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THE MANAGEMENT OF ATM NETWORKS CELL MULTIPLEXING USING NEURO-FUZZY CONTRROLLER

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ABSTRACT: - In this research a fuzzy neural network is proposed so, fuzzy mechanism and adaptive neuro fuzzy mechanism are designed and simulated to control the (flow rate) control action on cell multiplexing in (ATM). The cell flow rate on the output of neural-fuzzy controller. Has been simulated depending on the input variables, one of these inputs is the queuing message (message length), the second one is the number of inputs, and third is the type of massage. These input variables are used to build the fuzzy rules uses (FNN) as its condition and the control action as its consequence, combines these rules to represent the model or system. NN is used as a training algorithm to learn the weights of fuzzy system. The simulation process has been executed by using (MATLAB). In the light of this research, it is apparent that NNS and fuzzy logic based systems can play an important role in the control of cell multiplexing in (ATM) network, since they can provide adaptive model free, real time control to the user.

Keyword: Fuzzy Logic, Neural network, Cell-multiplexing, control management, ATM network.

1- INTRODUCTION

The importance of system modeling and control has attracted considerable attraction due to the large number of applications in different fields, such as control processes. In each field, a model can be used for understanding the behavior of the system, and wherever possible for prediction and control [1]. A model may be defined as a representation of the essential aspects of system, which represents knowledge of that system in a usable form.

The modeling process is necessary to understand the dynamic behavior of different systems in order to provide a mathematical treatment of the systems [2].The steady increase in the usage of communication network on technological applications at the last years, managing traffic flow on the online network is a necessary issue today. However development the efficient management of network resources is a complicated task. With traditional network management methods, it is difficult to obtain a comprehensive view of the state of the network and simultaneously discover important details from the traffic [3].

ATM is a modern technology enabling the integration of different traffic types within a single communication network. ATM networks are being developed to carry voice, and data traffics over high speed links using short fixed size cells consisting of 48 bytes of payload and 5 bytes of header. Various service classes have been defined in ATM for the supports of traffic with different quality of service (QOS) requirements. These classes consist of constant bit rate (CBR), real-time variable rate (rt-VBR), non-real time variable bit rate (nrt-VBR), available bit rate (ABR) and unspecified bit rate (UBR). Of these, an available bit rate (ABR) service has been introduced to support highly busty traffic data applications [3].

In order to achieve its potential, ATM networks will need to accommodate several interacting control mechanisms, such as flow control [4]. Although ATM networks can support a wide variety of rates and provide transmission efficiency by a synchronous multiplexing, a cell might be lost in ATM switches if cells are excessively fed into the networks. The traffic that successfully passes through the conformance monitoring functions is multiplexed at different points. In order to achieve statistical multiplexing applications, which have burst of traffic, they may be assigned to the same link in the hope that statistically hot all of them will generate bursts of data at the same time; the traffic may be equal or buffered before being transmitted on the link [5]. Due to the complex nature of the traffic control in ATM multiplexing and to minimize data loss, some researchers are looking for solutions by application of computational intelligence techniques to design intelligent control systems (adaptive network inference) system as neuro-Fuzzy algorithm as, an alternative approach to design a controller that it calculates the desired control action. The control mechanism developed using Fuzzy logic has to be tuned according to some parameters of the membership functions adjusted by experts. Experts rely on vague rules to make decisions of controller. Fuzzy logic is used to formalize the processing of imprecise rules. There is a need of effective method for tuning the membership functions to the situation of the network. This method can minimize the losses decreasing time and cost when adjusting parameters of membership function. Using intelligence methods, a new method can be generate that has representation of Fuzzy logic and ability of adapt the knowledge base of system as consequence, this process a achieve will adaptive network using a neuro- fuzzy algorithm gives us an alternative adaptive approach to design a controller for cell switching and multiplexing to optimize the cell sequences and to reduce cell losses. This needs initial membership functions and it is trained itself with training data.

There are some of the published researches on the subject. In the networking literature several control schemes have been proposed. The author [5] proposed modeling and simulating a Fuzzy Logic Controller (FLC) to control cell multiplexing in a synchronous mode(ATM) networking; which is a high performance cell oriented switching technology that utilizing of small size packet to carry different types of service for traffic. The author [6] uses fuzzy logic as an effective system control mechanism. MATLAB; the simulation kit used in development of the system and the author [7] ATM traffic model and traffic control using fuzzy controllers are simulated using Matlab. The results show that the controller system can perform all control tasks successfully for relatively high speed data transfers in ATM networks. The authors [8] proposed traffic control system. Fuzzy mechanism and adaptive neuro-Fuzzy mechanism are designed to controlling flow rate on an ATM switch using a specific method of the ABR (Available bit rate) service of the ATM technology.

2-ATM NETWORKS BASICS:

A synchronous transfer mode (ATM) also referred to as cell switching utilizes the concept of virtual circuit switching [9, 10]. It consists of (53) bytes fixed packet, which is used to transfer information simultaneously from either voice, data, or video sources. ATM has the ability to provide seamless networking as well as a universal networking platform. Various quality of service (QOS) parameters can be negotiated on an ATM network. They include call delay variables maximum cell transfer delay, (max CTD) peak to peak cell delay variation (p-p-CDV) ,cell error ratio (CER), cell misinsertion ratio (CMR), and severely errored cell block ratio (SECB). Various classes of ATM services guarantee different quality of service and traffic parameters which include: constant bit rate (CBR), real time variable bit rate (rt-VBR). Non-real time variable Bit rate (nrt-VBR), Available Bit rate (ABR) and Guaranteed frame rate (GFR)[6].ATM simultaneously attempts to support voice, data and video applications, each one having different performance requirements: it thus becomes imperative that for optimal utilization of the network, the system architecture requires complex, non-liner distributed control structures. In order to achieve it's potential, the ATM network will need to an accommodate several interacting control mechanisms such as cell admission control, flow and congestion control, input rate regulation, routing, bandwidth allocation, Queue scheduling and buffer management. It thus becomes necessary that a strategic system control architecture be employed in ATM control.

2-1 ATM Traffic control:

Traffic control management systems based on the decreasing the congestion over switches. If the congestion persists for long period of time, the buffer storage will be to maximum capacity and any additional data must be discarded on the ATM networks. In an effort to avoid congestion or to minimize such data loss a set of actions taken by the network, such as an ABR flow control scheme developed with various control techniques, such as artificial intelligence technique [8,11].

2-2 Cell switching and multiplexing [4]:

In an ATM network, cell queuing is required to alleviate congestion at switching nodes, congestion occurs when multiple cells simultaneously attempt to access an output link in a switch. Cell queuing can be arranged either by placing buffers at input ports (Called input queuing), or by placing cell buffers at the output ports (Called output queuing). Output queuing yields better performance in terms of cell delay and throughput, but computationally more demanding to operate than input queuing. On the other hand, in input queuing, if the head of –line blocking problem can be solved, comparable performance can be achieved. One way at solving this problem is to employ a mechanism called by bass queuing, when it is used, a controller module schedules the cells in an optimal fashion to enhance the switch throughput. A additionally, cells can be dispatched optimally if they are assigned priorities, with higher priorities assigned to real-time traffic such as voice and video and lower priorities assigned to data traffic, by an intelligent mechanism [12] the others have proposed a Fuzzy scheduler to optimize the cell sequences to reduce cell losses. In their mechanism, each traffic class in switch has its own portion of the dedicated and a Fuzzy algorithm manages the server have also worked on optimal scheduling their study is on application of recurrent ANNS to problem. In multiplexed system devices share the capacity of one link to many [13]. Signals are multiplexed using two techniques:

1-Frequancy division multiplexing (FDM).

2-Time division multiplexing (TDM).

The present research concentrated on (FDM). (FDM) is analogue techniques that can be applied with the band width of a link that is greater than the combined band width of the signals to be transmitted. IN (FDM); signals generated by each sending device modulate with different carrier frequencies. These modulated signals are then combined into a single composite signal that can be transported by the link. Carrier frequencies are supported by enough bandwidth to accommodate the modulated signal [5].

3-THE PROPOSED CONTROLLER DESIGN:

3-1 Fuzzy Controller.

Fuzzy control denotes the field in control engineering in which fuzzy set theory and fuzzy inference are used to derive control laws. The concept of a fuzzy set is an extension of the concept of an ordinary set, called a crisp set. For a crisp set X, an element belongs to X and shown with number 1 or not and shown with number 0. For a fuzzy set F(X) and element has real number in the closed interval [0, 1]. Fuzzy set defined by membership functions. Any value between 1 and 0 can express the grade of membership function which an element belongs to this fuzzy set. Fuzzy set makes it possible to use fuzzy inference. In the method of fuzzy inference, the knowledge of an expert in a field of application is expressed as a set of "IF-Then" rules.

Rules are expressed in the form:

If conditions Then actions

Fuzzy controllers are the applications of fuzzy sets and fuzzy inference in control theory [14]. Their operation is executed in four stages:

a- Fuzzification.
b- Rule base.
c- Decision making.
d- Defuzzification.

The four stages are shown in Figure (1).

The inference operations upon fuzzy rules performed by fuzzy inference systems as follows: In the fuzzification part, the in/out variables of a fuzzy controller can be divided into system variables (output) and linguistic variables (inputs). Fuzzy controller used (number of inputs, queu length and type of message) of system variables as the input and the control action (flow rate connection) as the output. The rule base (knowledge base).

Containing a number of fuzzy rules, is composed as follows:

R (n): If X1 and X2 and X3 then Y where X1, X2, and X3 are the input and Y is the output of the fuzzy system. In order to obtain the correct control, it is necessary to defuzzify the fuzzy sets and aggregate the qualified consequent parts to produce a crisp output at the last part.

3-2 The Design Process:

A: step1. An adaptive controller is a network structure consisting of nodes and directional links through which the nodes are connected. All nodes are adaptive; their outputs depend on parameters pertaining to these nodes. The parameters are (a,b,c). The weights of first layer are V, and the weights of the second layer are W. Learning rule specifies how these parameters should be change to minimize an error and to get new weights, which are the best weights, using in fuzzifier. To calculate the new weights of network according to the experts experience.

Let X1 is No. of input ; X2:is length of message ; X3:type of message

v : the wieght of the first layer ; w : the wieght of the second layer

W= [0.3 1 0.8]

$$V=\begin{bmatrix}0.8 & 0.9 & 0.3\\ 0.3 & 1 & 1\\ 1 & 0.9 & 0.9\end{bmatrix};$$

($\lambda = 0.5$; $\eta = 0.2\ Its\ constant$) ; (let the desired value d=0.87)

Net = V * X^T

$$\begin{bmatrix}net\ 1\\ net\ 2\\ net\ 3\end{bmatrix} = \begin{bmatrix}0.8 & 0.9 & 0.3\\ 0.3 & 1 & 1\\ 1 & 0.9 & 0.9\end{bmatrix}\begin{bmatrix}0.2\\ 1\\ 0.6\end{bmatrix} = \begin{bmatrix}1.24\\ 1.66\\ 1.64\end{bmatrix}$$

F(net)= Oj =$\left(2/1 + e^{-\lambda net}\right)$ -1

$$\begin{bmatrix}O_1\\ O_2\\ O_3\end{bmatrix} = \begin{bmatrix}0.3\\ 0.393\\ 0.388\end{bmatrix}$$

Net 4 = [0.3 0.8] $\begin{bmatrix}0.3\\ 0.393\\ 0.388\end{bmatrix}$

Net 4 = 0.793

O_4= 0.196

$f'_{(net)j} = \frac{1}{2}\ [1 - {O_j}^2]$

$$f'_{(net)} = \begin{bmatrix}0.455\\ 0.423\\ 0.425\end{bmatrix}$$

For calculate the amount of error (δ_{Oj})

$\delta_{Oj} = \frac{1}{2}\ [1 - {O_j}^2][d - O_j]$

δ_{O4}=0.324

For H/L

δ_{O1}=0.027

δ_{O2}=0.083

δ_{O3}=0.067

For calculate the new weight:

ΔVji =$\eta\delta_{Oi}$Xj

ΔV_{11} = 0.00108

ΔV_{12} = 0.00332

ΔV_{13} = 0.00268

ΔV_{21} = 0.0054

ΔV_{22} = 0.0166

ΔV_{23} = 0.0134

ΔV_{31} = 0.00324

$\Delta V_{32} = 0.00996$

$\Delta V_{33} = 0.00804$

$$\Delta V = \begin{bmatrix} 0.00108 & 0.00332 & 0.00268 \\ 0.0054 & 0.0166 & 0.0134 \\ 0.00324 & 0.00996 & 0.00804 \end{bmatrix};$$

The new weight of this network is:

$$V^{\text{new}} = V^{old} + \Delta V = \begin{bmatrix} 0.80108 & 0.90332 & 0.30268 \\ 0.3054 & 1.0166 & 1.0134 \\ 1.00324 & 0.90996 & 0.90804 \end{bmatrix}$$

B: step2. The cell multiplexing controller consists of three inputs and one output. It takes (queue length), (number of inputs) and (message type) as its input. Output of controller is (flow rate correction) control action as shown in Figure (2).

We try to obtain flow rate correction (control action) using controller. In the fuzzification step of the fuzzy inference system, we have three inputs, no. of input, queue length and message type. The triangular shaped membership function type is used for input. The graphic of the triangular membership is shown in Figures (3, 4, 5, 6, and 7).

The data interval is [0, 1] and the variables of input and output are defined by linguistic variables.

C: step 3. Is rule base in fuzzy inference system. We have 15 fuzzy rules come by 3 linguistic terms for queue length, No. of inputs and type of message. Following if-then rules shows these fuzzy rules constituted.

If (input 1 is too short) and (input2 is small) and (input 3 is text)

Then (output is slowly).

If (input 1 is too short) and (input 2 is small) and (input 3 is video)

Then (output is slowly).

If (input 1 is too short) and (input 2 is small) and (input 3 is audio)

Then (output is slowly).

If (input 1 is too short) and (input 2 is normal) and (input 3 is text)

Then (output is slowly).

If (input 1 is too short) and (input 2 is normal) and (input 3 is image)

Then (output is slowly).

If (input 1 is too short) and (input 2 is normal) and (input 3 is video)

Then (output is slowly).

If (input 1 is too short) and (input 2 is normal) and (input 3 is audio)

Then (output is slowly).

If (input 1 is too short) and (input 2 is large) and (input 3 is text)

Then (output is slowly).

If (input 1 is too short) and (input 2 is large) and (input 3 is image)

Then (output is slowly).

If (input 1 is too short) and (input 2 is large) and (input 3 is video)

Then (output is slowly).

If (input 1 is too short) and (input 2 is large) and (input 3 is audio)

Then (output is slowly).

If (input 1 is short) and (input 2 is large) and (input 3 is video)

Then (output is fast).

If (input 1 is normal) and (input 2 is small) and (input 3 is text)

Then (output is normal).

If (input 1 is long) and (input 2 is large) and (input 3 is video)

Then (output is normal).

If (input 1 is too long) and (input 2 is large) and (input 3 is video)

Then (output is fast)

And Figures (8, 9) show the rules base editor of system and the rules viewer.

D: Step 4. Third part: of the fuzzy inference system is fuzzy inference logic. Here, AND logic is applying to inputs the sub-algebraic product compositional rule of inference is employed in this system.

E: Step 5. Output variable is created after training step with neural network. In this part the neural-fuzzy system combines the features (advantages) of neural network and fuzzy inference system. [15]

One such neuro-fuzzy algorithm called adaptive neuro-fuzzy inference system has been used to build neuro-fuzzy controllers. The system is a feed forward type adaptive network, it consists of five layers. These layers are shown in Figure (10).

Layer 1: Every node in this layer computes the degree of membership of the input. Each node is using triangular shaped membership function.

Layer 2: There is one input only to each node at layer2.Every node in this layer multiplies the incoming signals and sends the product out:

$$O^2_i = w_i = UA\ (x_1)*\ UB\ (x_2)*UC(x_3)$$

Layer 3: In the rule layer, the firing strength of each rule is determined. Each node in this layer represents a rule and accepts the outputs of all the term nodes associated with the rules as inputs. The ratio of i^th^ rule firing strength to the sum of rules strengths is calculated as:

$$O^3_i = \overline{w_i} = \frac{wi}{\sum iwi}$$

Layer 4: Every node (i) in this layer has a node function as given in equation:

$$O^4_i = w_i\,(\overline{a}x_1+bx_2+cx_3)$$

Where is (w_i) is output of layer 3 and (a, b, c) are a consequent parameters.
x_1 is (Queue length) and x_2 is (No. of inputs) and x_3 is (message type).The parameters (a,b,c) are adjusted through the operation .

Layer 5: The unique node in the output layer passes the input value from layer5 to output.The output is computed as the summation of all incoming signals, as given in equation:

$$O^5_i = \frac{\sum i\ wi(ax1+bx2+cx3)}{\sum wi}$$

The designed architecture at the previous section is applied according to the supplied training data. This model requires initial parameters for the membership functions of the layer1 and supplied training data as shown in Tables (1, 2). [5]

The membership functions of adaptive neuro-fuzzy inference controller are changed after trained.

4- DISCUSSION

After applying and training all these neuro-fuzzy inference system steps to inputs, the output control action (cell rate) can be seen from Figure (11).

There is more adaptive shape according to condition of the network. In communication, one of the most important parameters is transmission time delay (TTD) in transmitting message and receiving it. The results of (TTD) of the model is shown in Table (3) and Figure(12),which are represents the changes in transmission time delay for (one cell, text message, image message, video message and audio message) due to changes in bit-rate from these curves and table, it has been found that changes in bit rate of a message in ATM network cause changes in (TTD), it has been shown that the message size is different so that it has obtained time delays for each type at message.

In conclusions from all results in Table (3) is shown that when the bit-rate is small, the time delay is very large and vice versa. Also the results show that the time delay is very limited in proposed system.

The throughput has been calculated for different messages (text, image, video and audio) as shown in Table (4) and Figure (13). The results are showing that the neuro-fuzzy controller for cell multiplexing provides effective control, achieving higher throughput.

By comparing the results of the current research with research results in source [5], which is the closest in term of the current work, uses fuzzy logic to manage the cell multiplexing in ATM. It is found that NNs and fuzzy logic can provide adaptive system real time control to the user.

5-CONCLUSIONS

1. An effective controller for the cell multiplexing in ATM network is achieved from a fuzzy controlled system that can effectively make good decisions and has a very high speed responding to sudden changes in input variables which cause congestion in queue of cells. But of course there are some restrictions of fuzzy rules and fuzzy sets. First of all, the rule size was limited, while the membership variables are restricted. Rules and the number of membership functions of fuzzy sets were chosen according to the intuitions of the experts.
2. The proposed work (adaptive neuro-fuzzy inference controller) combines the advantages of neural and fuzzy logic and offers good results. The controller is better system for controlling bit-rate (flow-rate correction) in cell multiplexing for ATM networks than using only fuzzy methods.
3. Neuro-fuzzy controller for cell multiplexing provides effective control, achieving higher throughout.
4. Delay Time is very limited in proposed system.

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Table (1): ABR Traffic Source Model Parameters.

Parameter	Distribution	Mean Value
idle	Geometric	Chosen to adjust network load
Number of generated packs in an active period	Geometric	10
Packet size	Geometric	8 Kbytes
Packet period	Exponential	0.5 msec.

Table (2): Traffic Parameters.

Parameter	Definition	Value
PCR	Peak cell rate	149.7 M bit/sec
MCR	Minimum cell rate	2 M bit/sec
NFP	Control interval	50 cell service providers

Table (3): Change Transmission Delay Time due to bit rate.

Bit Rate (M bit/s)	Transmission delay time				
	One cell (μ sec)	Text message (m sec)	Image message (m sec)	Video message (sec)	Audio message (sec)
155.52	2.726	10.49	21.91	1.7207	0.471
200.77	2.112	8.128	16.97	1.335	0.365
246.02	1.723	6.633	13.85	1.089	0.298
291.27	1.456	5.603	11.70	0.92	0.251
336.52	1.256	4.849	10.13	0.796	0.218
381.77	1.111	4.274	8.93	0.702	0.192
427.02	0.993	3.821	7.98	0.628	0.171
472.27	0.898	3.455	7.22	0.567	0.155
517.52	0.819	3.153	6.59	0.518	0.141
562.77	0.753	3.098	6.06	0.476	0.13

Table (4): Change in Throughput due to Transmission Delay Time.

Text message		Image message		Video message		Audio message	
Transmission Time delay (m sec)	Throughput (M bit/s)	Transmission Time delay (m sec)	Throughput (M bit/s)	Transmission Time delay (sec)	Throughput (M bit/s)	Transmission Time delay (sec)	Throughput (M bit/s)
10.49	155.58	21.91	155.55	1.7207	155.75	0.471	155.41
8.128	200.79	16.97	200.82	1.335	200.75	0.365	200.54
6.633	246.04	13.85	246.06	1.089	246.09	0.298	245.63
5.603	291.27	11.70	291.28	0.92	291.3	0.251	291.63
4.849	336.56	10.13	336.43	0.796	336.68	0.218	335.77
4.274	381.84	8.93	381.63	0.702	381.77	0.192	381.25
3.821	427.11	7.98	427.07	0.628	426.75	0.171	428.07
3.455	472.36	7.22	472.02	0.567	472.66	0.155	472.25
3.153	517.06	6.59	517.15	0.518	517.37	0.141	519.14
3.098	526.79	6.06	562.38	0.476	563.03	0.13	563.07

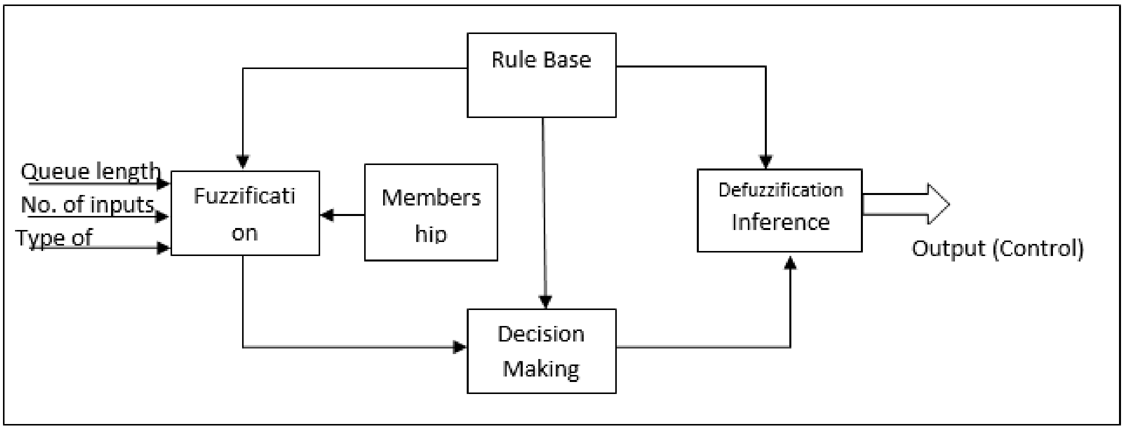

Figure (1): Fuzzy Controller.

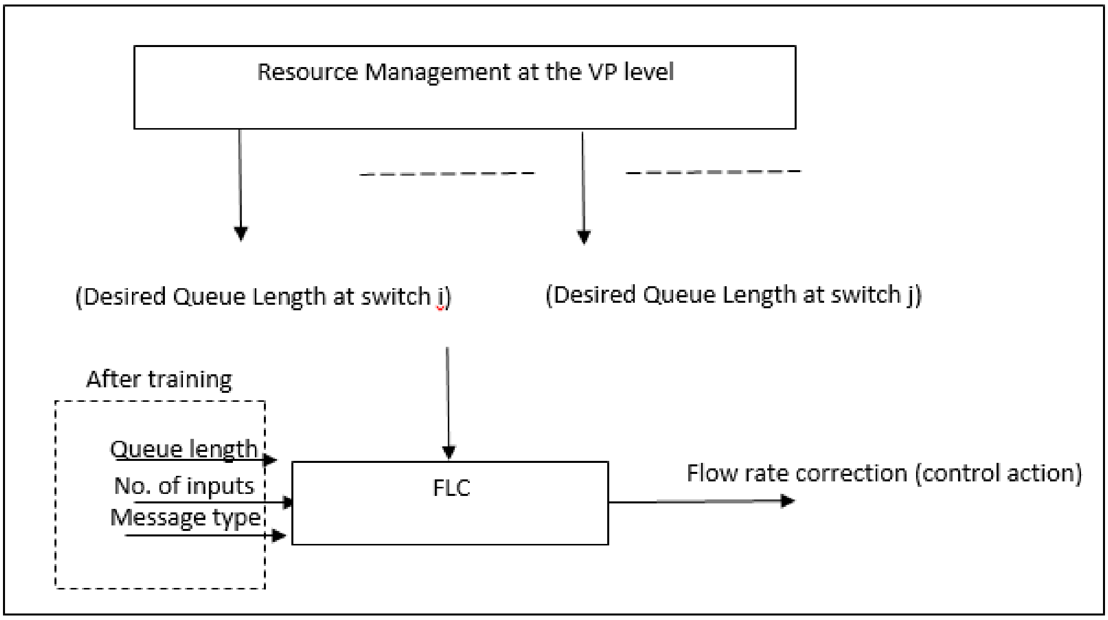

Figure (2): Block diagram of adaptive cell multiplexing controller.

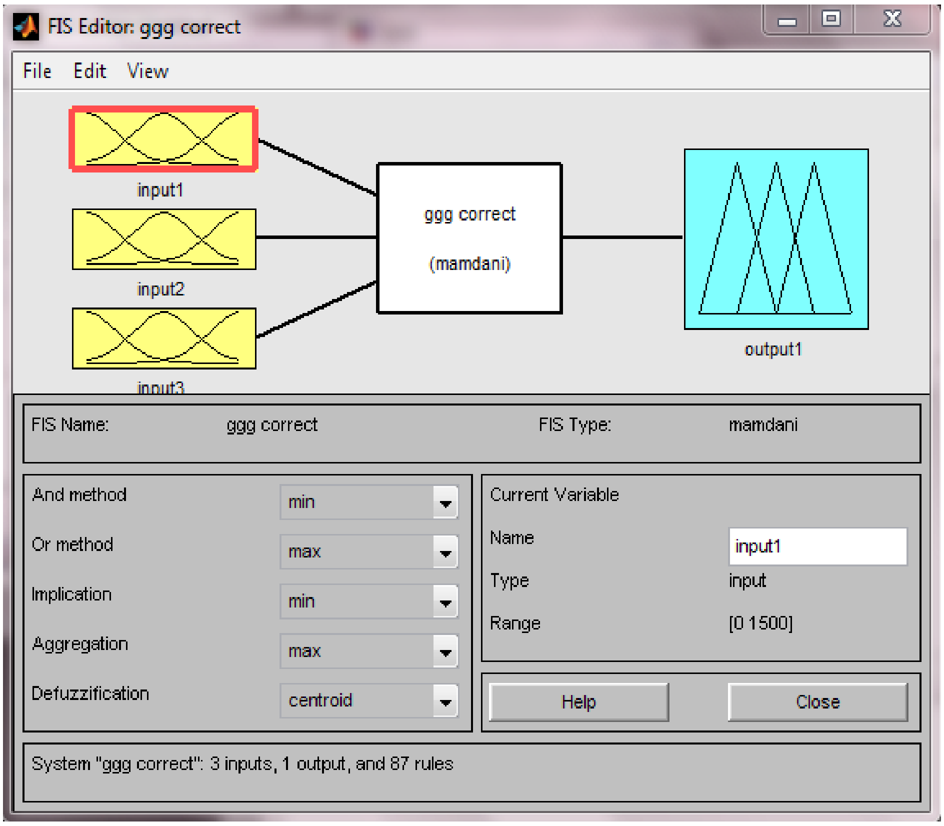

Figure (3): simulation of FLC for cell multiplexing.

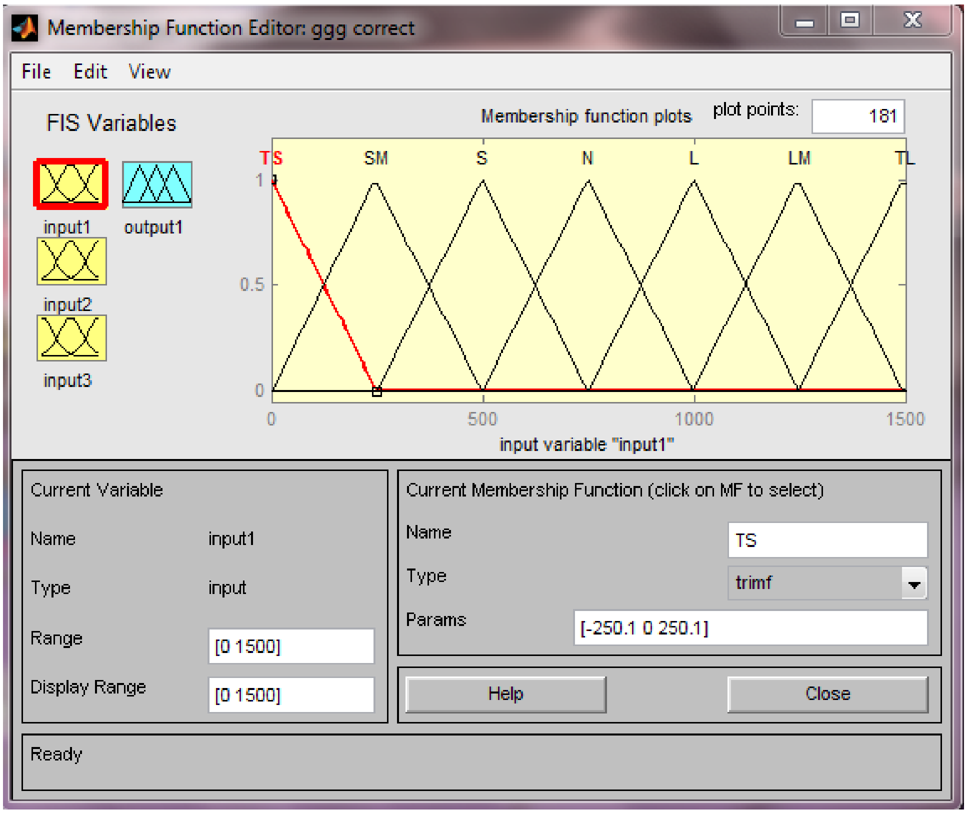

Figure (4): input variable (message length) membership function.

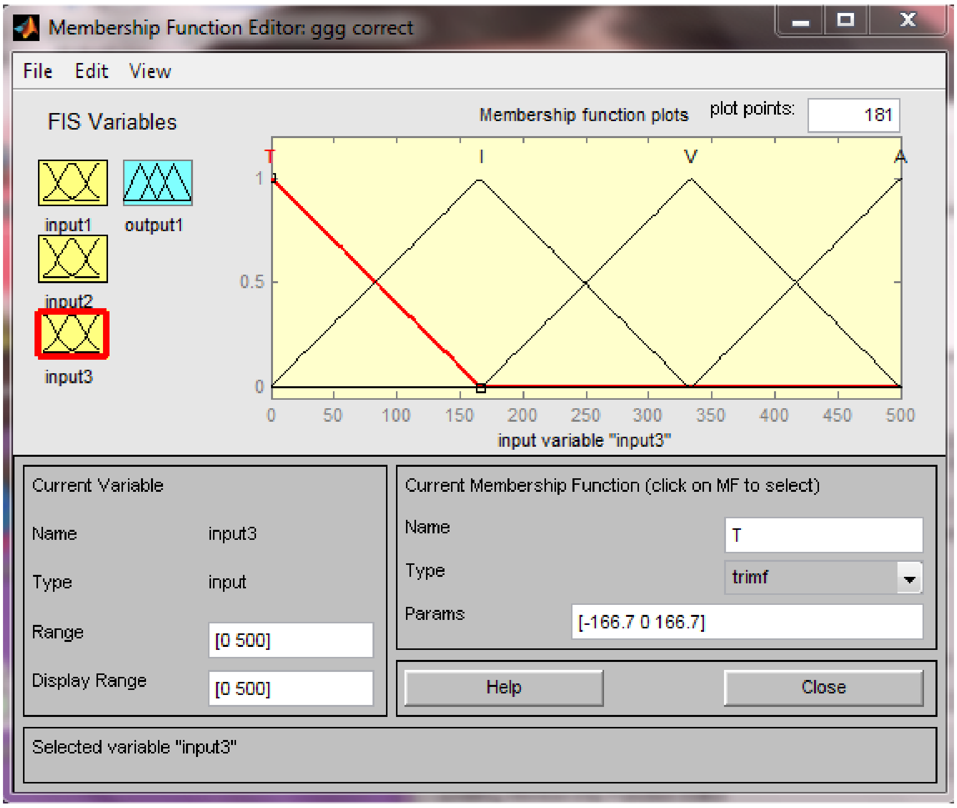

Figure (5): input variable (message type) membership function.

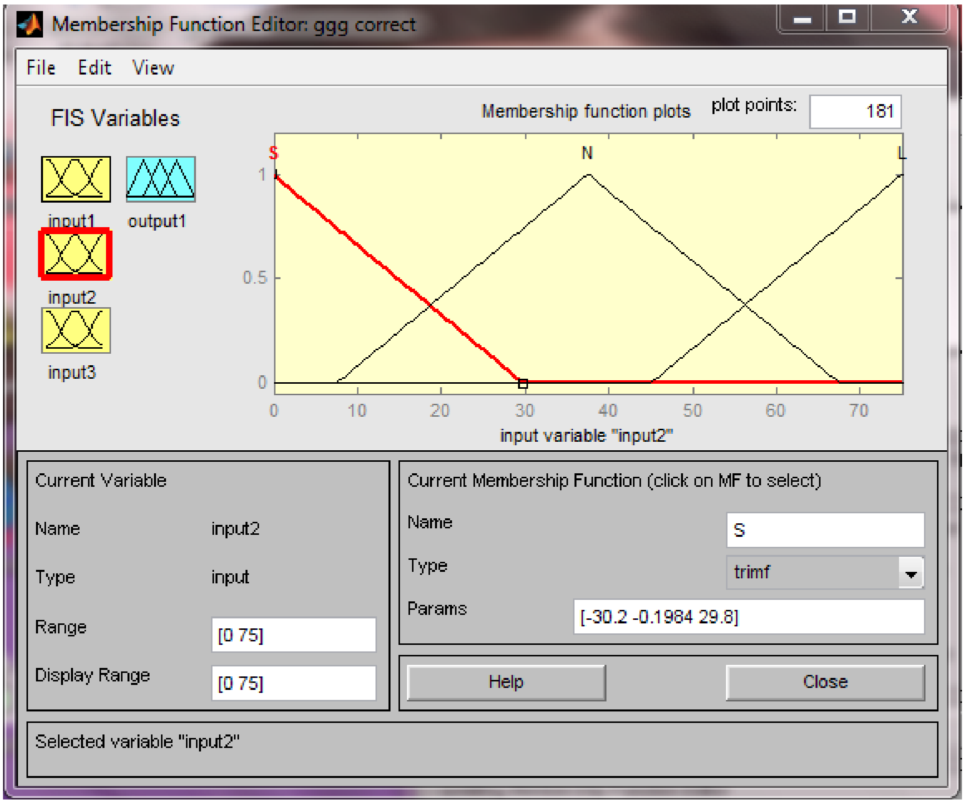

Figure (6): input variable (No. of inputs) membership function.

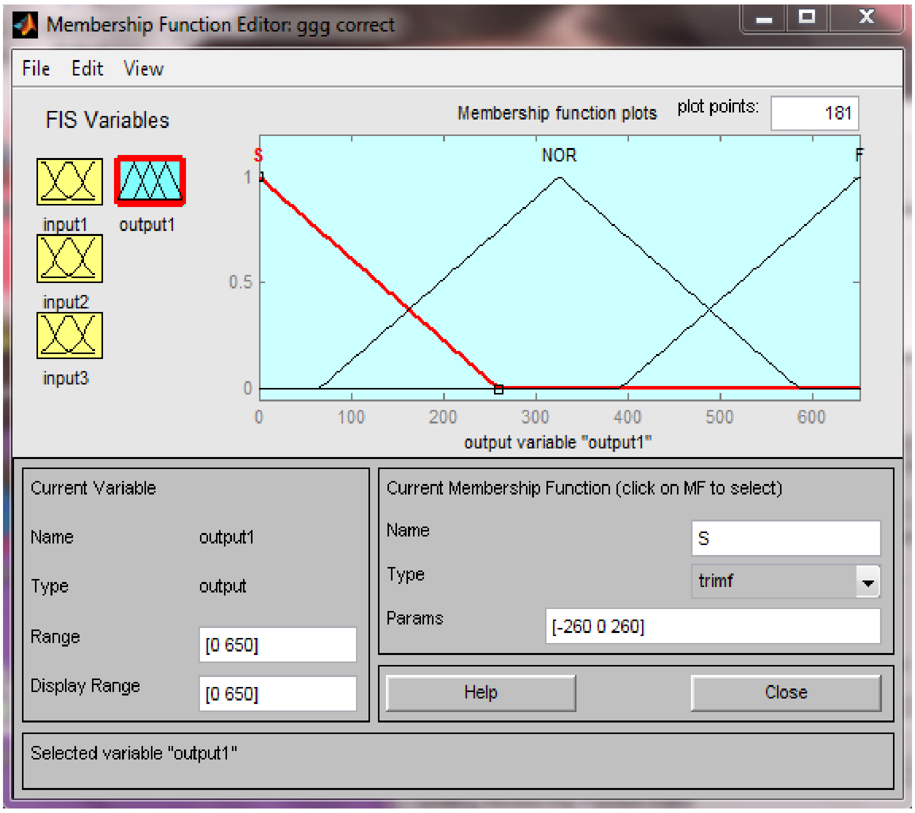

Figure (7): output variable (cell rate) membership function.

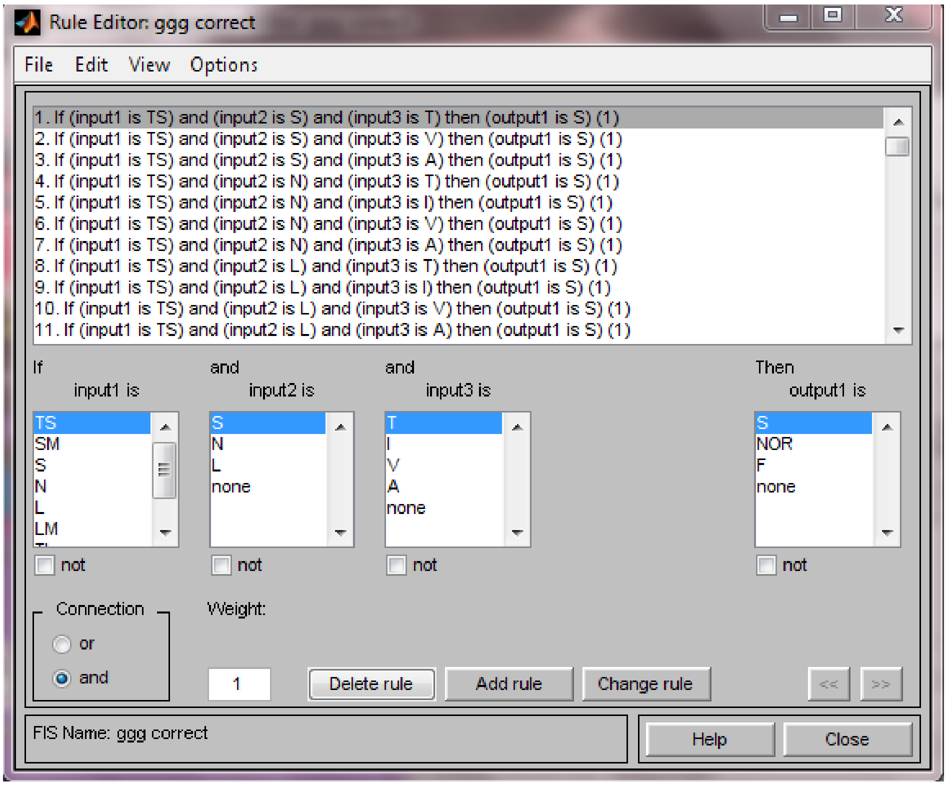

Figure (8): rules base editor.

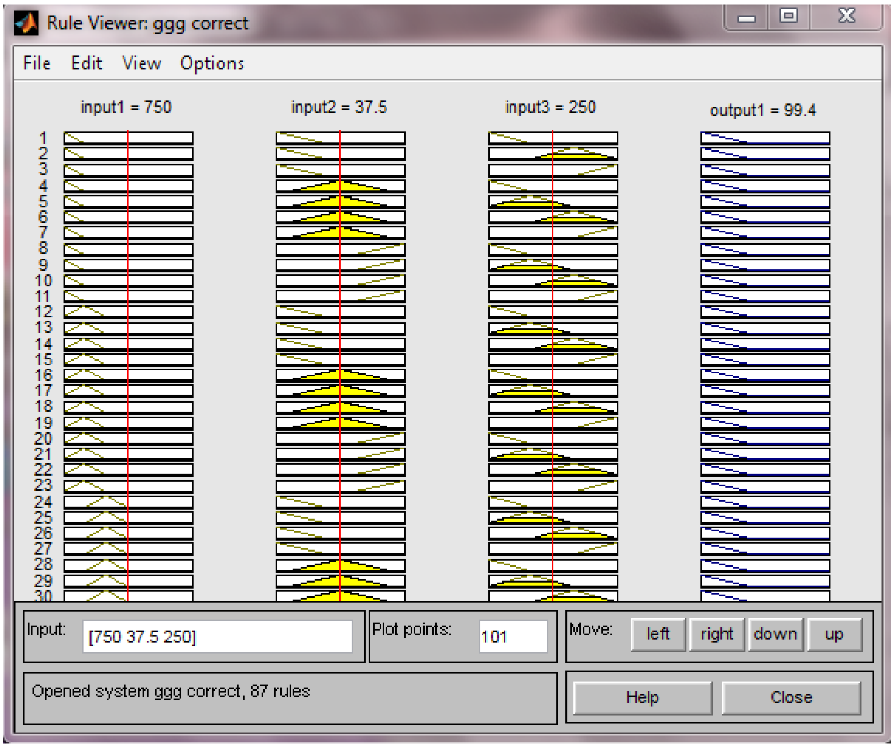

Figure (9): rule viewer.

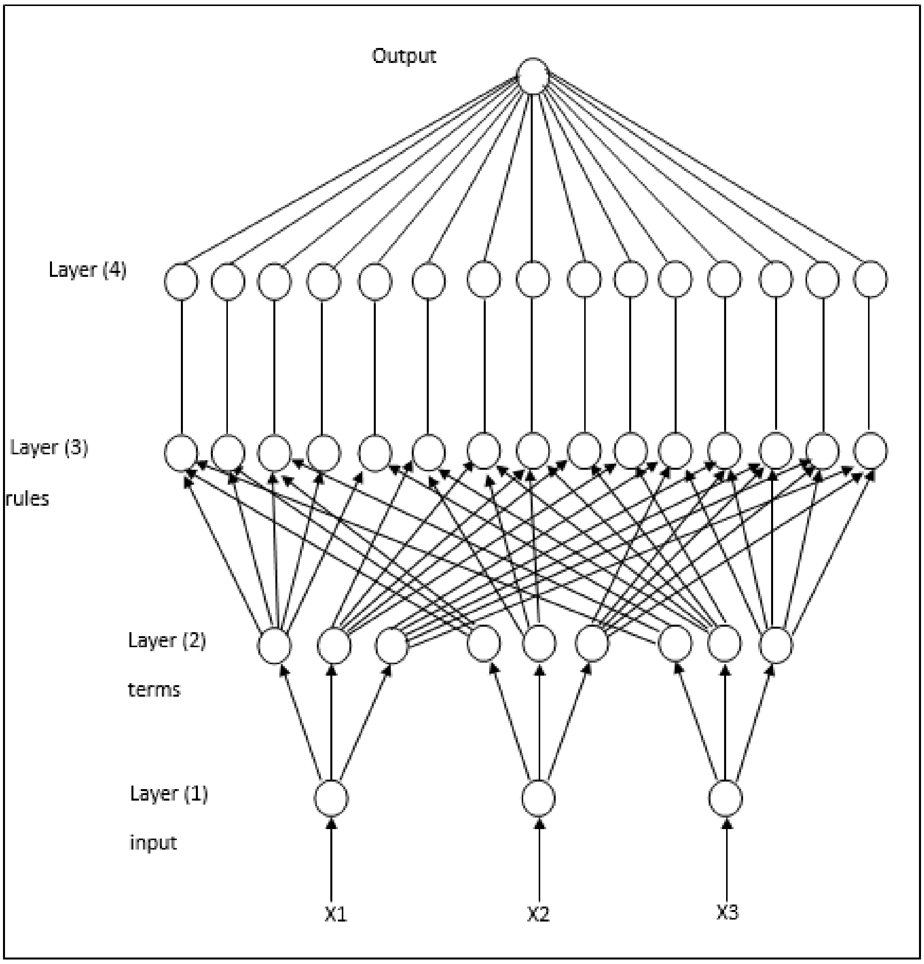

Figure (10): Adaptive neuro-fuzzy inference system architecture.

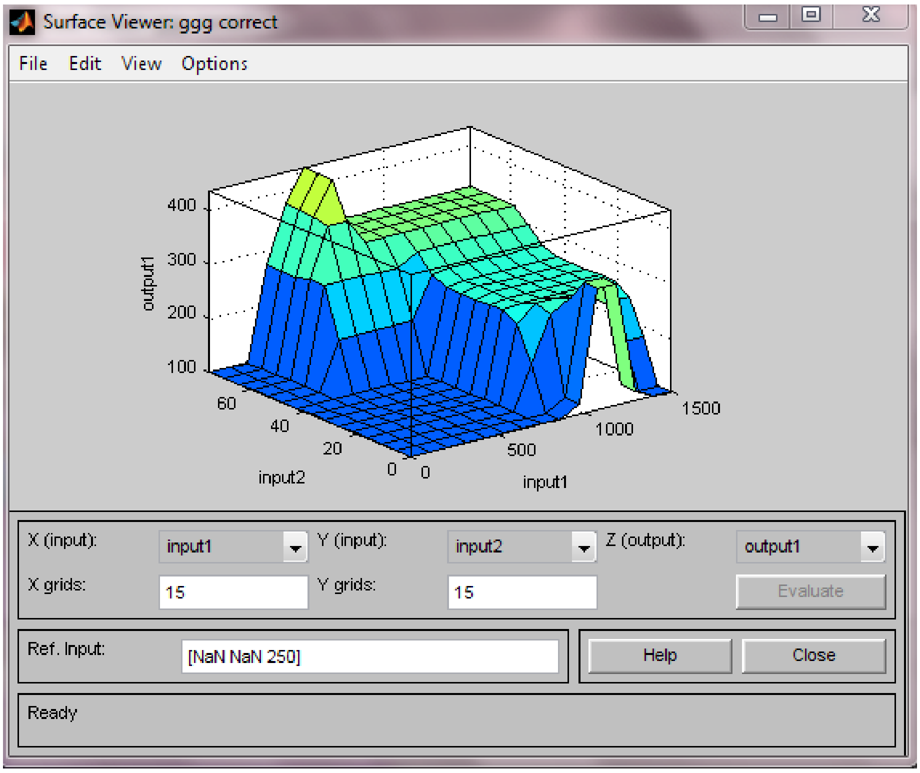

Figure (11): Output of the adaptive neuro-fuzzy controller.

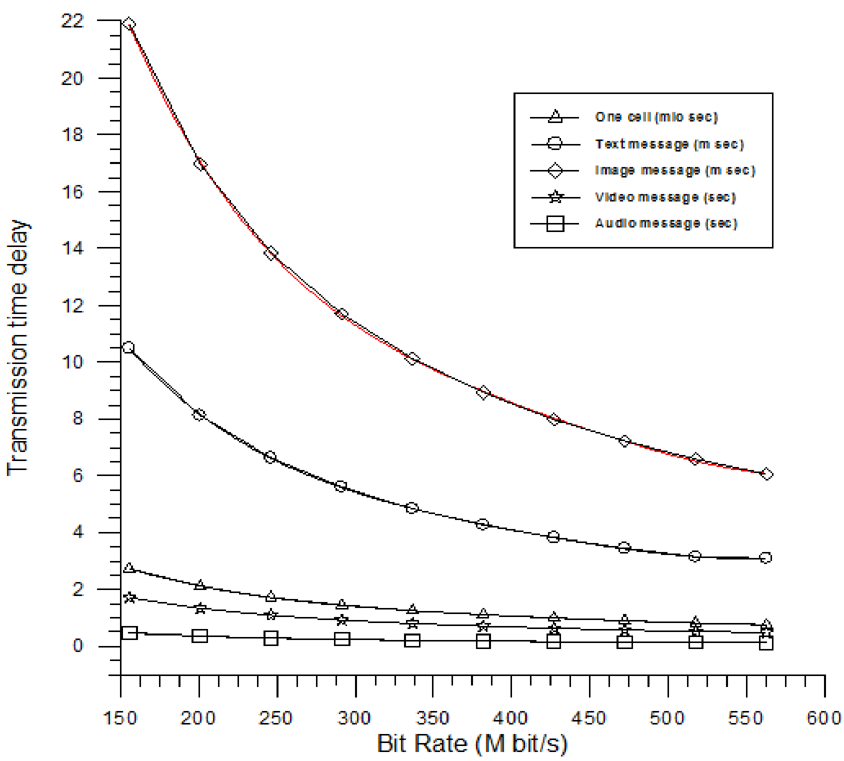

Figure (12): change in Transmission Delay Time due to changes in bit rate for one cell, text, image, video, audio message.

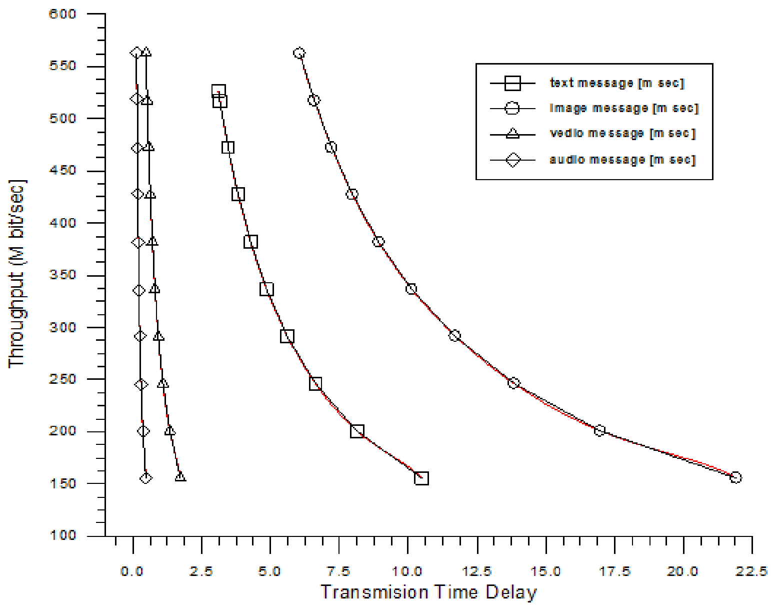

Figure (13): change in Throughput due to Transmission Time Delay for one cell, text, image, video, audio message.

السيطرة على معدل سريان البيانات المنقولة في نمط النقل الغير متزامن باستخدام الشبكات العصبية المضببة

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الخلاصة

في البحث الحالي تم بناء نظام مسيطر يستخدم الشبكات العصبية المضببة للسيطرة على معدل سريان البيانات المنقولة في (Cell–multiplexing) في نمط النقل الغير متزامن. حيث ان معدل مرور البيانات في الخلية (فعل السيطرة) هو خرج المسيطر العصبي المضبب الذي تم محاكاته باستخدام متغيرات دخل مضببة (طول الرسالة وعدد المدخل ونوع الرسالة) وهذه المتغيرات المضببة استخدمت في بناء القواعد المضببة(Fuzzy rule) باستخدام المنطق المضبب والشبكات العصبونية وتعتبر هذه المتغيرات هي شروط القاعدة (rule conditions) أما فعل السيطرة (control action) الخرج وتكامل هذه القاعدة (Rules)يمثل النموذج المقترح. الشبكات العصبونية استخدمت في البحث الحالي لخوارزمية تدريب لتعليم أوزان النظام المضبب. وفي ضوء نتائج البحث وجد ان استخدام الربط الهجيني للشبكات العصبونية و المنطق المضبب له دوراً مهماً في السيطرة على البيانات المنقولة في خلية (multiplexing).