PACKET ERROR RATE RECOGNITION FOR A NOISY COMMUNICATION CHANNEL

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Abstract: *This article presents a stage of research about the determination of the packet error rate during data exchange between two systems in noisy environment. The analysis is based on maximal loaded "point to point" communication channel with bit errors of periodical nature. The data exchange method is packet switching. Particular results are presented for data exchange through the PPP communication protocol.*

Key words: *Telecommunications and Networking, Communication channel performance, Data Exchange in Noisy Conditions, Packet Error Rate Recognition.*

INTRODUCTION

This article presents an algorithm for packet error rate prediction and an adaptive optimal frame length choice during data exchange between two systems in noisy environment.

In published results of previous stages of this research [1] is shown, that the adaptive optimal frame length choice - L_{opt} by the transmitting system is based on the exact determination of the packet error rate current value - T_{error}.

$$L_{opt} = \sqrt{c * T_{error}} \quad \text{[byte]} \qquad (1)$$

where:

c is the length of the control information in the frame.

Cases of incomplete determination, at which all transmitted frame are affected by bit errors, are analyzed [3]. It is proven that in those cases the accurate calculation of the real packet error rate value is impossible. A solution via selection of suitable prediction value in the boundaries of the critical interval C_{int} is presented.

$$C_{int} = L_{min} \div L_{old} \quad \text{[byte]} \qquad (2)$$

where:

L_{min} is the minimal frame length;

L_{old} is the currently used frame length.

The selection criteria is obtaining of possibly highest expected average efficiency of communication channel throughput, determined by the coefficient:

$$Keff\_pr_k = \sum_{i=L_{min}}^{L_{old}} p_i * Keff\_{ik} \qquad (3)$$

where:

$Keff\_pr_k$ is the coefficient of expected average efficiency at selected prediction packet error rate value equal to $k \in C_{int}$;

p_i is the probability the real packet error rate to be equal to $i \in C_{int}$;

$Keff\_{ik}$ is the efficiency coefficient of communication channel throughput at packet error rate equal to i bytes and frame length equal to L_{opt_k} bytes;

L_{opt_k} is the optimal frame length for packet error rate equal to k bytes.

1. OPTIMAL FRAME LENGTH PREDICTION

Optimal frame length prediction can be done according to the following method:

- the transmitting system periodically determines the count of erroneous frames F_{err} for a fixed time period named prediction interval;
- if the erroneous frames count F_{err} is less than the total count of transmitted frames N, the packet error rate value T_{error} is determined according formula (4):

$$T_{error} = \frac{N}{F_{err}} * L_{old} \quad [\text{byte}] \tag{4}$$

  where:

  L_{old} is the used frame length during the prediction interval;
- otherwise a prediction value for the packet error rate T_{error} is selected in accordance with the following:
  - for every possible value of the packet error rate in the boundaries of the critical interval is calculated the coefficient of expected average efficiency, according to formulas (3) or (4);
  - the packet error rate leading to highest coefficient value is selected as prediction value;
- the optimal frame length L_{opt}, corresponding to the selected packet error rate T_{error} is calculated according formula (1).

2. PACKET ERROR RATE PREDICTION

Methods and algorithm presented in part 1 lead to make a conclusion that the optimal frame length prediction by the transmitting system is based on the determination of the current packet error rate value. Cases of incomplete determination are of interest. Typical for them is that all transmitted frames in the prediction interval are hit by bit errors, F_{err} = N.

The selection of prediction value in similar situation will be illustrated with an example, in which the transmitting system has to determine the packet error rate T_{error}, using the following conditions:

- data exchange is made with communication protocol PPP (Point to Point Protocol);
- control data length in the frame is c = 10 bytes;
- minimal user data length in the frame is d_{min} = 2 bytes, maximal user data length is d_{max} = 1024 bytes;
- the frame length during the prediction interval is L_{old} = 130 bytes;
- all transmitted frames in this interval have been hit.

The result is a case of incomplete determination, at which a prediction value of the packet error rate has to be selected from the critical interval $C_{int} = 12 \div 130$ bytes. For that purpose it is necessary to evaluate the expected average efficiency of communication channel throughput for every value of $T_{error} \in C_{int}$, according to formula (3).

In order clear presentation of the analysis results the following assumptions will be made:

- possible real values of the packet error rate in the critical interval are four, respectively 120, 90, 60 and 30 bytes;
- the probabilities of their occurrence are equals;
- the expected average efficiency coefficient is calculated with accuracy up to four decimal characters.

Graphics, reflecting the influence of the user data length in the frame on the coefficient of communication channel efficiency K_{eff} for the selected four values of the packet error rate are shown on figures 1, 2, 3 and 4.

The results are received via simulating data exchange with the communication protocol PPP (Point to Point Protocol) [2].

Figure 1 presents the case of evaluation of the expected average communication channel efficiency at prediction packet error rate value T_{error} = 120 bytes. The according optimal user data length in the frame d_{opt} = 25 bytes in position A, results to coefficient of the communication channel efficiency K_{eff_A} = 0,5059. Positions B, C and D reflect the cases in which the actual period of the packer error rate differs from the selected prediction value.

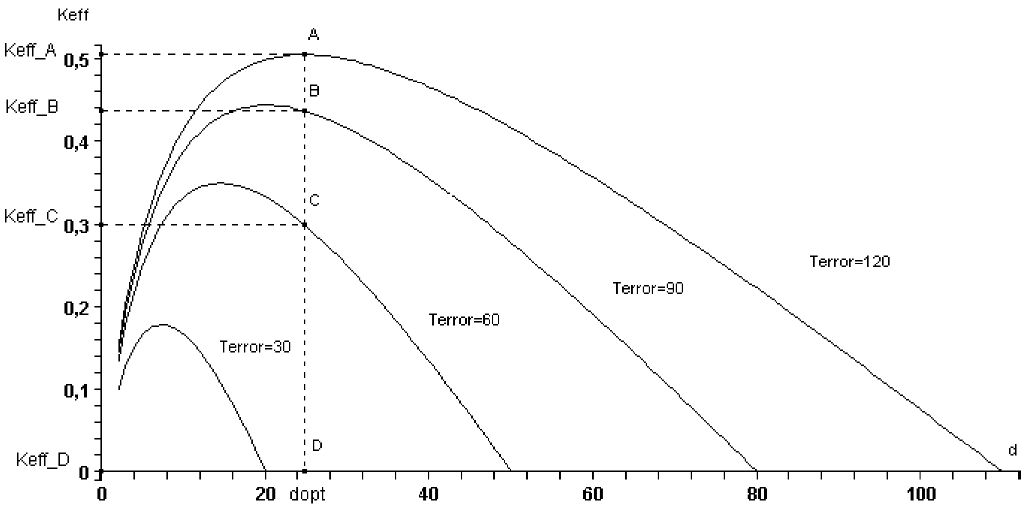

Fig. 1: Evaluation of the prospective average efficiency at prediction value T_{error} = 120 bytes

Calculation of the expected average efficiency according to formula (2) is narrowed down to (5) and (6):

$$Keff\_pr = p_A * Keff\_{A} + p_B * Keff\_{B} + p_C * Keff\_{C} + p_D * Keff\_{D} \quad (5)$$

$$Keff\_pr = 0{,}25 * (Keff\_{A} + Keff\_{B} + Keff\_{C} + Keff\_{D}) \quad (6)$$

where:

p_X is the probability for packet error appearance with period correspondent to the curve to which position X belongs (for X = A, B, C, D);

$Keff\_{X}$ is the value of the efficiency coefficient in position X.

The results of the calculations are generalized in table 1.

Table 1:

T_{error} = 120 bytes, d_{opt} = 25 bytes	
$Keff\_{A}$ = 0,5059	$Keff\_pr_{120}$ = 0,3100
$Keff\_{B}$ = 0,4365	
$Keff\_{C}$ = 0,2976	
$Keff\_{D}$ = 0,0000	

Figure 2 presents the case of evaluation of the expected average communication channel throughput efficiency at prediction packet error rate value T_{error} = 90 bytes.

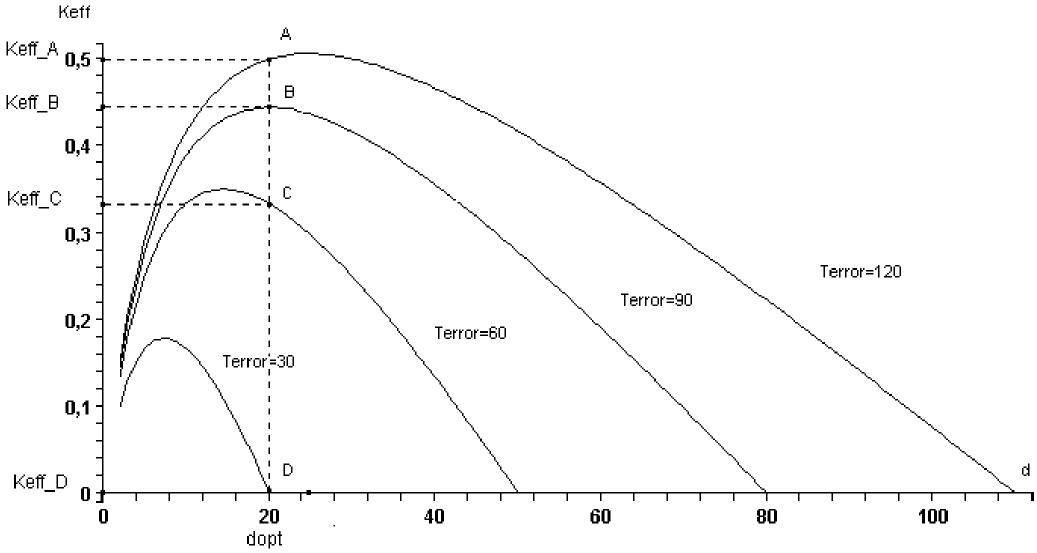

Fig. 2: Evaluation of the prospective average efficiency at prediction value T_{error} = 90 bytes

The results of the calculations are generalized in table 2.

Table. 2:

T_{error} = 90 bytes, d_{opt} = 20 bytes	
$Keff\_{A}$ = 0,5000	$Keff\_pr_{90}$ = 0,3194
$Keff\_{B}$ = 0,4444	
$Keff\_{C}$ = 0,3333	
$Keff\_{D}$ = 0,0000	

Figure 3 presents the case of evaluation of the expected average communication channel throughput efficiency at prediction packet error rate value T_{error} = 60 bytes.

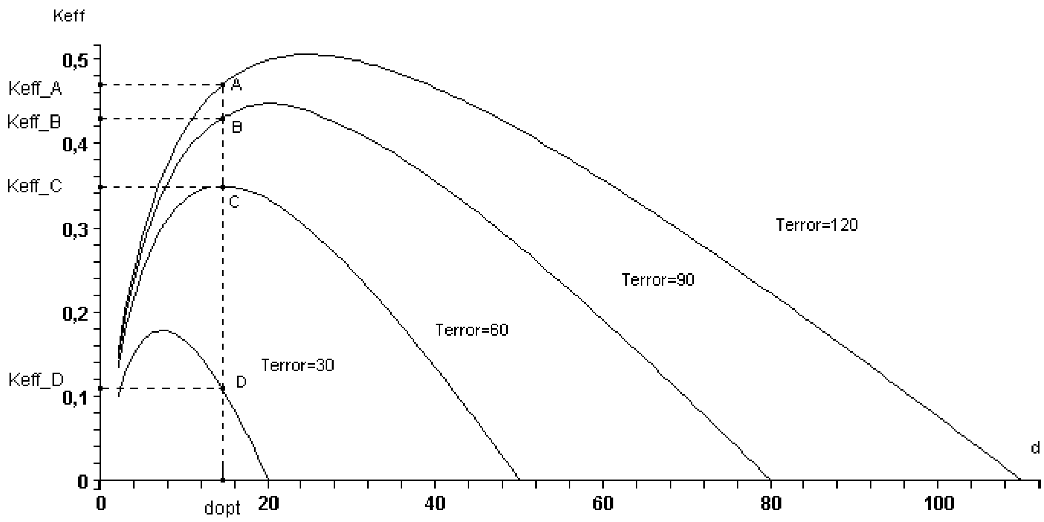

Fig. 3: Evaluation of the prospective average efficiency at prediction value T_{error} = 60 bytes

The results of the calculations are generalized in table 3.

Table 3:

T_{error} = 60 bytes, d_{opt} = 15 bytes	
Keff_A = 0,4750	$Keff\_pr_{60}$ = 0,3396
Keff_B = 0,4333	
Keff_C = 0,3500	
Keff_D = 0,1000	

Figure 4 presents the case of evaluation of the expected average communication channel throughput efficiency at prediction packet error rate value T_{error} = 30 bytes.

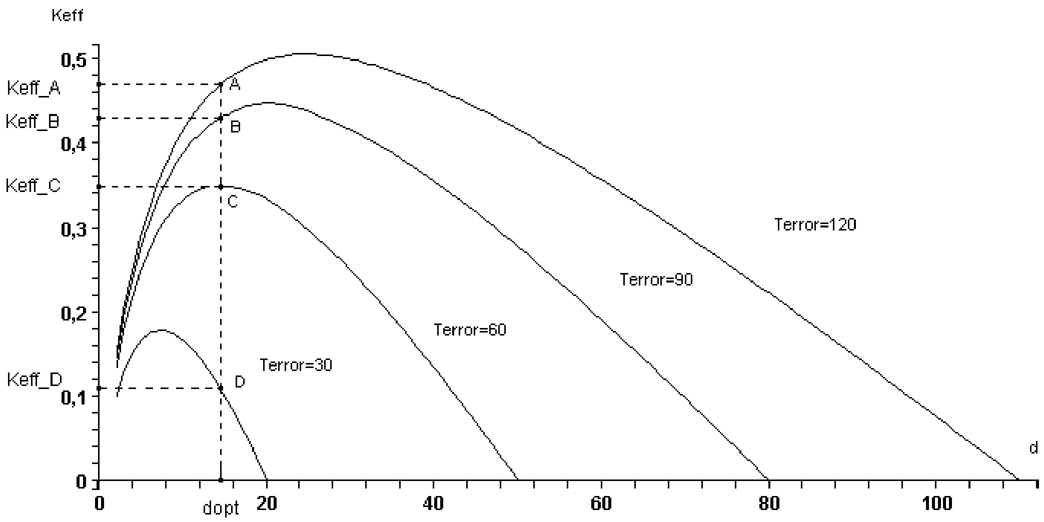

Fig. 4: Evaluation of the prospective average efficiency at prediction value T_{error} = 60 bytes

The results of the calculations are generalized in table 4.

Table 4:

T_{error} = 30 bytes, d_{opt} = 7 bytes	
Keff_A = 0,3534	$Keff\_pr_{30}$ = 0,2901
Keff_B = 0,3339	
Keff_C = 0,2950	
Keff_D = 0,1784	

The results for the four analyzed cases are generalized in table 5. Maximal value has the expected average efficiency coefficient $Keff\_pr_{60}$. In this case it determines the selection of prediction packet error rate value T_{error} = 60 bytes, leading to selection of optimal user data length in the frame d_{opt} = 15 bytes (Fig. 3, table 3).

Table 5:

Critical Interval C_{int} = 12 ÷ 130 bytes Possible equally probable values for Terror → 30, 60, 90, 120 bytes	
Prediction value of Terror	Expected average efficiency
T_{error} = 30 bytes	$Keff\_pr_{30}$ = 0,2901
T_{error} = 60 bytes	$Keff\_pr_{60}$ = 0,3396
T_{error} = 90 bytes	$Keff\_pr_{90}$ = 0,3194
T_{error} = 120 bytes	$Keff\_pr_{120}$ = 0,3100

With accomplishing such analysis it must be taken in mind that the real communications channel throughput efficiency always will differ from the calculated expected average efficiency, because the coefficient of expected average efficiency is a generalized virtual dimension. The expected average efficiency for a given frame length is calculated towards all possible values of the packet error rate in the critical interval, while the real efficiency – only towards the real packet error rate value. That's why the quantitative difference between the expected average communication channel throughput efficiency and the real channel throughput efficiency will depend on the difference between the selected prediction packet error rate and its real value.

The presented differences, for selected prediction value of the packet error rate T_{error} = 60 bytes, are generalized in table 6.

Table 6

Critical Interval C_{int} = 12 ÷ 130 bytes	
Selected prediction value of Terror	Expected average efficiency
60 bytes	$Keff\_pr_{60}$ = 0,3396
Real value of Terror	Real efficiency
30 bytes	$Keff\__D$ = 0,1000
60 bytes	$Keff\__C$ = 0,3500
90 bytes	$Keff\__B$ = 0,4333
120 bytes	$Keff\__A$ = 0,4750

3. CONCLUSIONS AND FUTURE WORK

Results, presented in table 5 show existence of dependency between the selected prediction packet error rate value T_{error} and the coefficient of expected average efficiency Keff_pr. At equal probabilities for occurrence of the possible packet error rate values in the critical interval, with increasing the value of T_{error} at first Keff_pr increases too, and then it starts to decrease. Therefore an optimal prediction value exists, at which the expected average communications channel throughput efficiency is maximal. This can be confirmed in the forthcoming analysis of the expected average efficiency for a bigger set of possible values of the packet error rate in the boundaries of the critical interval and even distribution of the probabilities for their occurrence.

REFERENCES

[1] Naydenov, G. Analyses of frame length influence on a 'point to point' communication channel performance. First International Scientific Conference - Computer Science'2004 (Technical University of Sofia, Bulgaria), 2004.

[2] Naydenov, G., Stoyanov, P. Adaptive frame length control for a 'point to point' communication channel. Seventh International Scientific Conference – Smolian'2005 (Technical College of Smolian, Bulgaria), 2005

[3] Naydenov, G. Optimal Frame Length Prediction for a Noisy Communication Channel. Second International Scientific Conference Computer Science'2005 (Chalkidiki, Greece), 2005

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