Fair Allocation Of Bandwidth To Mobile Users

Shivam Shrivastava, Sakshi Chourasia, Suraj Sangavkar , Nitesh Bhargava, Anant Nag

[#] *Computer Science Department, IIT Madras*
shivam.dawn@gmail.com
chourasiasakshi@gmail.com
surajsangavkar@gmail.com
nitesh.bhargv@gmail.com
nntnag17@gmail.com

***Abstract*—Fairness is an important metric in network resource allocation. Fairness metrics are used to determine whether users or applications are receiving a fair share of system resource. We Consider a Wireles cellular network with one Base station and N Mobile users.We have distributed the available bandwidth to all the mobile users fairly according to their bitrate request.**

I. Introduction

Fair allocation of bandwidth to users is an important issue in wireless systems. In a wireless system , Various users request for different bitrates but bandwidth of the base station is limited hence it cannot allocate the same amount of bandwidth as requested by any user. It is important to allocate bandwidth fairly among the users.
One method to allocate bandwidth to users is to allocate equal bandwidth to all the mobile users. This can work if bitrate requested by all the users is same but practically it is not always the case. The bandwidth should be allocated according to the need of the user requesting the bandwidth. It is not fair to allocate same bandwidth to a user requesting High bitrate and to the user requesting a low bit rate. Hence we use our fairness metric to allocate users bandwidth according to their bitrate request.
We Consider a wireless cellular network with one Base Station (BS) and N uniformly distributed Mobile Users (MU). Total available bandwidth is divided into K orthogonal sub channels. Call arrival from each MU follows Poisson distribution with parameter and call holding time is distributed as $exp()$. Bitrate request made by MU follows $80-20$ Pareto distribution where maximum 20% users can request for high bitrate. We have distributed the available sub channels fairly among MUs while considering number of users, their SINR and bitrate request. We used NS3 simulator to perform all of our simulations.

***Keywords*—Base Station, Mobile Users, Call holding time, Bandwidth**

II. Definitions

A. Users per unit area

Assuming a uniform distribution of the users in the cell, this variable is considered to be constant ,say $k \ \ users/km^2$. A circular distribution of the users is considered around the Base Station. Each user can be in three modes:

- *Idle* In this state. The MUs are Neither requesting any data nor they are allocated any bandwidth.
- *Requesting* In this state, The particular MU will be in the call arrival phase. He has made a call to the base station But he is yet to be allocated any bandwidth for the data transfer.
  To determine the users which are in call arrival phase Poisson distribution is used.
- *Busy* The user has been allocated some bandwidth and is in the call holding phase. Exponential () distribution is used to determine the users in the call holding phase.

B. Signal To Noise Ratio (SNR)

The Signal To Noise Ratio is defined as the ratio of Power of the Signal and the background Noise. i.e

$$SNR = \frac{P_{signal}}{P_{noise}}$$

Here P_{signal} is the Power of the signal at the respective MU. We know the distribution of the location of MUs. Hence using the distance d_i for the user i. Power of the signal at $MU \ i$ can be computed as

$$P_{signal,i} = \frac{P_{trans}}{d_i^2}$$

Where $P_{signal,i}$ is the power of signal at $MU \ i$.

III. Fairness Metric

Let us define for ith Mobile User:

B_i = Bitrate Request.
W_i = Ideal Bandwidth.
SNR_i = Signal to Noise ratio for the user i.

The above terms are related as :

$$B_i = W_i \times \log(1 + SNR_i)$$

Let the total bandwidth available be B_T Mhz and the allocated bandwidth for a user i be W_i'. Then the following equation must satisfy :

$$\sum_{i=1}^{N} W_i' \leq B_T$$

Two cases may arise :

$$\sum_{i=1}^{N} W_i \leq B_T$$

In this case $W_i' = W_i$ and all MUs are allocated their requested Bandwidth.

$$\sum_{i=1}^{N} W_i > B_T$$

In this case, We need to use our fairness metric to allocate the most optimum Bandwidth.

$$W_i' = \left(\frac{\frac{1}{log(1+SINR_i)}}{\sum_{i=1}^{n} \frac{1}{log(1+SINR_i)}} \right) \times B_T$$

where,

W_i' = bandwidth allocated to user i
B_T = total Bandwidth

IV. Fairness Index

Fairness inde are used in network engineering to determine whether users or applications are receiving a fair share of system resources. There are several mathematical and conceptual definitions of fairness.
Raj Jain's index rates the fairness of a set of values where there are n users and x_i is the throughput for the i^{th} connection. The result ranges from $\frac{1}{n}$ (worst case) to 1 (best case), and it is maximum when all users receive the same allocation. This index is $\frac{k}{n}$ when k users equally share the resource, and the other $n-k$ users receive zero allocation.

$$J(x_1, x_2....x_n) = \frac{(\sum_{i=1}^{n} x_i)^2}{n \sum_{i=1}^{n} x_i^2}$$

This metric identifies underutilized channels and is not unduly sensitive to a typical network flow patterns

V. Observations

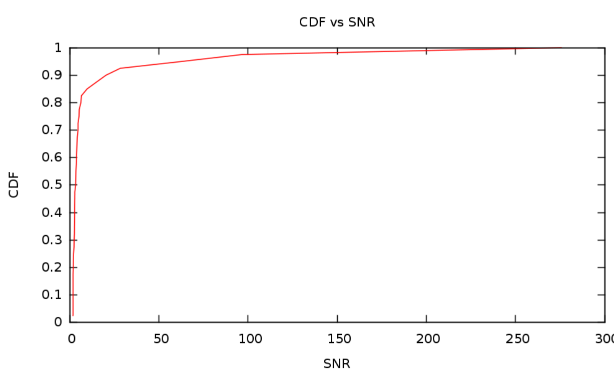

Fig 1. *The Graph shows variation of SNR. The graph is plotted with SNR on x axis and CDF on y-axis. We can observe from the graph that most of the SNR values are close to 1. All the values of SNR are positive. This is because we have no interference in the system and noise level is always less than the signal level.*

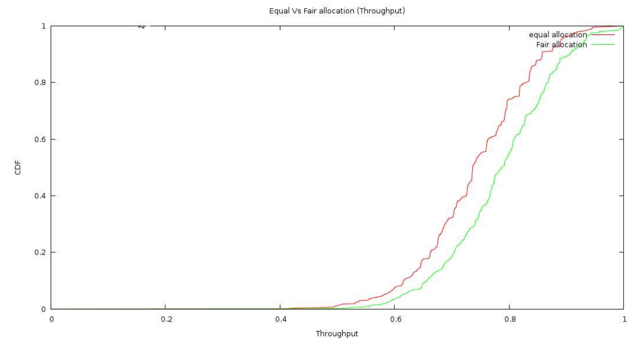

Fig 3. *The graph plots the throughput and CDF. The two plots represent Fair allocation and Equal allocation of bandwidth. As shown in the graph, The equal allocation graph has more values having low throughput whereas the fairly allocated graph has more values in the high range. This shows how the how throughput is affected on applying our metric and fairly allocating the bandwidth.*

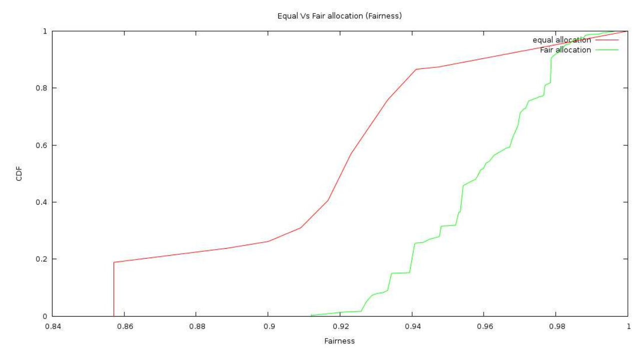

Fig 2. *The graph above shows the fairness.*
The two plots represent the Fair allocation and Equal allocation of bandwidth plotted with fairness on the x-axis and CDF on y-axis. We can see that on applying our fairness metric , Most number of users are having high fairness index whereas on equal allocation , most number of users had low fairness index. Thus it clearly shows improvement in the fairness of bandwidh allocation of the system.

VI. Conclusion

This project has made substantial progress towards improving our understanding of the wireless Base stations, Mobile users and their working. We have implemented N mobile users and a single Base station.We also implemented the call arrival, call waiting time using various probability distribution functions.
We started with a single base station and N distributed Mobile users. Each user requesting a particular bitrate. Our problem was to allocate bandwidth fairly to all the mobile users. We used the fairness metric described in section III to fairly allocate bandwidth to mobile users according to their request.

Finally we plotted graphs between CDF vs Throughput,CDF vs SNR and CDF vs Fairness of the system as shown in section V for equal allocation and allocation using our metric for fairness. Improvement in fairness of the system is clearly explained and shown in the graphs.

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