

# When Will Machines Make Machines?

## Using machine learning to develop EDA tools

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December 8, 2020

CMC EDA Workshop



**SCHULICH**  
School of Engineering

# Land Acknowledgement

“In the spirit of reconciliation, I acknowledge that I live, work and play on the traditional territories of the Blackfoot Confederacy (Siksika, Kainai, Piikani), the Tsuut’ina, the Nakoda Nations, the Métis Nation (Region 3), and all people who make their homes in the Treaty 7 region of Southern Alberta.”

The main task of an EDA Designer is  
to fit all of transistors and the wires  
in the chip

How do we fit ~~10 Billion~~ **1.2 Trillion** transistors in a chip?

We need to make machine intelligent enough to  
make themselves

# Intelligence

“Intelligence is measured by the capacity to remember and predict patterns in the world, including language, mathematics, physical properties of objects, and social situations.” Jeff Hawkins, 2004

“The ability to learn, understand, and make judgments or have opinions that are based on reason” Cambridge Advanced Learner’s Dictionary, 2006

“Sensory capacity, capacity for perceptual recognition, quickness, range or flexibility or association, facility and imagination, span of attention, quickness or alertness in response.” F. N. Freeman

# Intelligence - 1

“Intelligence is measured by the capacity to **remember** and **predict patterns** in the world, including language, mathematics, physical properties of objects, and social situations.” Jeff Hawkins, 2004

# Creative team – Eh?Predictor

Eh? Predictor



Aysa Fakheri-  
Tabrizi  
Alea



Logan Rakai  
Cloud Academy



Ismail Bustany  
Xilinx



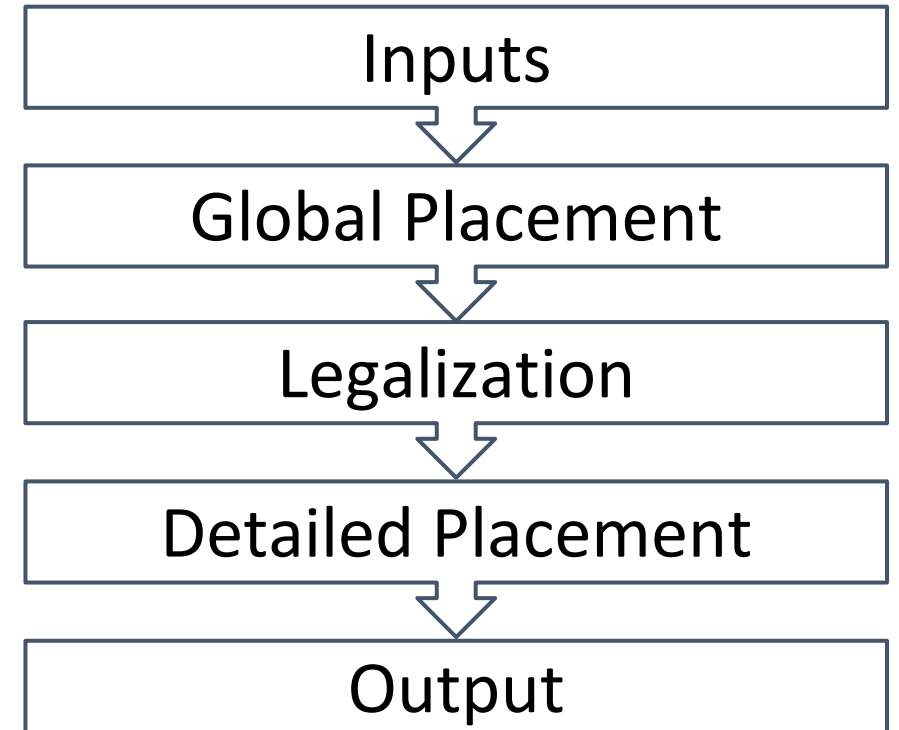
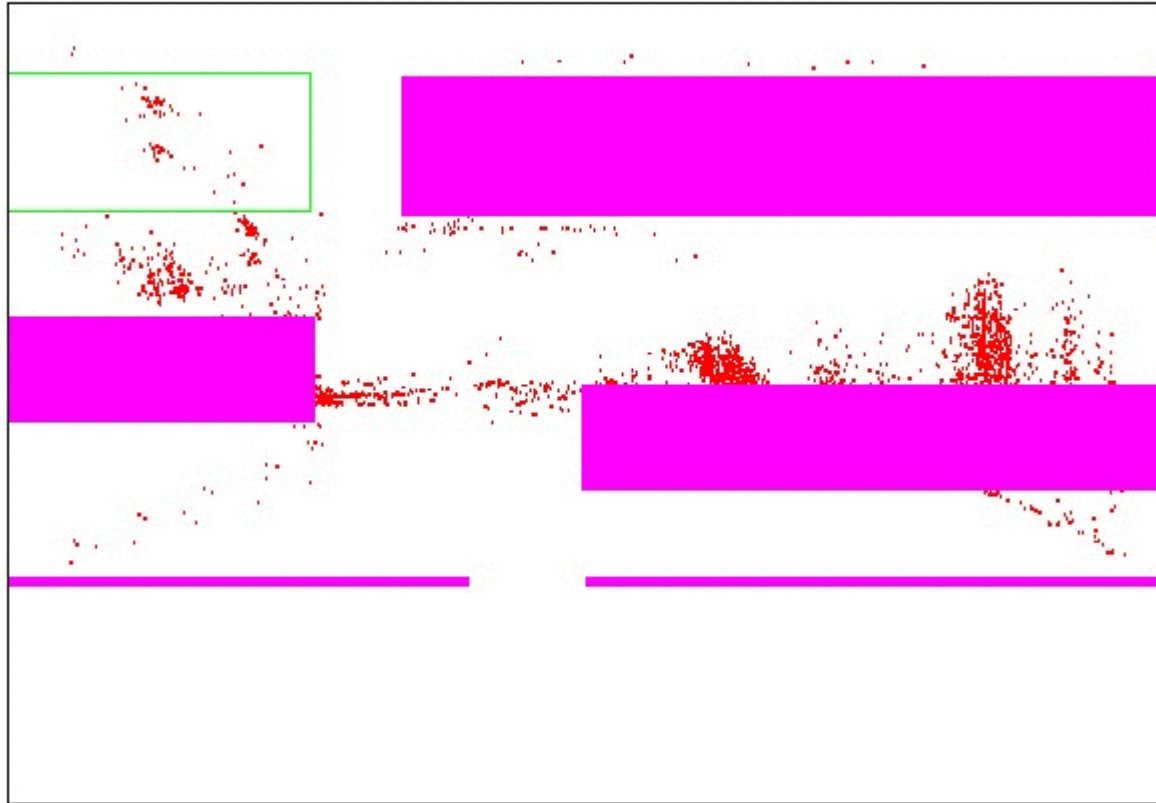
Nima Karimpour  
Darav  
Efinix Inc.



Laleh Behjat  
University of  
Calgary

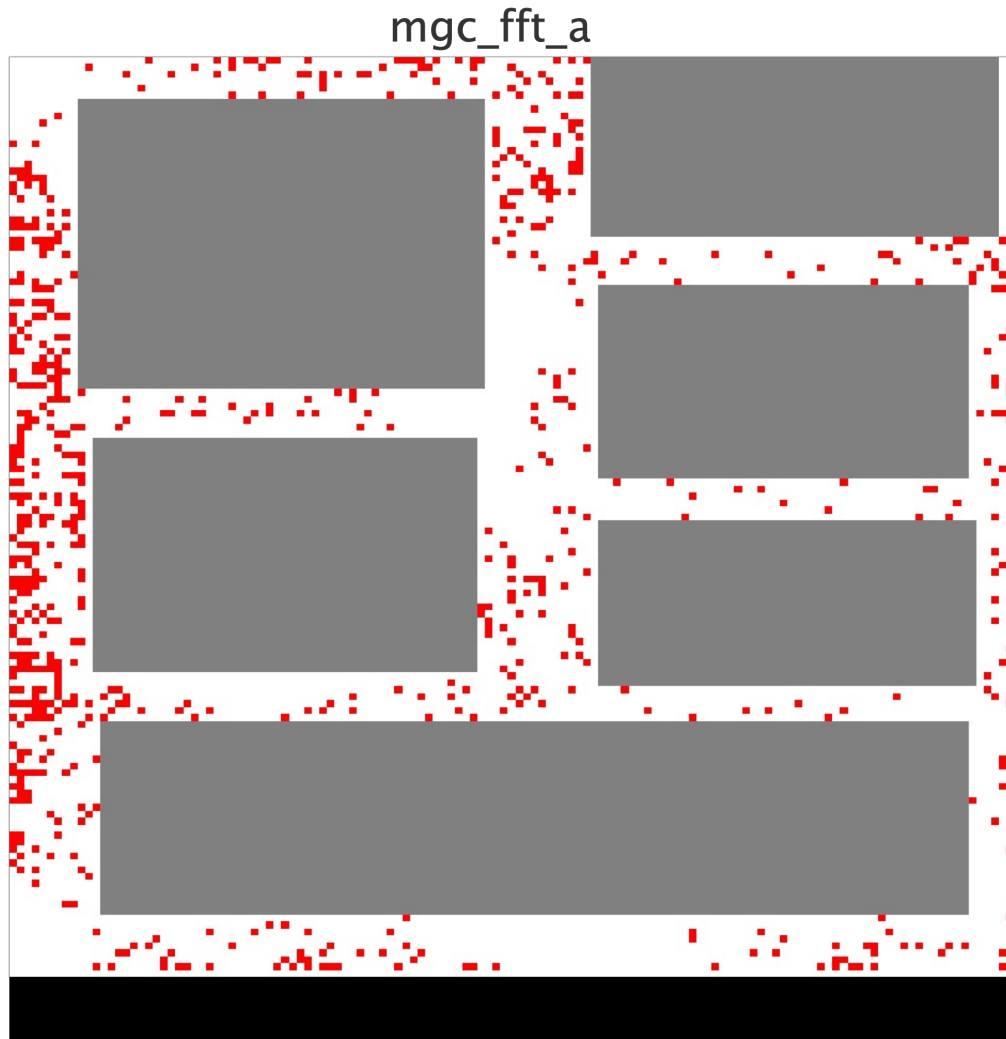


# Placement problem



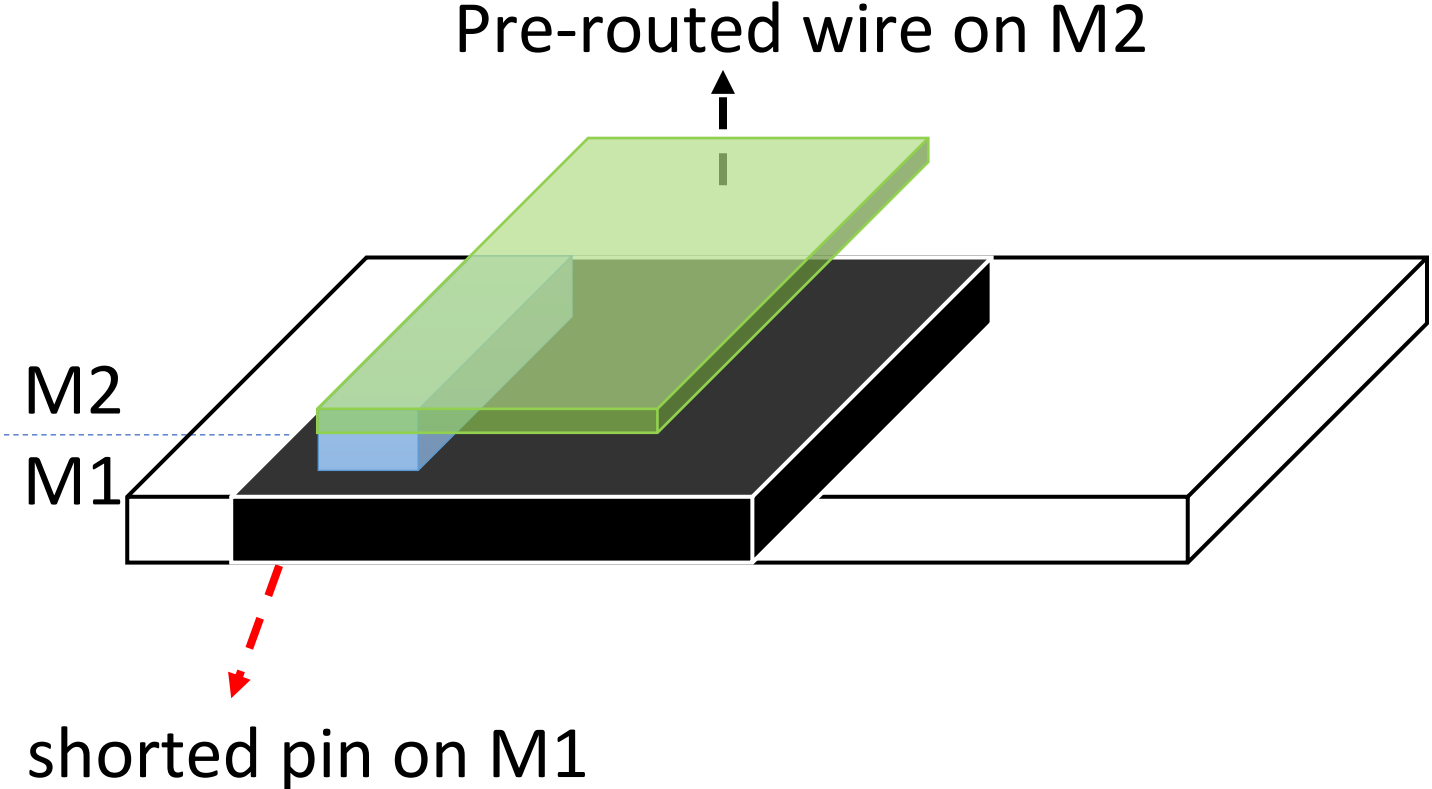
Catalyst for technical creativity -

No matter how good the placement, detailed routing is hard

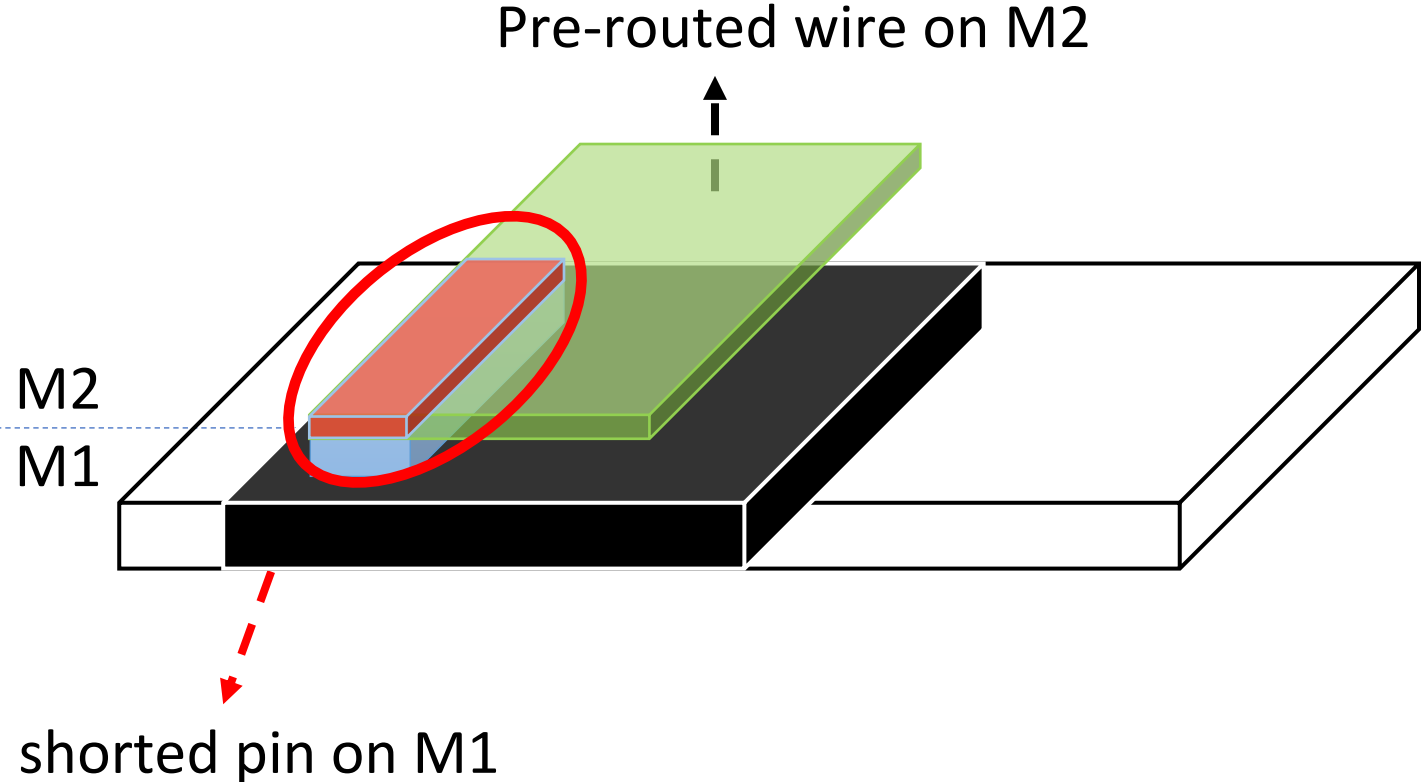


Shorts after routing for circuit  
mgc\_fft\_a

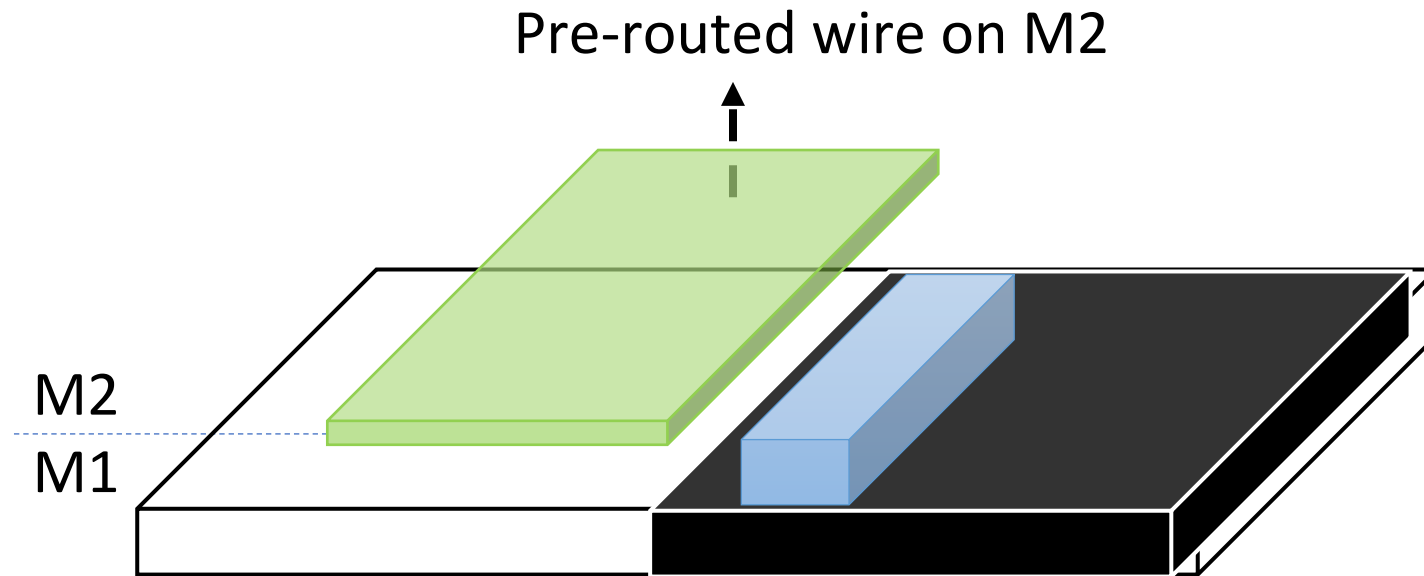
# Detailed routing



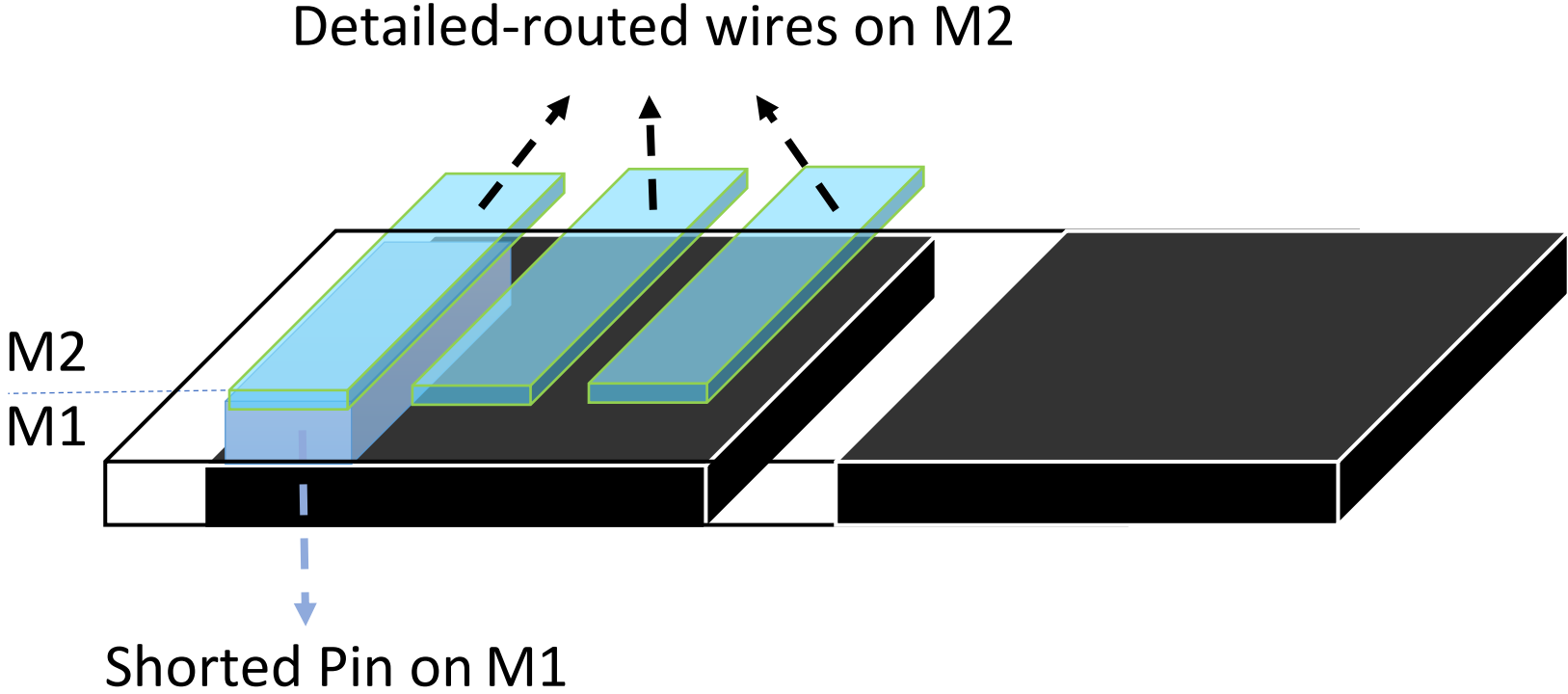
# Detailed routing



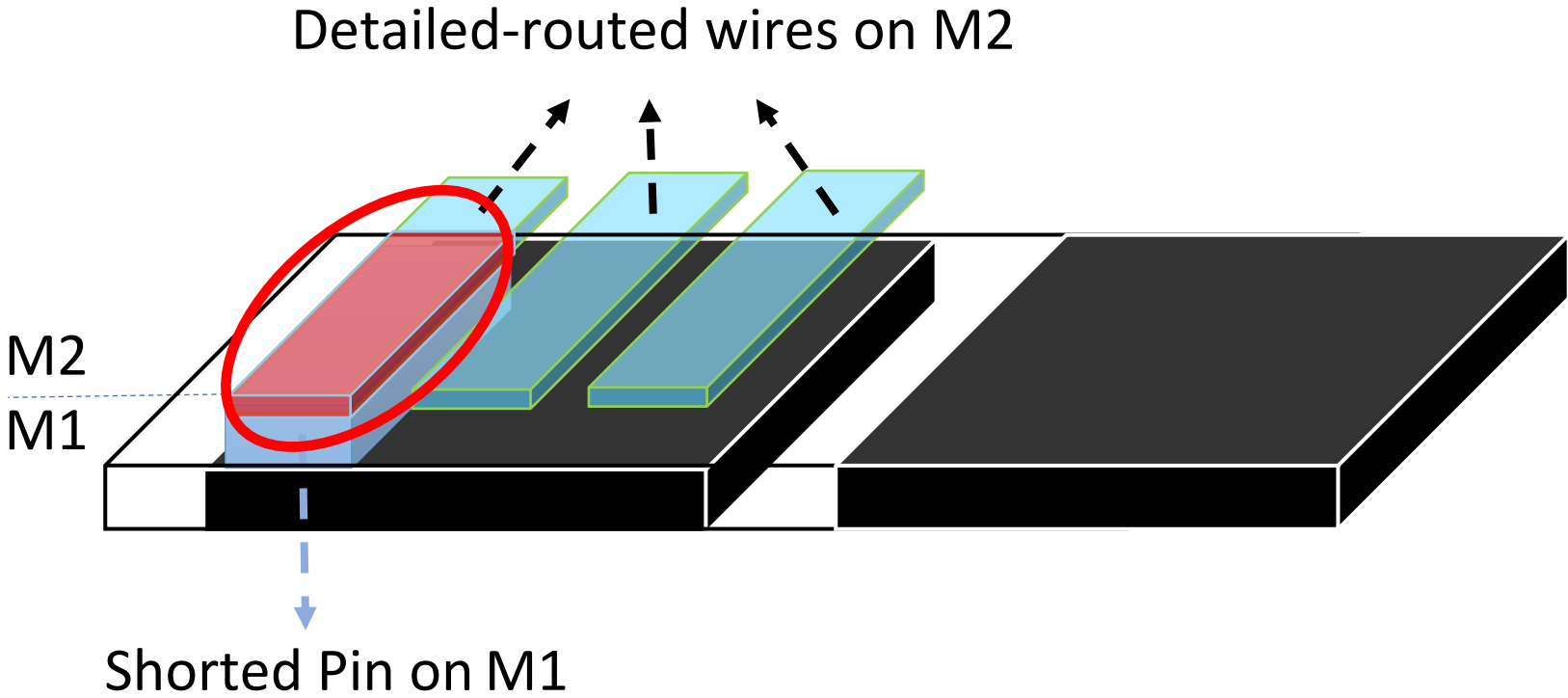
# Detailed routing



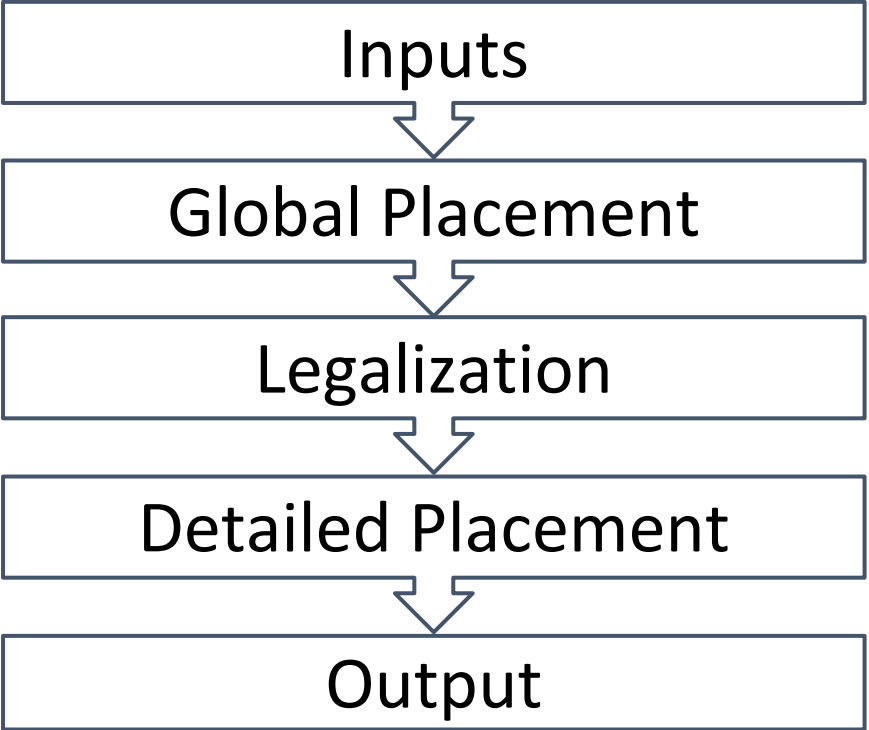
# Detailed routing



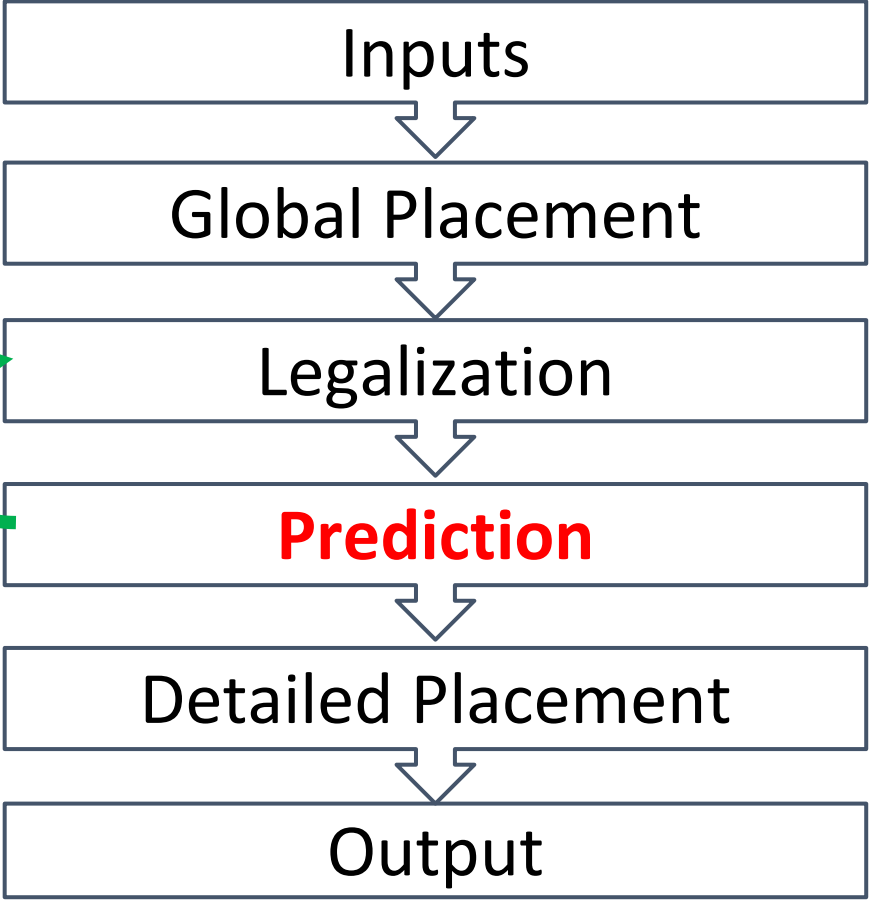
# Detailed routing



# Main idea

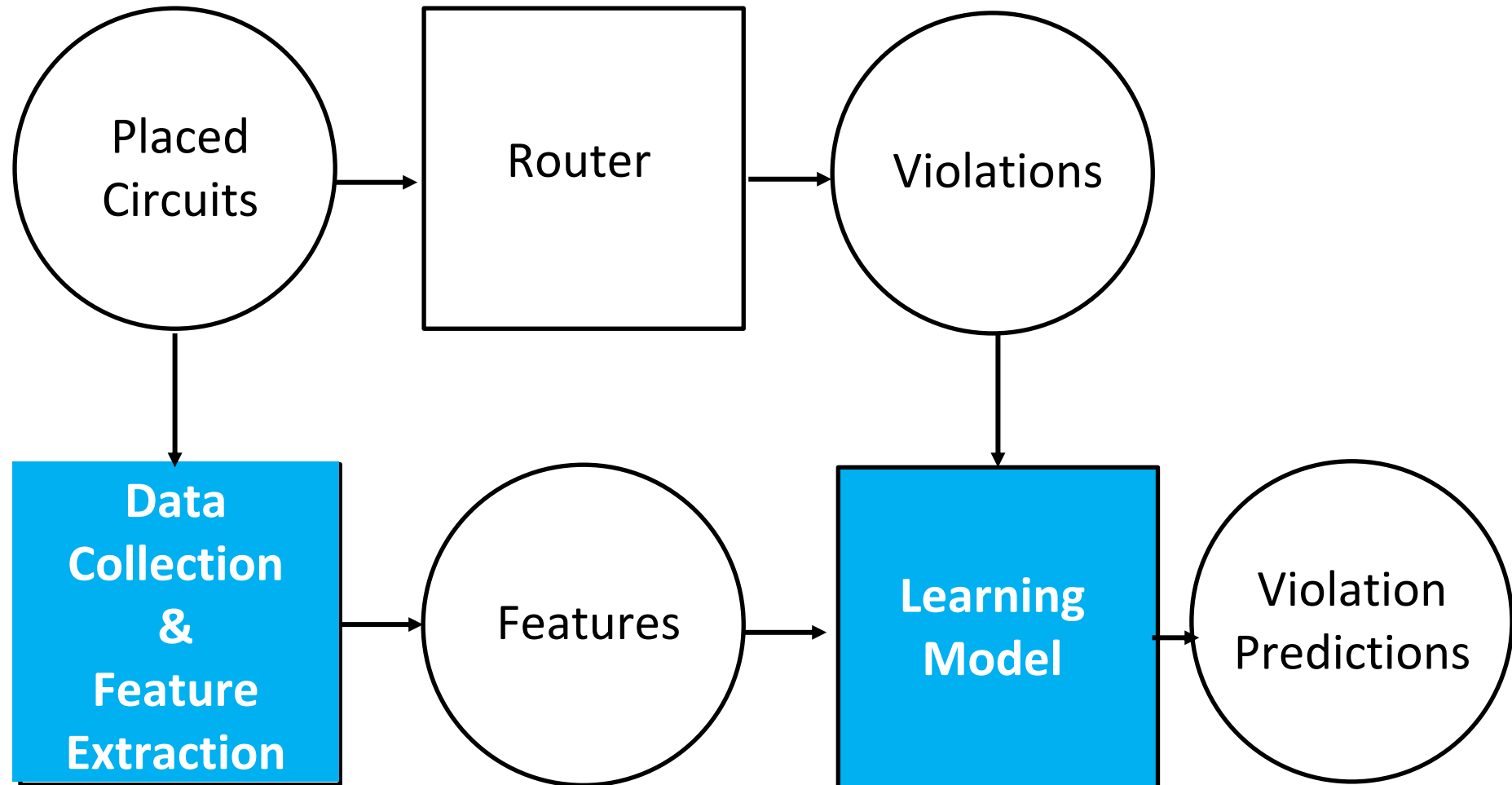


Correction

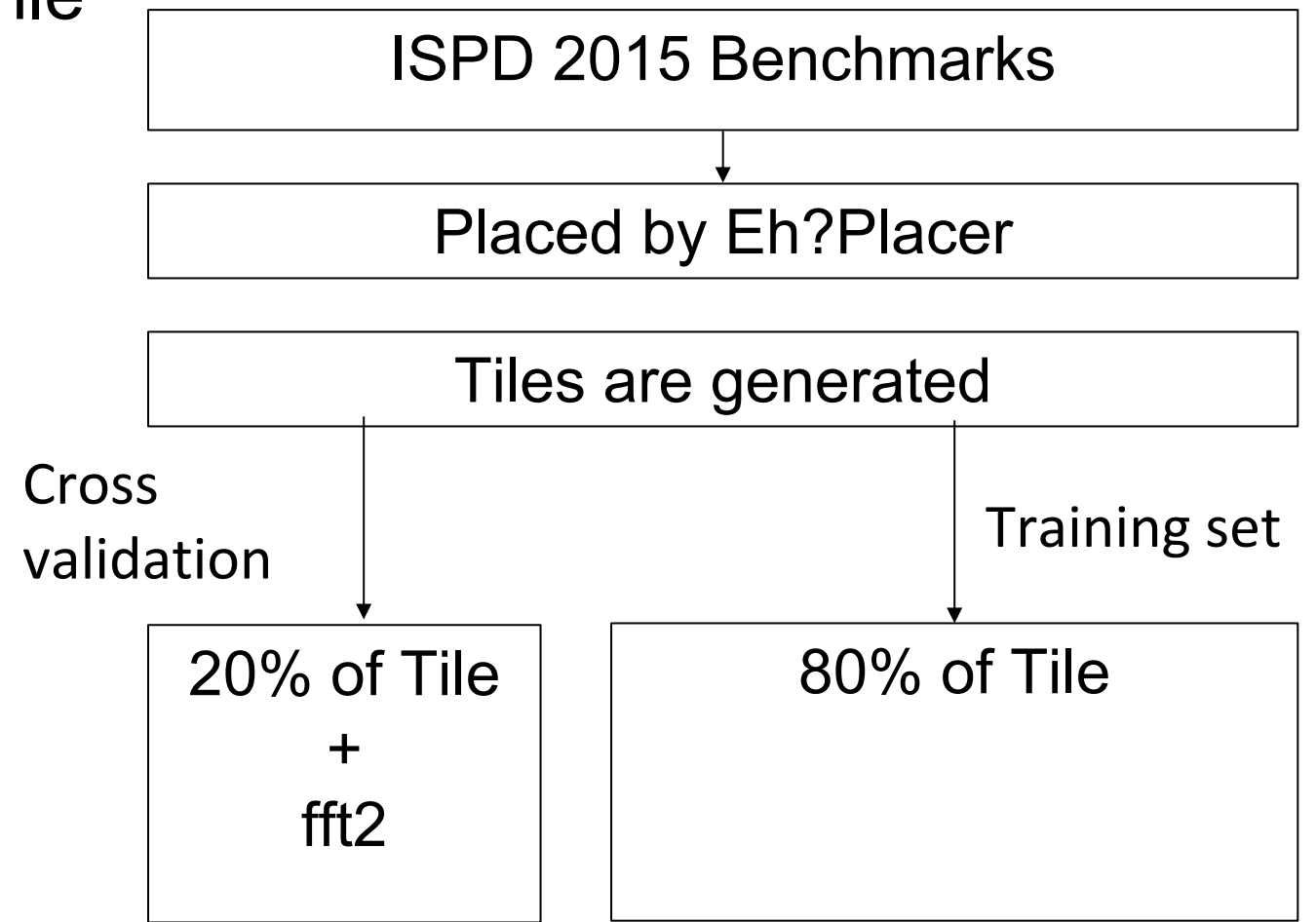
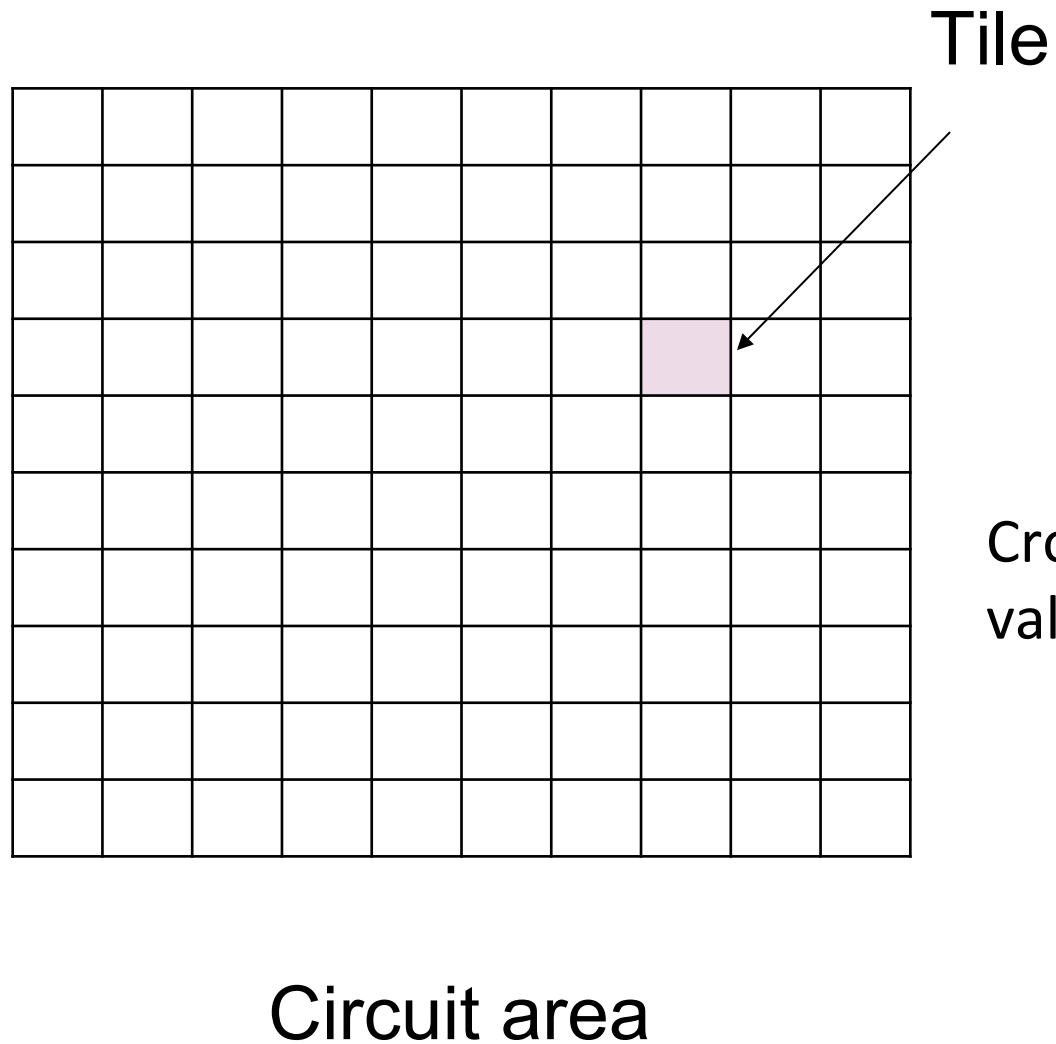




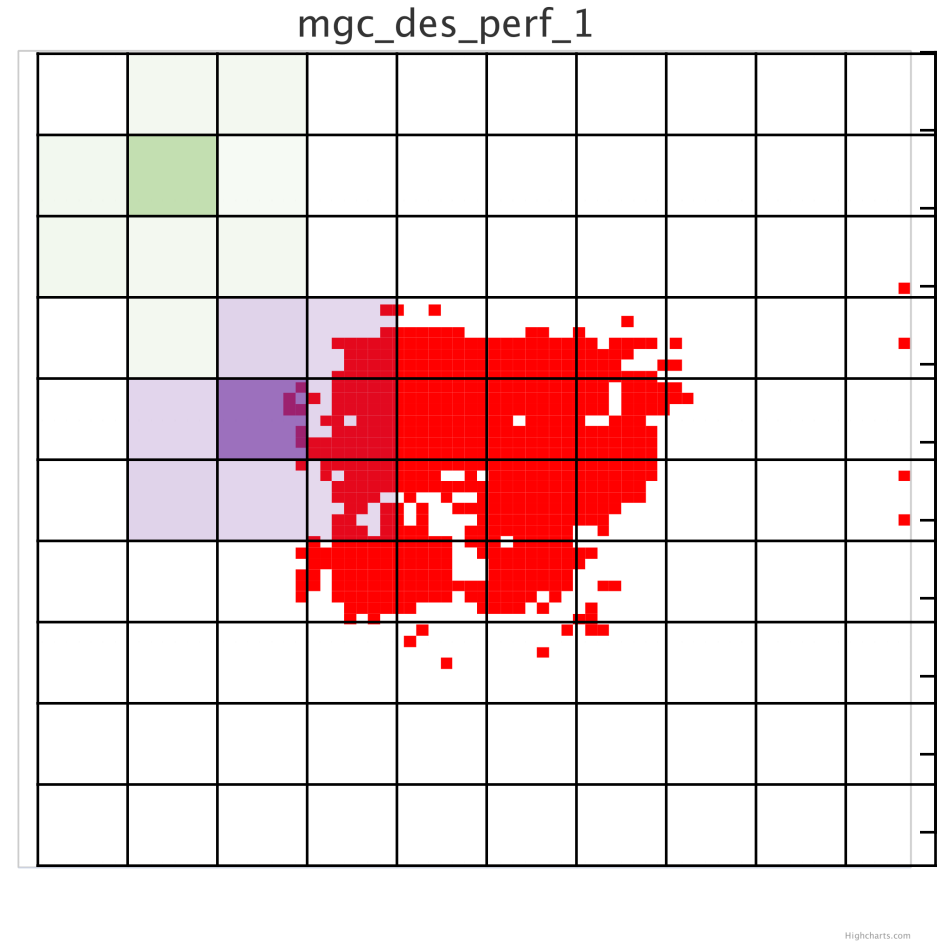
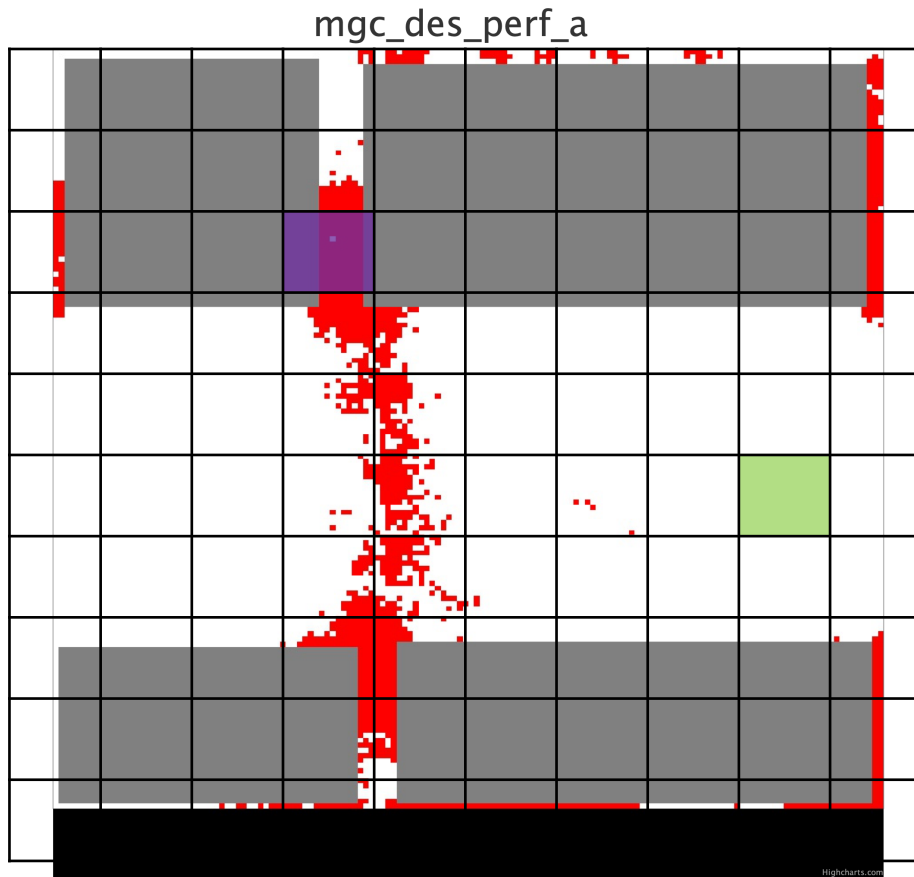
# Eh? Predictor



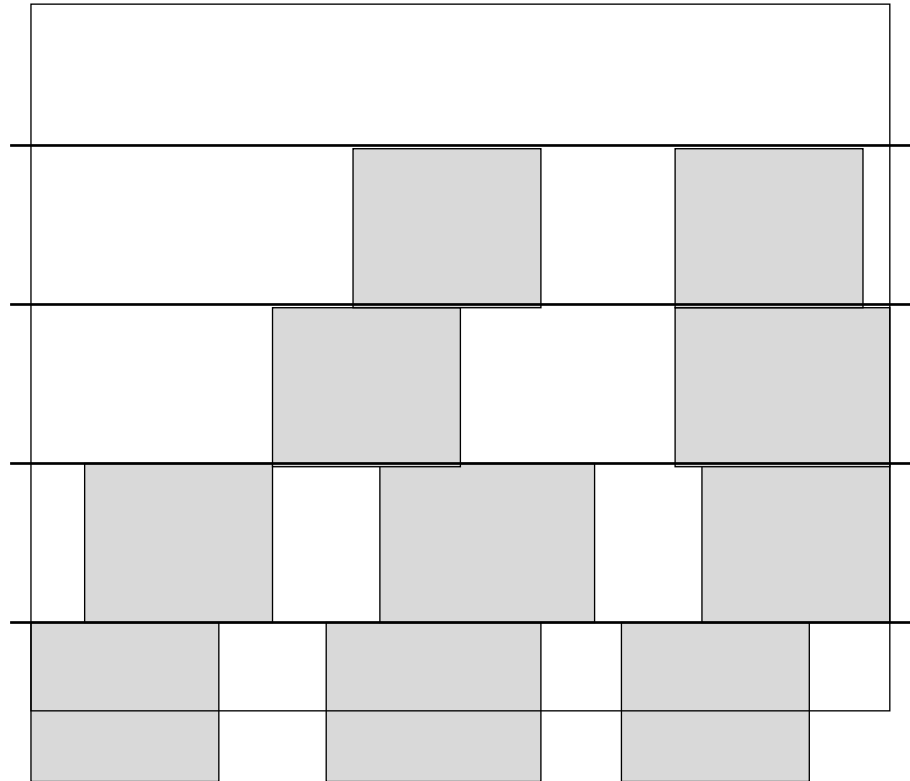
# Data Collection



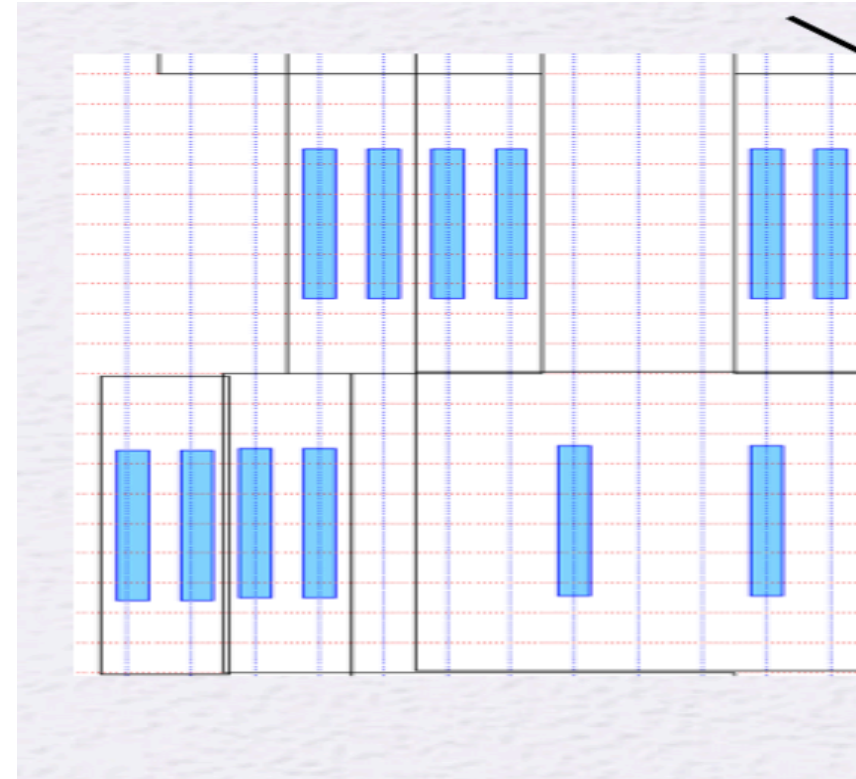
# Feature Extraction - Position



# Feature Extraction - Density



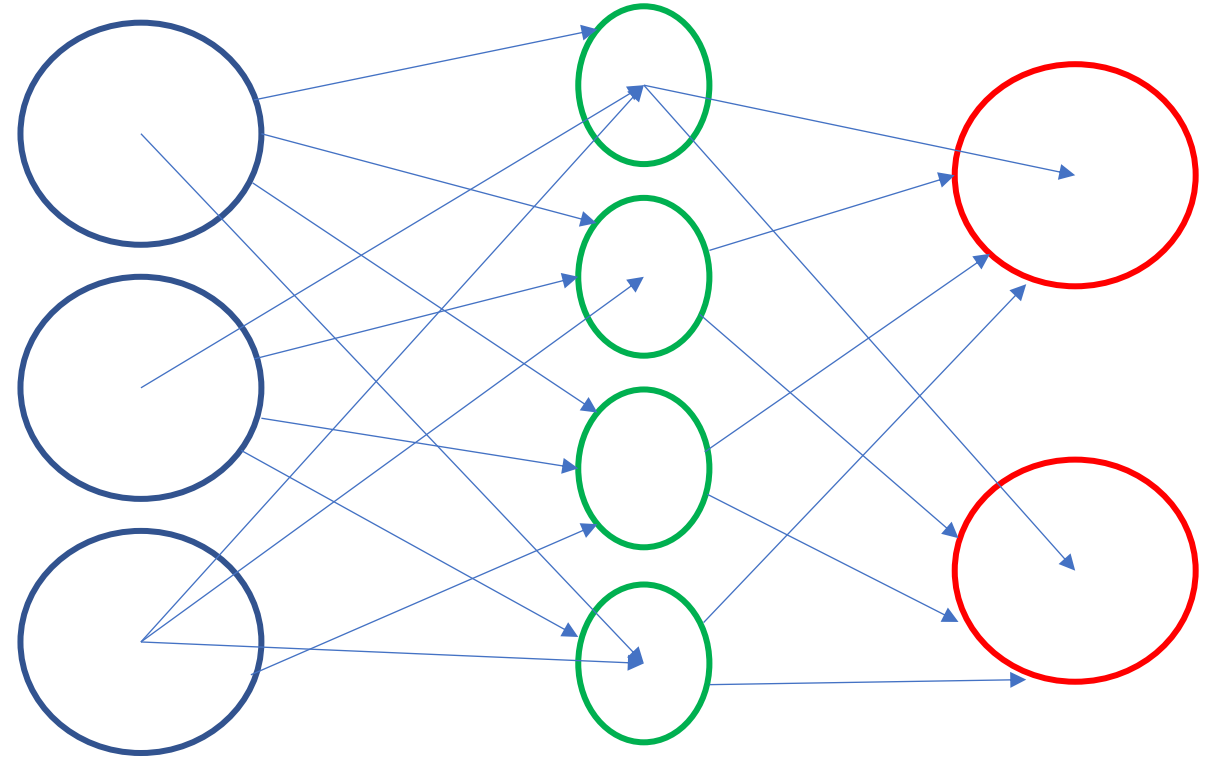
Cell Density



Pin Density

# Model Selection

Neural Network with up to 4 hidden layers



# Evaluation - TPR

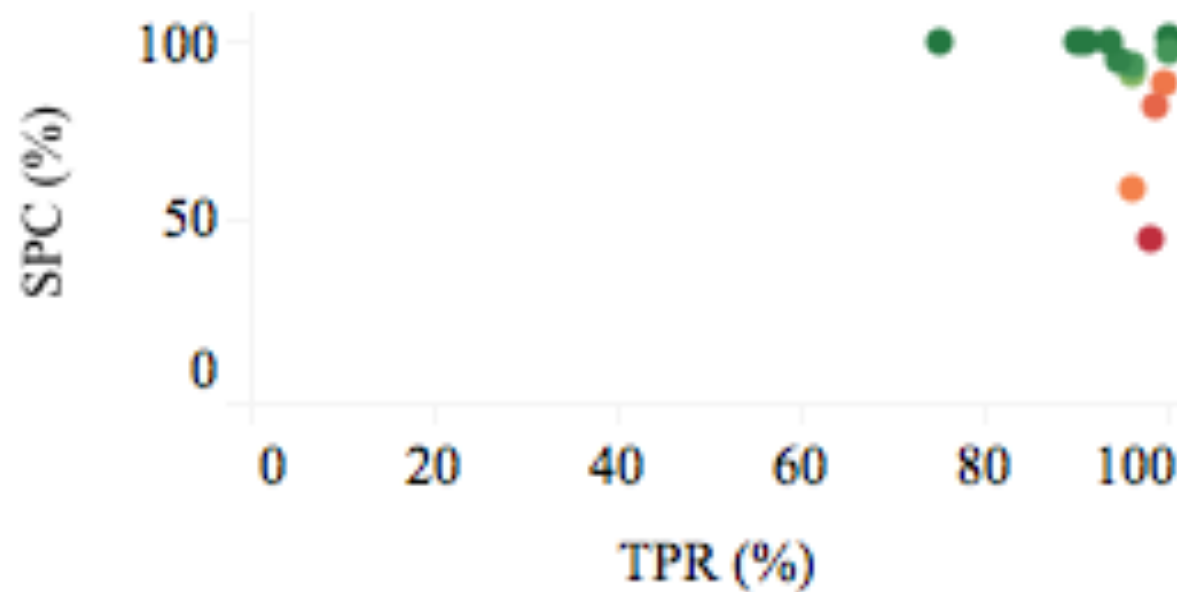
True Positive Rate (TPR):

**Overall** **93%**

#shorts > 500 96%

100 < #shorts < 500 87%

#shorts < 100 73%

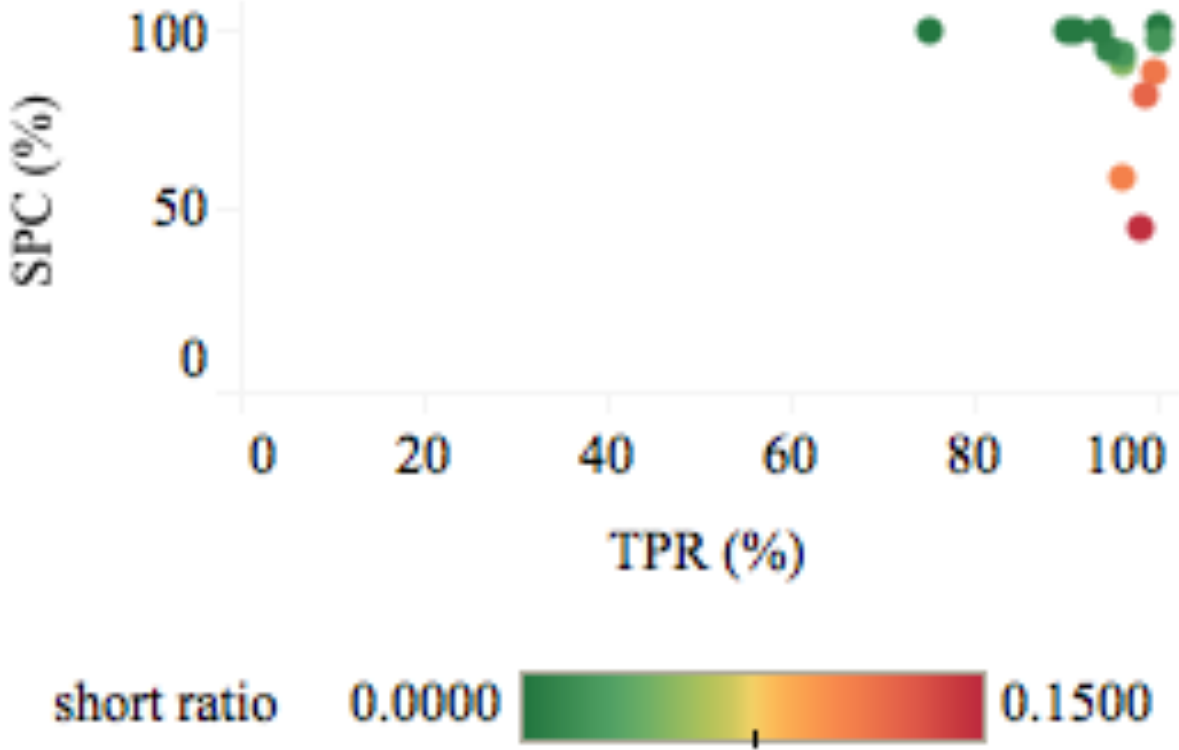


short ratio 0.0000  0.1500

# Evaluation - SPC

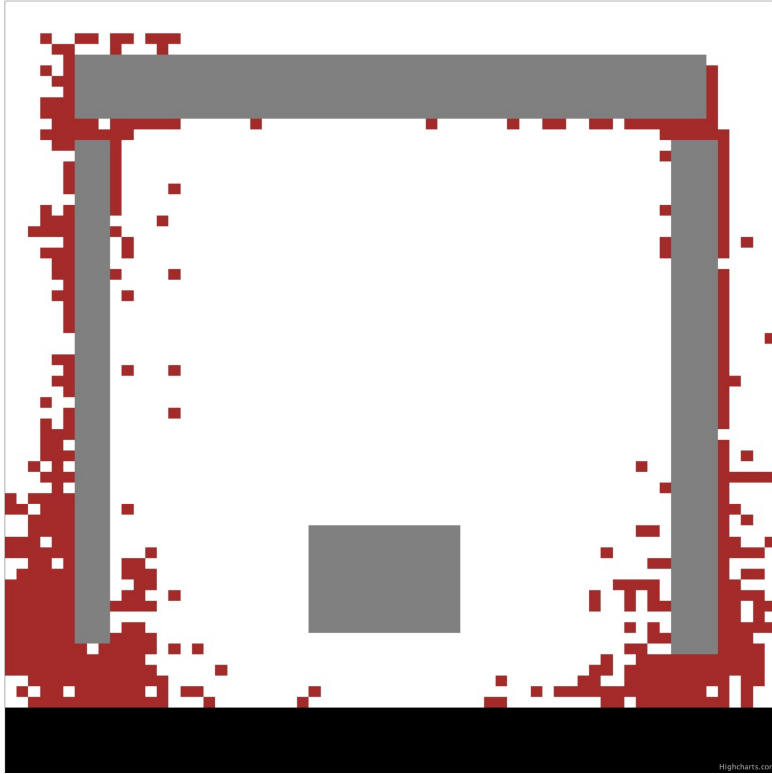
Specificity (SPC):

<b>Overall</b>	<b>93%</b>
#shorts > 500	60%
100 < #shorts < 500	91%
#shorts < 100	93%

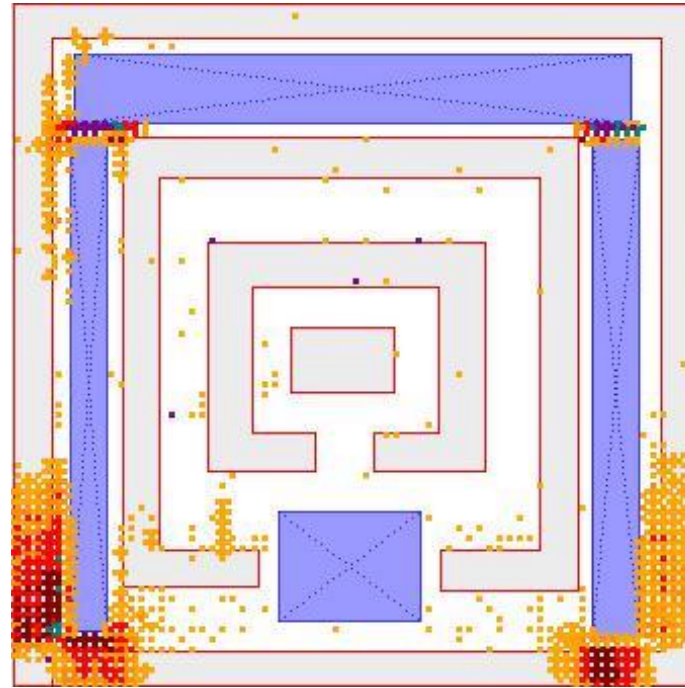


# Case Study – Narrow channel - bridge32\_a

mgc\_pci\_bridge32\_a

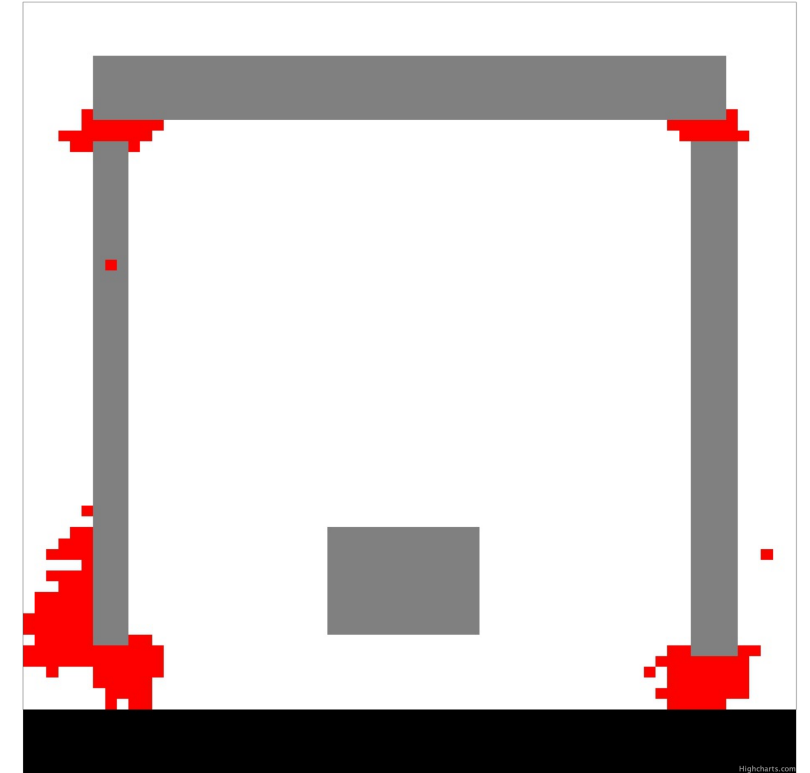


Our prediction



Global Routing

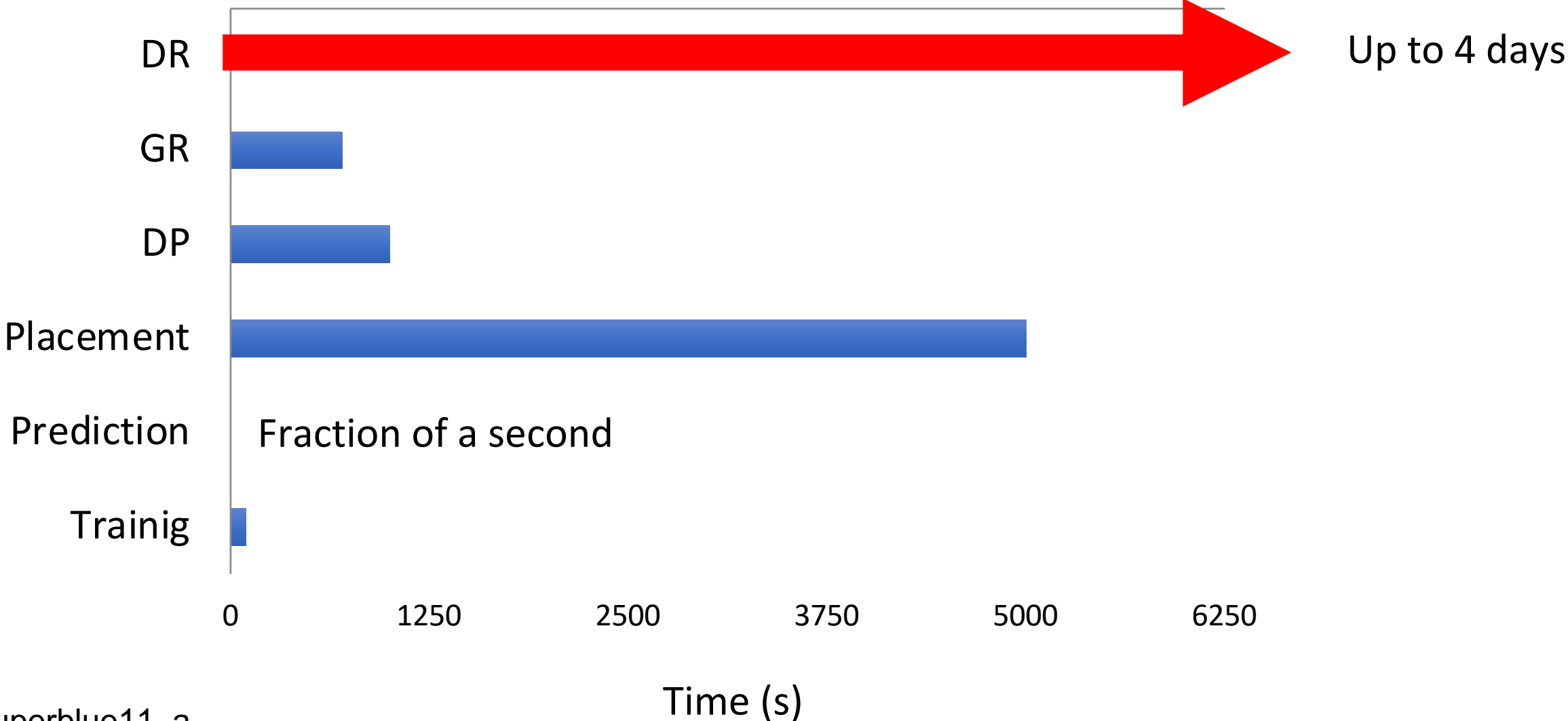
mgc\_pci\_bridge32\_a



Detailed Routing



# Runtime



# Bigger picture consequences

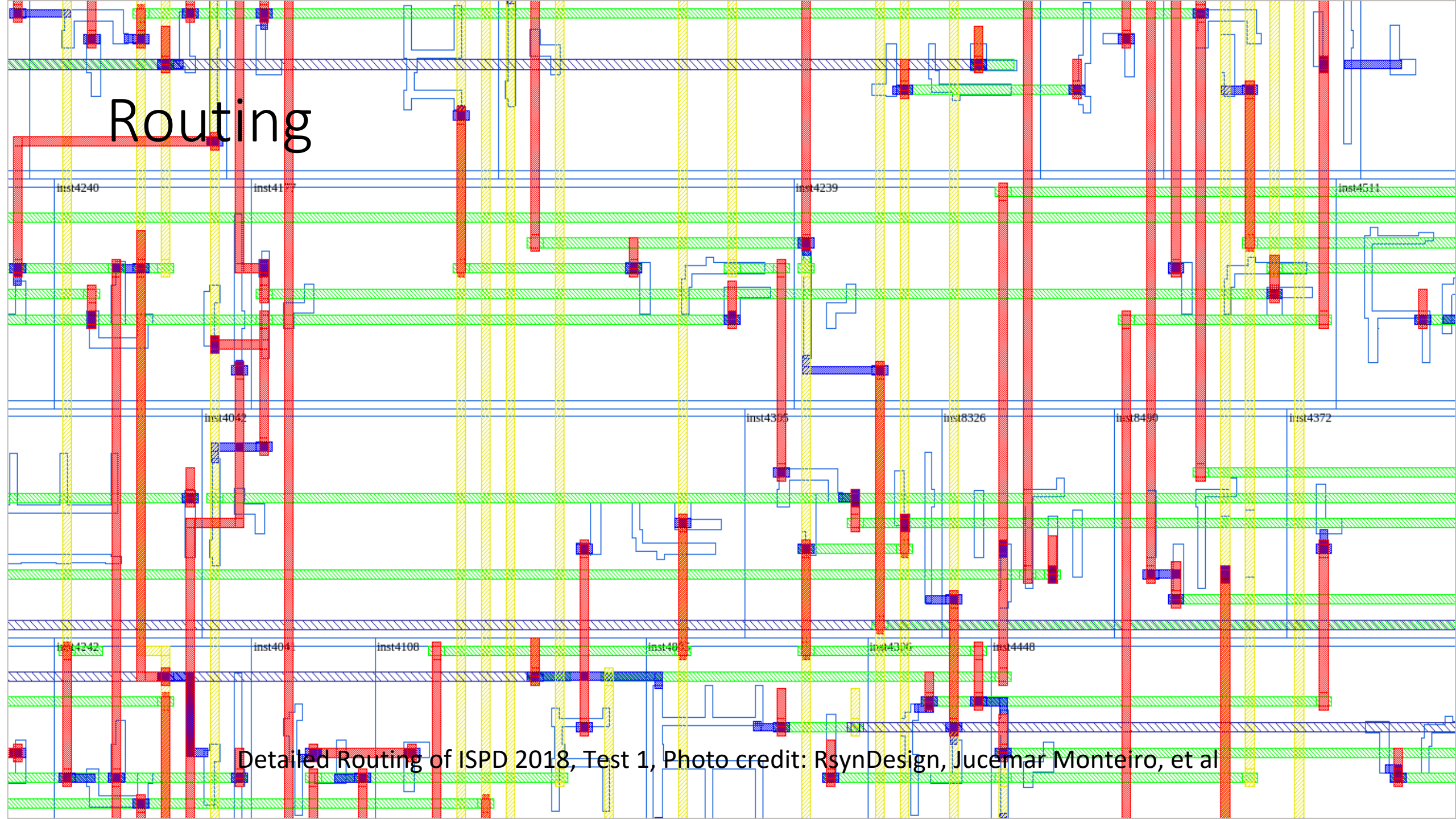
“Intelligence is measured by the capacity to **remember** and **predict patterns** in the world, including language, mathematics, physical properties of objects, and social situations.” Jeff Hawkins, 2004

EDA algorithms can remember and predict patterns.

# Intelligence

“The ability to **learn, understand, and make judgments** or have opinions that are based on reason” Cambridge Advanced Learner’s Dictionary, 2006

# Routing



Detailed Routing of ISPD 2018, Test 1, Photo credit: RsynDesign, Jucemar Monteiro, et al

# Detailed Routing

Very complicated

Too many constraints

No good models for optimization

Can we use Machine Learning to solve the routing problem?

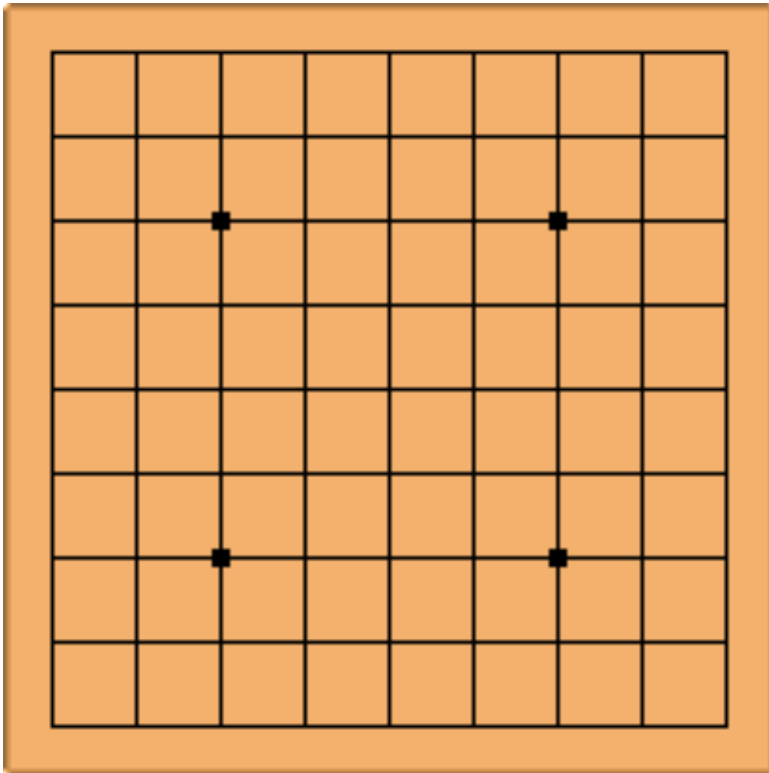
# Machine Learning Needs Data

Have 14 benchmarks available.

The best way to do this is to use Reinforcement learning.

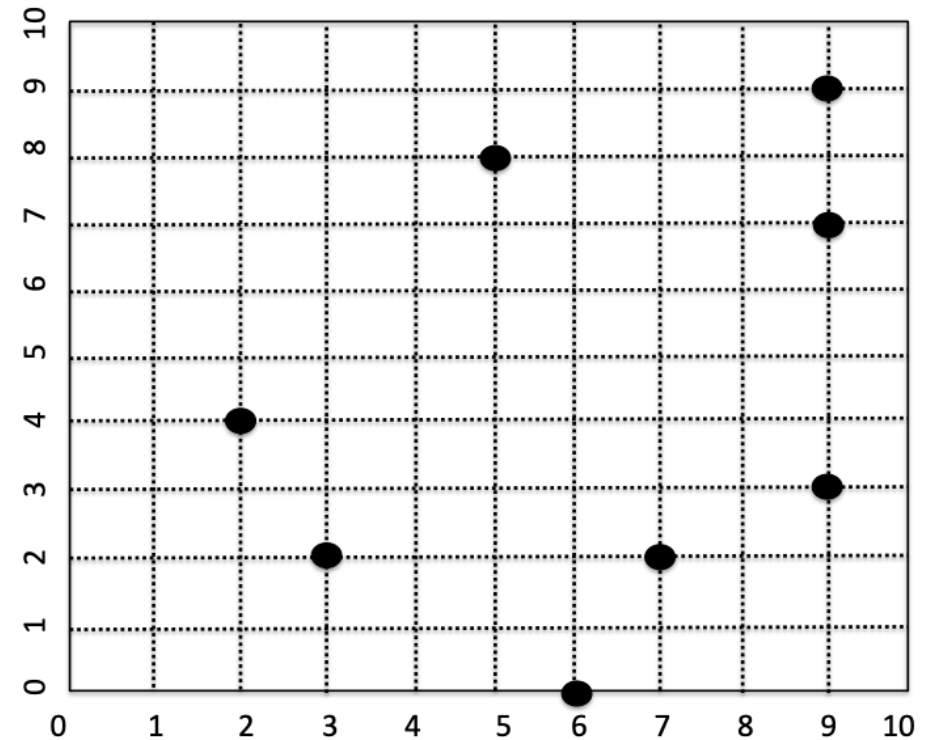
Inspiration came from AlphaGo Zero

# Catalyst – These board look alike



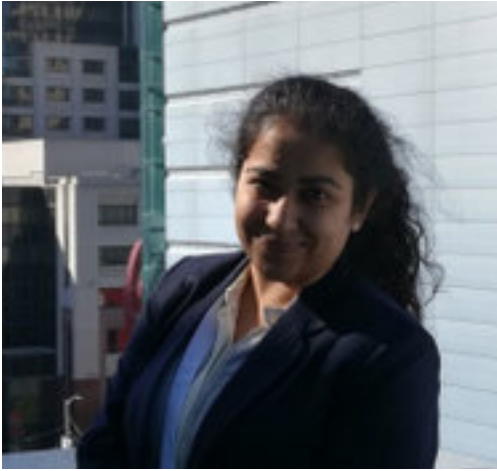
The game of Go Board

[Image Source : https://senseis.xmp.net/?Go](https://senseis.xmp.net/?Go)



Grid based Metal layers

# Creative Team



Upma Gandhi  
University of Calgary



Bill Swartz  
Timberwolf



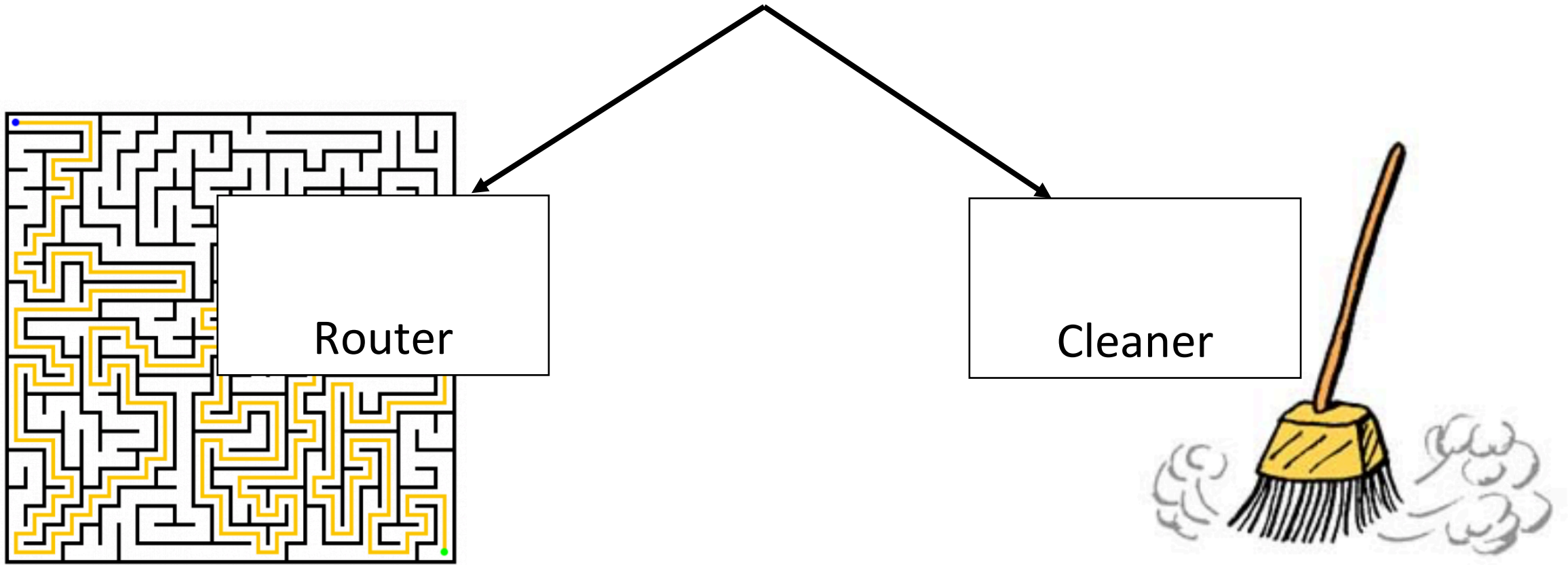
Ismail Bustany  
Xilinx



Laleh Behjat  
University of Calgary



# $\alpha$ PD-ROUTER Players



# $\alpha$ PD-ROUTER Players

0	1	2	3	4
5	6	7	8	9
10	11	12	13	14
15	16	17	18	19
20	21	22	23	24

Router:

Route all nets using  $A^*$

0	1	2	3	4
5	6	7	8	9
10	11	12	13	14
15	16	17	18	19
20	21	22	23	24

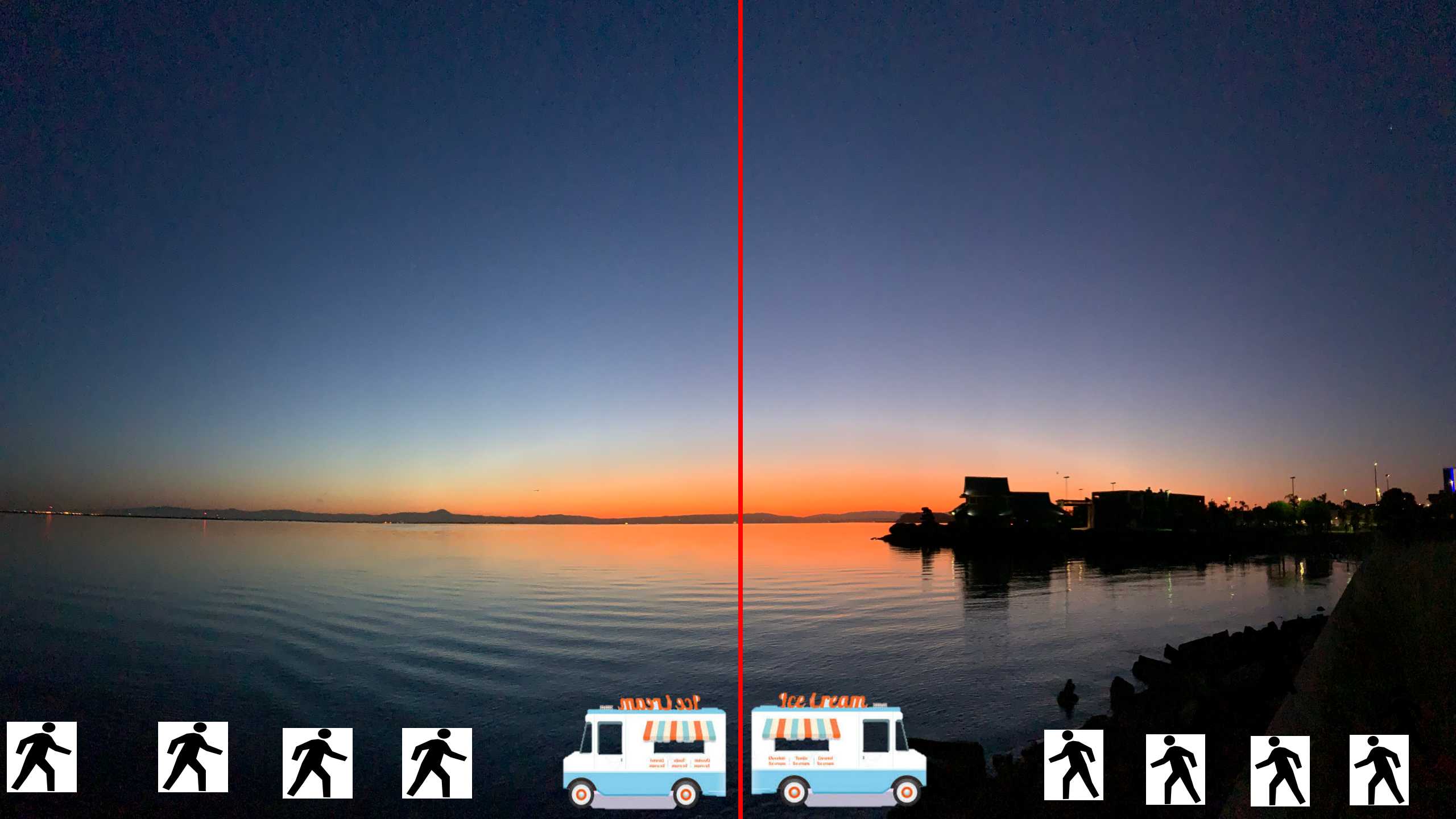
Cleaner:

Rip one of the candidate  
nets

# Competition versus collaboration

When the two players are competing against each other we often get to a Nash equilibrium. This equilibrium is not an optimal point.

In this case, we decided to make sure that our two players collaborate versus compete.



cleaner: Gets rewards based on routers ability to route

Prospective net boards to re-route

0	1 s1	2	3	4
5	6	7 d3	8 d1	9
10	11 d2	12	13	14 s2
15	16	17	18	19
20 s3	21	22	23	24

0	1 s1	2	3	4
5	6	7 d3	8 d1	9
10	11 d2	12	13	14 s2
15	16	17	18	19
20 s3	21	22	23	24

# Router: Gets rewards based on making less DRC

0	1	2	3	4
5	6	7	8	9
10	11	12	13	14
15	16	17	18	19
20	21	22	23	24

0	1	2	3	4
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# Bigger Picture Consequences

“The ability to **learn, understand, and make judgments** or have opinions that are based on reason” Cambridge Advanced Learner’s Dictionary, 2006

EDA Algorithms can learn, understand and make good judgments.

# Intelligence

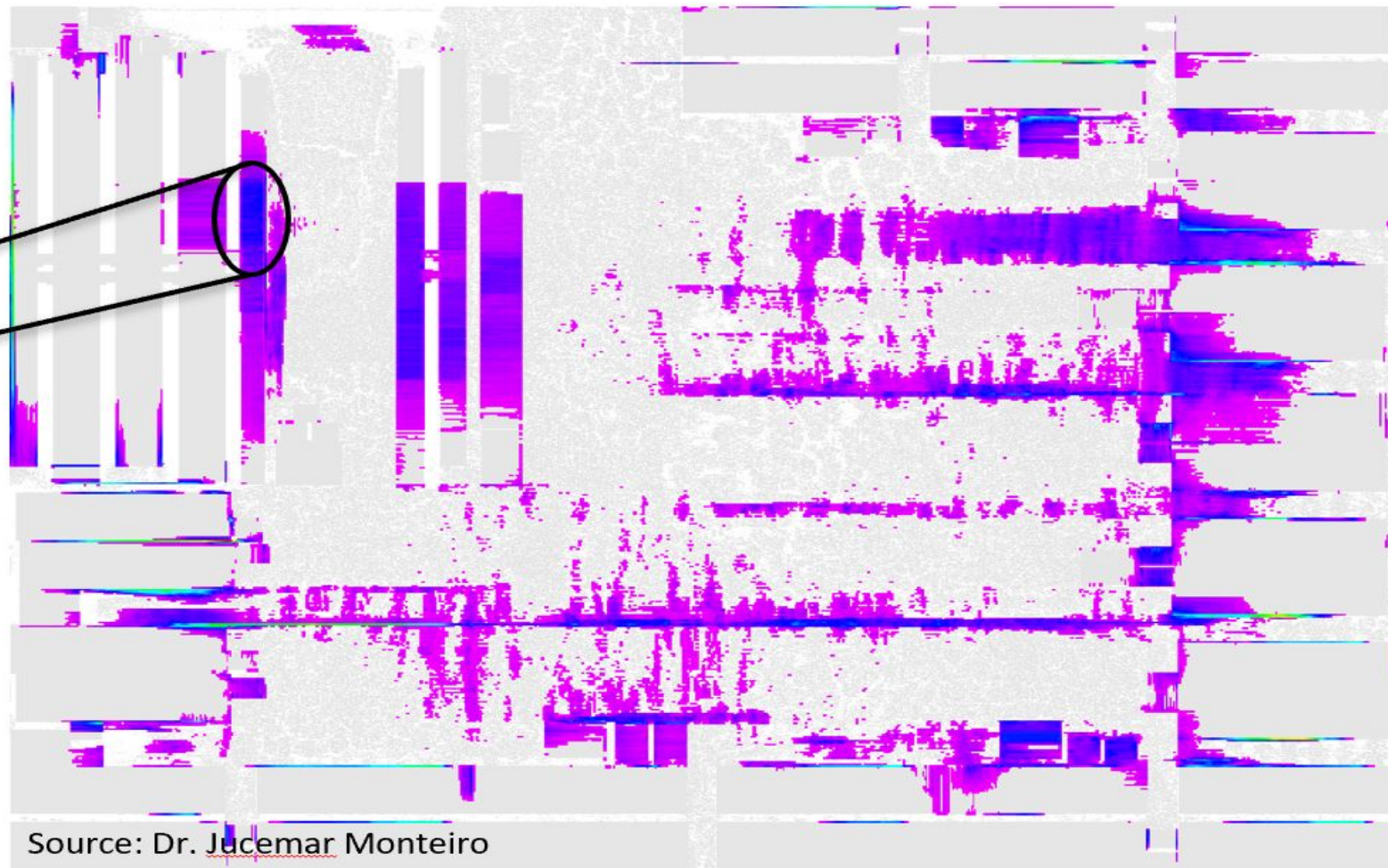
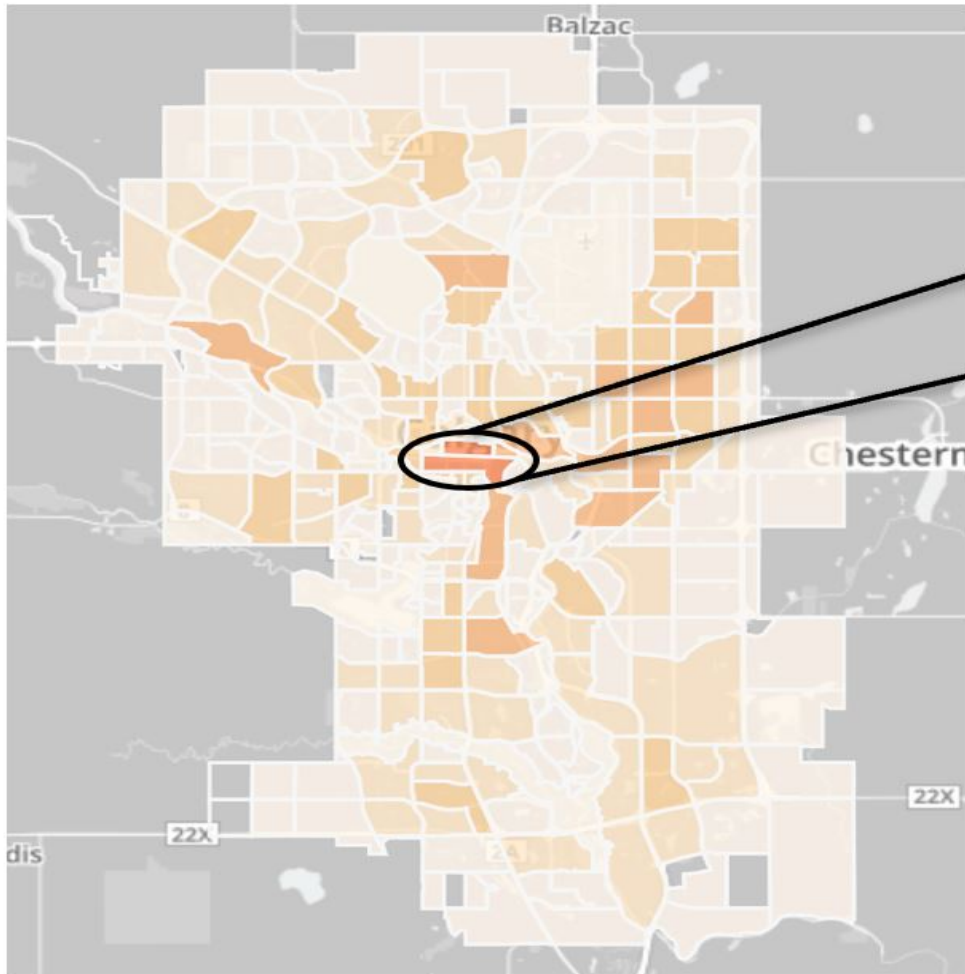
“Sensory capacity, capacity for perceptual recognition, quickness, range or flexibility or **association**, facility and imagination, **span of attention**, quickness or alertness in response.” F. N. Freeman



The advances in technology, especially in terms of the artificial intelligence and biological advances would mean that in the 21<sup>st</sup> century, we will be able to recreate our, systems, cities, societies and even ourselves. We will also create many different real and virtual worlds. We need researchers from all parts of the human knowledge to work together to shape a world that we all will not only survive but also thrive in.

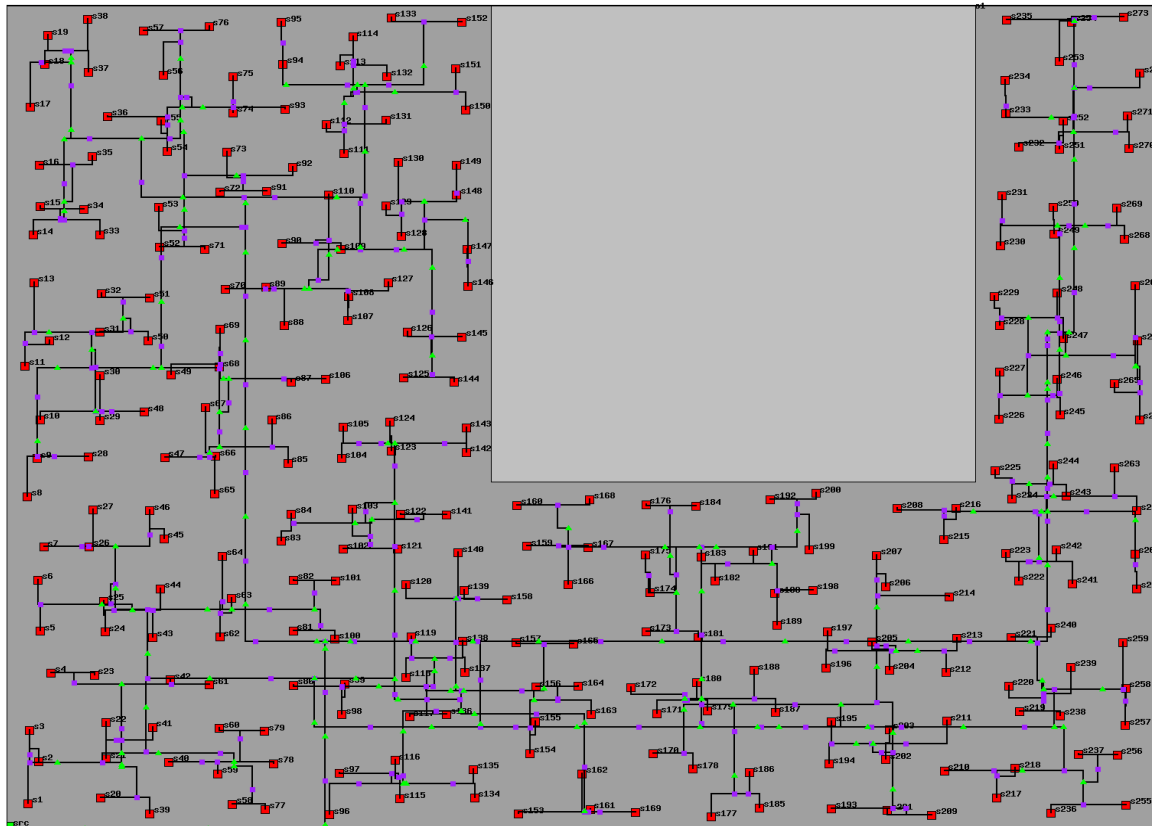
Can we use some of the EDA solutions to solve these pressing problems?

# Use Machine Learning to Make Safer Cities



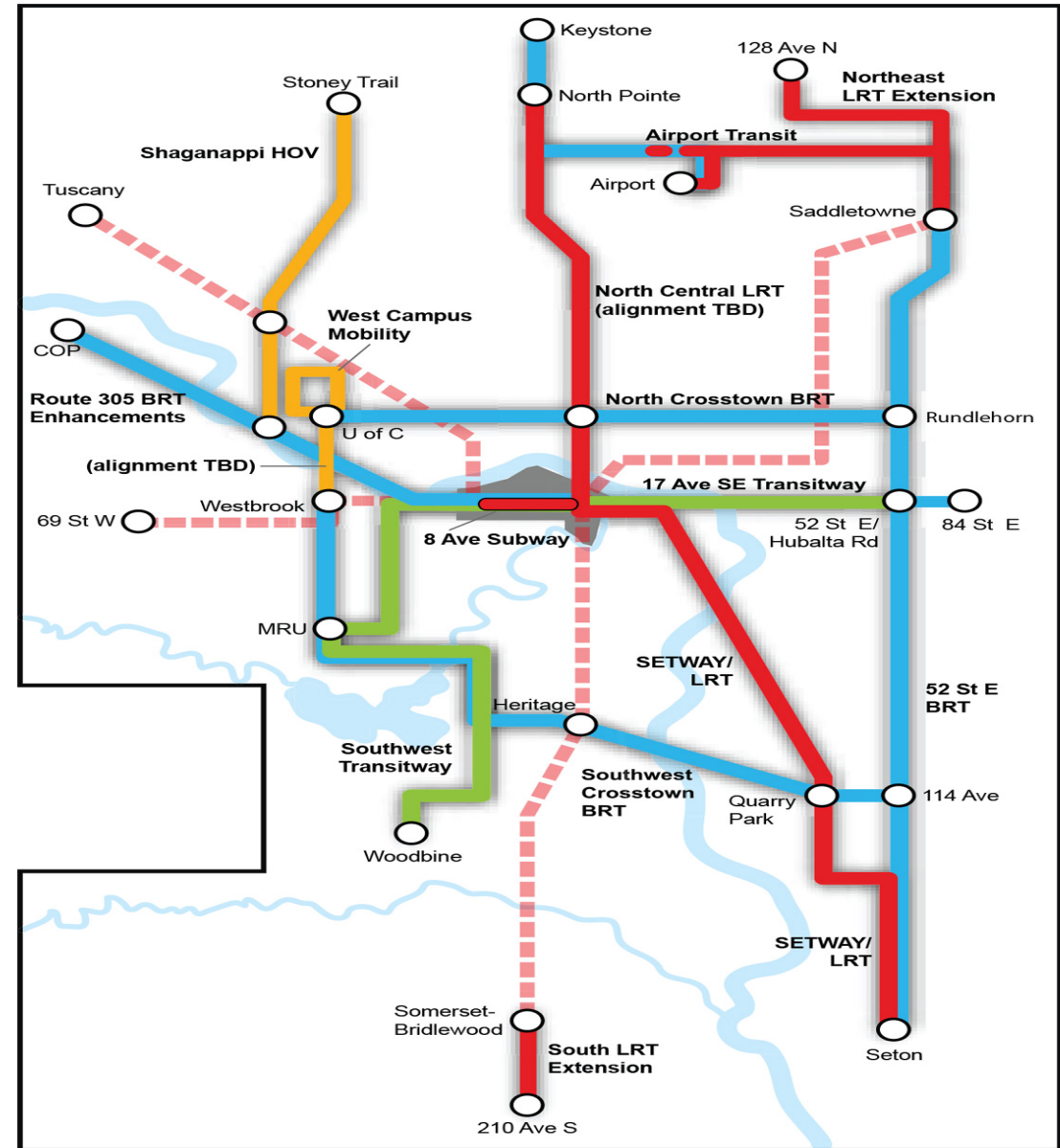
Source: [Dr. Jucemar Monteiro](#)

# Use Clock network Optimization for reducing power to send crude oil | pipelines



Crude oil pipeline, Texas  
photo credit Joe Raedle/News-makers via getty Images

Use reinforcement learning to make a collaborative public/private transportation system using autonomous vehicles



# Intelligence

“Sensory capacity, capacity for perceptual recognition, quickness, range or flexibility or **association**, facility and **imagination**, span of attention, quickness or alertness in response.” F. N. Freeman

Can we make EDA algorithms that make association and have imagination?

“We can only see a short distance ahead, but we can see plenty there that needs to be done”

– Alan Turing



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