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CORRECTION AND RETRANSMISSION OF DISCRETE DATA PACKETS IN REAL TIME CONTROL SYSTEMS

BY

LILIANA VORNICU-ALBU[*] and LUMINIŢA SCRIPCARIU

“Gheorghe Asachi” Technical University of Iaşi
Faculty of Electronics,Telecommunication and Information Technology

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Abstract. In this paper we will present a deterministic method for accurate correction and retransmission of discrete data packets as an alternative to the traditional probabilistic approaches in the communications area. We have chosen an algorithm that can be used for correction and retransmission of the initial constrained data packets and also for the correction and retransmission of data packets without initial constraints. At the initial transmission time we assume noiseless data and no other type of interference. So, the correction for discrete data packets is made in a proper way and data will be received without errors at the final station. The latency is reduced so the method can be used for communication in real time control systems.

Key words: error correction; retransmission; real time; control system.

1. Introduction

In the communication area, the topic of data correction, reconstruction and retransmission is based almost entirely on a stochastic formulation of the various problems involved (Lehocsky, 1991).

In this paper, we present a deterministic framework for an optimal correction, reconstruction and retransmission of discrete data packets, as an alternative that can be explored based on robust control ideas and formula about

[*]Corresponding author: *e-mail*: lvornicu@etti.tuiasi.ro

the correction blocks on the communication channels and the proper algorithm chosen for the system blocks design.

A real time communication system is defined as a system whose correctness is dependent on the calculated logical algorithm solutions (Vornicu & Dimitriu, 2000).

Some of the particular problems touched upon in this paper are the following:

1. Some of data packets have initial constraints established by the designer due to the communication system that will be used;

2. The level of the noise and EMI (electromagnetic interference) can affect the transmission operation and also can have a major influence on the discrete data packets;

3. A proper algorithm must be chosen for the data correction reconstruction and then the retransmission to the final station;

4. Performance optimization under channel uncertainly and combined procedure and estimation optimization under the initial power constraints;

5. The reception without errors at the final station, for a proper correction, a minimal transmission time and latency on the channel.

All these topics are relevant to standard themes in communications such as correction blocks design and equalization, receiver design and transmission channel (Vornicu, 2002a) which are traditionally dealt from the deterministic point of view.

The proposed method is the proper one mainly because it addresses the question of when perfect correction and retransmission of a discrete data is possible if the magnitude of the noise and EM interference is allowed to be anything as long as it is bounded by an *apriori* known bound. In other words, if these conditions are violated, an error will occur.

Certain constructions of optimal algorithms are provided. Some of them tie to the optimal control theory for the transmission problems.

To design such a correction real time system, it is necessary first to make a general analysis and then to consider all the factors that can be important in the system's functioning. These factors are the following: medium conditions (established by the designer), the initial constraints at different moments of time, such as the central processor transmissions to different measuring points, video transmissions or communication transmissions, medium perturbations (Vornicu, 2002a).

After the new hardware technologies have been developed, it was possible to run a real time system on general high- speed workstations, or on personal computers, respecting the contention principle (Vornicu & Dimitriu, 2001).

The paper is organized in five sections. Section **2** presents the schema of the system used to correct and retransmit data packets. Section **3** outlines the proposed solution which can be applied to correct error transmission in data packets, while section **4** describes the error correction algorithm, for two different transmission cases: with and without initial constraints. Finally, some conclusions are emphasized in section **5**.

2. System Definition

In the following, we will consider a system that has to allow the correction and retransmission for discrete data packets, as it is described in Fig. 1. At the initial transmission time t = 0, we assume that discrete data packets have no electromagnetic interference (EMI) or other types of interference.

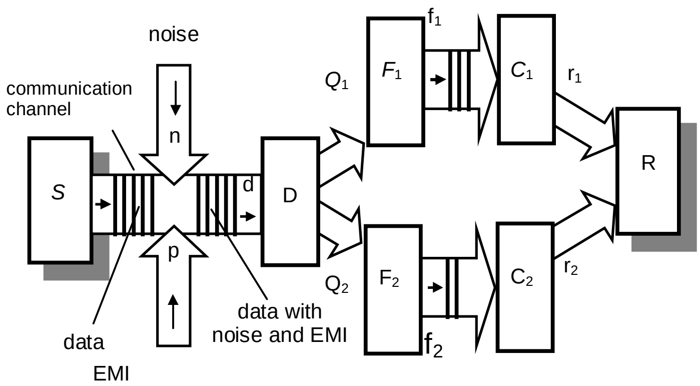

Fig. 1 – System principle schema.

During the transmission on the channel, noise and EM interference are added. These occur from others communication channels or medium interference.

The system contains the following blocks: S represents the source of discrete data packets that have to be transmitted. Some of the data have initial constraints and the others data packets have not initial constraints. We note that the initial constraints depend on the application in which discrete data are involved and also depend on the real time system designing and the communication channel. These initial constraints are refer to the transmission time, period, deadline, latency (latency is considered to be the time interval between the initial transmission time t = 0 and the time when data without errors arrive at the receiver); D is a decision block that analyses the data packets and divides them into two queues: the first queue is denoted Q_1 and contains data with initial constraints and the second queue is denoted Q_2 and contains data without initial constraints; F_1 and F_2 are filters. The principle schema includes two correction paths, one for data packets with initial constraints and another for those data packets transmitted without initial constraints. F_1 is a high level filter, designed to match the initial constraints of data and F_2 is a filter designed for data without initial constraints. The system designer, due to the type of data and the followed purpose, has to choose two different filters. Usually, for the constraint data, the designer has to choose F_1 as a superior rank filter, with steep slope. F_2 can be an active LPF (Low Pass Filter). After the filtering operation, each of two queues has to be corrected by two correction blocks, C_1 and C_2 respectively. Finally, the two data streams are concatenated and transmitted to the receiver; R is the final receiver block which extracts data and discards the unnecessary symbols.

3. The Proposed Problem Solution

We assume that $s = \{s_1, s_2 \dots s_k\}$ represents the discrete data packets to be transmitted on the communication channel. Some of the packets have initial constraints, some others not (Vornicu, 2002a).

Suppose there are $\{s_1, s_2 \dots s_j\}$, where $j \le k$ packets with initial constraint. Consequently, data packets without initial constraints will be the rest of them, denoted $\{s_{j+1}, s_{j+2} \dots s_k\}$.

The initial constraints such as the transmission time and latency are imposed by the real time system or the communication channel. Other constraints, such as period and deadline, depend on the data type. We assume that initial constraints are defined as follows:

The set of constrains is $C = (c_1, c_2 \dots c_j)$, where $c_1 = (c_{11}, c_{12} \dots)$ corresponds to s_1 data packet, $c_2 = (c_{21}, c_{22} \dots)$ corresponds to s_2 data packet and $c_j = (c_{j1}, c_{j2} \dots)$ corresponds to s_j data. Each data with initial constraints must satisfy them and have to be received to the final station with all these constraints and also without transmission errors.

On the transmission channel data meet the noise and EM interference. Consequently, at the decision block arrive the following sequence:

$$d = (s_1 + c_1, s_2 + c_2 \dots s_j + c_j, s_{j+1}, s_{j+2} \dots s_k) \cup n \cup p,$$

where n is the noise sequence on the communication channel and p denotes the EM interference.

The decision block splits the sequence d into two parts d1 and d2 and sends them through two queues Q_1 and Q_2, respectively.

The proper algorithm is described as it follows:

a) initialize the system S to be able to transmit data without errors: $s = \{s_1, s_2, \dots, s_k\}$;

b) set the initial constraints: $c = \{c_1, c_2 .., c_j\}$;

c) set the combined data sequence of packets, with and without constraints: $s' = s \cup c = \{s_1, s_2 \dots s_j, s_{j+1} \dots s_k\} \cup \{c_1, c_2, \dots, c_j\} = \{s_1 + c_1, s_2 + c_2 \dots s_j + c_j, s_{j+1}, s_{j+2}, \dots s_k\}$;

d) send data s' on the communication channel;

e) set the received sequence affected by interference: $d = s' + n + p$;

f) split d into two sequences: $d_1 = \{s'_1, s'_2 \ldots, s'_j\} \cup n \cup p$ and $d_2 = \{s'_{j+1}, s'_{j+2}, \ldots, s'_k\} \cup n \cup p$;

g) clean data sequences, d_1 and d_2, by passing them through the filters F_1 and F_2, respectively. The corresponding outputs will be f_1 and f_2;

h) send data to the correction blocks, C_1 and C_2;

i) retransmit data without errors to the receiver R.

4. Algorithm Description

We consider two sequences s_j and $s_{j+1,}$ where $j+1 \leq k$ are indistinguishable at the transmission time t if and only if $s_j(m) \neq s_{j+1}(m)$ for some $0 \leq m \leq t$ and there exists n_1 and n_2 such that:

$$d\ (n_1) \neq d\ (n_2) \text{ at any time } t.$$

The system has a real time solution if and only if there are no sequences s_l and s_{l+1} indistinguishable at the time $l = 0, 1 \ldots$

First, we must initialize the system to transmit the discrete data packets and the proper constraints. Then the system will send the discrete data packets on the communication channel and will also make the difference between initial constraints for each data packet. After this, there will be two different types of data, with initial constraints or without initial constraints.

Each type will be transmitted after error correction and packets reconstruction. The receiver will finally have the correct discrete data packets.

The flowchart of the proposed algorithm is given in Fig. 2.

5. Conclusions

The described method presents a deterministic formulation for various communications transmitting problems and provides a solution based on error correction techniques and some filter blocks insertion on the communication channel (Dimitriu & Vornicu, 2001; Deng *et al*., 1997).

It is easier to correct data on the communication channel instead to receive it at the final station and then to correct it.

Using the described method, the transmission time is substantially reduced and also data is received without errors (Vornicu, 2002b; Vornicu, 2003). The latency is minimized due to the applied algorithm.

The presented system intended for correction, reconstruction and retransmission of error free data packets, can be used for any communication channel that is affected by noise and any others medium interference, such as EMI.

The system designer must choose the proper algorithm for filter construction depending on the transmission conditions.

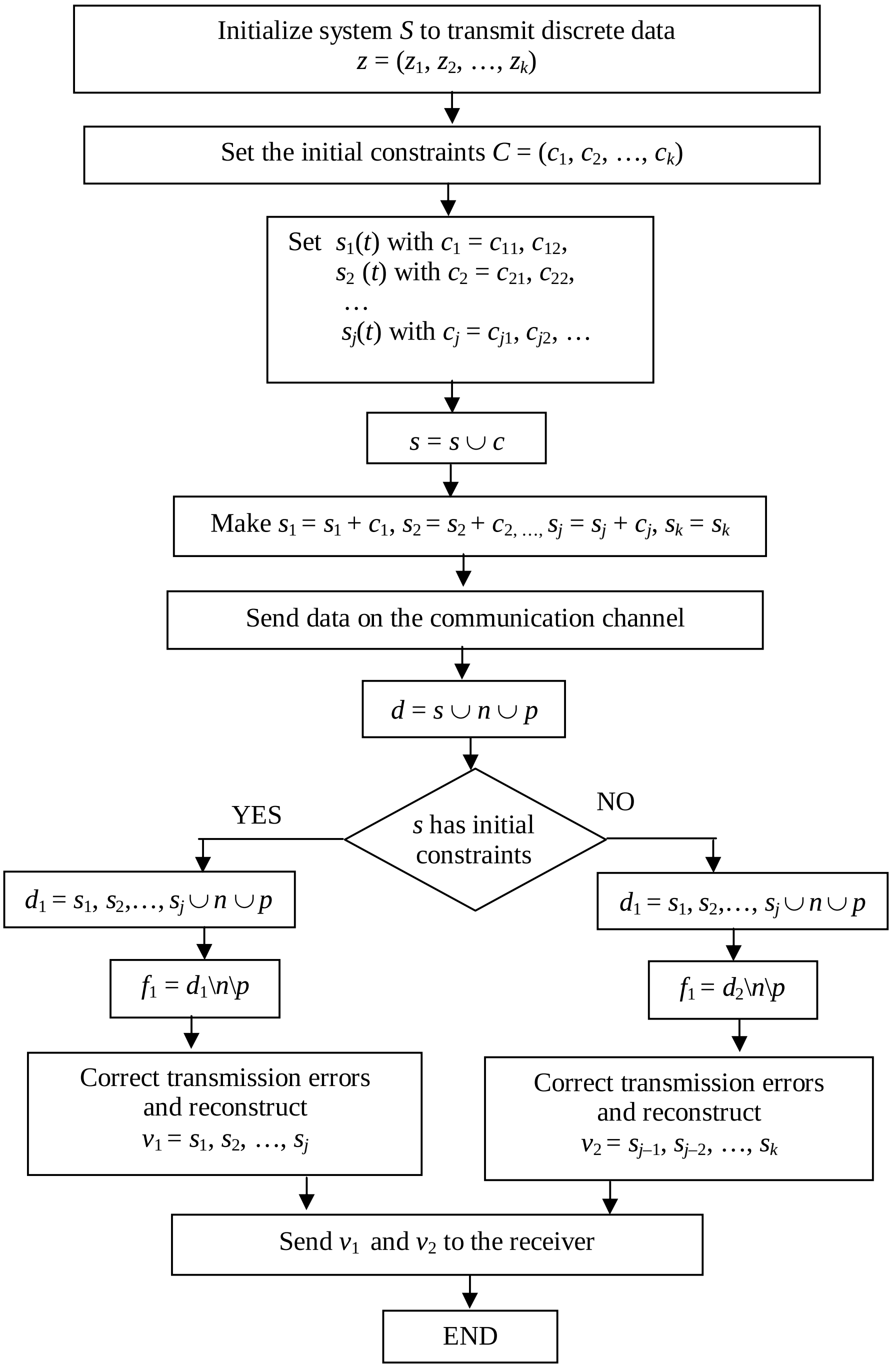

Fig. 2 – Flow Chart.

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CORECȚIA ŞI RETRANSMISIA PACHETELOR DISCRETE DE DATE ÎN SISTEME DE CONTROL ÎN TIMP REAL

(Rezumat)

Se prezintă o metodă deterministă de corecție a erorilor şi retransmisie a pachetelor discrete de date ca o alternativă la metodele tradiționale utilizate în sistemele de telecomunicații. Am ales şi prezentat algoritmul de corecție şi retransmisie a pachetelor de date cu şi fără constrângeri inițiale. Este prezentată, de asemenea, şi schema de principiu a sistemului folosit. Întârzierea de transmisie este micşorată în comparație cu sistemele tradiționale ceea ce face ca metoda să poată fi folosită cu succes pentru comunicații în sisteme de control în timp real.