Content Distribution through WiFi Network

Background: Every year Internet traffic is increasing in exponential rate and a significant portion of that traffic is because of wireless Internet. In year 2010, wireless traffic was accounted for 34% of overall Internet traffic where it is being expected by 2014, traffic due to wireless Internet will exceed the traffic from wired Internet. So, we need special attention to reduce congestion due to wireless Internet.

Motivation: In recent times, WiFi networks are being deployed across the city (e.g. Paris, Tokiyo). This kind of network is referred as municipal WiFi network. In such network, Access Points (APs) are being deployed across the city in different road junctions and even in between two neighboring road junctions when neighboring road junctions are far apart from each other say more than 200 m. Every AP can communicate with the users in its range and the neighboring APs through wireless communication. However, this kind of networks are under utilized. To reduce Internet congestion, this network can be exploited for many local area applications.

Contribution: In this paper, we exploit this network for content delivery in urban area, where memory of APs is being used for hosting files and WiFi for the means of connectivity to access files from APs. A number of popular files can be offered towards urban citizen through this infrastructure for downloading. As users move from source to destination within city, user can select and download file of their choice. This will be a fast and cheap solution for content delivery in WiFi network which will reduce the Internet congestion as well. In the following section we formally define our problem.

I. Problem Definition

Let us assume that the Total number of APs in a municipal WiFi network is n. Every AP has a limited and same amount of storage for hosting files; let us say storage for storing up to m files (assuming all files are of same size say S). With this infrastructure, municipal WiFi network is offering p number of popular files (popularity of p files are different) for downloading. Higher value of p with fixed infrastructure (that is for fixed n and m) will satisfy more users. However, with this infrastructure, maximum files that can be hosted is $n \times m$. System capability (C_{sysy})is defined as the ratio of number of files that are being offered and maximum files that can be hosted. formally C_{sys} can be expressed as

$$C_{sys} = \frac{p}{n \times m} \tag{1}$$

There are total q users in the system and users are moving from their source to destination according to a given mobility model and initial locations of all users are chosen randomly. In the way of user's journey, every user wants to download a single file chosen based on popularity among the offered p files. User u_i spent t_i time either to download the chosen file completely or to reach from its source to its destination whichever is shorter and experienced a download speed, say d_i bytes/second. Let us also assume that user u_i actually downloaded D_i bytes in t_i time. Goodput ratio of an user signifies the ratio of bytes actual downloaded and the bytes which can be downloaded at max within that time. Goodput ratio of user u_i is denoted as g_i where g_i can be formally expressed as

$$g_i = \frac{D_i}{t_i \times d_i} \tag{2}$$

where g_i varies from 0 to 1 and higher value of g_i signifies better performance.

Average goodput ratio of the system is denoted as G_{avg} where G_{avg} can be formally expressed as

$$G_{avg} = \frac{1}{q} \times \sum_{i=1}^{q}(g_i) \tag{3}$$

Similar to g_i, G_{avg} also varies in between 0 and 1.

Let us also assume that downloaded bytes get executed in user's local device and the execution rate is e_i (e_i bytes are executed per second). However, executer needs consecutive bytes starting from byte 1 in order to execute. During t_i, if executer is idle then that period is added to waiting time of the user and is denoted as w_i. Waiting ratio signifies the ratio of waiting time (w_i for user u_i) and total time spent (t_i for user u_i). Waiting ratio of user u_i is denoted as W_i and can be formally expressed as

$$W_i = \frac{w_i}{t_i} \tag{4}$$

Waiting ratio also varies between 0 and 1, and lower waiting time signifies good performance.

Average waiting ratio of the system is denoted as W_{avg} and formally expressed as

$$W_{avg} = \frac{1}{q} \times \sum_{i=1}^{q}(W_i) \tag{5}$$

So the performance of the described system depends on three factors: C_{sys}, G_{avg} and W_{avg}. Performance of the system is denoted as P_{sys} and formally can be defined as

$$P_{sys} = \frac{C_{sys} \times G_{avg}}{W_{avg}} \tag{6}$$

Our goal is to maximize system performance.