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Simulation model of ANN and PID controller for TCP/AQM wireless networks by using MATLAB/Simulink

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ABSTRACT

The wireless network transmission control protocol/active queue management (TCP/AQM) is a network that was chosen as a topic for research a basis is laid to simulate the proposed network and to conduct the simulation under certain conditions. To manage the queue control protocol (TCP/AQM) was chosen. The solution for many modern systems depends on placing additional units called controllers, which work to improve the performance of the work of the systems. The current simulation system can be described according to the test cases that were conducted, where four test cases were identified with sequential steps. In this work there are two control methods by simulation and mathematical model of wireless network TCP/AQM with proportional, integral and derivative (PID) controller and neural network. Simulation is conducted for cases in order to determine the performance of each case through comparison according to appropriate criteria to determine the best. The first case is a wireless communication network system with with a traditional controller PID type. The second is a wireless communication network system, a large neural network controller. Simulations were conducted to choose the best methods among those suggested for nonlinear systems and to enhance and achieve the possibility of adopting MATLAB to perform the required simulation.

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1. INTRODUCTION

The demand has been increasing and continuously to use internet systems continuously, which caused and birthed the problem of congestion [1]-[3]. It needs appropriate ways to reduce lost time and loss of data or late access to data with the importance of arriving at the right time [4]-[6]. The use of different control methods to obtain the best performance for the work of similar systems that operate in real time [7]-[9]. Previous experiences have proven as confirmed by the current study through verification using traditional systems with a linear system [10]-[12]. Expert systems that fit nonlinear systems have also been approved [13]-[15]. Work on building the proposed systems depends on building [16]-[18]. The mathematical model and identifying how to loosen. The appropriate specifications and obtaining the conversion function that is adopted in addition to the control systems. Also represented mathematically and building an integrated system from the crescent of a simulation model using the MATLAB program. It has been proven by previous studies, including the studies of current researchers on the possibility of representing. Simulating control systems and systems other to verify the performance of its work under the circumstances action is proposed [19]-[21].

The current study was conducted as a simulation using MATLAB to put the study as a research in the hands of the specialists. A simulation model was adopted that will be detailed in the subsequent sections, which represents the mathematically controlled protocol using the transfer function. Traditional control systems and expert systems were also adopted in order to obtain the best methods for the best performance. The study proved, by verifying the possibility of obtaining a better performance for the work of the selected control protocol, with the use of artificial neural network (ANN) neural networks, better than the use of traditional proportional, integral and derivative (PID) systems, which in turn proved that its use improves the work of nonlinear systems [22]-[24]. In this simulation for testing the system with the presence of traditional and expert control systems it keeps the package from losing and timely delivery, which gives high reliability and quality of performance. There are two parts: first part with PID controller, second partwith neural network. Simulation and mathematical model of wireless network transmission control protocol/active queue management (TCP/AQM).

2. SIMULATION AND MATHEMATICAL MODEL WIRELESS NETWORK TCP/AQM

In this section, there are two parts. First part with PID controller. Second partwith neural network. Simulation and mathematical model of wireless network TCP/AQM. In this section, model was designing by two nonlinear in (1) and (2). It shows the dynamics of TCP work in terms of taking the rate for the window size in (1) of the protocol used TCP in addition to the average length of the delay list in (2) [25]-[27].

$$\dot{w}(t) = \frac{1}{R(t)} - \frac{w(t)}{2}\frac{w(t-R(t))}{\frac{q(t-R(t))}{C}+T_p}p(t-R(t)) \tag{1}$$

Where: w: window size in packets, R: full-trip time in seconds, T_p: delay in seconds, q: queue length in packets, C: capacity in packets/seconds, N: load factor and p: packet.

$$R(t) = \frac{q(t)}{C} + T_p$$

$$\dot{q}(t) = \begin{cases} -C + \frac{N(t)}{R(t)}w(t) & if\ q(t) > 0 \\ max\left\{0, -C + \frac{N(t)}{R(t)}w(t)\right\} & if\ q(t) = 0 \end{cases} \tag{2}$$

The simulation and mathematical model of wireless network TCP/AQM for input output transfer function that use (3). Table 1 show the factors suppose of the network of TCP/AQM system in this simulation [28], [29].

$$T.F = \frac{122.8*s^3+3299*s^2+2455*s+3.252*e^{04}}{s^4+1.136*s^3+20.14*s^2+11.26*s+99.8} \tag{3}$$

Table 1. The factors suppose of the network of TCP/AQM system

The factors suppose of the network	Full-trip time	Capacity of the link	Load factor	Promulgation delay	Desired queue size	Maximum queue lengthin the router of sending
Value	0.25	15	60	0.2	300	700
Units	sec	Mb/sec	-	sec	packets	packets

Simulation depends on constant system states time and time variable in terms of system parameters of packets and queue length and thus window size. Simulation also depends on system states with controller PID or ANN. Therefore, it can be said that there is a first case that can be found in the simulation model in the form of a single number under a fixed address and with traditional control. The second is fixed under the control of a neural network. The third is a variable with a traditional console. Finally, a variable with a neural network as a control unit. To compare the two control cases two states are selected at the steady state and the other variable, i.e. in a closed loop with a controller PID or ANN. The simulation cases shown in Figures 1-6. In Figure 1, the system demonstrated a closed loop with a fixed queue length PID controller in packets. In Figure 2, the system demonstrated a closed loop with ANN for a fixed queue length in packets. In Figure 3, the system demonstrated a closed loop with a PID controller variable queue length in packets. In Figure 4, the system is shown in a closed loop with ANN for the variable queue length in packets. In Figure 5, the system is shown in a closed loop with a controller PID as well as a controller ANN for comparison and optimization of fixed queue length in packets. In Figure 6, the system showed a closed loop with controller PID as well as controller ANN for comparison and optimization of variable queue length in packets.

In Figures [7]-[10] show the simulation model of training. In the Figure 7 show the simulation model of training (nn train tool) for neural network. In the Figure 8 show the training performance (plot perform) for neural network. In the Figure 9 show the training state (plot train state) f or neural network. In the Figure 10 show the training regression (plot regression) for neural network.

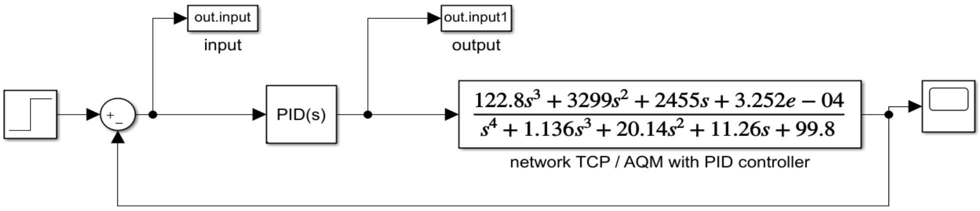


Figure 1. Simulation of network with PID controller at constant q

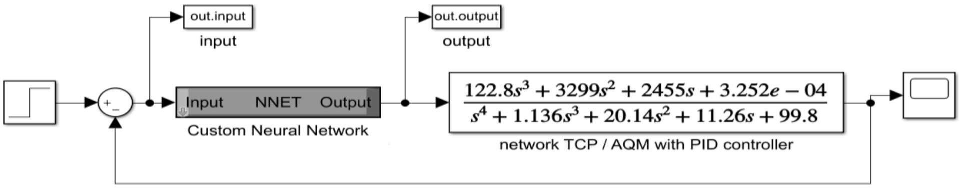


Figure 2. Simulation of networkwith neural network at constant q

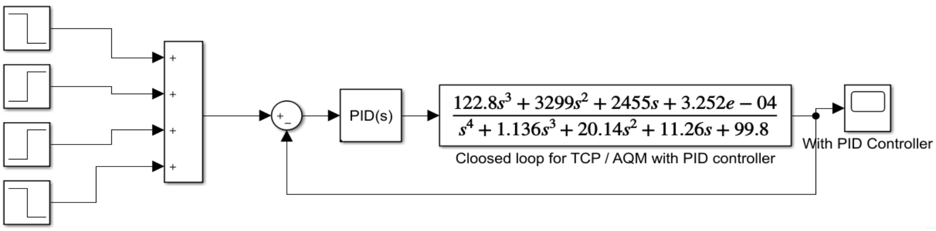


Figure 3. Simulation of networkwith PID controller at variable q

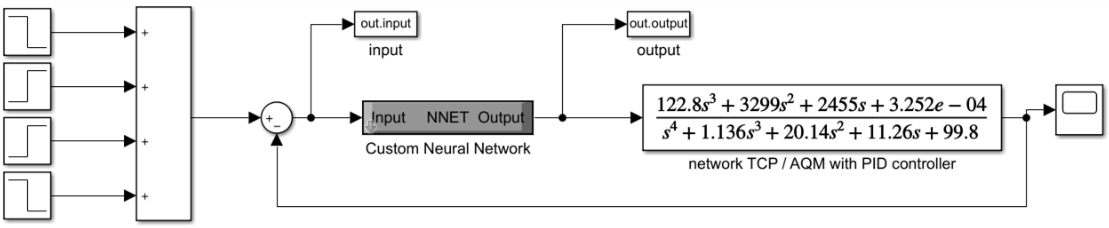


Figure 4. Simulation of networkwith neural network at variable q

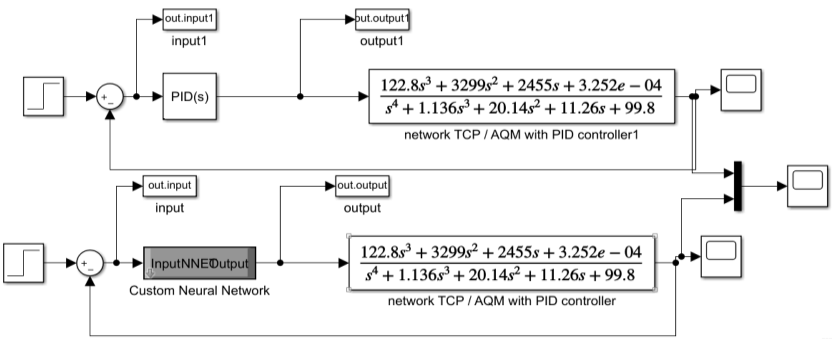


Figure 5. Simulation of networkwith PID controller and neural network atconstant q

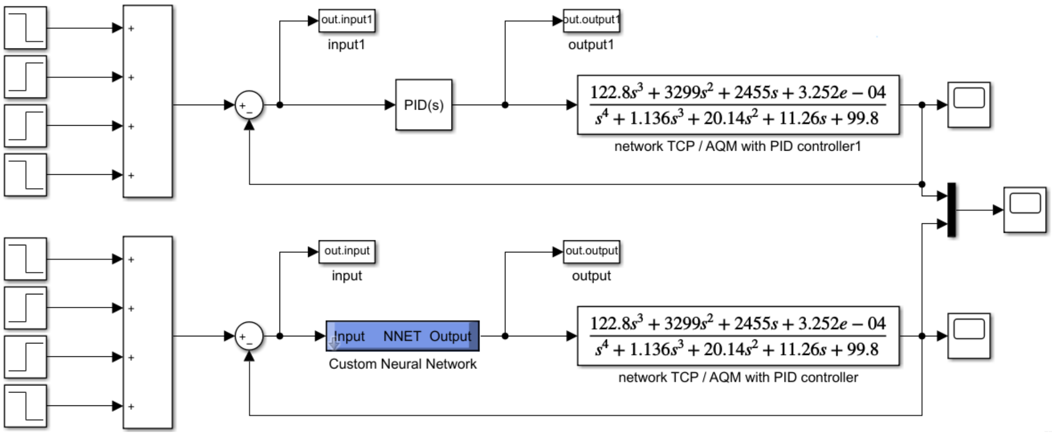


Figure 6. Simulation of networkwith PID controller and neural network at variable q

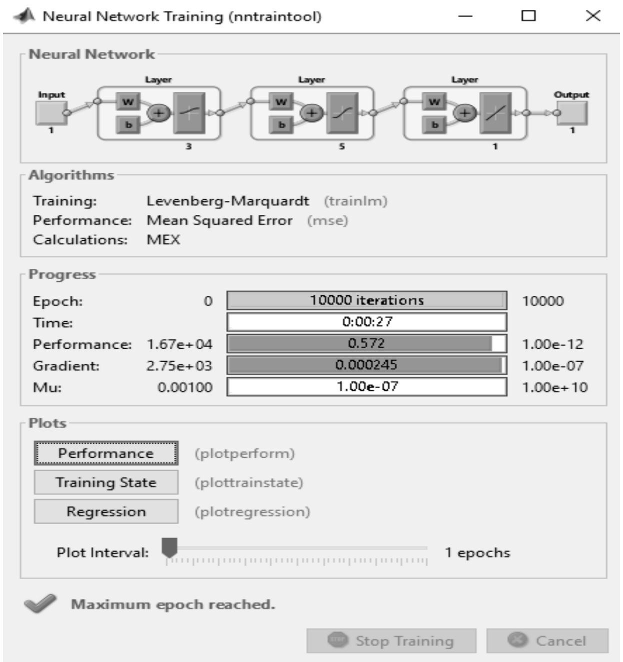


Figure 7. Training (nn train tool)

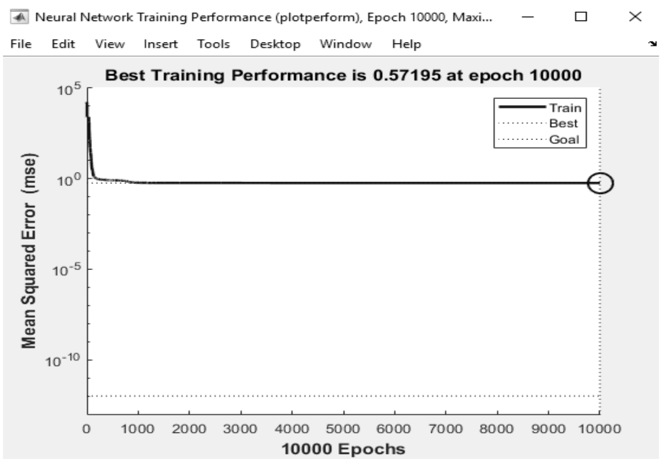


Figure 8. Training performance (plot perform)

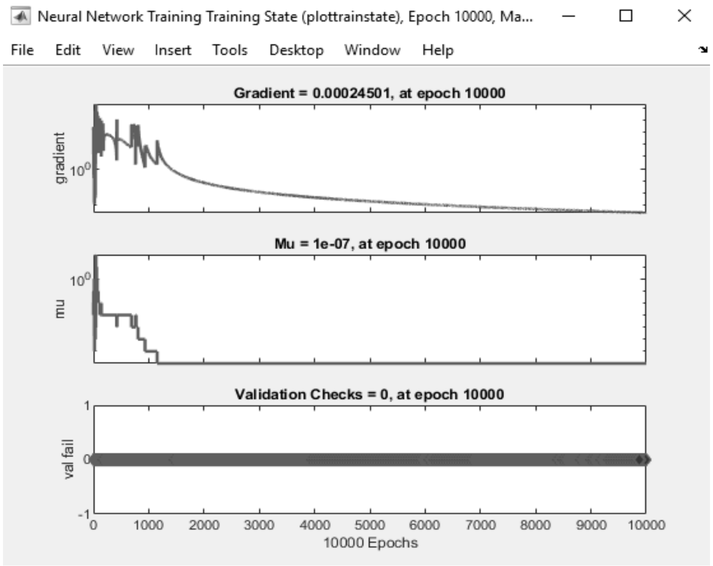


Figure 9. Training state (plot train state)

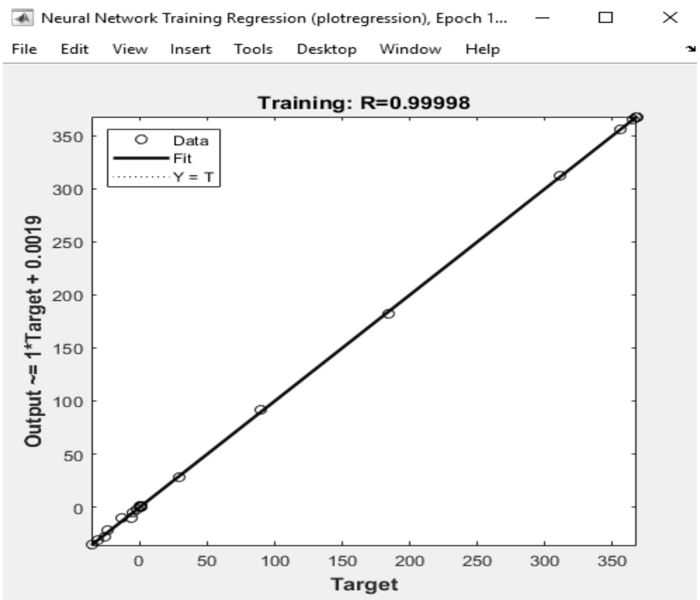


Figure 10. Training regression (plot regression)

3. SIMULATION RESULT OF WIRELESS NETWORK TCP/AQM

In this section, there are six test cases for simulating models in Figures 1-6 to obtain the results of simulating the behavior of a TCP/AQM wireless network with the proposed control systems. First, the simulation results of the TCP/AQM wireless network with the PID controller atconstant queue lengthusing the simulation model are shown in Figure 1 which shows the simulation results shown in Figure 11. Second with neural network atconstant queue length using the simulation model are shown in Figure 2 which hadresponse shown in Figure 12. Third with PID controller and neural network atconstant queue length using the simulation model are shown in Figure 3 which shows the simulation results shown in Figure 13. Fourth, the simulation results of the TCP/AQM wireless network with the PID controller atvariable queue length using the simulation model are shown in Figure 4 which hadresponseshown in Figure 14. Fifth with neural network atvariable queue length using the simulation model are shown in Figure 5 which shows the simulation results shown in Figure 15. Sixth with PID controller and neural network atvariable queue length using the simulation model are shown in Figure 6 which hadresponseshown in Figure 16.

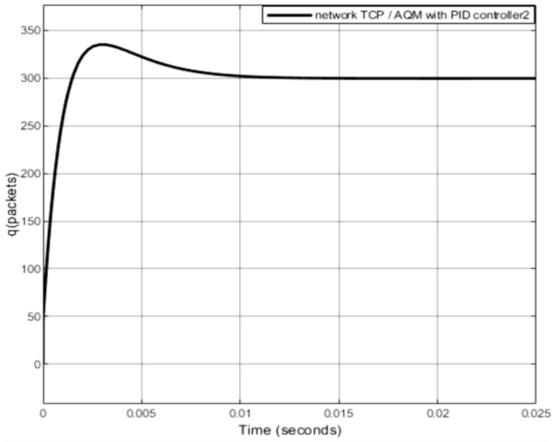


Figure 11. Response with PID controller at constant queue length

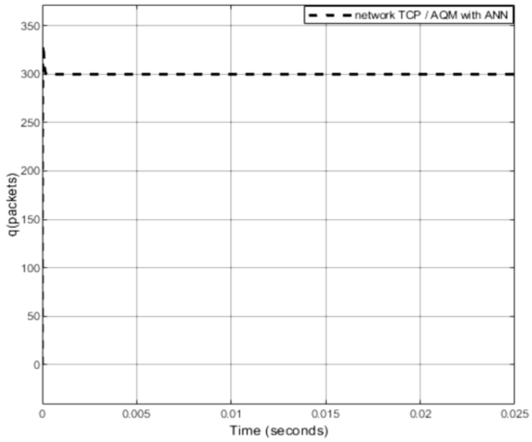


Figure 12. Response with neural network at constant queue length

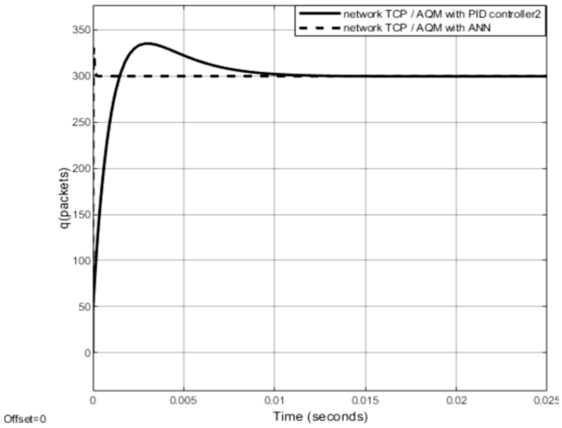


Figure 13. Response with PID controller and neural network at constant queue length

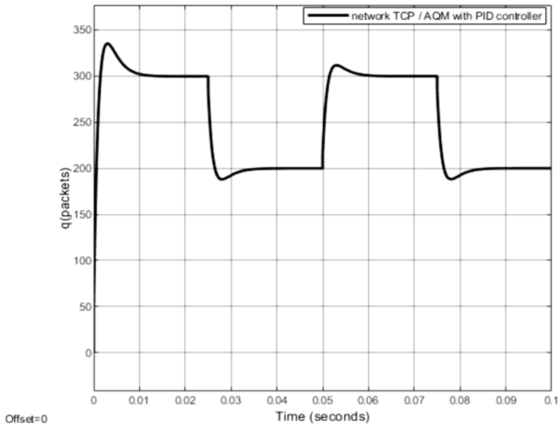


Figure 14. Response with PID controller at variable queue length

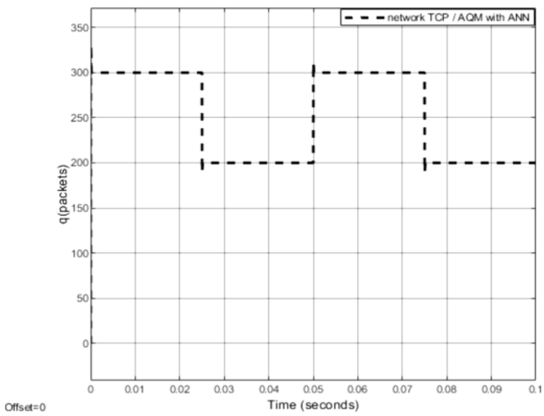


Figure 15. Response with neural network at variable queue length

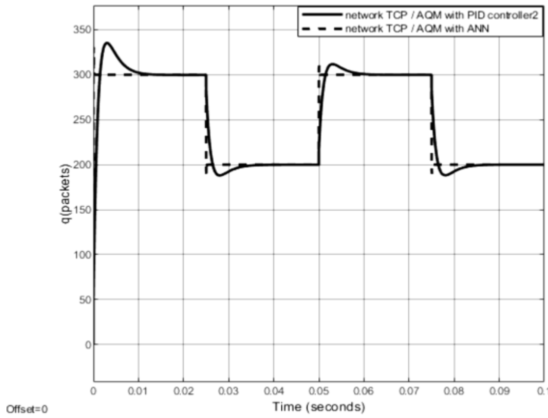
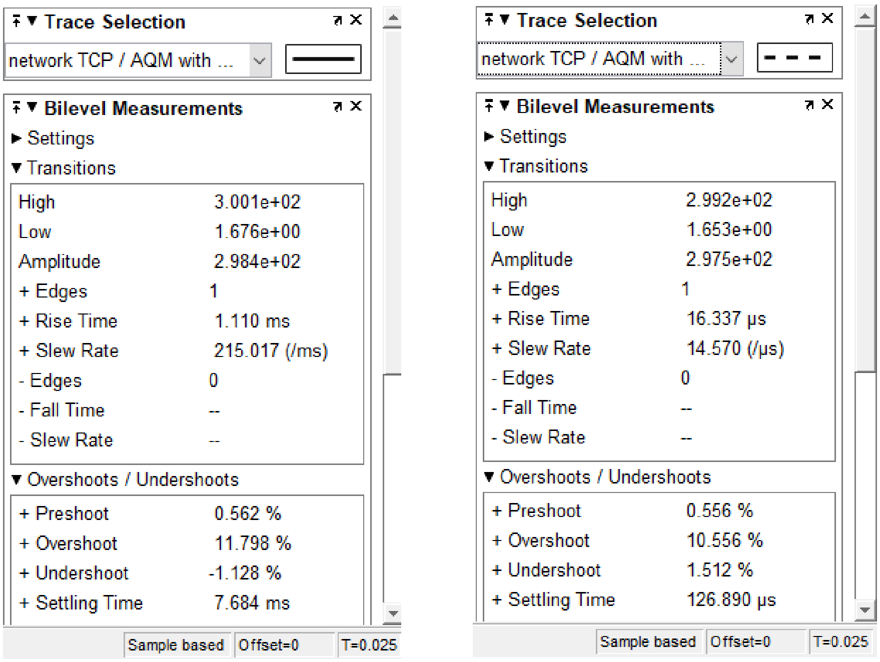


Figure 16. Response with PID and neural network at variable queue length

In the simulation results of wireless network TCP/AQM with PID controller and with neural network that like the overshoot for PID controller was equal 11.798% and with neural network equal 10.556% microsec.

Undershoot was equal for PID controller was equal -1.128% and with neural network equal 1.512%. Settling time for PID controller was equal 7.684 ms and with neural network equal 126.890 microsec. Rise time for PID controller was equal 1.110 ms and with neural network equal 16.337 microsec. The comparative between neural network and PID controller of TCP/AQM that show in Figure 17 that include two part, first the PID controller of TCP/AQM that show in Figure 17(a). Second the neural networkof TCP/AQM) that show in Figure 17(b). The response of TCP/AQM with neural network and PID controller that show in Table 2.



(a) (b)

Figure 17. Comparative between neural network and PID controller of TCP/AQM: (a) PID controller of TCP/AQM and (b) neural networkof TCP/AQM

Table 2. Response of TCP/AQM with neural network and PID controller

Controller Type	Rise Time	Overshoot	Undershoot	Settling Time
PID	1.110ms	11.798%	-1.128%	7.684ms
neural network	16.337 microsec	10.556%	1.512%	126.890 microsec

4. CONCLUSION

After conducting a simulation of the proposed system, which was represented by a model to enhance the reliability of the network by adopting methods of adding control to improve the performance of the network work. Its results show the advantage of using expert systems and overcoming traditional systems through response time, response speed, and over or under overrun rate. In the simulation results of the wireless TCP/AQM network with the PID controller and with the neural network that bypassing the PID controller was equal to 11.798% and with the neural network equal to 10.556% microseconds, which shows the speed of performance is better using the neural network as a controller compared to the traditional PID. Undershoot was equal for PID controller was equal to -1.128% and with neural network equal to 1.512% which shows faster performance using neural network as controller as compared to traditional PID, and settling time for PID controller was equal to 7.684ms and with neural network equal to 126.890 µs which The performance speed is better using the neural network as a controller compared to the traditional PID, and the rise time of the PID controller is 1.110 ms and with the neural network equal 16.337 microseconds, which shows the speed of performance is better using the neural network as a controller compared to the traditional PID. It showed better response speed, bypass rate and stability using the neural network as a controller compared to the traditional PID.

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