TNC Controller Influence on Transmission Delays in Packet Radio Network

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Abstract: TNC controllers are microprocessor-based circuits made for Packet Radio network. This paper presents the results of transmission start and end delays in an experimental Packet Radio network with the use of various types of TNC controllers. These results are compared to the analytical results obtained using a previously developed analytical model of TNC controller. Presented considerations may help in analysis of TNC controller application possibilities in certain time-bounded applications.

Keywords: communication networks, communication protocols, embedded systems

1. INTRODUCTION

Packet Radio network (Karn et al., 1985) may be considered as an example of a simple, wireless wide area network. It was created in the early 1980's, when other currently popular means of communication, such as Internet network and cellular telephony, were not widely available yet. Unfortunately, as a deed of radio amateurs, Packet Radio network was never a popular solution, which may be acknowledged by a small number of literature covering this subject. Nowadays, because of high popularity of Internet, cellular telephony and wireless LANs, it application evolves – existing infrastructure is used as a transmission medium for amateur telemetry and remote control networks, working according to APRS (*Automatic Position Reporting System*) protocol requirements (Wade, 2000).

A complete Packet Radio network station consists of a computer (or other DTE device) and radio transceiver (Dąbrowski, 1994). Because of different methods of information exchange, these devices can't cooperate with each other directly. It is therefore necessary to apply specific data format processing techniques. It can be performed entirely within a computer or by attachment of external devices. An example of such a device is TNC (*Terminal Node Controller*).

In previous works, an analytical model of AX.25 protocol, used as a data link layer in Packet Radio network, has been presented (Zieliński, 2008). This model allows estimate the influence of individual protocol parameters on its performance, and, what follows, effective throughput observed by a user. An analytical model of TNC controller has also been presented (Zieliński, 2009a). This model allows estimate the influence of TNC controller on effective throughput or transmission delays in the network. It also allows estimate minimum buffer capacity necessary to fulfil expectations of some applications in certain conditions. In this paper, measurement results of transmission delays in a real, experimental Packet Radio network are presented. They may be treated as an attempt to verify the aforementioned analytical model of TNC controller.

The rest of the paper is organised as follows. First, the analytical model of transmission using TNC controllers is briefly presented and transmission delays are defined. Next, experimental Packet Radio network is described and TNC controller types used in tests are characterised. Finally, experimental results achieved for various controllers are presented and analysed.

2. THEORETICAL ANALYSIS

The analysis of TNC controller operation (Zieliński, 2009a) concerns the case of information transmission between two computers (or other devices), connected with a pair of TNC controllers. In this case – due to buffering of transmitted data and processing of their format – transmission runs in several stages. The network configuration together with transmission stages is presented on fig. 1.

For the purpose of the analysis, let's assume that transmission is performed under perfect conditions. Thus, let's accept the following assumptions:

- the network consists of only two stations, communicating via half-duplex link,
- transmission is free from collisions and transmission errors, thus no retransmissions are necessary,
- frame processing time within TNC is negligible.

The last condition is accepted in order to define a "perfect" TNC controller. Thus, the difference between estimated network achievements and measurements done in an experimental network may be treated as a quality measure that allows compare various types of TNC controllers.

2.1 Transmission Time and Throughput in AX.25 Protocol

Transmission time via wireless link (between TNC controllers) corresponds to transmission using AX.25 protocol. Let's accept the following notations:

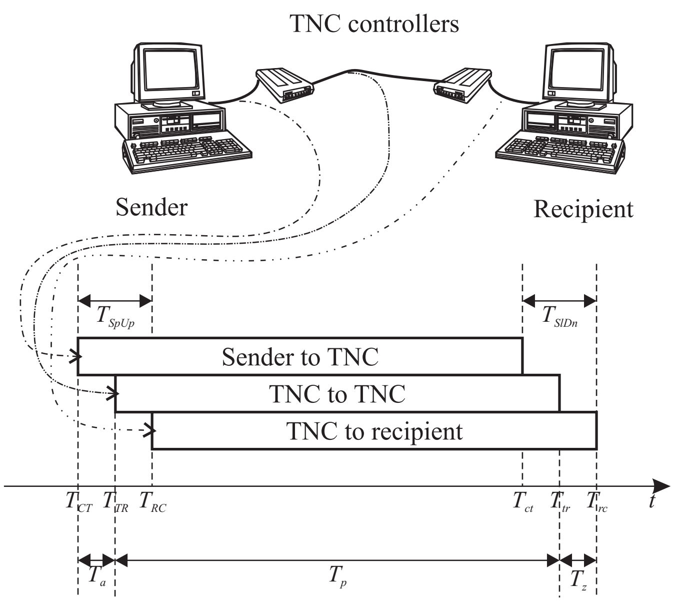

Fig. 1. Network configuration and transmission stages

- k – window size, i.e., maximum number of commonly acknowledged frames (range 1 to 7),
- N_1 – maximum capacity of data field in an information or unnumbered frame (range 1 to 256),
- T_2 – time that elapses between the end of latest information frame and acknowledge; depending on software and parameters, this delay may or may not occur during transmission and may be set manually or automatically;
- T_{103} – time for stabilisation of transmitter parameters after transmission start and for carrier detection in receiver; depends on radio transceiver capabilities and, in most cases, varies from few tens to few hundreds milliseconds;
- T_{102} – slot duration for carrier sense-based collision avoidance; typically about 50 to 300 ms;
- p – persistence parameter of carrier sense-based collision avoidance (not defined by protocol description but implemented in most of the software); typically equal to 63 which means transmission probability of 25%;
- R_w – wired link (RS-232) transmission rate;
- R_{wl} – wireless link (AX.25) transmission rate.

In the case of half-duplex link, transmission time of the L_D-bytes long data equals to (Zieliński, 2008):

$$T_p = \left\lceil \frac{L_D}{k \cdot N_1} \right\rceil (T_2 + T_{CS} + T_{103} + T_{RR}) + \left\lceil \frac{L_D}{N_1} \right\rceil T_I, \quad (1)$$

where T_{RR} – acknowledge transmission time:

$$T_{RR} = \frac{63}{62} \frac{160}{R_{wl}} \quad (2)$$

and T_I – information frame transmission time:

$$T_I = T_{RR} + \frac{63}{62} \frac{8N_1}{R_{wl}} = \frac{63}{62} \frac{160 + 8N_1}{R_{wl}}. \quad (3)$$

In (1), T_{CS} is carrier sense time, which, in perfect conditions, may be simplified to the average:

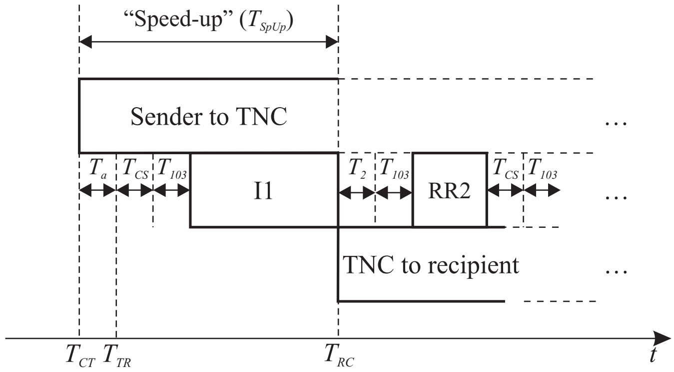

Fig. 2. Explanation of "speed-up" time (T_{SpUp}) calculation

$$T_{CS} = \frac{256 T_{102}}{2(p+1)}. \quad (4)$$

Knowing T_p, we can estimate effective throughput of the wireless link operating according to the rules of AX.25 protocol:

$$V_{wl} = \frac{8L_D}{T_p}. \quad (5)$$

AX.25 protocol, however, is used only between the TNC controllers. In the considered network, we must also take into account transmission time between TNC controllers and computers using serial RS-232 port. Effective throughput of this link – assuming that each character is represented by 10 bits – equals to:

$$V_w = \frac{8R_w}{10}. \quad (6)$$

2.2 Transmission Delays

In certain applications, not only effective transmission speed may be important, but also delays resulting from buffering and format processing of transmitted data. It is particularly interesting how much time elapses between transmission start at the sender and reception start at the recipient, and how much time elapses between transmission end at the sender and reception end at the recipient. We will refer these times as transmission start and transmission end delays, respectively.

Transmission Start Delay. Transmission start delay, corresponding to the "speed-up" phase shown on fig. 1, is equal to the sum of transmission times of N_1 characters via the wired link and a single information frame via the radio link, including carrier sense and transmitter start-up times. It is thus equal to

$$T_{SpUp} = \frac{10N_1}{R_w} + T_{CS} + T_{103} + \frac{63}{62} \frac{160 + 8N_1}{R_{wl}}. \quad (7)$$

The explanation of (7) is shown on fig. 2. Transmission start delay does not depend on the relation between effective throughput of wired and wireless link.

Transmission End Delay. Transmission end delay, corresponding to the "slow-down" phase shown on fig. 1, is much more difficult to estimate. It results from information buffering in TNC controller memory. When the