# Rent's Rule Based FPGA Packing for Routability Optimization

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## **FPGA Packing Problem**

- Typical FPGA CAD flow
  - Synthesis
  - <u>Packing</u>
  - Placement
  - Routing
- Packing: group BLEs into clusters
  - BLE-level netlist 
     → Cluster-level netlist
- Routability optimization / minimize placement wirelength
  - A challenge for packing



#### **Previous Work**

Packer	Authors	Year
VPack	Betz and Rose	1997
<u>T-VPack</u>	Marquardt et al.	1999
RPack	Bozogzadeh et al.	2001
<u>iRAC</u>	Singh and Marek-Sadowska	2002
Hierarchical FPGA clustering	Marrakchi et al.	2005
P-T-VPack	Lamoureux and Wilton	2006
Un/DoPack	Tom et al.	2006
DPack and HDPack	Chen et al.	2007
A novel packing algorithm	Wang et al.	2008
MO-Pack	Rajavel and Akoglu	2011
PPack and TPPack	Feng	2012
YAMO-Pack	Yang et al.	2013
AAPack-E	Luu et al.	2014



#### What's Wrong

- For routability optimization, all previous works use "minimizing cutsize" as the heuristic
  - Absorb as many signals as possible into clusters
- The issue: cutsize alone does not capture the interconnect complexity





#### Climb up a Tree to Look for Fish?





## The Right Criteria

- Rent's rule / Rent characteristic
  - Well studied to model interconnect complexity
  - Highly correlated to placement wirelength
    - Rent's rule based pre-placement wirelength estimation





### **Optimize Rent Characteristic**

- Use recursive bipartitioning to obtain clusters
  - The same method to extract Rent's rule/Rent characteristic (but stop at cluster size level)



Achieve optimal/near-optimal Rent characteristic



#### Results



Reduce minimal channel width by 36% (in other words, T-VPack needs 55% more routing tracks than necessary!)



