

# EXHIBIT 5



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(12) **United States Patent**  
**Konda**

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(54) **VLSI LAYOUTS OF FULLY CONNECTED GENERALIZED AND PYRAMID NETWORKS WITH LOCALITY EXPLOITATION**

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(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 116 days.

(57) **ABSTRACT**

VLSI layouts of generalized multi-stage and pyramid networks for broadcast, unicast and multicast connections are presented using only horizontal and vertical links with spacial locality exploitation. The VLSI layouts employ shuffle exchange links where outlet links of cross links from switches in a stage in one sub-integrated circuit block are connected to inlet links of switches in the succeeding stage in another sub-integrated circuit block so that said cross links are either vertical links or horizontal and vice versa. Furthermore the shuffle exchange links are employed between different sub-integrated circuit blocks so that spatially nearer sub-integrated circuit blocks are connected with shorter links compared to the shuffle exchange links between spatially farther sub-integrated circuit blocks. In one embodiment the sub-integrated circuit blocks are arranged in a hypercube arrangement in a two-dimensional plane. The VLSI layouts exploit the benefits of significantly lower cross points, lower signal latency, lower power and full connectivity with significantly fast compilation.

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§ 371 (c)(1),  
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PCT Pub. Date: **Apr. 21, 2011**

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**Related U.S. Application Data**

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(51) **Int. Cl.**  
**G06F 17/50** (2006.01)

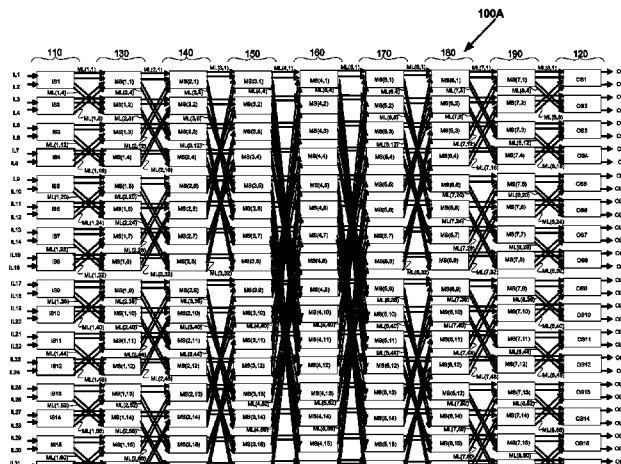
(52) **U.S. Cl.**  
CPC ..... **G06F 17/509** (2013.01); **G06F 17/5054** (2013.01)

USPC ..... **716/121**

(58) **Field of Classification Search**  
USPC ..... **716/100, 121**  
See application file for complete search history.

The VLSI layouts with spacial locality exploitation presented are applicable to generalized multi-stage and pyramid networks, generalized folded multi-stage and pyramid networks, generalized butterfly fat tree and pyramid networks, generalized multi-link multi-stage and pyramid networks, generalized folded multi-link multi-stage and pyramid networks, generalized multi-link butterfly fat tree and pyramid networks, generalized hypercube networks, and generalized cube connected cycles networks for speedup of  $s \geq 1$ . The embodiments of VLSI layouts are useful in wide target applications such as FPGAs, CPLDs, pSoCs, ASIC placement and route tools, networking applications, parallel & distributed computing, and reconfigurable computing.

**20 Claims, 43 Drawing Sheets**



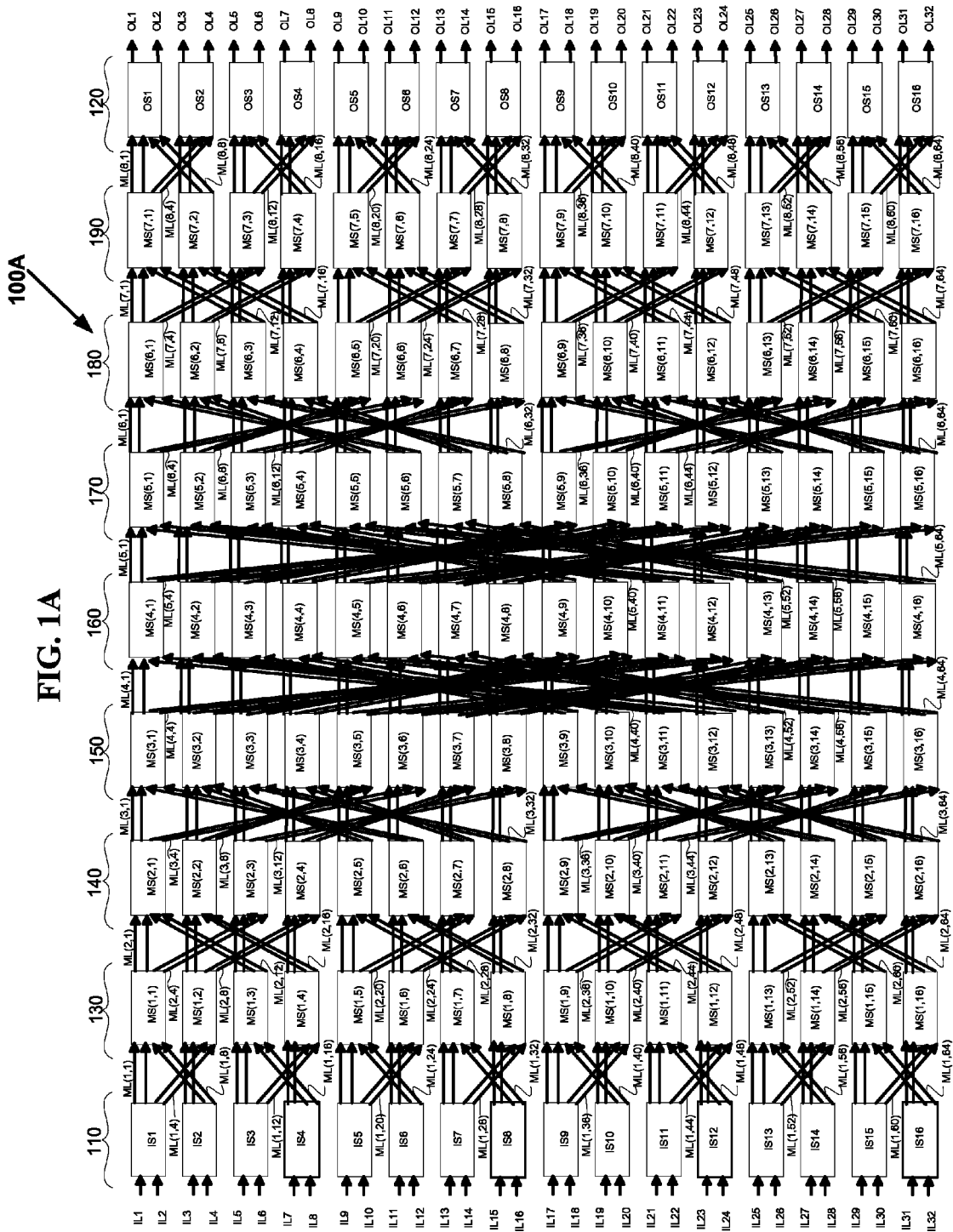
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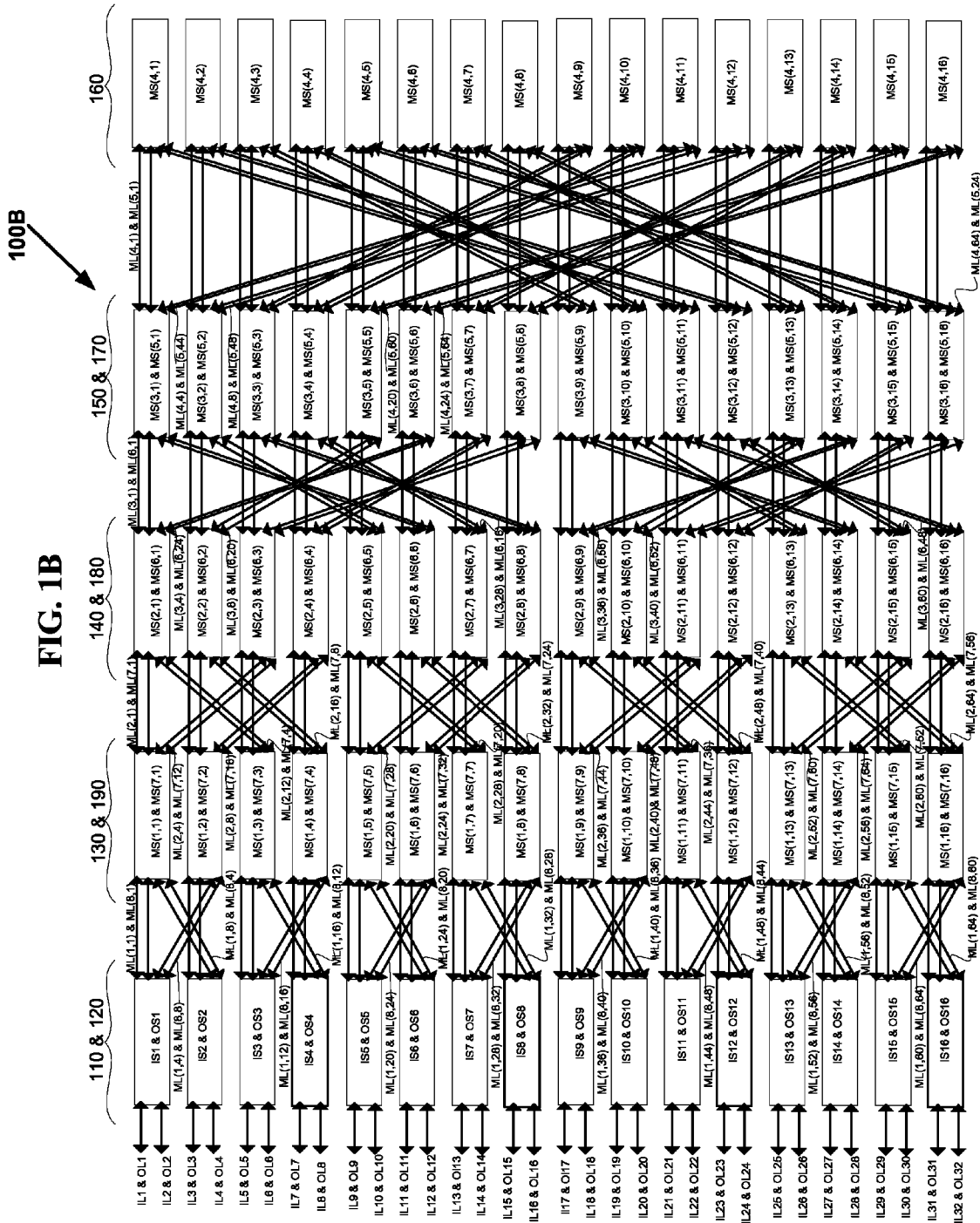


FIG. 1B

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