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# On Switchbox Routing Algorithm

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**Abstract**

We present new switchbox routing algorithm that consider the characteristic of net crossings. The routing strategy is based on parallel bubble sorting technique. Non-Manhattan wires as well as overlapping wires are introduced. Preliminary results show that a class of switchbox routing problems can be routed by using smaller overall interconnection length than the Manhattan models provide.

## 1. Introduction

Switchbox routing is one of the most important phases of physical design of VLSI chips as well as PC boards. There are many works [1], [3], [5], [6] in which the routing of VLSI chips is bringing to channel switchbox routing In this paper, we propose a new routing model, which is based on parallel sorting technique. The routing strategy is very different from the Manhattan approach. In particular, vertical constraints no longer exist. Furthermore, the solution produced by either model consists of a minimal set of net crossings which leads to a small number of vias.

## 2. The Problem

A switchbox is a rectangular region with no inside obstructions and with terminals lying on all four sides. Formally a switchbox is defined as a region R = {0,1,...,m} x {0,1,...,n} where m and n are the positive integers. The connectivity and location of each terminal is represented as LEFT(i) = k, RIGHT(i) = k, TOP(i) = k and LEFT(i) = k, depending on which side of the switchbox it lies on, where i stands for the coordinate of the terminal along the edge and k for its identification number.

TOP = $t(1), t(2), .....t(n)$
BOT = $b(1), b(2), .....b(n)$
LEFT = $l(1), l(2), .....l(n)$
RIGHT = $r(1), r(2), .....r(n)$

We assume that these numbers are the labels of grid points located along the top, bottom, left and right edges of a rectangle. Points having the same positive label have to be interconnected, i.e. they define nets. A 100% routing completion is required and the objective is to minimize the number of vias and to have minimal overall interconnection length. Without loss of generality we can assume that numbers at the BOTTOM of the switchbox are in natural order, at the TOP and LEFT they are placed arbitrarily. And in the RIGHT side, they must be located in some natural order, which is: for each of the terminals it is fixed that the lower terminal must not have greater number then it's above one.

TOP = 1,4,10,5,7,2,3
BOTTOM =1,2,3,4,5,7,10

LEFT = 4, 1, 2, 3, 5
RIGHT =10, 7, 5, 2, 1

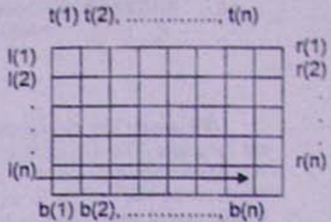


Fig. 1

## 3. Switchbox model

It is clear that any sorting algorithm based on exchanges can be easily converted to a channel routing algorithm [2],[4],[7],[8], and by modification of which we can produce switchbox routers. The steps of an algorithm swap a pair of numbers only once if they are in wrong order. Therefore this sorting algorithm produces a minimal crossing solution. In this kind of approach we use the intermediate places of tracks in rectangular grid for complete routing (Fig.1, through two tracks of rectangular grid). Since in one pass at least one number moves to its final place, it would require at most n steps to sort the n numbers. Each intermediate step of sorting will produce adjacent permutations and will require one track. The numbers can be scanned either from left to right or vice versa, and the number of passes required to complete sorting will depend on the direction of scan. After the sorting we can modify the channel to switchbox by assuming some constraints. Lets we have terminals in left and right too. After the terminals in TOP and BOTTOM are sorted in above mentioned manner, as a second step of an algorithm we must route the terminals which are located in LEFT and RIGHT sides. The model allows an existence of multiterminal nets and empty nodes. In Fig. 2 is shown switchbox routing example.

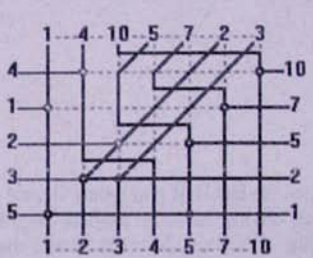


Fig. 2

As we say earlier, since in one pass at least one number moves to its final place, it would require at most n steps to sort the n numbers for first part of an proposed switchbox routing algorithm.

*Sequence of algorithm steps:*

First part, as say is a presentation of sorting algorithm which sorts the numbers of terminals in TOP and BOTTOM sides of a switchbox. At first phase the number with maximal number moves to its final place. That is, it moves into node from where can be made interconnection with corresponding pair by directed line. This is produced trough intermediate parts of the grid (Fig.2, i.e. 10-net). The rest of the nets in same level which are placed within this interval are moves to other side with -45°-wires. Then the next net with the maximal number selected and the same steps are applied on it and it moves to its final place. After which the steps are as for previous nets. If two nets are adjacent to each other they are swapped by 45°-wires. If the net during the sorting take its' final place it doesn't participate in further sorting steps.
The Second part consists of routing of nets which are in LEFT and RIGHT sides.
Connections are made in following manner: The algorithm look up higher left terminal at first and made connection from corresponding node of the net directly into terminal in left (i.e. net 4, Fig.2). In the sequence the terminal from right is hold to made connections in same manner. So this part is finished after all connections are made.

## 4. Layer assignment

Layer assignment problem in this algorithm is solved as follows: All wires which are moved to right are assigned to first layer. Mentioned wires in this algorithm perform moves to right along with intermediate places of grid or moves with +45°-wires. Second layer is assigned to wires which performs left side moves along with intermediate places of grid or to -45°-wires. Vertical wires can be assigned to any layer since any other wires. Vias are introduced for layer changes between a +45° and -45° wire.
There is an example of such a switchbox presented in Fig.3.

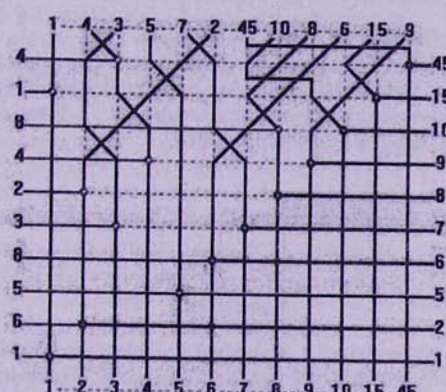


Fig. 3

## 5. Conclusion and Future Work

As we know in switchbox routing problem we are involved with vertical constraint frequently. In this approach the algorithm excludes problems connected with vertical constraints.
Make the following conclusions:

- There is no need to deal with vertical constraints
- Extra columns outside the switchbox span are never used
- Wirelength is expected to be shorter due to diagonal wires
- Being a minimal crossing solution, we expect only small number of vias is required. We observed that most nets require zero or one net via, whereas Manhattan routing typically requires at least 2 vias per net.
- It is inherently suitable for parallel mode of operations.

Future work should optimize the extension to exclude the constraint connected with RIGHT side, and the problem will be solved by using of Lee type algorithms.

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## Միացման արկղերի ուղեգծման մի ալգորիթմի մասին

Վ. Մանուկյան


**Ամփոփում**

Աշխատանքում դիտարկված է միացման արկղերի ուղեգծման ալգորիթմ, որում օգտագործվում են անկյունագծային լարեր: Ուղեգծման տակտիկան հիմնված է պղպջակային տեսակավորման վրա: Արդյունքները ցույց են տալիս, որ միացման արկղերի ուղեգծման այս դասը կարող է իրացվել լարերի ավելի փոքր ընդհանուր երկարությունների դեպքում, քան դասական Մանհեթենյան մոդելների դեպքում: