Liquid: Fast Placement Prototyping Through Steepest Gradient Descent Movement

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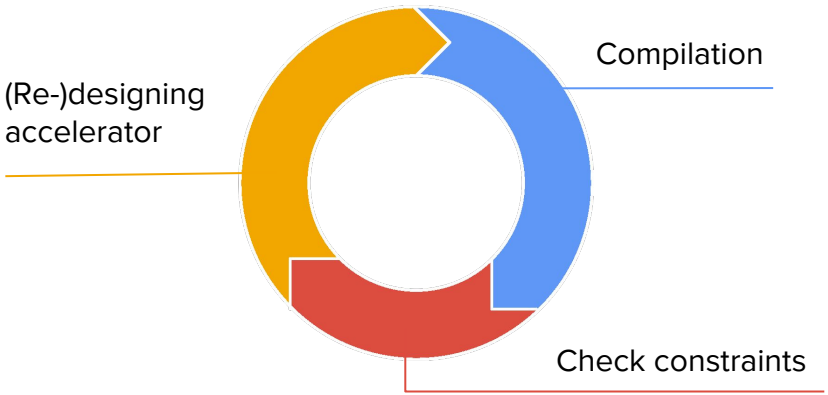
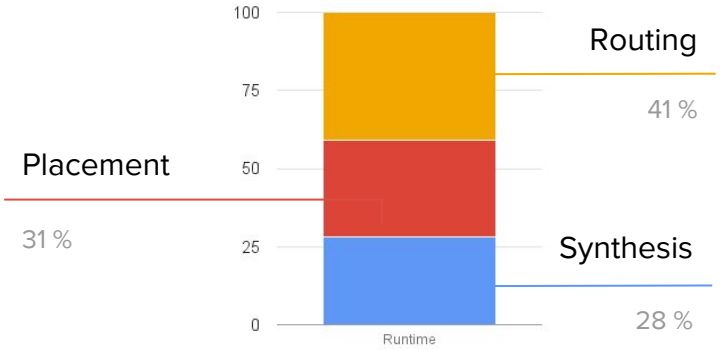
Problem: Slow FPGA design cycle



Design cycle



Runtime breakdown

Vivado - VTR benchmark designs

Example: Bitcoin miner design - 1M blocks:
Quartus II placement tool requires 20 minutes.

Current solution: Multi-threaded versions of existing approaches

Two common placement techniques:

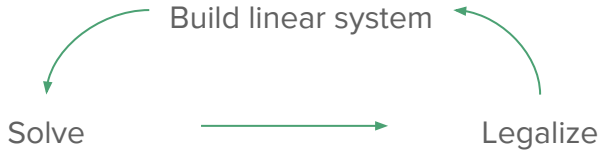
- Simulated annealing
- Analytical placement

} Not designed to exploit the high number of cores in GPU accelerators

Design new placement technique based on analytical placement

Analytical Placement: largest runtime consumer?

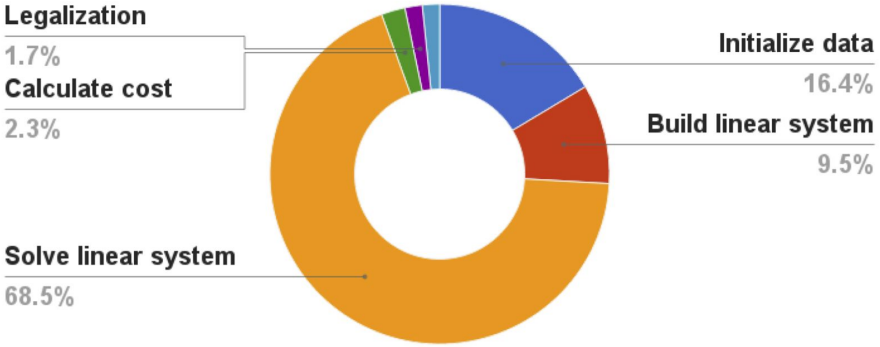
Analytical placement cycle



Stop condition: solved solution cost reaches fraction of legal solution cost

Is it necessary to exactly solve the linear system?
Legalization partly destroys the solution anyway.

Solve linear system → **Optimize system**
Liquid

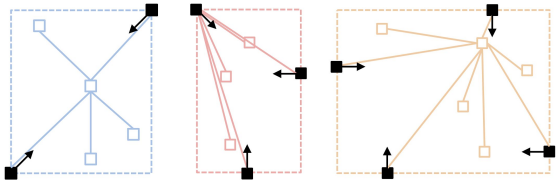


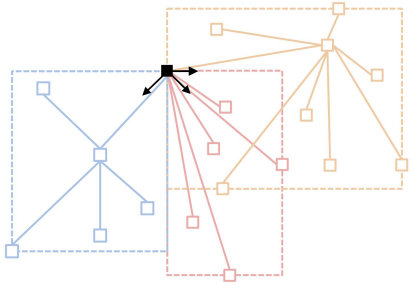
Runtime breakdown analytical placement

Bitcoin miner design

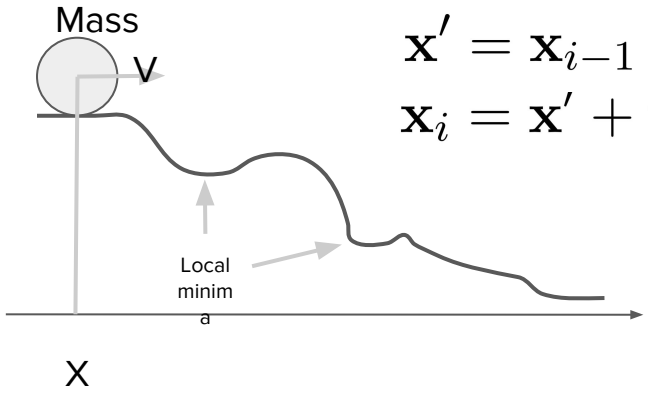
Liquid: Iterative SGD optimization

- Optimize system by moving each block several times in the direction which reduces the cost the most
- Momentum simulation to smooth out and make less prone to local minima





$$\mathbf{v}_i = \mu \cdot \mathbf{v}_{i-1} - \gamma \cdot \nabla \mathbf{C}(\mathbf{x}')$$
$$\mathbf{x}' = \mathbf{x}_{i-1} + \mu \cdot \mathbf{v}_{i-1}$$
$$\mathbf{x}_i = \mathbf{x}' + \mathbf{v}_i$$



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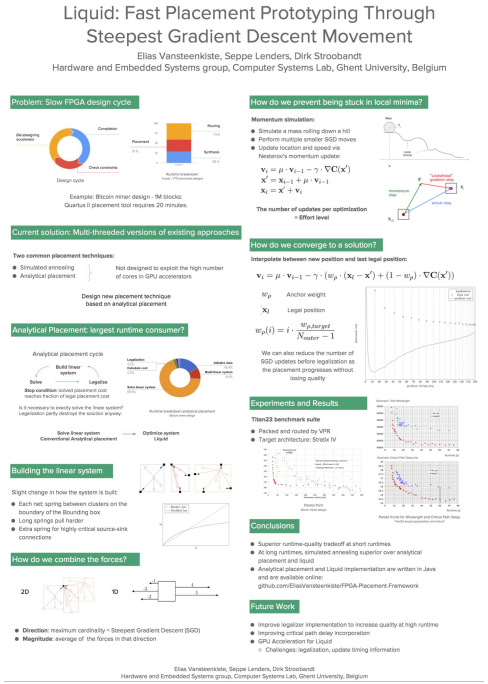
For more information about

- Implementation details
- Results

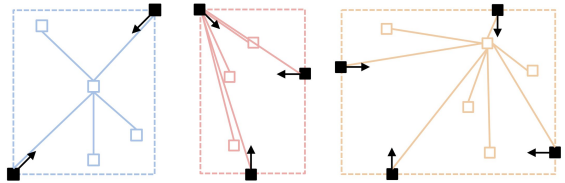


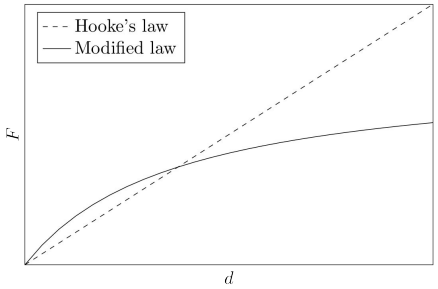
Liquid: implementation details

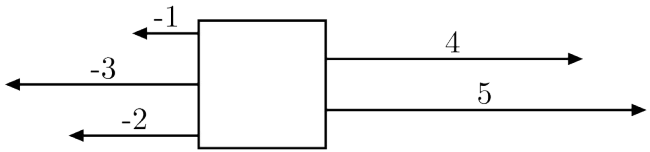
Slight change in how the system is built:

- Each net: spring between extreme clusters
- Long springs pull harder
- Extra spring for highly critical source-sink connections

Combining spring forces:



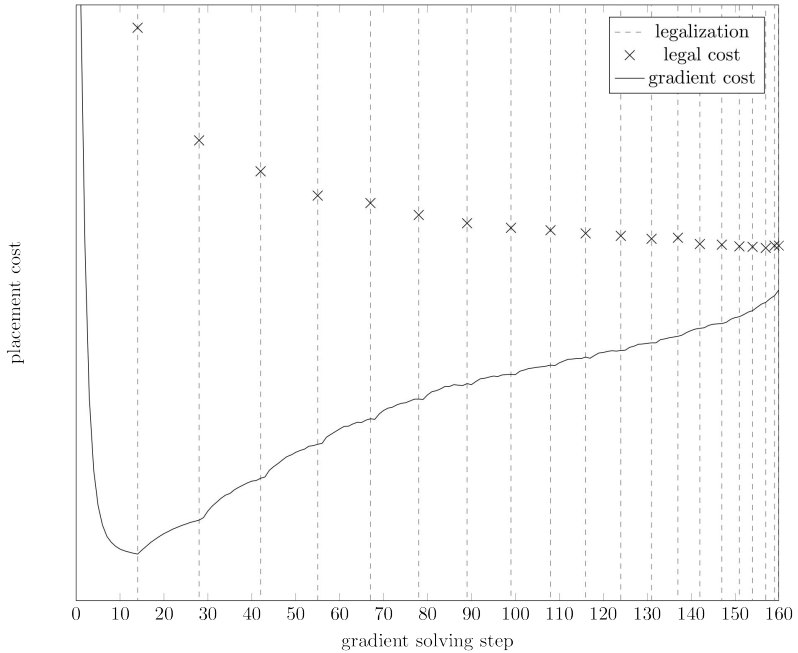




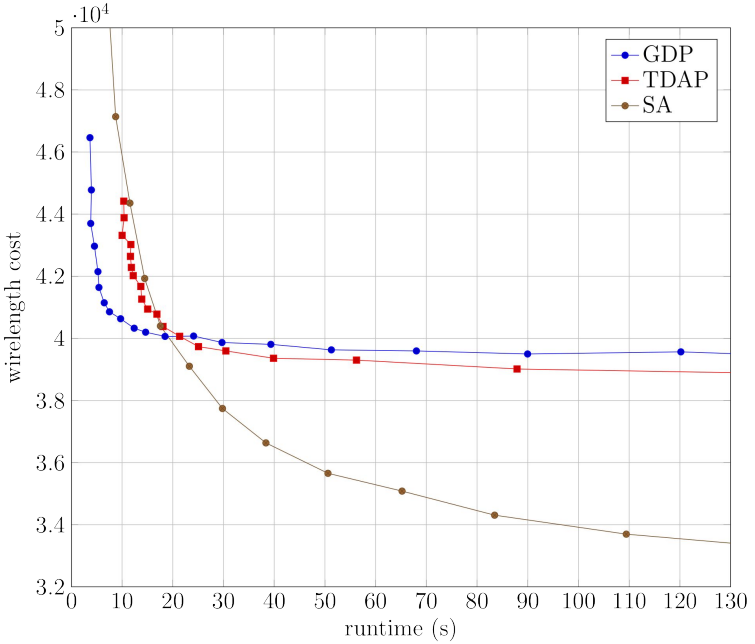
Effort level

Number of gradient descent iterations before legalization

Decreases as placement progresses



Results


$\cdot 10^4$
5
4.8
4.6
4.4
4.2
4
3.8
3.6
3.4
3.2
wirelength cost
0
10
20
30
40
50
60
70
80
90
100
110
120
130
runtime (s)
GDP
TDAP
SA

Conclusion and Future work