NUMERICAL EXAMINATION OF ALGORITHMS FOR NON-CONFLICT TRAFFIC SCHEDULING IN CROSSBAR SWITCHING NODES

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Abstract: In this paper we discuss fourteen algorithms for non-conflict scheduling of the traffic in switching nodes of type Crossbar. The comparative analysis of algorithms gives an overview of their potentiality related to the performance, speed and required memory as a function of the types and size N of matrixes used for simulation of the input connectivity matrix T. An approach for performance improvement of the best of algorithms is proposed.

Key words: network nodes, node traffic, crossbar switch, conflict elimination, packet messages.

INTRODUCTION

In this paper we consider fourteen algorithms for implementation of conflict-free schedules in the switching nodes of type Crossbar. In particular, the algorithms solve the problem of avoiding conflicts in the switching nodes. The conflicts are available in the following two cases:

- When one source of message requests communication to two or more message receivers
- When one message receiver receives communication requests from two or more message sources.

The evasion of the conflicts is directly related to the switching node performance.

The status of the switch of the switching node is represented by the so called connection matrix. For N x N dimensional switch the dimension of the connection matrix T is N x N also, where every member $T_{ij} = 1$ if the connection request from i- source to j- receiver exists. In the opposite case $T_{ij} = 0$.

A conflict situation arises if any row of the connection matrix has more than a single 1, which corresponds to the case when one source requests a connection with more than one receiver. The presence of more than a single 1 in any column of the matrix T also indicates a conflict situation, it means that two or more sources have requested a connection with the same receiver.[1].

The paper presents results from a comparative analysis of fourteen algorithms in terms of speed and required memory in the cases of different sizes of connection matrix through fourteen software models.

AN APPROACH FOR CONFLICT ISSUE SOLVING

One of the possible approaches for conflict issue solving is based on the extensive study and analysis of various algorithms for non-conflict scheduling. In the next sections, we consider the following algorithms and their program implementation in software models.

1. Classic algorithm with masks matrixes (**CMA**) [12]. The corresponding software model **(SMCMA)** is described and examined in [11].
2. Algorithm with joint mask matrixes (**JMA**) [12]. The software model **(SMJMA)** based on this algorithm is described and examined in [11].
3. Classic algorithm without masks matrixes (**CWA**) [13]. The corresponding software model **(SMCWA)** is described and examined in [11].
4. Algorithm considering the message direction (**DAA**). The algorithm and the corresponding software model **(SMDAA)** are described and examined in [15].
5. An algorithm by diagonal connectivity matrix activation (**ADA**). The algorithm and the corresponding software model **(SMADA)** are described and examined in [8].
6. Algorithm with joint diagonals activations (**AJDA**) [6]. The software model **(SMAJDA)** based on the algorithm is described and examined in [7].
7. Algorithm with diagonal activations of joint sub-switching matrices (**ADAJS**). The algorithm and the corresponding software model **(SMADAJS)** are described and examined in [4].
8. Classic algorithm with sparse mask matrixes (**CSM**) is described and examined in [9]. The corresponding software model **(SMCSM)** is described and examined in [10].
9. Algorithm with joint sparse mask matrixes (**JSM**) is described and examined in [9]. The corresponding software model **(SMJSM)** is described and examined in [10].
10. Adaptive algorithm for management by weight coefficient of the traffic in Crossbar commutator (**AAM**). The algorithm and the corresponding software model **(SMAAM)** are described and examined in [2].
11. Optimum adaptive algorithm for management by weight coefficient of the traffic in Crossbar commutator (**AAMO**). The algorithm and the corresponding software model **(SMAAMO)** are described and examined in [2].
12. An algorithm by diagonal connectivity matrix activation by finite automat (**ADAFA**). The algorithm and the corresponding software model **(SMADAFA)** are described and examined in [5].

13. Algorithm with joint diagonals activations by finite automat (**AJDAFA**). The algorithm and the corresponding software model **(SMAJDAFA)** are described and examined in [5].
14. Algorithm with diagonal activations of joint sub-switching matrices by finite automat (**ADAJSFA**)[5]. The algorithm and the corresponding software model (SMADAJSFA) are described and examined in [5].

The software models are developed and used for investigation of the scheduling algorithms. All models are written in Matlab programming language and tested on a Workstation Dell Precision 420. The software models match completely the corresponding algorithms for non-conflict traffic scheduling in crossbar switching nodes.

EXAMINATION OF SOFTWARE MODELS

In order to analyze and compare the algorithms, we have performed numerical experiments with different sizes N of the connection (traffic) matrix. The software models are examined with respect to the speed of execution and the required memory. The size N of the traffic matrix is varied from 10 to 300 with a step of 10 for **SMCMA, SMCWA, SMDAA, SMJMA, SMAAM and SMAAMO.** For software models **SMCSM, SMADA, SMAJDA, SMJSM, SMADAFA, SMAJDAFA, SMADAJSFA and SMADAJS** the size N is varied within the range from 100 to 300 with a step of 50. This difference in the numerical experiments is due to the substantial difference in the speed of execution of the two groups of software models.

The results from examination of the software models are represented in graphical form. Figure 1 and Figure 2 show the obtained results with respect to the speed of execution **S [Sec.]** and memory resources **M [KB].**

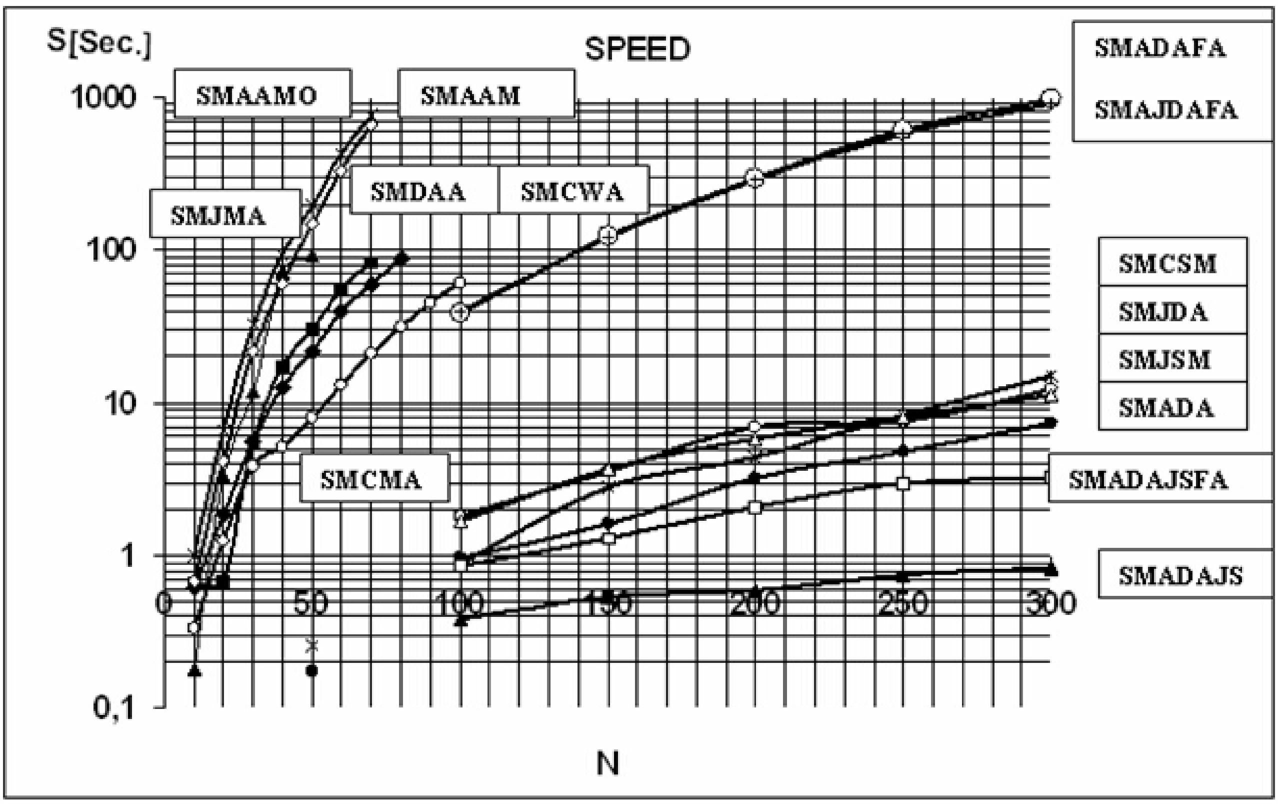

Figure 1. Speed

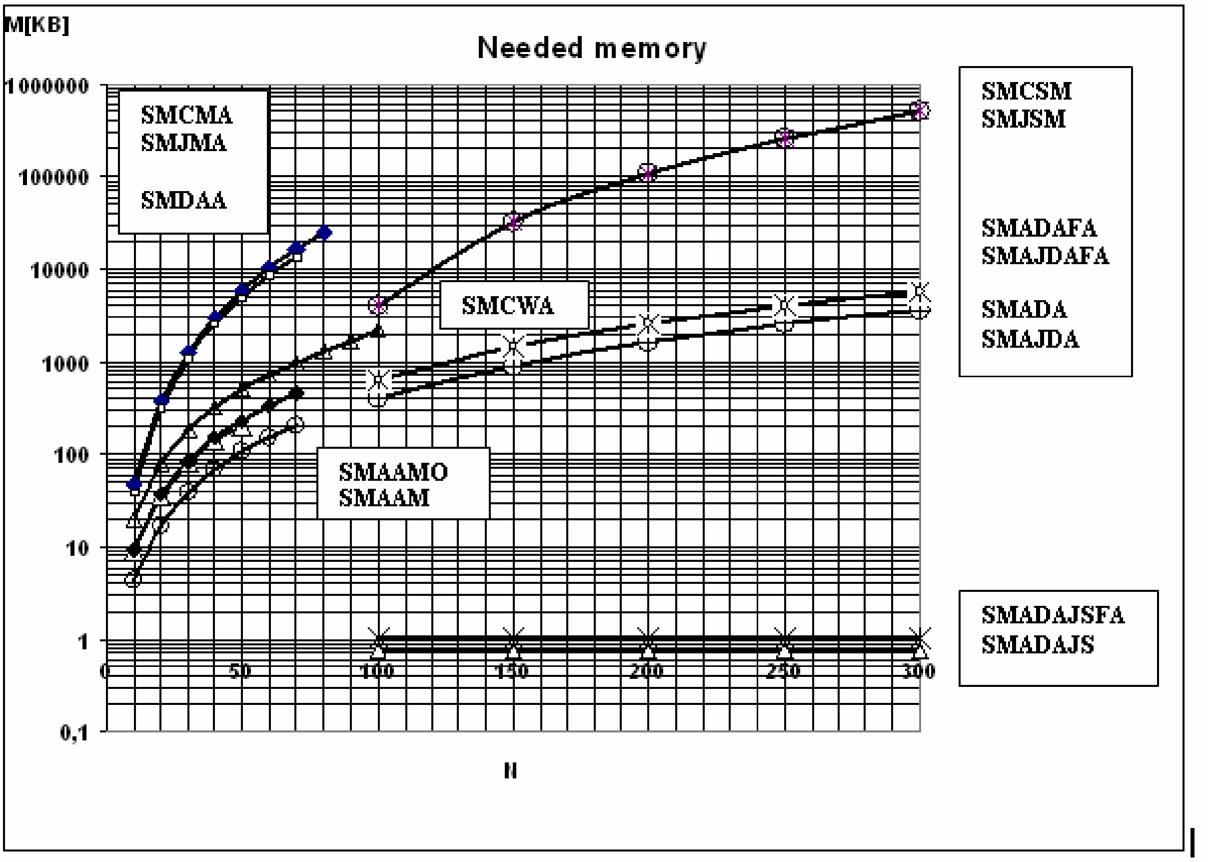

Figure 2. Needed memory.

The experimental results show that software models **SMCMA, SMCWA, SMDAA**, **SMJMA, SMAAM** and **SMAAMO** are times slower than software models **SMCSM, SMADA, SMAJDA, SMJSM**, **SMADAJSFA** and **SMADAJS** making them unsuitable for connections matrix sizes greater than one hundred.

Among software models **SMCSM, SMAJDA, SMJSM SMADA, SMADAJSFA** and **SMADAJS,** the fastest is **SMADAJS**. In terms of memory needed software model **SMADAJS** is most economical. This model is based on the algorithm with diagonal activations of joint sub-switching matrices **(ADAJS).**

SOFTWARE MODELS PERFORMANCE

A software models performance **(P)** is defined as a ratio of the non- nil resolutions to the total number of the solutions. **R(v)** is the set of the nil solutions, **R(w)** is the set of the non-nil solutions, and **R** is a set of the all solutions[1].

R=R(v)+R(w) **(1)**

P=(R(w)/R).100[%] **(2)**

From formula 2 it is visible that when the nil solutions **R(v)** vanish to nil, than the performance P vanish to 100%, [1].

To facilitate the performance examination, 5 kinds of matrixes for simulation of the input connectivity matrix **T** are chosen. The special input matrixes **2A, 2B, 2C, 2D** and **2E** [1] are represented on **Figure 3**.

Table1 presents the investigation results related to the performance **P** of the software models.

APPROCH FOR ADAJS PERFORMANCE IMPROVEMENT

From the research done on the fourteen algorithms for conflict-free schedule in switching nodes of type Crossbar, ADAJS is with the best indicators.

We propose an approach for ADAJS performance improvement using sub-matrices processing optimization. Two algorithms are used to obtain conflict-free schedule in the sub matrices in theADAJS algorithm:

1. Algorithm with joint diagonals activations (**AJDA**) [6].
2. Algorithm by diagonal connectivity matrix activation (**ADA**) [8].

Typical for both algorithms is that they admit zero solutions, which reduces their productivity.

Applying the new approach, the joint diagonals are used again but with a periodical check is performed for depletion of requests. Furthermore, an initial check is done whether

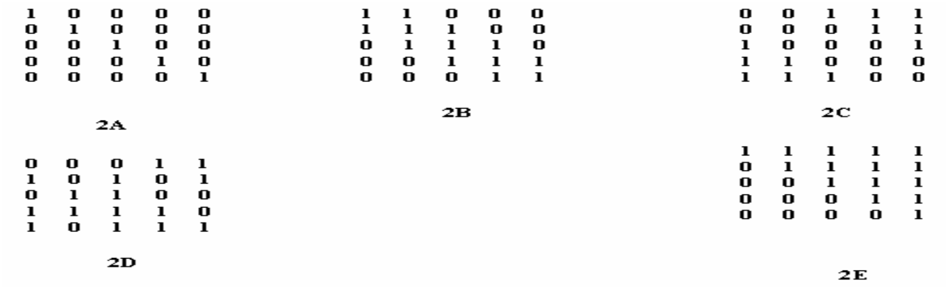

Figure 3. Five special input matrices.

Table 1. Performance

P[%]	2A	2B	2C	2D	2E
SMCMA	6,66%	20%	80%	86,6%	53,3%
SMJMA	12,5%	37,5%	87,5%	100%	100%
SMCWA	6,66%	20%	80%	86,6%	53,3%
SMDAA	13,3%	33,3%	80%	93,3%	53,3%
SMADA	6,66%	20%	80%	80%	53,3%
SMAJDA	6,66%	20%	80%	80%	100%
SMADAJS	20%	60%	80%	80%	100%
SMCSM	6,66%	20%	80%	93,3%	53,3%
SMJSM	12,5%	37,5%	87,5%	100%	100%
SMAAM	100%	100%	100%	100%	100%
SMAAMO	6,66%	20%	80%	80%	53,3%
SMADAFA	6,66%	20%	80%	80%	53,3%
SMAJDAFA	6,66%	20%	80%	80%	100%
SMADAJSFA	20%	60%	80%	80%	100%

the sub matrix is not zero. Another characteristic of the new approach is that it is checked for the presence of requests for service in the diagonal perpendicular to the main diagonal. Thus the check for requests includes joint diagonals parallel and perpendicular to the main one. On Figure 4 we have illustrated the main diagonal, the perpendicular to the main diagonal and the jointed pairs of diagonals parallel to them. The new approach guaranties 100% performance independently of the sub-matrix type. It is achieved because a zero sub-matrix is not processed and zero solutions are not exist, in case of requests depletion the processing stops.

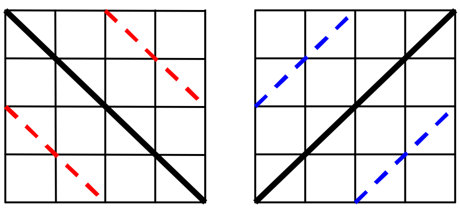

Figure 4

CONCLUSION

Software models **SMCMA, SMCWA, SMDAA**, **SMJMA, SMAAM** and **SMAAMO** are times slower than software models **SMCSM, SMADA, SMAJDA, SMJSM**, **SMADAJSFA** and **SMADAJS** making them unsuitable for connections matrix sizes greater than one hundred.

Among software models **SMCSM, SMAJDA, SMJSM SMADA, SMADAJSFA** and **SMADAJS,** the fastest is **SMADAJS**. In terms of memory needed software model **SMADAJS** is most economical. This model is based on the algorithm with diagonal activations of joint sub-switching matrices (**ADAJS**).

The applied approach guaranties 100% performance of the **ADAJS** algorithm for arbitrary input sub-matrices types.

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