# SOP: Smart Offloading Proxy Service for Wireless Content Uploading over Crowd Events

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***Abstract*—Since commercialization of the Internet in mid-1990, human culture has changed dramatically due to booming of innovative online services. To cope with demands of network service providers to effectively and efficiently deliver contents and services to their clients, content distribution network technologies have been developed. These technologies have been optimized to transfer data from servers to users. It is not meant to support mobile users to upload and share real-time captured multimedia contents with his/her peers through social network services. It is even more difficult for the current network to support mobile users in a hot social event to shared live pictures and videos to their social network in real time. In this paper, we present our design of smart offloading proxy (SOP) service for wireless content uploading over crowd events. To test efficiency of SOP, we simulate a mobile network environment with wireless access network connected through a long-haul WAN to the target social network server. Preliminary experiments show that with an error rate of 1% in the WAN, a mobile user may experience long file-uploading time of approximately 100 seconds in uploading a 10 MB file when a 54 Mbps WIFI media is simultaneously accessed by users randomly arrived at the inter-arrival time of 10 seconds. In contrast, it takes less than 10 seconds to upload the file if the WIFI is lightly loaded and the WAN is error free. We also show that by properly scheduling WIFI bandwidth to the mobile users, the file-uploading time can be reduced.**

***Keywords*—*crowd events, mobile network, offloading service, proxy***

## I. Introduction

The ubiquitous use of mobile devices has shortened the distance between people. With the growing trend of sharing life events on social networks, upload traffic has been increasing in recent years. In wireless network, the available throughput of an access point is shared by nearby mobile devices. For example, [1] shows that for mobile devices accessing the same 54-Mbps WIFI base station, a total of 31.4 Mbps of shared upstream and downstream traffics can be achieved if packets are assembled into size of 1500 byte. Slow network speed due to bandwidth sharing is a common problem for metro passengers especially during commuting hours [2].

A crowd event is a social gathering of a big crowd of people. Examples include public assemblies, concerts, sport competitions, and demonstrations. It is characterized by a certain amount of service requests accompanied by sporadic arrival of much larger amount of requests [3]. The flash traffic generated by the huge amount of people in the crowd usually barricades network usage. It also leads to slow network speed or malfunctioned services since the resources, e.g., bandwidth, token, and connection, are scrambled between users [4], [5]. On the other hand, frequent handover among stations in metropolitan rapid transit, subway, or high-speed rails can also cause services malfunction [6], [7].

There are studies focusing on eliminating the burden in poor network transmission [8], [9], [10]. A content delivery network (CDN) geographically distributed its nodes for delivering contents efficiently [11], [12]. There are also studies target on optimizing the last-mile delivery problem, i.e., from the CDN edge server to end user terminal [13], [14], [15]. For data upstream, which is mostly left unattended by legacy CDNs, there are few solutions for improving its performance [16].

Offloading service is used as an auxiliary for helping its client to complete an uploading job [17]. Example application includes computing, transmission, and buffering. There are studies focus on improving connection reliability and performance in a hybrid network. Balasubramanian et al. [18] leverage delay tolerance and fast switching between Wi-Fi and mobile 3G network in order to reduce 45% 3G usage for a 60 second delay tolerance in simulation. Lee et al. [19] design different tolerant delay degree level in their experiment in which up to 65% mobile data traffic and 55% energy consumption can be saved. Zhu et al. [20] propose a cache server into the edge network to cache uploaded data intermediately in order to shorten the transmission time on-the-fly.

User handling and scheduling are also important research topic for data delivery. Newman et al. [21] introduce a prototype of agent-based distributed dynamic services for monitoring and management workflow of an end-to-end grid system. Johan et al. [22] present a measurement study of BitTorrent that focuses on availability, integrity, flash-crowd handling, and download performance among a large number of user. Gunnar et al. [23] give an overview about the tracking system of Spotify, and measure the service performance and user behavior.

In this study, we focus on delivering multimedia in a mobile network environment with wireless access network connected through a long-haul WAN to the target social network. We propose the Smart Offloading Proxy (SOP) service by adding a proxy server at the WIFI base station to improve users experience in uploading files to remote servers. We also show that the file-uploading time can be reduced by properly

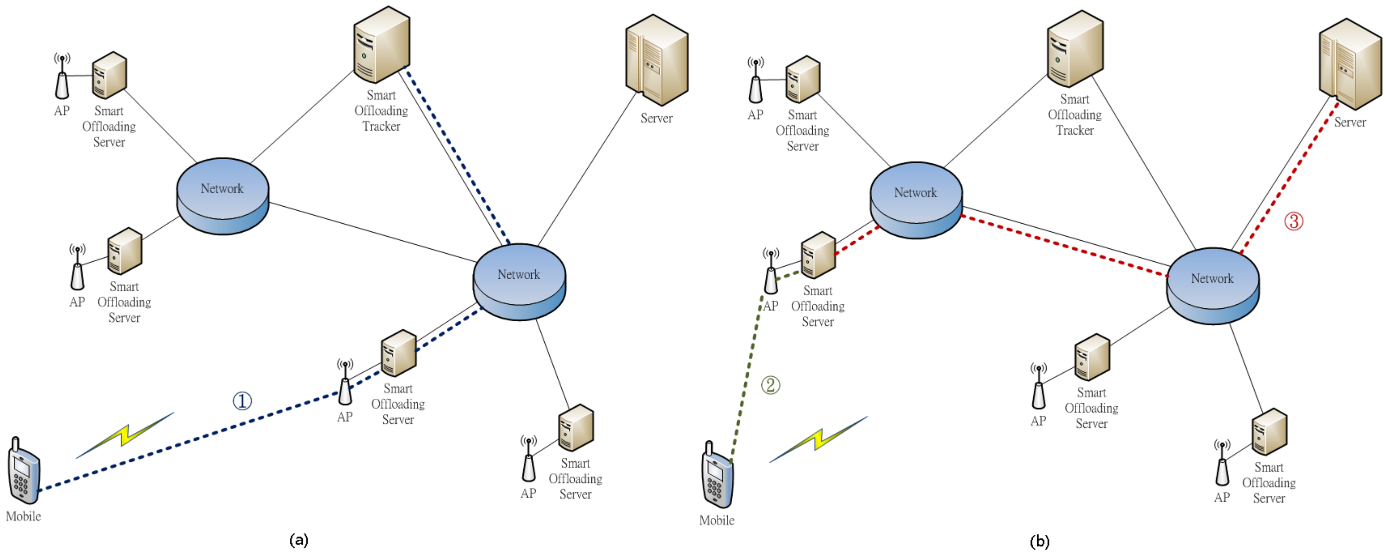


Fig. 1: An example of mobile network with Smart Offloading Proxy service. (a) User device sends a request to the tracker for connecting information of a offloading server. (b) User device then connects to the suggested offloading server and then starts it uploading tasks after connection established.

scheduling WIFI bandwidth to mobile users.

## II. Smart Offloading Proxy Service

In this section, we present the Smart Offloading Proxy (SOP) service to improve the users experience in uploading files over the mobile network. We hypothesize that network utilization in crowd events can also obtain better performance if users can finish their uploading task and then leave the system as soon as possible. Here we present the prototype of our proposed system. We then introduce various scheduling schemes that controls the bandwidth allocated to users for deducing file-uploading time.

### A. Architecture

Fig. 1 illustrates a network with Smart Offloading Proxy (SOP) service. A SOP service consists of a set of offloading trackers and servers. A Smart Offloading Tracker (SOT) is a tracking system focuses on providing suggestions of proper offloading servers for users. In order to make a feasible offloading server suggestion, it will analyze all the server information it recorded, including geolocation, loading and bandwidth capacity. A Smart Offloading Server (SOS) is a storing system for caching uploaded data temporarily. It targets on providing a lower round trip time (RTT) and higher throughput for users. By enabling the request to send/clear to send (RTS/CTS) mechanism of the 802.11 wireless networking protocols, network resource scrambling between users can be deduced.

To upload a file via SOP service, connection between end user and an offloading server should be established. User information will be collected and sent to the SOT for offloading server election, as shown in Fig. 1 (a). SOT will choose proper offloading servers by analyzing the information it recorded and the information user provided. Then, connect information and a token of the candidate SOS will be sent back to the user. After retrieving the information, a connection between the user and the SOS can be established. To make the occupation of network resources as short as possible, the SOS caches uploading data from users. The SOS then supersedes as a proxy to transmit data to the target server, as shown in Fig. 1 (b).

### B. Bandwidth scheduling

To improve user experience in uploading, we then introduce various schemes for scheduling the bandwidth allocated to users.

*1) Method 1-Equal bandwidth:* Bandwidth will be shared equally to jobs.

*2) Method 2-Longest remaining job first:* Bandwidth will be allocated as a reciprocal according to the elapsed time of a job.

*3) Method 3-Shortest k jobs with equal bandwidth:* Bandwidth will be shared equally to the shortest $k$ jobs with shortest execution time.

*4) Method 4-Shortest k jobs with longest remaining time:* Bandwidth will be allocated to the shortest $k$ jobs as a reciprocal of elapsed execution time.

*5) Method 5-Shortest remaining k jobs with equal bandwidth:* Bandwidth will be shared equally to the shortest $k$ jobs with shortest remaining time.

*6) Method 6-Shortest remaining k jobs with longest remaining time:* Bandwidth will be allocated to the shortest remaining $k$ jobs as a reciprocal of elapsed execution time.

## III. Experiment

### A. Simulation environment

We use the ns-3 simulator to evaluate the performance gaining of our proposed system. Our simulation environment

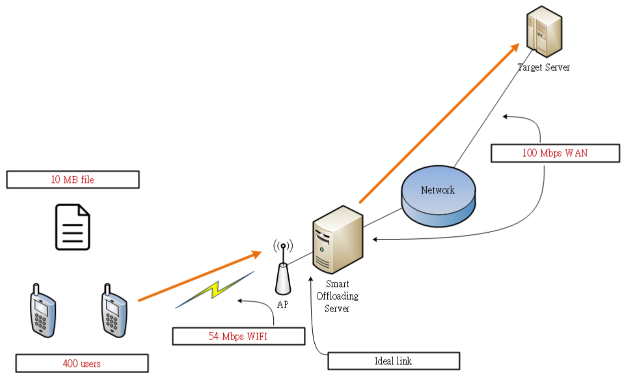


Fig. 2: Simulation environment of our proposed system

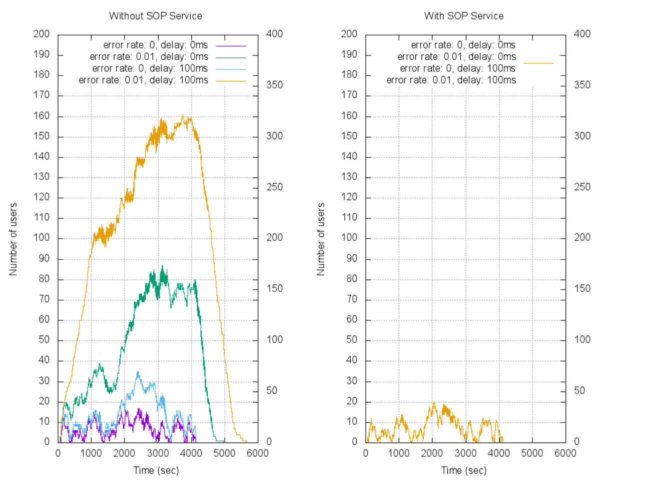


Fig. 3: Number of users waiting for finishing file-uploading tasks in different WAN situations

is show in Fig. 2. We use a 54 Mbps wireless AP for users. The bandwidth between AP and SOS is infinite with 0 delays. The bandwidth in the transition path between SOS and the target server is a 100 Mbps WAN. To simulate the interference of WAN, we design four scenarios according to the packet lose rate and the propagation delay, as shown in Table I. We also plan 400 users to be joined to the simulation environment sequentially in a Poisson distribution $\lambda = \frac{1}{10}$.

To simulate the crowd events with bandwidth scheduling schemes, we set up a 1000 seconds simulation with the crowd events occurs from 50 second to 200 second by using a Poisson arrival rate at $\frac{1}{3}$. Note that to simplify the simulation, we here ignore the process of SOT and assume there is an infinite storage in SOS.

TABLE I: WAN situations

| | Packet loss rate | Propagation delay (ms) |
|---|---|---|
| Case 1 | 0 | 0 |
| Case 2 | 0.01 | 0 |
| Case 3 | 0 | 100 |
| Case 4 | 0.01 | 100 |

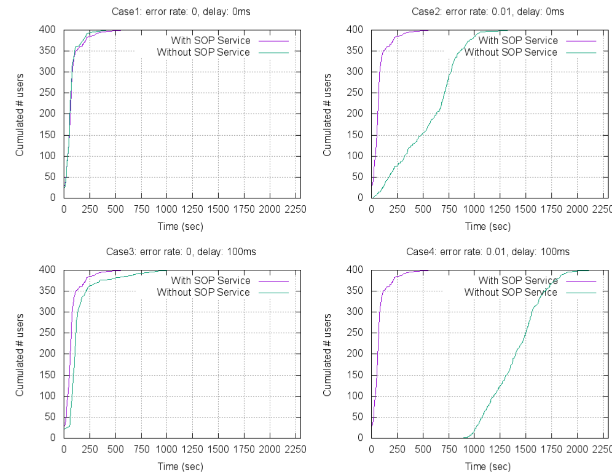


Fig. 4: Cumulative distribution of file-uploading time in different WAN situations

### B. Result

Fig. 3 shows the residues of active users in simulation. As the result without SOP service, the number of active users resided in system may be varied in different network conditions. In summary, for the factor affecting the number of active users in system, the impact of packet loss rate is greater than the propagation delay. However, there is no difference between the residues by introducing the SOP service in our simulation.

Fig. 4 shows the cumulative distribution of file-uploading time. With SOP service, tasks are finished at 600 second, even in different WAN conditions. In simulation without SOP, finish time of the last file-uploading task may be varied depending on the packet loss rate and propagation delay.

Fig. 5 and Fig. 6 show the file-uploading time with different bandwidth scheduling methods. In summary, Method 1 and 2 are fair for users but not efficiency in the whole system; however, other methods achieve better performance for the simulation if the file-uploading time of each task is known. For methods 3 to 6, with different number of jobs $k$ for picking up, the file-uploading time will become longer in the increasing of $k$.

## IV. Conclusion

In this study, we focus on delivering multimedia in a mobile network environment with wireless access network connected through a long-haul WAN to the target social network. We propose the Smart Offloading Proxy (SOP) service by adding a proxy server at the WIFI base station to improve users experience in uploading files to remote servers. We also show that the file-uploading time can be reduced by properly scheduling WIFI bandwidth to mobile users.

We evaluate our proposed system with ns-3 simulator. Experiments show that by adding a proxy server at the WIFI base station, a mobile user may experience better file-uploading time in uploading files to remote servers. We also show that by properly scheduling WIFI bandwidth to the mobile users, the file-uploading time can be reduced.

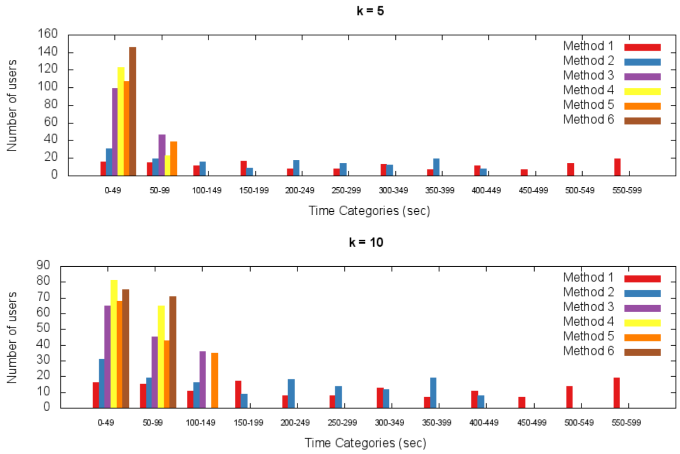


Fig. 5: Distribution of file-uploading time by using different scheduling methods and job size $k$

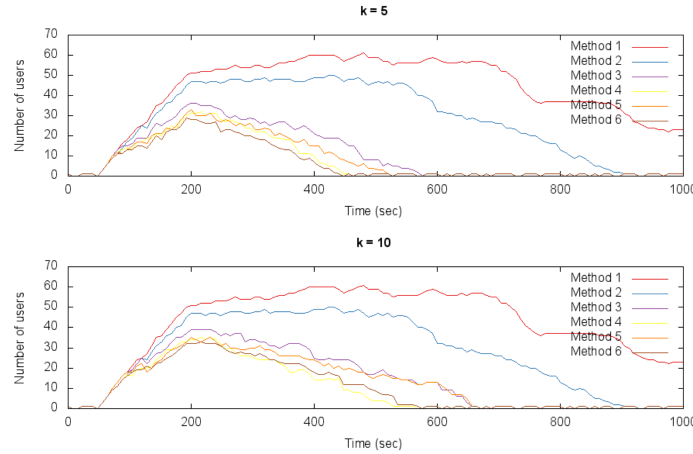


Fig. 6: Number of users waiting for finishing file-uploading tasks by using different scheduling method and job size $k$

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