

A Comparative Study of the Effects of Different Genetic Algorithm Selection Mechanisms on Variable Bit Rate (VBR) and Alternate Bit Rate (ABR) Asynchronous Transfer Mode (ATM) Networks

C. Ihekweaba

Abstract—This paper presents the basic features of a modern Telecommunication switching Technique; The Asynchronous Transfer Mode (ATM). It further discusses Genetic Algorithm, it's sequence of operations, and application areas. With reference to an ATM Quality of Service parameter; Cell Transfer Delay (CTD), three GA selection mechanisms are in turn applied in the control of the Alternate Bit Rate (ABR) and Variable Bit Rate (VBR), ATM classes, finally, test results and subsequently, the best selection Mechanism for the network are elucidated.

Index Terms—Alternate Bit rate, Asynchronous Transfer mode, Genetic Algorithm, Variable bit rate.

I. INTRODUCTION

The Asynchronous Transfer mode (ATM) [1] is a current switching system that employs the Virtual Packet Switching techniques [2], to deliver Multimedia (Video, Audio, Data) information simultaneously through the same network. Since ATM simultaneously attempts to support voice, data and video applications, each one having different performance and Quality of service (QoS) requirements, it becomes imperative that for optimal utilization of the network, the system architecture requires complex, non linear, distributed control structures. In order to achieve its potential, the ATM network will need to accommodate several interacting control mechanisms such as Call Admission control, Flow and Congestion control, Input Rate regulation, Routing, Bandwidth allocation, Queue scheduling and Buffer management. The basic quality of services (QoS) parameters that can be negotiated on an ATM network include the following: Cell Transfer Delay(CTD), Cell Delay Variation(CDV), Cell Loss Ratio(CLR), Maximum Burst Size(MBs) Peak Cell Rate(PCR) and Sustainable Cell Rate(SCR)[3].

The Genetic Algorithm (GA) is a method for solving both constrained and unconstrained optimization problems that is based on natural selection, the process that drives biological evolution[4],[7]. The Genetic Algorithm repeatedly modifies a population of individual solutions. At each step, the genetic algorithm selects individuals at random from the current population to be parents and uses them to produce the children for the next generation. Over successive generations, the population "evolves" toward an optimal solution[4]. You can apply the Genetic Algorithm to solve a

variety of optimization problems that are not well suited for standard optimization algorithms, including problems in which the objective function is discontinuous, non-differentiable, stochastic, or highly nonlinear[8]. GA is a non-traditional based optimizing technique which can be used to optimize complex telecommunication networks such as the ATM network[5], [11], [12]. GA's sequence of operations can be briefly described as Coding, Initialization, Evaluation, Reproduction, Crossover, Mutation and Termination condition[6].

II. G A METHODOLOGY AS ADOPTED IN THE WORK

Encoding Mechanism: This step is to represent the variables of the optimization problem in the form of genes. The network configuration has been encoded based on the multi-parameter encoding mechanism. Route tables are created for all pairs of node combinations. The entries in the route table, correspond to the virtual paths included between pair of nodes. The entries in the route table is called genes and a pool of genes is referred to as the chromosome

Initialization: Between each pair of nodes, a route (gene) is selected from the route table and that forms the configuration string(CS). Chromosomes with different genes are randomly selected as the initial chromosomes. A pool of CS that satisfies the given constraint is maintained. These random chromosomes constitute the population, the size of which is equal to the random number of chromosomes.

Evaluation: Each chromosome in the population is assigned a specific value, this is associated with the gene arrangement and is referred to as fitness. Due to the differences of genes arrangement, the fitness value of the chromosome in the population is used to evaluate the chromosome for its survivability. For optimum results, it is necessary to give a higher fitness score, the closer a chromosome comes to solving the problem[9].

Reproduction: From evaluation, Chromosomes with different gene arrangements have different fitness values. Reproduction is to increase the number of good chromosomes and decrease the number of the poor chromosomes in the next generation.

Selection: Based on the fitness function, parents are selected and children are produced [10]. In this paper we

have taken into consideration the roulette wheel selection, Tournament selection mechanism, and Remainder selection.

The Roulette Selection Mechanism chooses parents by simulating a roulette wheel, in which the area of the section of the wheel corresponding to an individual is proportional to the individual's expectation. The algorithm uses a random number to select one of the sections with a probability equal to its area.

In Tournament Selection, the system chooses each parent by choosing tournament size players at random and then choosing the best individual out of that set to be a parent. Tournament size must be at least two (2).

Remainder Selection Mechanism assigns parents deterministically from the integer part of each individual's scaled value, and then uses roulette selection on the remaining fractional part. For example, if the scaled value of an individual is 2.3, that individual is listed twice as a parent because the integer part is 2. After parents have been assigned according to the integer parts of the scaled values, the rest of the parents are chosen stochastically. The probability that a parent is chosen in this step is proportional to the fractional part of its scaled value.

Crossover: This procedure exchanges genes between the father and the mother chromosomes. Two chromosomes are randomly selected from the population as parent chromosomes. The crossover points are chosen to be less than the number of genes in the chromosome and then the genes are swapped between the crossover points. Two new chromosomes with the genes from both the parent chromosomes are obtained. This procedure is called Two-point crossover. There are other methods such as the single-point crossover. However, this paper considers the two-point crossover method.

Mutation: In order to have a new chromosome which differs from the chromosomes in the population, a mutation operation is used. A chromosome is randomly selected as the mutated chromosome. The mutating gene is randomly selected from the number of genes in the mutating chromosome and then the value of this gene is flipped into another value. The operation repeats until the variation of the mean fitness of the population is very small.

Finally, the best chromosome in the population is

decoded as the solution of the optimization problem. In this paper we have considered mutation rate of 0.5% .

Termination Condition: Termination condition can be taken when average fitness is almost equal to the sum fitness or the algorithm can be repeated for a fixed number of generations. This paper has considered the first of the two conditions.

III. THE SYSTEM OBJECTIVE FUNCTION

GA has been used in previous studies, to optimize and design ATM networks, in a related work, the Cell Transfer Delay(CTD) is regarded as an indirect measurement of cell loss probability[5]. Therefore, this paper considers Cell Transfer Delay(CTD) to be optimized on ABR and VBR categories of service, using three selection mechanisms; Tournament, Roulette wheel and Remainder. The objective function that can be embedded into the backbone network to meet the traffic demand is shown below. [3]

$$\text{Min CTD}_{\text{VBR \& ABR}} = \frac{1}{H_3^{(1)}} \sum_{k=1}^m \frac{f_k^{(1)}(f_k^{(1)} + f_k^{(2)})}{x_k \Phi (x_k \Phi - f_k^{(1)})}$$

$$\text{Subject to , } f_k^{(1)} + f_k^{(2)} < x_k \Phi, k = 1, m, \\ f_k^{(1)} < x_k^{(0)} \Phi, k = 1, m,$$

Where;

CTD Average transfer delay for VBR cells

$f_k^{(1)}$ An aggregate VBR traffic data flow vector

$f_k^{(2)}$ An aggregate ABR traffic data flow vector

x_k No. of the basic transmission link

Φ Bandwidth of the basic transmission link (Mbit/s)

k Total number of VPs.

m Total number of nodes in the network

H_3 Total external load on the network.

TABLE 1 TRAFFIC SPECIFICATION MATRIX

ATM Nodes	0	1	2	3	4	5	6	7	8	9	10	11	12	13
0	0	13	20	20	10	12	15	20	10	10	13	12	14	11
1	10	0	18	15	14	15	20	15	10	10	13	10	14	12
2	13	12	0	15	10	20	16	10	14	15	18	18	12	10
3	13	18	20	0	18	13	14	10	12	18	12	10	20	13
4	10	15	10	20	0	8	10	19	10	17	18	20	12	10
5	12	10	12	16	10	0	18	10	20	12	14	18	13	10
6	8	10	12	18	13	16	0	10	15	20	10	12	18	9
7	12	16	8	10	15	16	10	0	15	11	10	12	12	10
8	14	10	20	20	12	12	15	20	0	12	10	13	20	14
9	14	8	11	19	16	13	12	16	15	0	10	10	12	15
10	18	20	18	20	12	10	18	18	8	18	0	20	13	13
11	18	15	12	13	16	12	10	10	12	16	20	0	16	15
12	18	20	10	19	12	12	11	13	12	18	8	20	0	18
13	16	18	11	13	12	10	10	13	15	13	16	15	20	0

IV. TEST RESULTS

On simulation, using the Traffic Specification matrix shown in Table 1, and flow table in Table II, the GA utilization table for the different selection methods, was generated; (Table III). Also, Average Cell Transfer Delay rates were generated in Table IV. The necessary plots for average Cell Transfer Delays were generated for each mechanism (Fig.1 ,Fig. 2, Fig.3).

TABLE II FLOW TABLE FOR GENERIC ROUTING OF VBR AND ABR

VP no.	Capacity	VBR Flow	ABR Flow
<u>0</u>	150	97	30
<u>1</u>	150	74	20
<u>2</u>	225	130	48
<u>3</u>	225	124	32
<u>4</u>	225	100	84
<u>5</u>	150	63	46
<u>6</u>	150	113	30
<u>7</u>	150	89	112
<u>8</u>	150	90	106
<u>9</u>	150	52	28
<u>10</u>	150	32	56
<u>11</u>	150	30	20
<u>12</u>	150	55	30
<u>13</u>	150	40	20

TABLE III UTILIZATION TABLE FOR DIFFERENT GA SELECTION MECHANISM ON VBR AND ABR

VP No.	GA-Utilization		
	VBR & ABR Tournament	VBR & ABR Roulette	VBR & ABR Remainder
<u>0</u>	23.58	21.89	21.66
<u>1</u>	23.4	18.33	21.09
<u>2</u>	15.92	9.21	14.56
<u>3</u>	9.71	11.98	11.41
<u>4</u>	12.38	17.36	15.31
<u>5</u>	16.46	13.02	15.53
<u>6</u>	8.14	11.01	15.32
<u>7</u>	-0.78	19.22	21.13
<u>8</u>	4.71	14.89	12.51
<u>9</u>	-0.08	17.91	16.87
<u>10</u>	14.81	10.89	19.14
<u>11</u>	16.02	10.02	16.85
<u>12</u>	10.61	11.32	12.98
<u>13</u>	14.21	18.46	18.68
Avg.	12.1	14.67	16.65

TABLE IV AVERAGE CELL TRANSFER DELAY RATES

Mechanism	Best fitness	Mean fitness
Tournament	0.38689	0.52108
Roulette wheel	0.52532	0.70732
Remainder	0.35179	0.47539

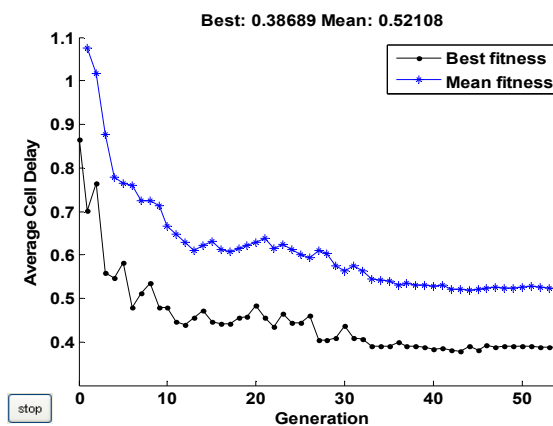


Fig 1 A Plot of the Tournament Selection mechanism on VBR and ABR Traffic

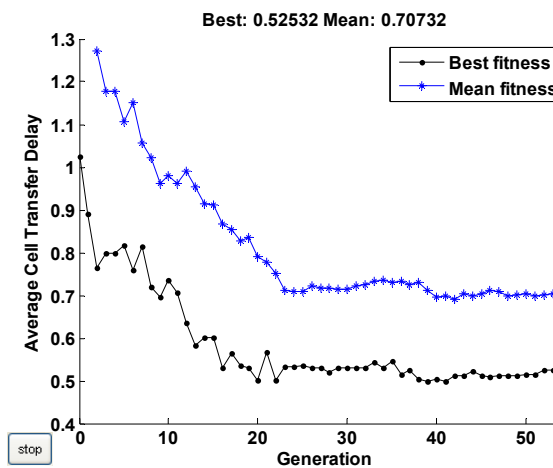


Fig 2 A plot of the Roulette Selection mechanism on VBR and ABR Traffic

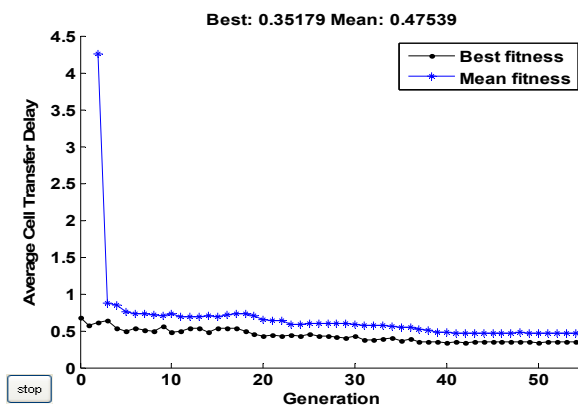


Fig 3 A Plot of the Remainder Selection mechanism

V. DISCUSSIONS

Results of comparison prove that out of the three mechanisms, the remainder selection mechanism (Fig 3) gives a better result than the roulette wheel (Fig 2) and tournament selection methods (Fig 1). In the case of Roulette wheel selection mechanism, it was observed, that the average Cell Transfer Delay and the variation in the Cell Delay were slightly high throughout the generation. Tournament selection method as observed, gave better results than the Roulette wheel method. In the case of Remainder selection, it was observed, that the variations were within acceptable limit and the average Cell Transfer Delay was better than the tournament and roulette wheel selection methods. The average Cell Transfer Delay that was observed by the remainder selection is 3.52usec (Table IV). On the basis of VP flow and utilization factors (Table II), it can be inferred that remainder selection mechanism is utilizing the VP's more efficiently than the other.

VI. CONCLUSION

The future ATM based broadband integrated service digital network is expected to support varied traffic with varied traffic patterns, so dynamic routing is an important factor for desired network performance. All these service categories were introduced to attain the ability to transfer heterogeneous traffic, adequate network resources dispatching for each traffic component, more network flexibility and usability. ATM service categories (CBR, VBR, and ABR) make it possible for users to choose specific combinations of traffic and performance parameters. In this paper we have compared three mechanism of selection method in GA on different categories of service to dynamically route ATM network traffic. Our experimental results show that tournament selection method gives the best average cell transfer delay for CBR, which is 3.52usec while remainder selection method gives the best average cell transfer delay for VBR and ABR according to the experimental network model. Also the results obtained by implementing the new initialization technique shows that the GA does not converge to a consistent value prematurely as a result, the solution obtained is optimal and the amount of time required by the GA, to generate an optimal solution,

is also reduced. Thus optimized bandwidth is achieved.

REFERENCES

- [1] http://searchnetworking.techtarget.com/sDefinition/o..sid7_gci213790.00.html
- [2] http://www2.rad.com/networks/2004/PacketSwitching/main.htm#_To_c80455261
- [3] Leonid Huliannytskyi and Andrii Bakian "Optimization of ATM Telecommunication Networks" International Journal "Information Theories and Applications" vol 12.
- [4] <http://arxiv.org/ftp/cs/papers/9809/9809085.pdf>
- [5] <http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.5.2654>
- [6] <http://www.rennard.org/alife/english/gavintrgb.html>
- [7] <http://www.ai-junkie.com/ga/intro/gat1.html>
- [8] http://www.mathworks.com/products/gads/index.html?s_cid=adw_genalgorithm_cat2
- [9] <http://www.ai-junkie.com/ga/intro/gat3.html>
- [10] <http://www.ai-junkie.com/ga/intro/gat2.html>
- [11] <http://neo.lcc.uma.es/staff/francis/pdf/melecon06.pdf>
- [12] http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6W86-43S6W98-3&_user=10&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=08253bb6f36bef68ee004c287c69d7e2

BIOGRAPHY



Ihekweaba Chukwugoziem holds a Bachelors degree in Electrical/Electronics Engineering Anambra State University of Technology, Enugu, Nigeria in 1987. A Masters degree in Computer Science and Engineering from the same University in 1990. A Doctorate degree in Communication & Engineering, Enugu State University of Science and Technology Enugu, Nigeria. The Author's

major field of study is Application of Computational Intelligence in Data Communication Networks.

He has been involved in several projects in Data Communications and has taught Computer Science and Engineering since 1987. He has presented papers in several conferences, published articles in several journals and three books in wide use in several higher institutions.

Engr. Ihekweaba is a member of Nigeria Society of Engineering (NSE), Council for regulation of Engineering in Nigeria (COREN), Nigeria Computer Society (NCS) and Computer Professionals of Nigeria (CPN).

He is currently the Acting Head, Department of Computer Engineering, Michael Okpara University of Agriculture, Umudike.