Fifth Int. Workshop on GNs, Sofia, 10 Nov. 2004, 25-31

GENERALIZED NET MODEL OF SCHEDULE FOR ELIMINATION OF CONFLICTS AT THE PACKET CROSSBAR SWITCH WITH MINIMUM MEMORY USING

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1. Introduction.

In time-multiplex communication systems, crossbar packet switches route traffic from the input to output where a message packet is transmitted from the source to the destination. The randomly incoming traffic must be controlled and scheduled to eliminate conflict at the crossbar switch where the conflict is that two of more users may simultataneously access to a single output.The goal of the traffic-scheduling for the time-multiplex crossbar switches is not only to maximize the throughput of packet through a crossbar switch but also to minimize packet blocking probability and packet waiting time [1].

The attempts to reach simultaneously three goals – to maximize the throughput, to minimize blocking probability and to minimize packet waiting time – leads to problems with non-polinomial completeness of the solutions. (NP-comlete) [2]. Some solutions, which satisfied a part of goals are suggested, relatively with completeness $O(n^2)$ for sequental algorithm. Different apparatus are used : systematic method of finding distinct representatives from the row sets of a traffic matrix [3], algorithm based on a cellular automation [4], and neural network [5]. Corresponding to this, the direct and correct comparison of the suggested algorithms is very hard.

We suggest, that the correct evaluation of the distinguish solution may be obtain, if they are described by one and the same formal apparatus. It must posses modeling power with possibilities for simultaneous presentation as of data flow as of controlling actions. It may also modell a parallelism of interactions, to leave time scale, and no at last to have graphical form.

We consider that the Generalized nets (GN) [6,7] may be used for such tasks because of us possibilities to model as the structure of the investigated object, as the dynamics of the flowing in it processes. The GN are contemporary development, suggesting detail reflection of the structure and time relation in parallel processes.

In this paper we shall use GN apparatus for specification of the shedule which eliminate conflicts at the packet crossbar switch. This shedule reaches the second showed goal – to minimize packet blocking probability. It may be used as a basic point for comparison with other suggested solutions, because also use a minimum memory.

2. Shedule for elimination of conflicts at the switch.

A request for packet transmission through an *n x n* crossbar is described by an *n x n* traffic matrix T. In the traffic matrix T, each element t_{ij} ($t_{ij} \in [0,1]$)represents a request of packets from input *i* to otput *j*. For example, $t_{ij}=0$ means that there is no packet to be transmitted on the *j*th output line from the *i*th input line. $t_{ij}=1$ means that at least one packet on the *i*th input line should be transmitted on the *j*th output line of the crossbar [1].

Conflict situation is created when at any row of the traffic matrix the number of ones is bigger then one. This is corresponding to case when one source announces connection with more then one receiver. Existance of more then one (1) at any column of matrix T is also showing that conflict situatiion is available and means, that more then one source is announced connection to the same receiver [8].

The suggested shedule is a modification of non-conflict shedule, obtained through sequent transformations of traffic matrix using preliminary defined matrices-mask [9]. The follow changes are made:

- the number of the mask-matrices is decreased to minimum from 2(*n*-1) to *n;*
- the number of matrices forming non-conflict shedule also is decreased to *n*, relativly;

It is the minimal number for this type algorithm (the formal proof is not object of this paper).

- mask-matrices do not take memory because they are forming by the way of computing – through transition with one cell to the right of the diagonal of identity matrix with size *n x n*.;
- there is no necessity to compute redused and modified matrices, and connected with the operations;
- for current computing are used only 3 integer variables.

The sequence of computations for obtaining of non-conflict shedule is the following.

Process is iterative. At the first iteration the main diagonal of traffic matrix T is recorded in the main diagonal of new matrix R, which we call matrix of allowed non-conflict connections R^1. At the second iteration we record elements, remoted one cell to the righ of the main diagonal of T, at the same places of next matrix R^2. When the limit of the column of matrix T is reached, we pass to the first element of next row. When the limit of the row of T is reached, iteration is ended and R^2 is formed. The last *n*-iteration begins from last element (cell) of first row of T, follows first element of second row, then second element of third row i.e. to the (n-1) element of *n* row. When R^n is formed from *n*-iteration the process is finished – all elements of T (requestes) exist in shedule determined by non-conflict matrices R^1, R^2,…,R^n. The probability for conflict when requests are satisfyed is zero.

3. GN-model of the calculus of shedule.

The offered decision in GN type is showed on the fig.1.

The tokens in the GN-model presented the matrix and variables. They have six paramerers : <n>, <T>, <k>, <R^k>, <i>, <j>..

The token α come into position l_1 with initial characteristic “<n>, <T>”.

The characteristic <n> has size $n \in N$ (*n x n*) of matrix T and R. The characteristic <T> showed the traffic matrix T. The characteristic <R> showed the switched matrix R. The characteristic <i> showed the number of row of matrix : i $\in$ [1,n]. . The characteristic <j> showed the number of column of matrix : j $\in$ [1,n]. The characteristic <k> showed the number of iterations, k $\in$ [1,n].

The concrete descriptions of places are :

l_1 - start; l_2 – initial parameters;

l_3 - first row is chosen l_4 – element is recorded;

l_5 - next row is chosen; l_6 – next column is chosen;

l_7 - R^k is writen; l_8 – ready for next iteration;

l_9 - first column is chosen; l_{10} – to next cell;

l_{11}- stop; l_{12} – k-column is chosen;

The formal description is:

z_1=< $\{l_1\}$, $\{l_2\}$, r_1, v (l_1)>, where

r_1 =

	l_2
l_1	true

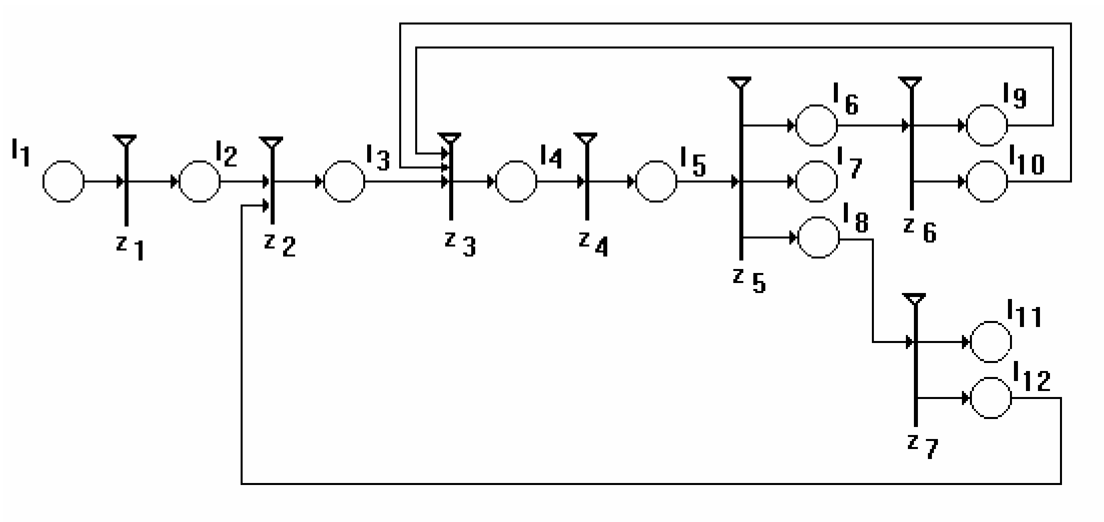

Fig.1. GN-model of algoritmh

The characteristic functions are : Φ_2="<k>:=1, <R^k>:=0, <j>:=1, "

z_2=< $\{l_2, l_{12}\}$, $\{l_3\}$,r_2, v (l_2, l_{12}) > , where

r_2 =

	l_3
l_2	true
l_{12}	true

The characteristic functions are : Φ_3="<i>= 1" .

z_3=< $\{l_3, l_9, l_{10}\}$, $\{l_4\}$,r_3, v (l_3, l_9, l_{10}) > , where

$r_3 =$

	l_4
l_3	true
l_9	true
l_{10}	true

The characteristic functions are : Φ_4="$<R^k_{ij}>:= <T_{ij}>$"

$z_4 =< \{ l_6, l_{13}\}, \{ l_7 \}, r_4, v (l_6, l_3\} >$, where

$r_4 =$

	l_5
l_4	true

The characteristic functions are :Φ_7="$<i>:= i+1$" .

$z_5 =< \{ l_5\}, \{ l_6, l_7, l_8\}, r_5, v (l_5) >$, where

$r_5 =$

	l_6	l_7	l_8
l_5	$\neg W_1$	true	W_1

The predicate W_3 have the following forms: W_1 =" $i>n$ " .

The characteristic functions are :Φ_6="$<j>:= j +1$" , Φ_7= "R^k> to swich", Φ_8= "$<k>:= k + 1$".

$z_6 =< \{ l_6\}, \{ l_9, l_{10}\}, r_6, v (l_6) >$, where

$r_6 =$

	l_9	l_{10}
l_6	W_2	$\neg W_2$

The predicate W_4 have the following forms: W_2 =" $j > n$" .

The characteristic functions are : Φ_9="$<j>:= 1$" , . Φ_{10}= "*".

$z_7 =< \{ l_8 \}, \{ l_{11}, l_{12} \}, r_7, v (l_8) >$, where

$r_7 =$

	l_{11}	l_{12}
l_8	W_3	$\neg W_3$

The predicate W_5 have the following forms: W_3 =" $k > n$ " .

The characteristic functions are : Φ_{11}="*" , Φ_{12}= "$<j>:= k$".

4. Properties of the constructed GN-model.

Capacity of all arcs are equal to one. Capacity of all places is also one, except of place l_7.which has capacity *n*. Priorities of places are equivalent, priorities of transitions are equivalent – i.e. priorities are not necessarily.The GN has no local and global temporal components. Therefore, the constructed GN is a reduced GN form concerning common class Σ of all GN.

The chosen kind and sequenceof applying of mask-matrices introduce priorities in service of requests. The requests, disposed on main diagonal of T will be serviced element, formed by *n*-iteration. When is nessecary priorities of service may be changed through transposition of row and columns of matrix T.

5. Conclusion.

The forming of shedule is made by sequent computation – in a single time interval fires only one transition, The task permitted parallelism. If *n* computing devices are available, *n* matricies R^1, R^2, …, R*n* will be formed only for one iteration If n^2 devices are available, *n* matricies R^1, R^2, …, R*n* will be formed for time of one operation. So, the suggested GN model may be use for comparision not only with sequent but with parallel algorithms.

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