, $1 \leq s \leq S$, $1 \leq l \leq L$) be the *transmission unit* of video k, segment s, and layer l. We study and optimization problem within a recurring scheduling windowpane of W pieces. We refer to a solution as a schedule and all of us call an protocol that runs at the base station in order to compute schedules as being a scheduler. The scheduler within the base station usually takes feedback from networks, and computes a fresh schedule every DW′ secs ($1 \leq W' \leq W$). The feedback includes transmission unit availability $y^u_{k,s,l}$ and mobile device location $\omega_u = (\omega_{u,x}, \omega_{u,y})$. We let $y^u_{k,s,l} = 1$ if mobile device u holds unit $t_{k,s,l}$, and $y^u_{k,s,l} = 0$ otherwise. We use $\omega_{u,x}$ and $\omega_{u,y}$ to denote the longitude and latitude of u, and this can be derived from Global-Positioning-System (GPS) functionality, cellular network triangulations, in addition to WiFi fingerprints. Each mobile device u reports its $y^u_{k,s,l}$ and ω_u for the base station, and the base station maintains their state of availability and device location for everyone mobile devices $1 \leq u \leq U$. Provided that the base station maintains a global view of the actual hybrid cellular and adhoc network, the scheduler about the base station includes a potential to locate global optimum solutions.

The base station sends a whole new schedule to all cellular phones every DW' secs. The mobile phones then distribute transmission units adopting the schedule. To keep up with the tractability, our schedule doesn't explicitly specify the actual transmission time of transmission unit. Rather, we take a *precedence list* $P = \{(p_{s,i}, p_{l,i}) \mid 1 \le i \le WL\}$ as an input, where $p_{s,i}$ and $p_{l,i}$ represent the relative portion number and layer amount of precedence i transmission unit in just about every scheduling window. A lot more specifically, let s_c really do the first segment of the current scheduling windowpane, mobile devices send scheduled transmission units from the following order.: $t_{k,sc+ps,1,pl,1}$, $t_{k,sc+ps,2,pl,2}$, . . . , $t_{k,sc+ps,WL,pl,WL,}$ for any $1 \le k \le K$. Mobile phones skip transmission models that haven't been received, and check the availability again whenever a transmission unit is totally sent. For concrete discussion, we employs the following precedence list: $\{(0, 1), (1, 1), . . . , (W - 1, 1), (0, 2), (1, 2), . . . , (W - 1, 2), . . . , (0,L), (1,L), . . . , (W - 1,L)\}$ if not otherwise specified.

IV. VIDEO ADS DISSEMINATION PROTOCOL

In this section, we briefly condition our basic suggestions to solve the problem defined in the previous section, and then go into the details of the proposed video advertising dissemination protocol.

A. Basic Ideas

Our basic ideas are the following: (1) divide each content into multiple chunks with the same size like Bit-torrent to ensure all terminals can bring about the transmission involving video ads material (2) let terminals exchange as many chunks as feasible through WiFi network so that the cellular network utilization is minimized (3) enable terminals autonomously choose their actions amongst downloading, broadcasting, or receiving the chunk based solely on local details Multiple nearby terminals downloading exactly the same chunk via this cellular network is not efficient regarding cellular network utilization. In order to prevent this situation, it truly is desirable that only 1 terminal which understands the demand of an chunk in their proximity downloading the chunk as well as distributes it for the terminals in their proximity.

We propose a protocol including things like two phases: (i) demand trade phase where terminals in a very WiFi radio range exchange the data on what bits each terminal witout a doubt retains and need to download down the road; and (ii) action decision phase in which each terminal decides which action (download the chunk from cell phone network, broadcast the chunk it already retains, or wait to obtain a chunk showed by other terminal) to take. In the requirement exchange phase, each terminal you periodically broadcasts the hello message which usually tells which chunks u really wants to receive and which usually chunks it witout a doubt retains. Each terminal makes and maintains the table called neighbor table from your received hello messages and probabilistically decides its action while using neighbor table. Each terminal takes on the list of following actions: (1) down load a chunk (which zero neighbor terminals have) by way of cellular network; as well as (2) broadcast the chunk via Wifi network for friend terminals. In this action decision period, each terminal autonomously decides its action while using neighbor table. For efficient using cellular network, it takes the action for getting a chunk by way of cellular network with the probability inversely proportional to the quantity of terminals which need to receive the amount. Similarly, for efficient exchange of bits via WiFi multilevel, each terminal broadcasts a chunk who's already retains with the probability inversely proportional to the quantity of terminals which possess the same chunk.

B. Video Ads Dissemination Protocol

We give the detailed protocol description below.

1)Demand Exchange Phase: Before a terminal decides its action, it needs(1) demand facts and (2) control information, for just about every chunk of content. Each terminal oughout informs other terminals of u's demand and possession information by means of periodically broadcasting any hello message as shown in Fig. 2. Each hello message consists of demand information and possession information of its sender terminal, where demand facts and possession facts are represented by way of content ID along with a sequence of bits indicating whether the corresponding chunk has already been retained or certainly not, respectively. Each terminal creates and maintains a neighbor dining room table from received hello their messages as revealed in Fig. 3, where each row is made up of sender id as well as hello message. This table is updated whenever when a terminal receives a hello there message. When a terminal doesn't receive hello messages for many times from a sender inside table, it removes the row from the sender.

Each terminal is aware which chunks are certainly not retained by any kind of nearby terminals by means of scanning the neighbor table.

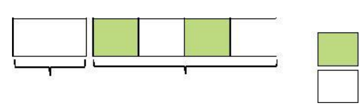

Fig. 2. Hello Message

Fig. 3. Neighbor Table

2)Action Decision Phase: With this phase, we control terminals so that only a couple of terminals within each WiFi airwaves range downloads a chunk via cellular network and broadcasts a different chunk via Wireless network, respectively.

Let N_w(ch) denote how many terminals which want a chunk ch within a WiFi radio variety. We define the value degree for a terminal inside WiFi radio variety to download the actual chunk *ch* via cellular network by equation (1).

$$W_c(S) = \frac{1}{N_{w(S)}} \quad (1)$$

In this article, the importance degree assigned a great action represents exactly how importantly the terminal takes this course of action. Each terminal broadcasts a chunk due to the sharing if some other terminals want your chunk. We regulate the particular probability of broadcast by each terminal to ensure that multiple terminals don't broadcast the same chunk concurrently. Let N_h(ch) denote the number of terminals which already retain a chunk *ch*. We define the importance degree for a terminal to broadcast the chunk *ch* via WiFi network by equation (2).

$$W_h(S) = \frac{1}{N_{h(S)}} \quad (2)$$

Here, the importance degree assigned for an action represents exactly how importantly the terminal takes this course of action. Each terminal broadcasts a chunk to its sharing if other terminals want the particular chunk. We regulate the particular probability of send out by each terminal to ensure multiple terminals will not broadcast the same chunk as well. Let p_{ch} that a terminal selects a chunk *ch* with importance degree w_i is defined by the equation (3).

$$P_{ch} = \frac{w_i}{\sum_{K=1}^{N} w_k} \quad (3)$$

3)Flow of each phase: The actual demand exchange phases as well as the action decision period are executed in parallel. In your demand exchange period, each terminal waits to take delivery of hello messages via other terminals as it periodically sends some sort of hello message. In the event the terminal receives some sort of hello message, your terminal updates their neighbor table. In the action decision period, each terminal waits to take delivery of messages from other terminals while other terminals broadcast pieces via WiFi circle. If the terminal is not using cellular circle, it selects some sort of chunk from mobile network roulette dependant on equation (1) along with (3) and commences downloading the amount. When the terminal is not using the Wi-fi compatability network, it selects some sort of chunk from broadcast roulette dependant on (2) and (3) along with broadcasts a amount via WiFi circle at probability β. In this article, β is some sort of coefficient for keeping away from collision by simultaneous supply transmission from numerous terminals.

V. EXPERIMENTAL EVALUATION

To be able to evaluate to what extent the offered method suppresses the amount of cellular network use when downloading online video ads satisfying the actual deadline constraint, we all evaluated our method by simulations recreating usage in metropolitan environments.

A. Configurations of simulation

For the evaluation, we produced a network simulator which often simulates events from 1ms resolution. We recorded the following observed values each second.

- Elapsed time in simulation
- Average time when almost all terminals obtain almost all requested chunks
- Average proportion of chunks delivered electronically via cellular network to everyone requested chunks.

The ratio connected with using cellular network cr is defined as the ratio of the volume of chunks N_d which are downloaded via cellular network to the number of chunks N_s as follows.

$$cr = \frac{N_d}{N_s} \times 100 \quad (4)$$

The number of contents is several, and the size of each and every content is 1. 5MB. just about every content is divided into 1000 sections, so the size of each and every chunk is 1. 5kB. Just about every terminal randomly selects two contents and starts downloading any time simulation starts. Deadline is set uniformly to half an hour after the beginning of simulation. In order to simulate the bandwidth limitation involving cellular network, we set the limitation making sure that each base section of cellular system can connect around 64 terminals together. We set bandwidth for cellular network being 1. 2Mbps as follows, thus each bit needs 10ms being downloaded via cellular network.

$$\frac{1000}{10} \times 1.5\text{kB} \times 8\text{bit} = 1.2\text{Mbps} \quad (5)$$

The air radius for WiFi is scheduled to 200m, and we employed Nakagami Distribution since the probability of profitable packet transmission above WiFi. The probability P_R of successful tranny is defined by (6) once the distance d between your transmitter and your receiver is a lot less than 139m(= CR), and (7) any time d is more than CR. The probability distribution is additionally shown in Fig. 4.

$$P_R = e^{-3\left(\frac{4d}{CR}\right)^2}\left(1 + 3\left(\frac{4d}{CR}\right)^2 + \frac{9}{2}\left(\frac{4d}{CR}\right)^4\right) \quad (6)$$

$$P_R = e^{-3\gamma\left(\frac{(4d)^2}{CR}\right)^2}\left(1 + 3\gamma\left(\frac{(4d)^2}{CR}\right)^2 + \frac{9}{2}\gamma^2\left(\frac{(4d)^2}{CR}\right)^4\right) \quad (7)$$

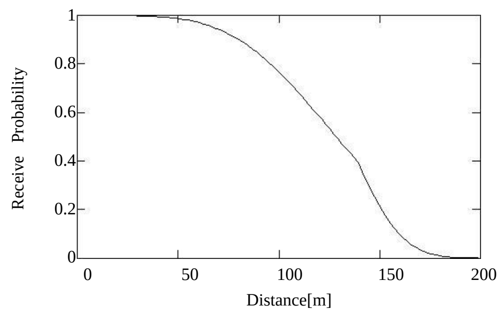

Fig. 4. Probability of successful packet transmission vs distance

In the simulations, we assume that broadcasting some sort of packet in Wi-Fi compatibility ad-hoc mode requires 7ms, and appropriately, the bandwidth is determined to 1. 7Mbps because shown in (8), according to the simulation parameters.

$$\frac{1000}{7} \times 1.5kB \times 8bit = 1.7Mbps \quad (8)$$

While broadcasting a packet in WiFi ad-hoc method, if another critical simultaneously transmits a packet in the radio range, any packet collision comes about. In order to simulate this situation, we configured our simulator to ensure when a terminal receives 2 or more packets simultaneously; almost all packets are received as error packets. Every terminal uses CSMA/CA while transmitting a bundle, so if any terminal hears a different terminal sending any packet when starting up transmitting a bundle, the terminal will not start transmitting your packet. Since we have been simulating broadcasting with ad-hoc mode, there's no exponential backoff.

B. Experiment method

We compared the case when only the particular cellular network is employed and the situation when WiFi and cellular networks utilized together for parameters shown in Table I.

C. Result

In case of using only the particular cellular network, it took 155 seconds for all terminals to total downloading. If Wi-Fi ad-hoc communication can be used together, the obtain took about 10 units, but the usage of cellular network had been reduced to regarding 7% by modifying parameters.

TABLE I
PARAMETERS FOR EXPERIMENT

Collision avoidance coefficient (β)	0.0005–0.005 by 0.0005 step
Hello message interval	5, 10, 30, 60 sec
Field size	500x500 m, 1000x1000m
Mobility	Fixed (0Km/h), Random Way Point(4km/h)
Number of terminals	500

1) Adjusting collision avoidance coefficient and interval of sending hello messages: Figs. 5 and 6 show the ratio connected with cellular network usage and also the time to download all ads, respectively, in the field of 500×500m square without mobility of nodes, while varying collision prevention coefficient β and time interval they would of sending hi messages. The figures show which the ratio of cellular network usage steadily decreases as β lessens. This is for the reason that frequency of bundle collision is lowered, and thus accomplishment ratio of sending chunks and hi messages improves. The figures also show if we increase this frequency of delivering hello messages, this ratio of cellular network usage drastically decreases, and this minimum ratio reaches about 7%. This is due to terminals are in a position to know which chunks are possessed by means of neighboring terminals, and thus how many redundant downloading connected with chunks via cellular network is lowered.

The figures show if we set β in order to 0.001 in order to 0. 0025, some time to complete getting is reduced. This is due to if β is too big, too many collisions occur, while in case β is as well small, too small number of packets is changed via WiFi. If we slow up the frequency of delivering hello messages, some time to download most ads is lowered. This is mainly because many chunks are downloaded in the cellular network.

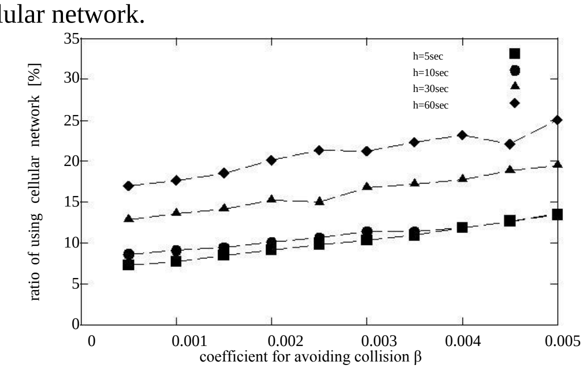

Fig. 5. Ratio of using cellular network in 500x500m field (no mobility)

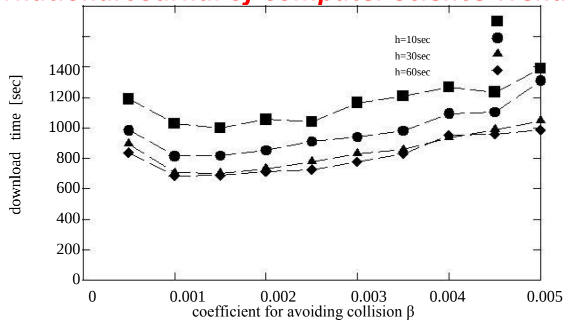

Fig. 6. Completion time of download in 500x500m field (no mobility)

2) Varying size of field: We compared the ratio of cellular network usage about the field of 500×500m square and 1000×1000m square. The result can be shown in Fig. 7. The ratio is leaner when how big field is more compact, and when the actual field size can be larger, some terminals couldn't finish downloading before deadline. This is really because more terminals can be given a hello message transmitted by the terminal and more chunks can be received via WiFi, in denser node case.

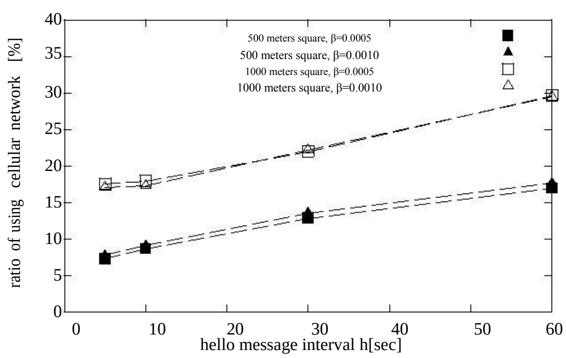

Fig. 7. Ratio of cellular network usage vs varied field size (no mobility)

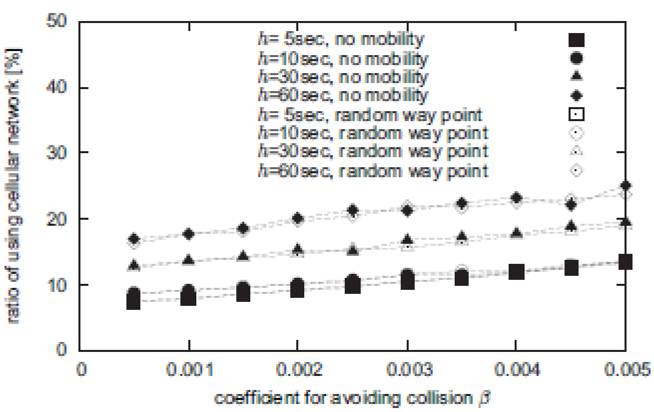

Fig. 8. Ratio of cellular network usage vs mobility

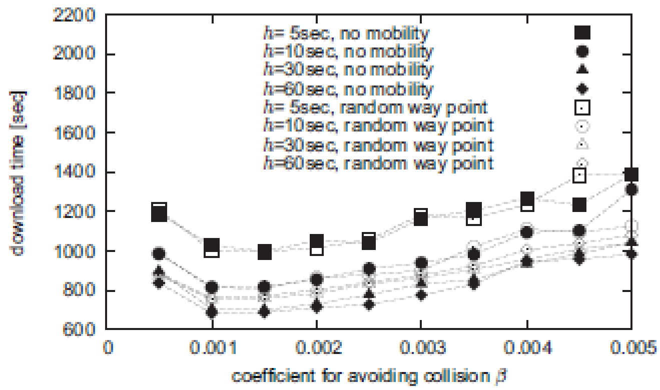

Fig. 9.Time needed to download vs mobility

3) Mobility: Most of us introduced terminal range of motion and observed the actual ratio of cell phone network usage plus the time to get all ads for the field of 500×500m square. The result is shown in Figs. 8 and 9. We make sure no significant difference between your two cases. Associated with that in our method each airport terminal u uses only one-hop neighbor information and also when u's neighbor node goes out of a u's radio stations range, there is no significant influence involving u's action determination. Thus, it is known as that our approach is robust adequate against node range of mobility.

VI. CONCLUSION

In this paper, we proposed a method for video ads dissemination for a lot of users with different preferences and timeliness based on their contents. Our method makes use of both cellular network and the ad-hoc mode associated with WiFi, aiming with reducing cellular circle usage. We assessed our proposed approach by simulations. We confirmed that our method satisfies your deadline constraints although reducing 93% associated with cellular network consumption.

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