MULTIPLE NETWORKS SCHEME ANALYSES TO IMPROVE CONTROL SYSTEM BY USING TRUE TIME TOOLBOX

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ABSTRACT

NCS is the combination of control system with control loops that used to regulate feedback signals among system. With the promising research vogue in academic and industry domains stimulate the emergence and advancement of networked control system. In nonlinear systems one of the foremost altercates is communication delays and packet losses. In this paper we analyzed different network control schemes, data rates and other network parameters to investigate the performance of our control system in a comprehensive way. It is also demonstrated by simulations and practical experiments that the several network control systems can compensate for arbitrary communication data dropout to attain anticipated performance and loop stability. The results demonstrate that as the data rate increases, frame size becomes lower and path loss exponent is decreased. Moreover, the control system response can be improved by increasing transmit power and error coding threshold.

Keywords: *Network Control System, Stability Analysis, Wireless Network & Time Delay*

INTRODUCTION

Typical control system normally contains controller for industries that controlled process and some kind of input output channel generally a communication network (Young, 1964). The academic research and theoretical analysis on the performance of NCS communication network has been improved by the pre-set parameters of the control system. Such studies reduced NCS modeling and analysis carefully labeled and articulated to form a particular class of CSSs (Guo-Ping, Jian & Yun-Bo, 2013: Baillieul & Antsaklis, 2007). This fact is not shocking that during last few decay NCS gain more and more attention (Gupta & Chow, 2010). Although, due to the communication network limited bandwidth and simultaneously many users share the network. Overall System performance effect by some bad singularities, such as signal delay, packet loss etc that leads towards instability. In the manifestation of data packet loss and delay in transmission, several techniques have been suggested for NCS, For instance, methodology based on switching system (Chen, Zhang & Li, 2016; Yu, Wang & Chu, 2004) the fuzzy model approach and optimal control technique (Xiong & Lam, 2007; Imer & Yksel, 2006).

Consistent with the hypothetical analysis of NCSs, rudimentary emphasis of the control theory school of thought concerned with the synthesis problems. Remarkable efforts deliberate on extension of current control theory instead of comprehensive use of the NCSs physiognomies. To expect enhanced system performance the proficient use of predetermined parameter as a designable factor (Xiang & Jian, 2008; Liu, Xia & Rees, 2007). In this paper we propose a network model to obtain proper outcomes in simulation scheme to analyze this unpredictable behavior of the different network model and finding the closed loop response. The network types used in this article define particular communication rules that result in unique behavior of the data stream. Network delays or data loss may reduce in the real-time control loop. This is the key cause that we must incorporate network models into simulation scenarios to improve controller robustness and stability. In this article, we practice the real time toolbox as a simple and easy way to implement on variety of network types.

LITERATURE REVIEW

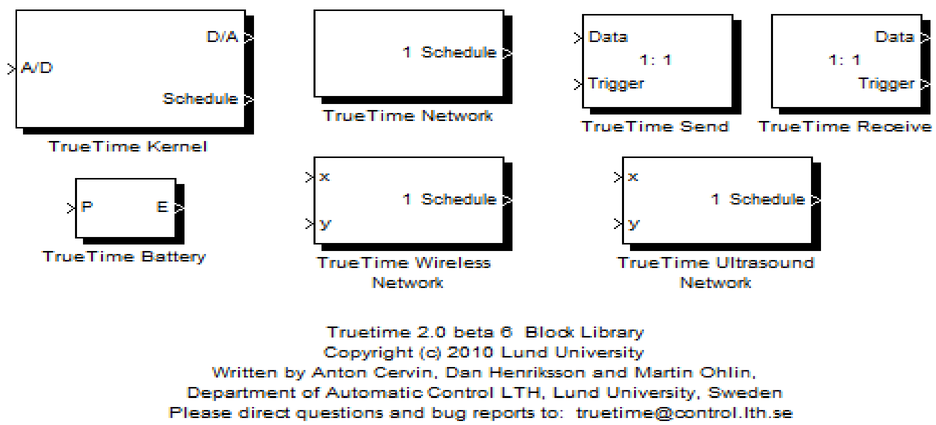
The origin of control systems linked to the famous physicist, Maxwell, when he conducted dynamics analysis of the centrifugal governor in 1868 (Maxwell). The next achievement was a conventional control system ensued by Wright brothers in 1903.The first form of analog NCSs was evaluated by Avro Vulcan in 1950s that was simplest and initial pattern of analog fly by wire flight control system. The next stage was introduced in 1975 that focus on distributed control system (DCS) by Honeywell and Yokogawa. In recent years' communication network technology have shown outstanding progress. NCSs condense system wiring and cost, system maintenance facilitate, and enhance system reliability and flexibility (Yang, 2006). Although limited bandwidth causes several problems such as packet loses, random delay and packet mess up (Zhang, Gao & Kaynak, 2013), that leads towards degradation and instability of NCSs. Control of Network and control over network dual parts of NCS. There are two main categories comprises remote control systems and shared network control system of control over network which use by communication networks. The Specification, benefits, and appropriateness of each connection category are diagrammatically illustrated by (Chow & Tipsuwan, 2005).

This manuscript emphasis on closed loop system response. CLS is described as a system where a controller, match the output with a specific condition and change the error into a control action that is designed to minimize the error. Control theory perspective NCSs effects in communication network roughly speaking there are three distinct features namely, the packet-based transmission, network topology and the limited network resources (Stallings, 2000). The network delay effect discussed by using Ture time Toolbox a simulation tool to create a simulation model. It is concluded that NCS performance improve by reduced forward delay proportion from the total delay (Aung & Naing, 2015). Three different types of Network model examined with several parameter and scenarios.

True Time Tool Box

True Time is a real-time control scheme simulator that is based on Mat lab and Simulink. In the real time circumstances this toolbox simplifies controller mission execution, network broadcast transmission and non-stop plant dynamics in real time. This toolkit includes general purpose networks such as switched Ethernet, CAN, round robin TDMA, FDMA. It also provides support for battery powered devices and analog wireless systems.

Figure. 1. True time Block library

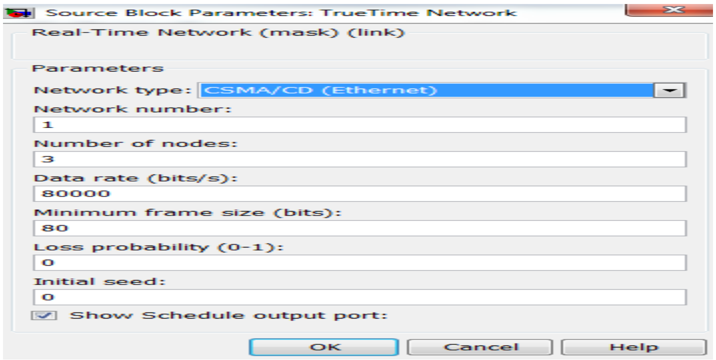


True Time Network Block

In the local network the real time network module simulates the broadcast data packets. When the device desires to transmit data, the "start of transmission" signal is signaled in the network block of the corresponding input channel and the information pass through. On the output channel after the transmission is complete, the "Transfer Complete" signal. The transmitted message is stored in the device's buffer. The message holds information about sender and receiver message data, optional real-time parameters and the data length. The real time network supports six modes of network, containing Ethernet, token bus round robin, CSMA (CAN), CSMA (CD), FDMA and TDMA. Often, the delays triggered by network propagation are not considered as they are usually ignored in the local network. Simulation is only supported at the packet level. More advanced protocols in the kernel should split the message into packets.True time network parameters:

- Number of nodes
- Minimum frame size (in bits)
- Pre-processing delays (s)
- Post-processing delays (s)
- Data rate (bits/s)
- Loss probability (0-1)
- Network number

Fig. 1.1 Source block parameters for a true time network.



RESEARCH METHODOLOGY

In our proposed methodology we analyze three type of Network model including CSMA/CD, CSMA/AMP and 802.11b/g network model by using different types of parameter depend on the characteristics of the network model. Our proposed system based on True time toolbox simulation used to find the results and findings on closed loop response. We suggested a second order system and controlled it with PD controller while our reference signal is a square wave of amplitude 1. Transfer function of Second Order continuous time system is:

$$G(s) = \frac{1000}{s^2+s} \qquad (1)$$

The proportional integral derivative implementation also called PID controller allowing to the resulting equations.

$$P(k) = K\big(r(k) - y(k)\big) \qquad (2)$$

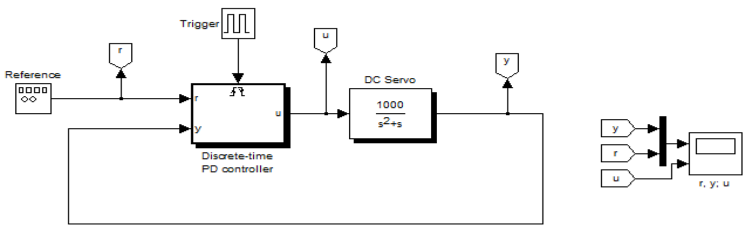
$$I(k+1) = I(k) + \frac{Kh}{T_i}(r(k) - y(k)) \qquad (3)$$

$$D(k) = \frac{T_d}{Nh+T_d}D(k-1) + \frac{NKT_d}{Nh+T_d}(y(k-1) - y(k)) \qquad (4)$$

$$u(k) = P(k) + I(k) + D(k) \qquad (5)$$

The controller parameters for closed loop bandwidth of $w_c = 20\, rad/s$ and a relative damping of $\zeta = 0.7$.We have implemented a PD controller with parameters as K=1, h=0.010, Td=0.04 and N=100. The closed loop system response without network model is shown in figure below.

Figure 1.2. System response without N/W Model



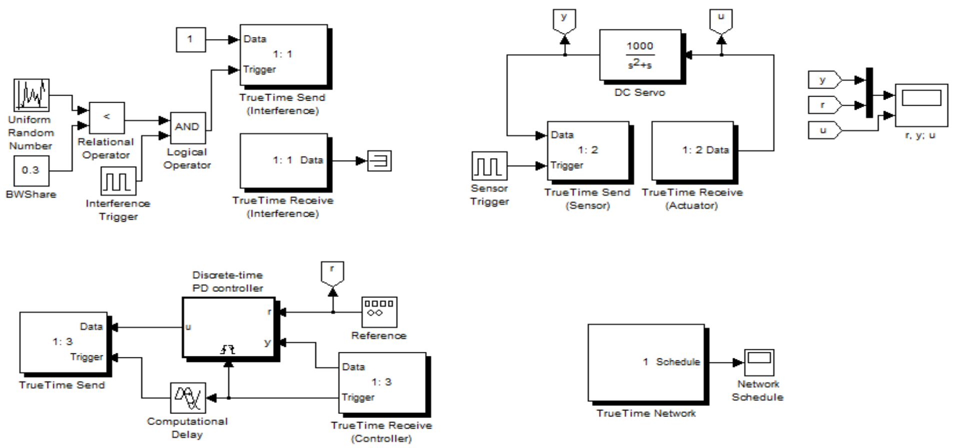
Closed Loop System Response with (CSMA/CD)/(Ethernet) Network Model

In this model after situation of bump will generate when two or many nodes will be in waiting condition for the cable to be idle when the network is engaged, the sender will be in waiting position till it manifestation to be free. When a pileup situation generate, the sender will back off for a time defined by

$$t_{backoff} = {}^{minimum\ frame\ size}/_{data\ rate} \times R$$

Where $R = rand(0, 2^K - 1)$ (discrete uniform distribution) and K is the collision number of a row. After waiting, the node will attempt to retransmit. The closed loop system response with CSMA/CD NETWORK MODE is shown in the following figure.

Figure 1.3 System acknowledgement with N/W Model



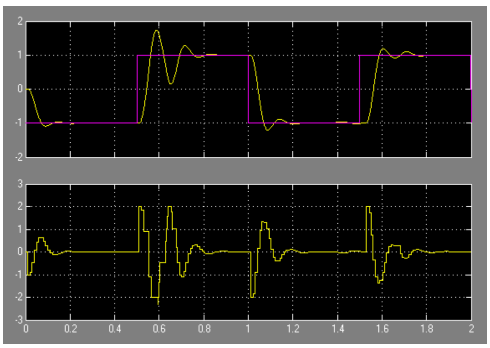


Figure 1.4 System response with CSMA/CD Network scheme Data rate 80000 bits/s frame size 80 bits with 0 loss probability.

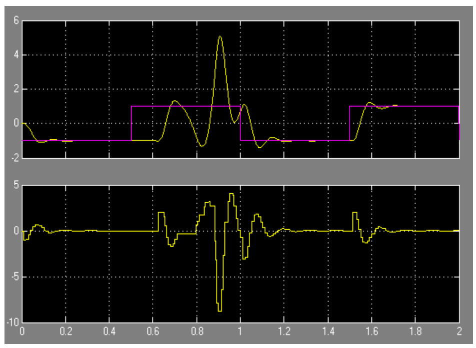


Figure 1.5 System response with CSMA/CD Network scheme Data rate 80000 bits/s frame size 100 bits with 0 loss probability.

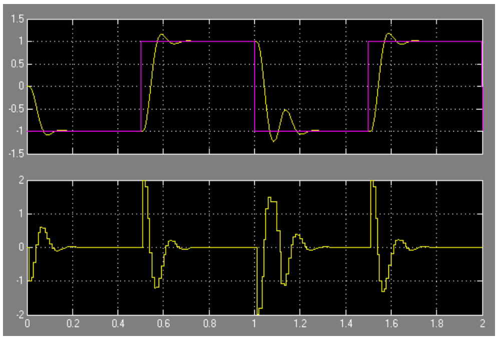


Figure 1.6 System response with CSMA/CD Network scheme Data rate 100000 bits/s frame size 80 bits with 0 loss probability

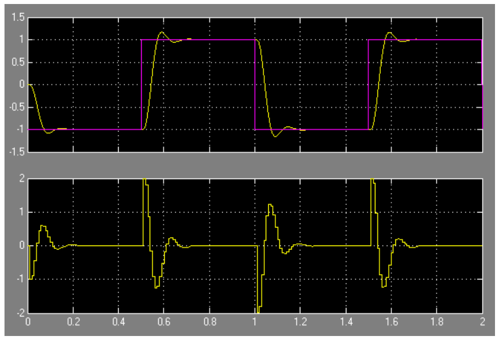


Figure 1.7 System response with CSMA/CD Network scheme Data rate 100000 bits/s frame size 10 bits with 0 loss probability

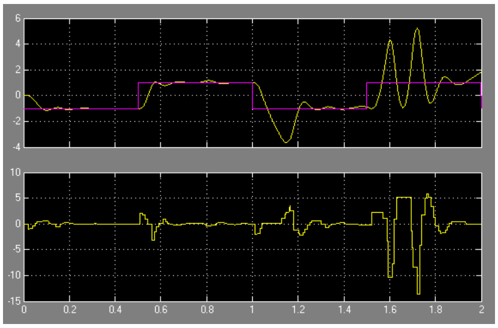


Figure 1.8 System response with CSMA/CD Network scheme Data rate 80000 bits/s frame size 80 bits with 0.1 loss probability

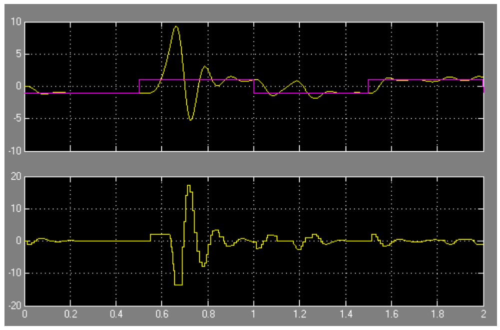


Figure 1.9 System response with CSMA/CD Network scheme Data rate 50000 bits/s frame size 10 bits with 0 loss probability

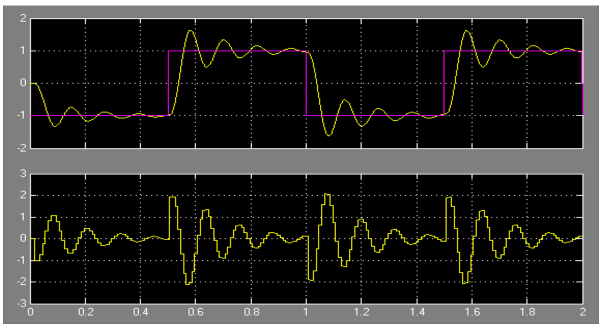


Figure 1.10 System response with CSMA/CD Network scheme Data rate 20000 bits/s frame size 80 bits with 0 loss probability and only 2 nodes are communicating in the network

Closed Loop System Response with CSMA/AMP Network Model

In our CAN network the sensor is given the first priority then controller output and on last disturbance is given 3rd priority. The system response for different parameters is as follows:

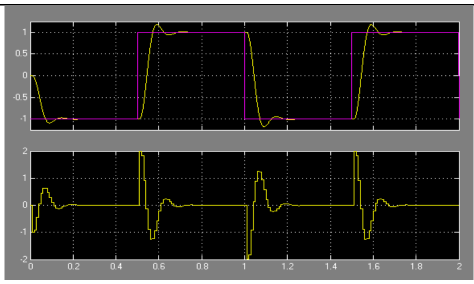


Figure 2.1 System response with CSMA/AMP Network scheme Data rate 80000 bits/s frame size 80 bits with 0 loss probability.

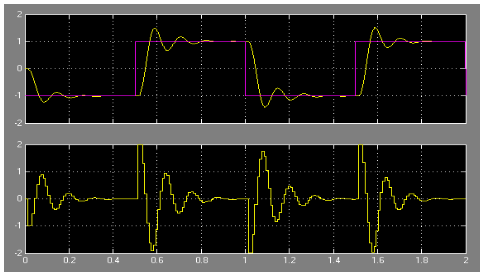


Figure 2.2 System response with CSMA/AMP Network scheme Data rate 80000 bits/s frame size 150 bits with 0 loss probability.

Closed Loop System Response with 802.11b/g (WLAN) Network Model

Now a days IEEE 802.11b / g protocol is used for each and every laptops and mobile devices. The protocol has been modified based on CSMA/CA. In the proposed simulation, the package is modeled as follows: The node is found free during transmission proceeding and stayed at 50 us, the transmission may be done. If you find that the media is engage, select and reduce the random back off time, the same as when the conflict. In the same network after node begins to send its comparative location to entire additional nodes, according to the path loss formula the signal level in all of these nodes is considered. $1/d_a$

Reference node does not distinguish between the news of its conflict, so the ACK message is sent in the MAC protocol layer. Transport node's point of view, message collisions and lost messages are similar. Uncertainty ACK is not established throughout the entire ACK break before the message resent by waiting for any back-off time within the dispute window. The size of the dispute window is twice the size of each message retransmission. If the media is occupied, or less than 50 idle, the back-off timer stops. Until, sender abandons the message, only retransmissions limit the number of retransmissions and are not retransmitted.

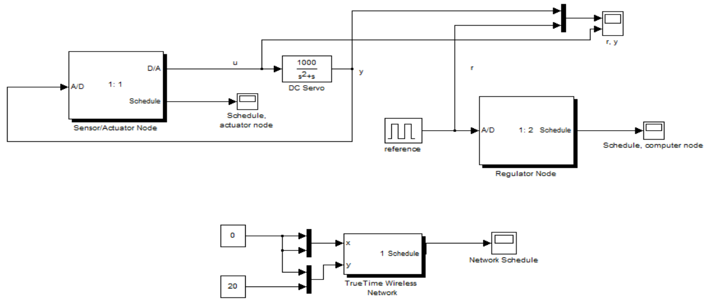
$$d = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2} \qquad (6)$$

Parameters of Wireless Network Block:

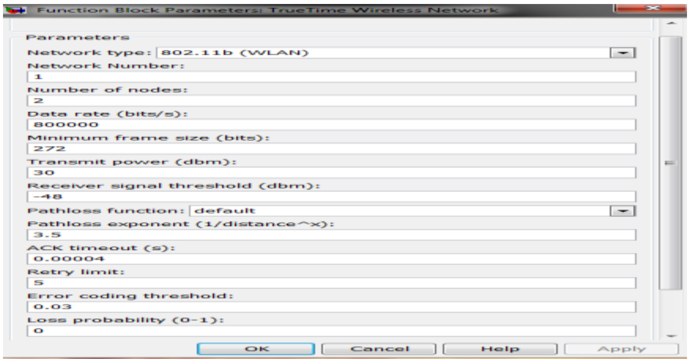
- Number of nodes
- Minimum frame size (in bits)
- Data rate (bits/s)
- Path loss exponent
- Network number
- Transmit Power
- Receiver Signal Threshold
- ACK timeout
- Retry limit
- Error Coding threshold [0,1]

The closed loop system response with *802.11 b/g network model* is shown in the following figure.

Figure 3.1 System acknowledgement with WLAN N/W Model



A. Reference Signal is set as square wave of amplitude 1 and other parameters of wireless network are set as:


Function Block Parameters: TrueTime Wireless Network

Parameters
Network type: 802.11b (WLAN)
Network Number:
1
Number of nodes:
2
Data rate (bits/s):
800000
Minimum frame size (bits):
272
Transmit power (dbm):
30
Receiver signal threshold (dbm):
-48
Pathloss function: default
Pathloss exponent (1/distance^x):
3.5
ACK timeout (s):
0.00004
Retry limit:
5
Error coding threshold:
0.03
Loss probability (0-1):
0

OK Cancel Help Apply

The coordinates x and y for nodes are set as (0,0) for node 1 and (0,20) for node 2.

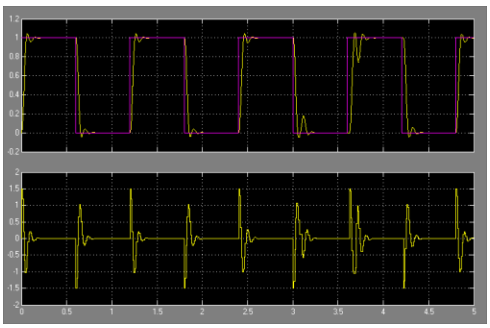


Figure 3.2 System response with 802.11b/g WLAN Network scheme Data rate 800000 bits/s frame size 272 bits with 0 loss probability, path loss exponent as 3.5,error coding threshold 0.03.

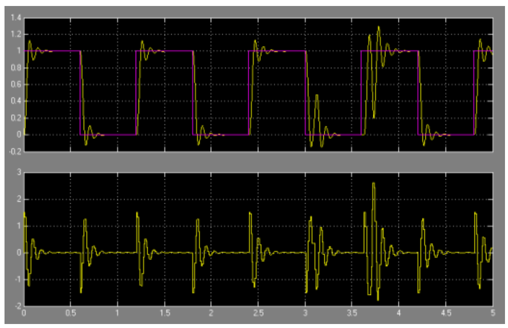


Figure 3.3 System response with 802.11b/g WLAN Network scheme Data rate 200000 bits/s frame size 272 bits with 0 loss probability, path loss exponent as 3.5,error coding threshold 0.03.

RESULTS AND DISCUSSION

In Ethernet/(CSMA/CD) network model by increasing the data rate of our proposed network scheme improves the control response of the system while decreasing it results in large overshoot of our system and oscillatory behavior. If we decrease the frame size of the system back off time after collision decrease which results in timely control action and increasing robustness of the system. More over the third parameter of the system packet loss probability also degrade the system response. Increasing nodes in the network also degrade performance of control system due to Bandwidth sharing.

In CSMA/AMP NETWORK MODEL increasing the data and prioritizing the important parts of the control system improves the performance decreasing the frame size does not affect the system output as there is no back off time after collision in this network scheme. Although increasing the frame size increase the delay and system response degrade. Bandwidth sharing does not effect as much as CSMA/CD because the important components of the control system has high priority. In 802.11b/g (WLAN) Wireless network scheme increasing data rate lowering frame size, decreasing path loss exponent, increasing transmit power and error coding threshold improves the control system response while increasing loss probability decreasing ACK timeout and decreasing receiver signal threshold impact negatively on control response and robustness.

CONCLUSION

Due to wide range of numerous advantages and widespread applications of NCS real time implementation and closed loop system response of several network model investigated in this paper. The analysis based on the characteristics of network has been discussed in detailed on the basis of different parameter such as number of nodes, frame size, process delay .data rate and control system response. The control network stability can be enhanced by some other tactics such as switch system and switch delay system methods. Practical experiments and simulation result illustrated that proposed scheme compensated for random network communication data dropout and achieved desired results.

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