Prices Drop as you Shop

How Jet is Using GPU based Smart Merchant Selection to Gain a Competitive Advantage

Today

1. Intro
2. E-Commerce Market Potential
3. Problem
4. Brute Force Approach with GPUs
5. A Smarter AI Powered GPU Solution

Intro

Introduction

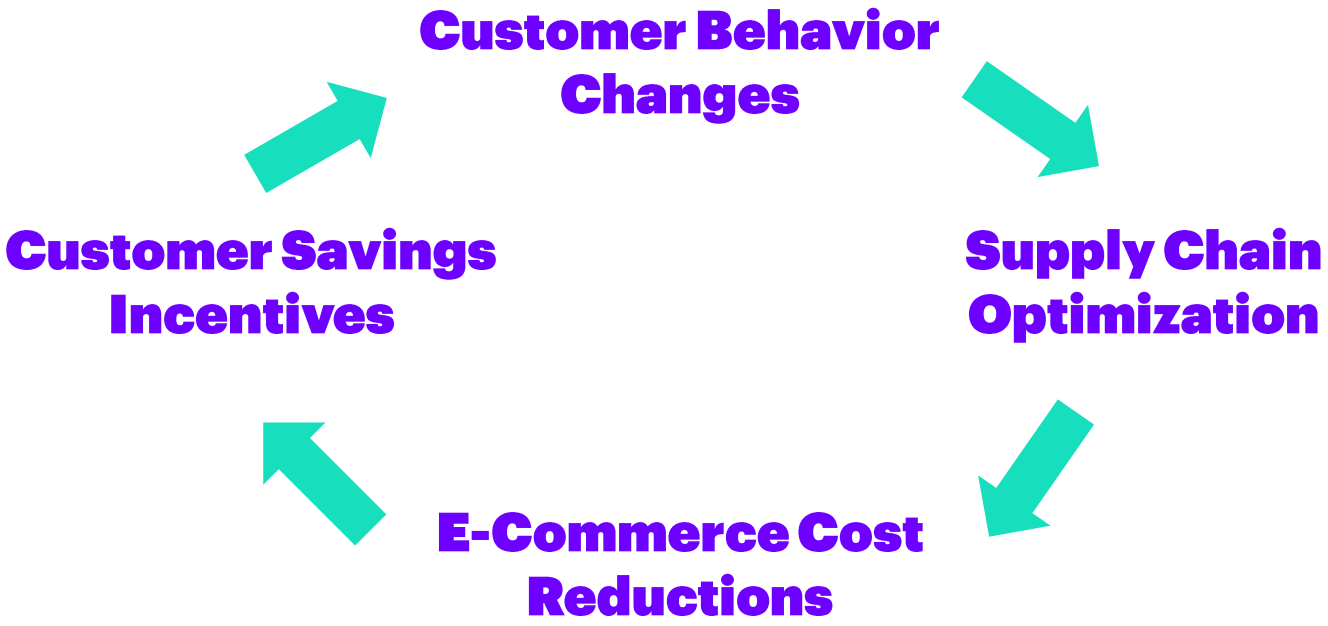
Ecommerce site dedicated to **savings**

Revolutionary pricing engine

Top technology and fulfillment platform

Acquired by **Walmart** in mid 2016

Jet's Unique Approach to E-Commerce



Smarter Shopping at the Basket-Level

Buy 1	Buy 2	Buy 3	Buy 4	Buy 5
$31.99/ea	$31.63/ea	$30.44/ea	$29.69/ea	$29.31/ea

$31.94
If you opt out of free returns on this item, you pay less. Details

$31.73
If you pay by debit card, you pay less. Details

$31.68
If you opt out of free returns on this item and pay by debit card, you pay less. Details

Buy 1	Buy 2	Buy 3	Buy 4	Buy 5
$31.99/ea	$31.63/ea	$30.44/ea	$29.69/ea	$29.31/ea

Introduction

QuantAlea

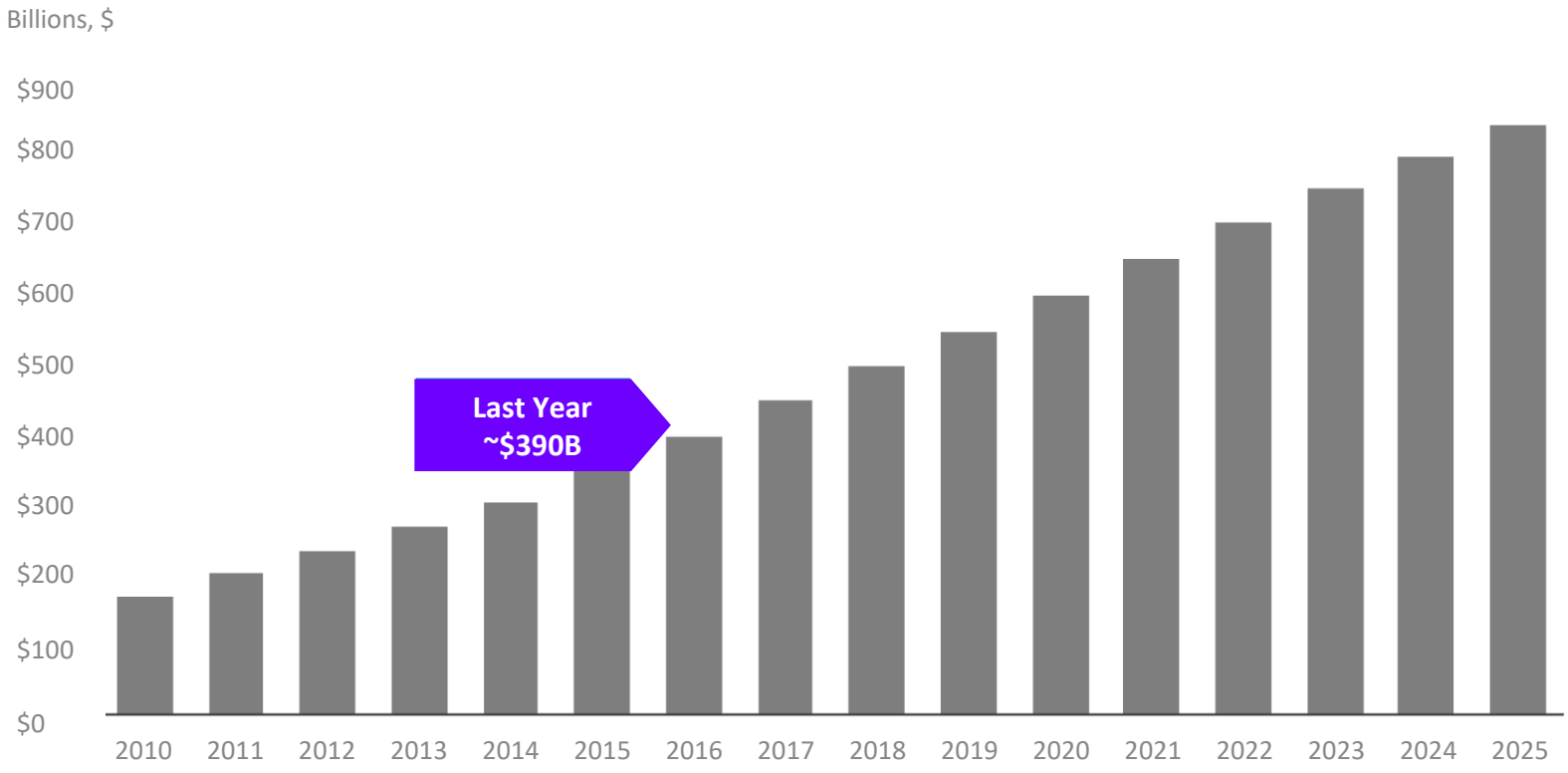
Machine learning and Cognitive computing

Numerical HPC algorithm design and implementation

Specialized in **GPU computing** and parallel algorithms

The Potential of E-Commerce

E-Commerce Market Expected to Grow Rapidly



Source: Forrester – July 2016

Problem

Jet Pricing Engine

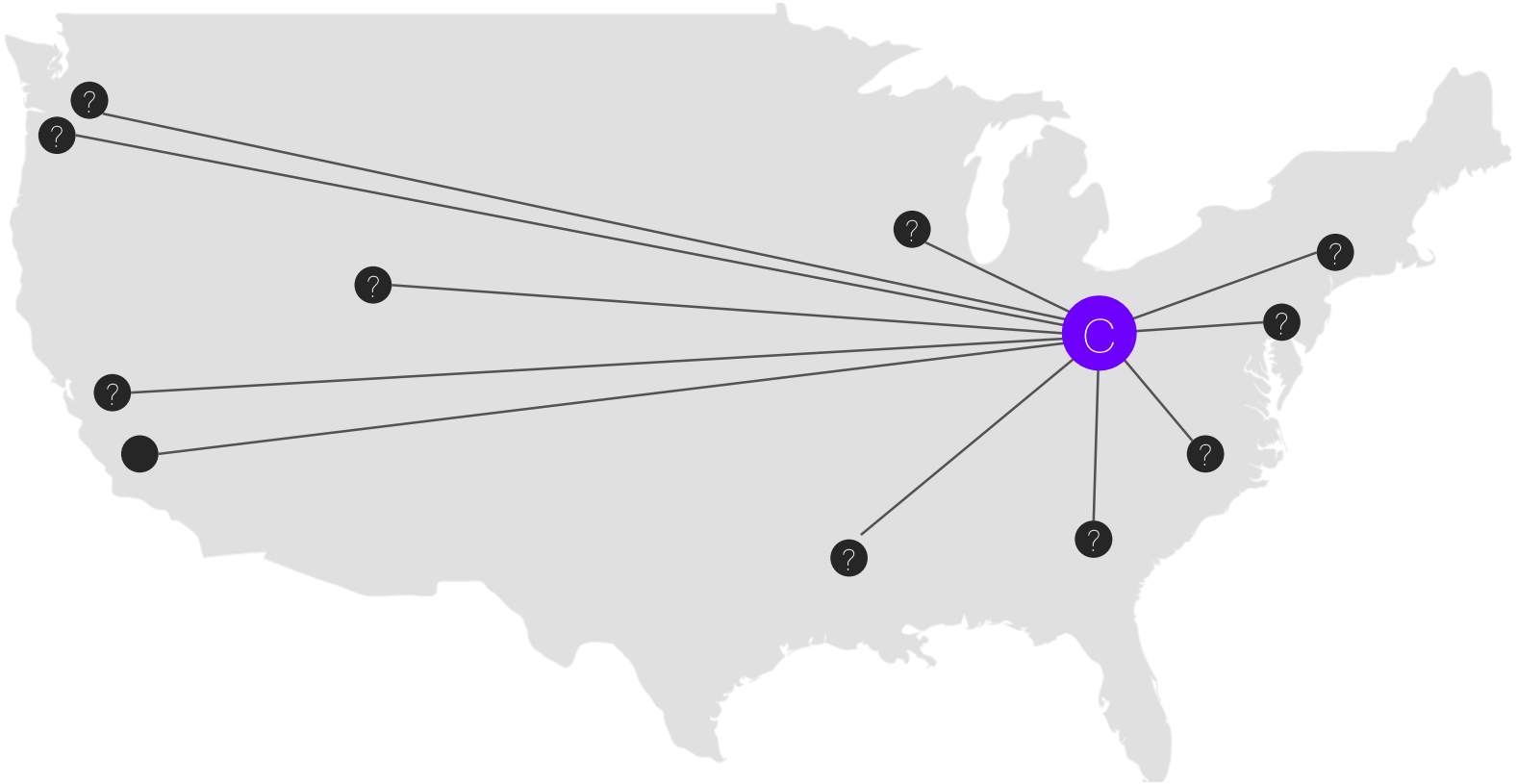
Users **shop for products**

Platform decides about most **optimal fulfillment** during shopping and at checkout

Savings come from

- Cheapest net item prices
- Pack items together for fewer boxes to ship
- Conditions, merchant commission, basket rules
- More efficient fulfillment

Smart Merchant Selection



Example
Small Cart

Four items with four offers each

	Sku 1	Sku 2	Sku 3	Sku 4
Merchant 1	15	15		33
Merchant 2	15	16		33.5
Merchant 3		18	19	31
Merchant 4	12		16	30
Offers	3	3	2	4

Shipping	Skus	Shipping	Skus
7.5	1+2	7.5	4
8.5	all		
3.5	2,3,4	4.5	3+4
5.5	1,3,4		

Number of Combinations = 3 * 3 * 2 * 4 = 72

Which is the cheapest combination?

Example
Solution – Cheapest Net Price

Try cheapest net price first

	Sku 1	Sku 2	Sku 3	Sku 4
Merchant 1	15	15		28
Merchant 2	15	16		33
Merchant 3		18	19	31
Merchant 4	12		16	28

Shipping	Skus	Shipping	Skus
7.5	1+2	7.5	4
8.5	all		
3.5	2,3,4	4.5	3+4
5.5	1,3,4		

Net	12	15	16	28	
Shipping	5.5	7.5	5.5	5.5	
Gross	17.5	22.5	21.5	33.5	95

Example
Solution – Merchant 2 / Merchant 4

We can do better by packing items together

	Sku 1	Sku 2	Sku 3	Sku 4
Merchant 1	15	15		28
Merchant 2	15	16		33
Merchant 3		18	19	31
Merchant 4	12		16	28

Shipping	Skus	Shipping	Skus
7.5	1+2	7.5	4
8.5	all		
3.5	2,3,4	4.5	3+4
5.5	1,3,4		

Net	15	16	16	33	
Shipping			5.5	8.5	
Gross	15	16	21.5	41.5	94

Example
Solution – Merchant 1 / Merchant 4

We can do even better

	Sku 1	Sku 2	Sku 3	Sku 4
Merchant 1	15	15		28
Merchant 2	15	16		33
Merchant 3		18	19	31
Merchant 4	12		16	28

Shipping	Skus	Shipping	Skus
7.5	1+2	7.5	4
8.5	all		
3.5	1	4.5	3+4
5.5	1,3,4		

Net	15	15	16	28	
Shipping		7.5	5.5	5.5	
Gross	15	22.5	21.5	33.5	92.5

Example
Best Solution – Merchant 1 / Merchant 3

We can do even a little bit better

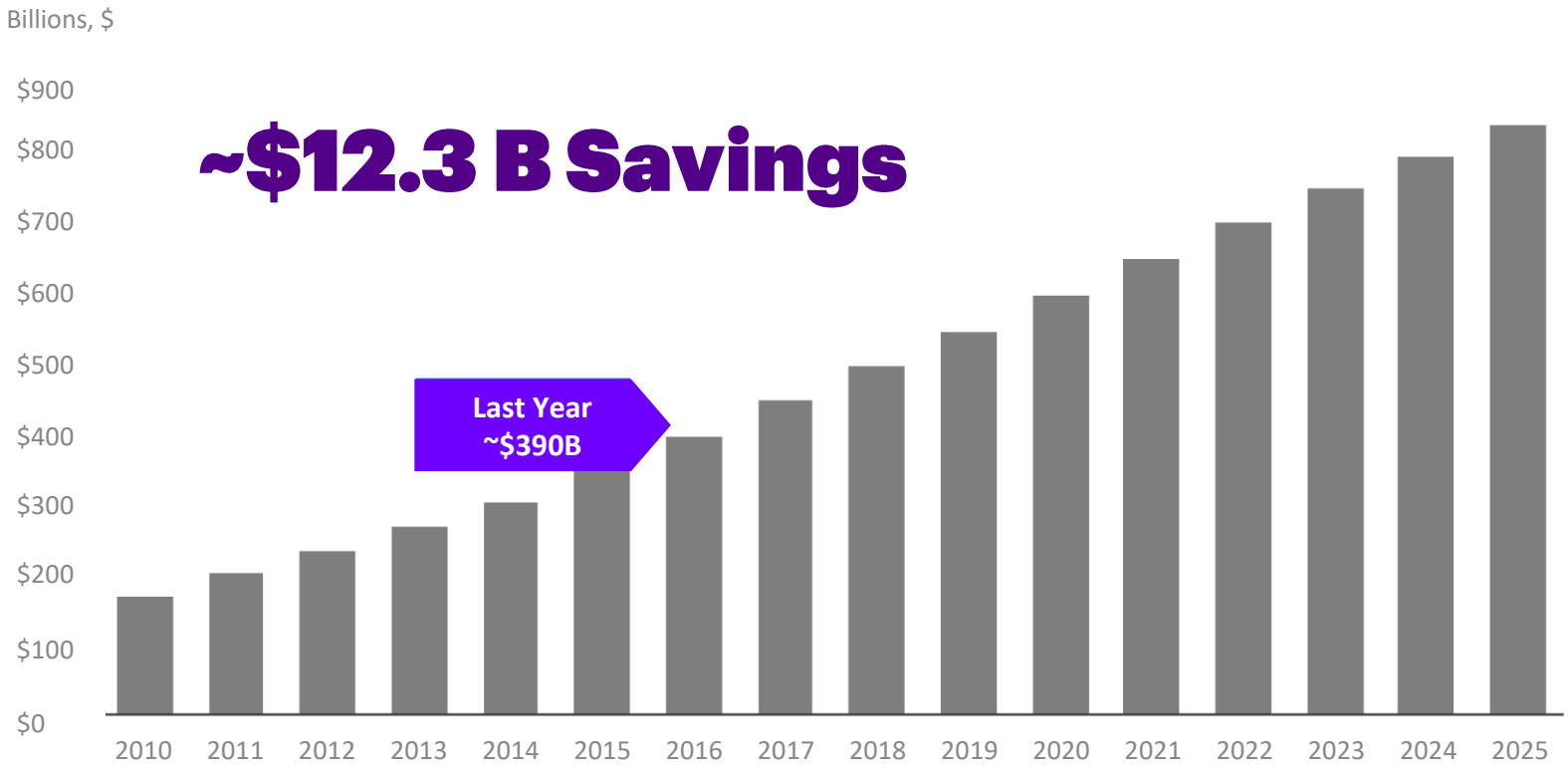
	Sku 1	Sku 2	Sku 3	Sku 4
Merchant 1	15	15		28
Merchant 2	15	16		33
Merchant 3		18	19	31
Merchant 4	12		16	28

Shipping	Skus	Shipping	Skus
7.5	1+2	7.5	4
8.5	all		
3.5	2,3,4	4.5	3+4
5.5	1,3,4		

Net	15	15	19	31	
Shipping		7.5		4.5	
Gross	15	22.5	21.5	35.5	92

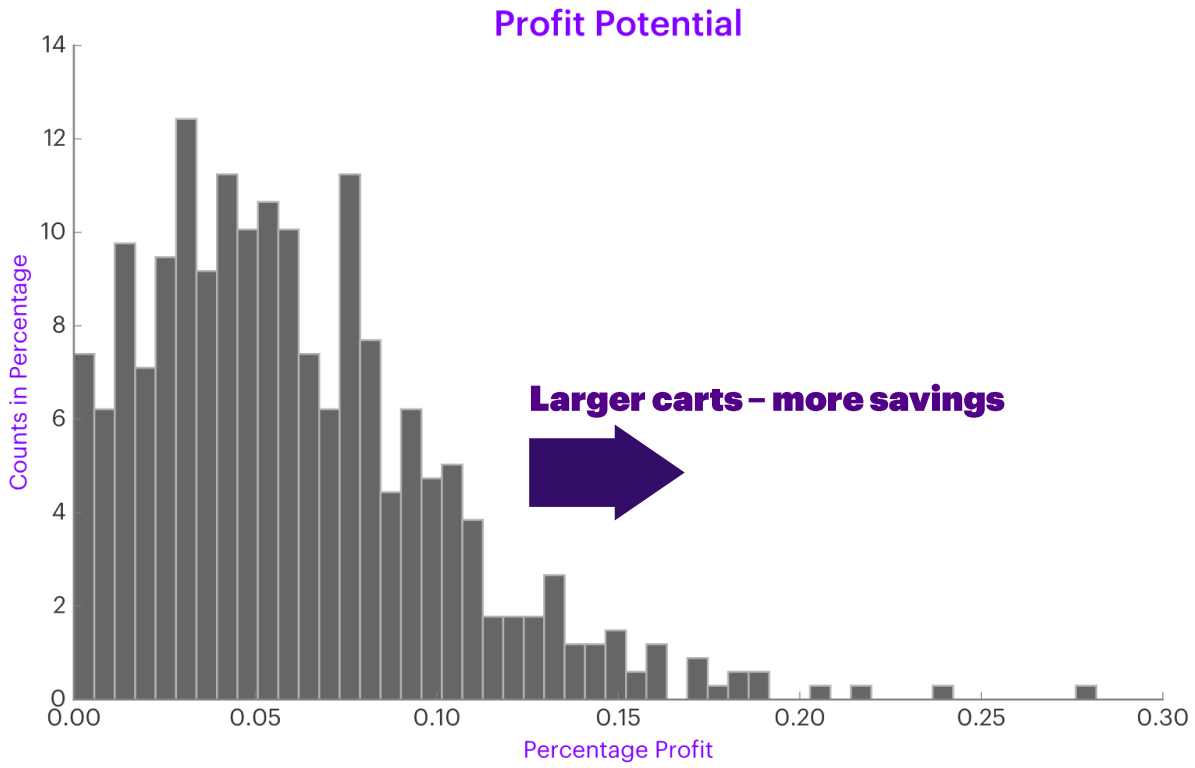
Optimal merchant selection saves 3$

Savings Potential



Source: Forrester – July 2016

Savings Potential
Larger Carts – More Savings



Speeding up with GPUs

Full Search
Embarrassingly Parallel

1

Large number of ways to fulfill a shopping cart

2

Cart pricing can be executed independently

Ideal problem to solve in parallel with GPUs

Cart Pricer on GPUs

Implement pricing algorithm on GPU

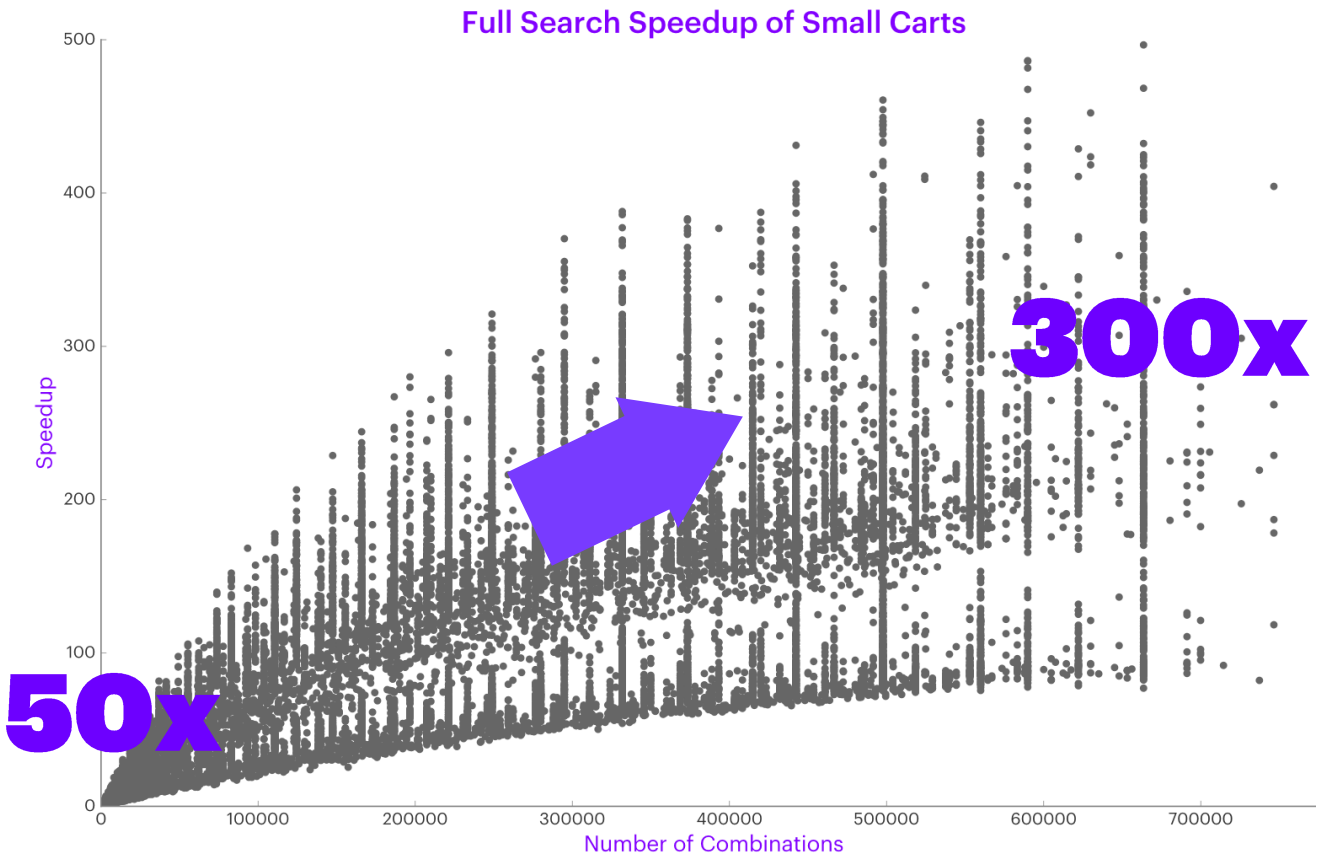
Challenging control flow logic

- Shipping costs
- Commission rules

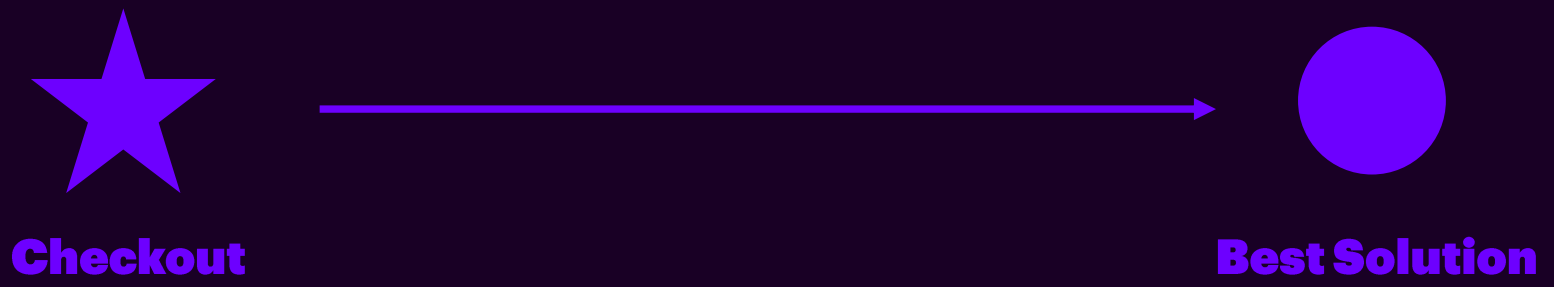
Complicated input data structure

Have to cope with non-coalescing memory access patterns

Full Search on GPU



How far can we go?



Full Search
Exponential Complexity

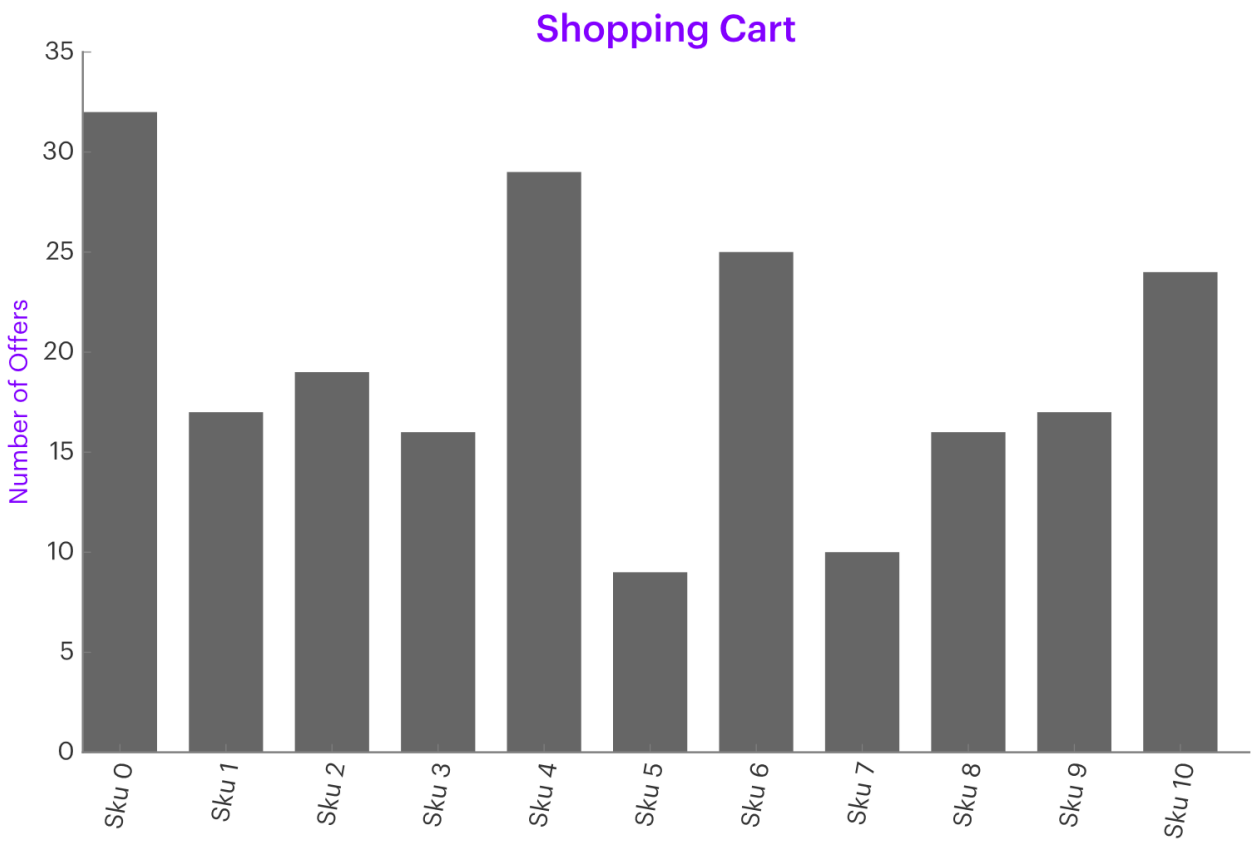
Complexity =

Number of combinations =

Num offers for item 1 * . . . * num offers for item k

Example

Somebody wanted to build a computer



Exponential Complexity

Number of combinations =

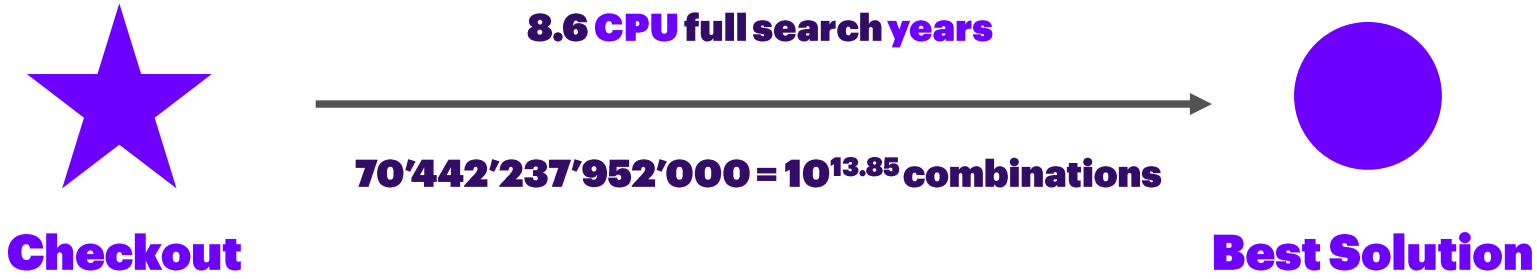
Offers for item 1 * Offers for item 2 * . . . . * Offers for item 10

= 32 * 17 * 19 * 16 * 29 * 9 * 25 * 10 * 16 * 17 * 24

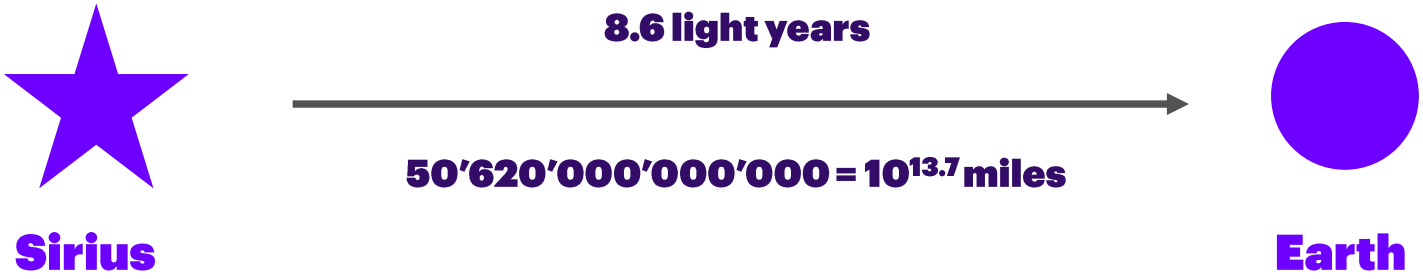
= 70'442'237'952'000 combinations

= $10^{13.85}$ combinations

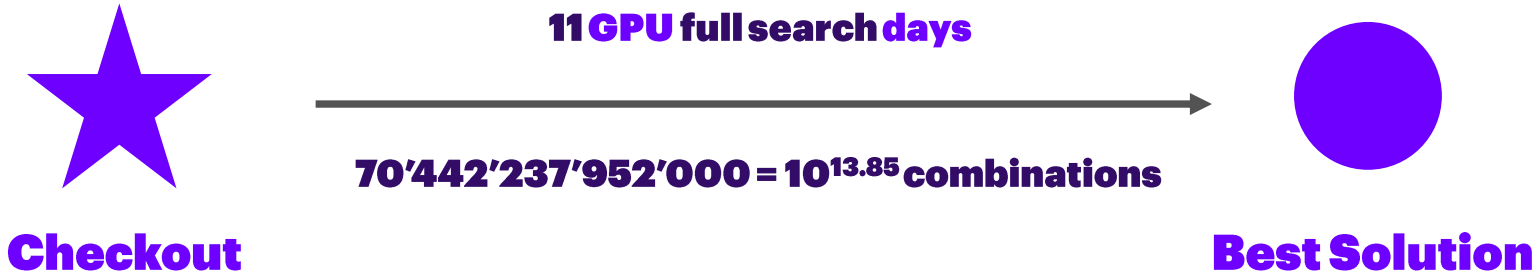
Full Search
CPU Years



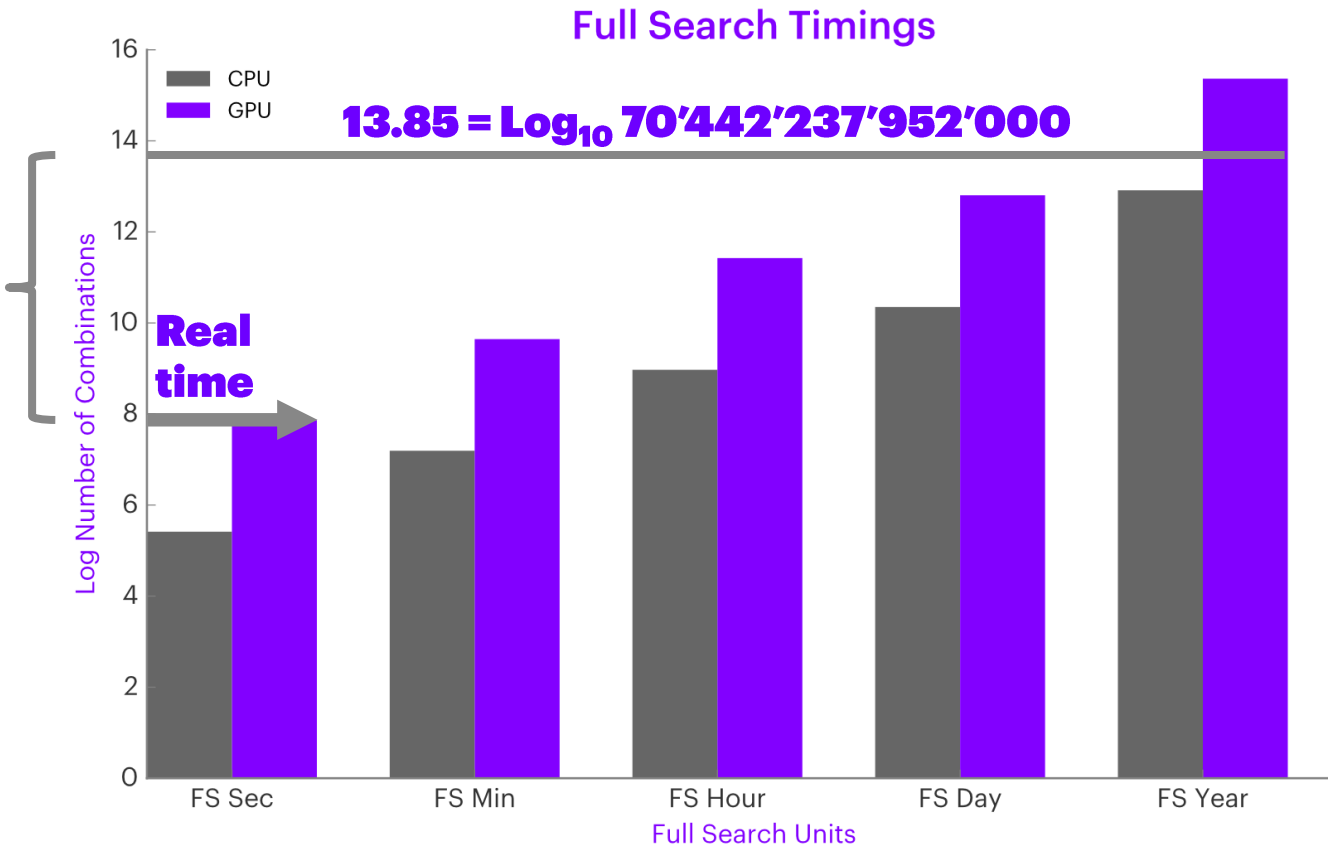
In Perspective



Full Search
GPU Days



Performance Gap



Conclusion

- Real time response < 1s required
- Full search prohibitive even on GPUs
- Require alternative solution that scales

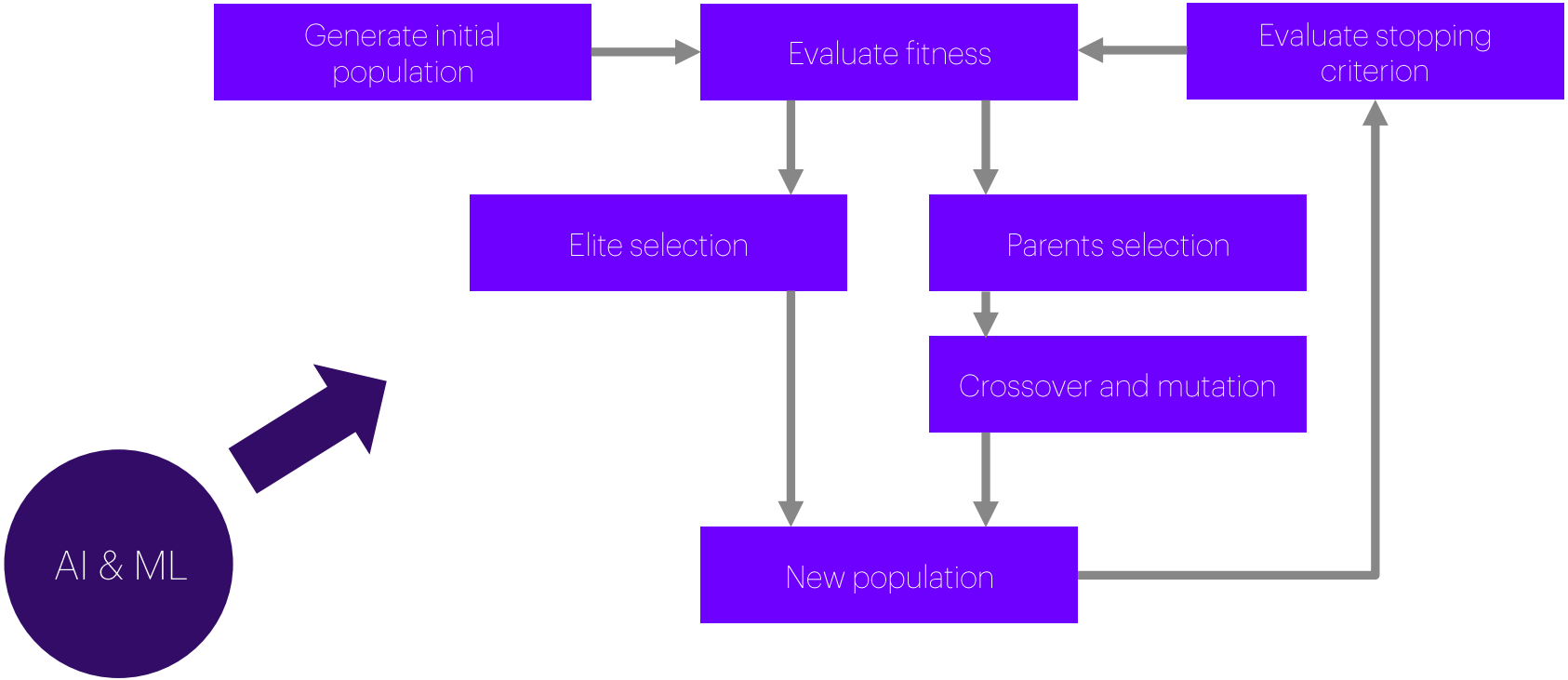
Genetic Algorithm on GPU

Genetic Algorithm

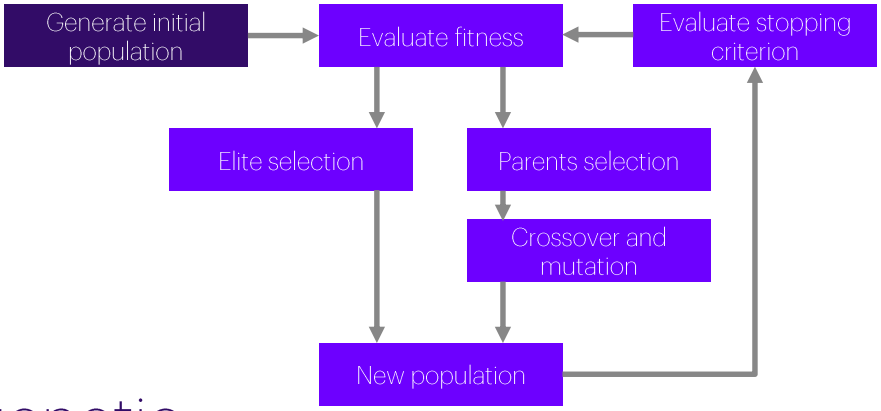
Apply **Genetic Algorithms** to solve the problem

- GA can only find approximately optimal solutions
- Standard GA does not work
  - Search space is astronomically large
  - Need a reliable approx. solution in near real-time
- Rely on AI & ML to choose GA configuration
- Generation iteration is serial, extending the population size dramatically allows to reduce iterations

Genetic Algorithm
Schematic Description



Genetic Algorithm



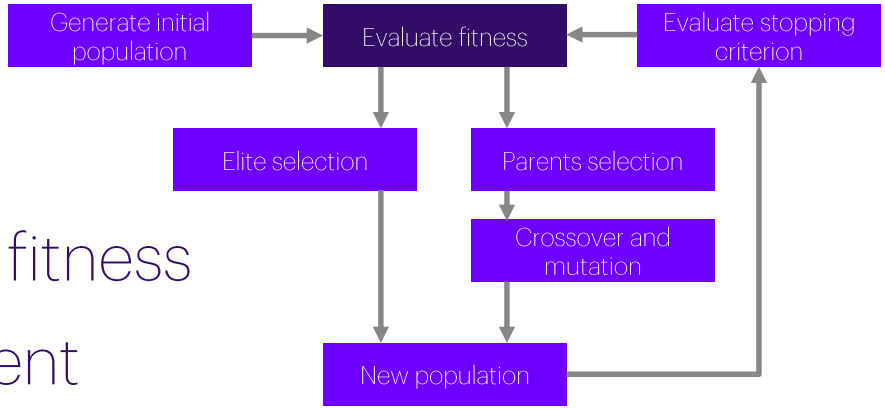
Include merchant combination which are likely to be good

Identify two parts in population

- Dynamic part → subject to genetic reproduction
- Static part →used as «boundary» in genetic reproduction

Rely on **parallel BFS graph algorithm** to speed up initial population creation

Genetic Algorithm



Decode chromosome to cart

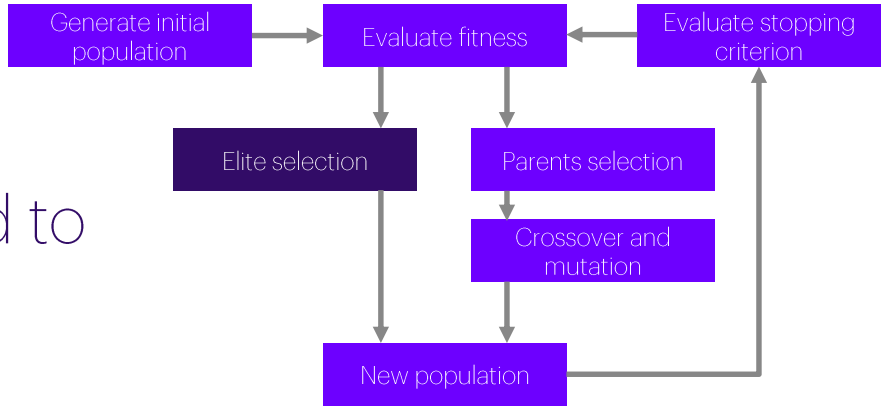
Price cart, cheaper cart = higher fitness

Sort by score for elitism and parent selection

Use parallel key value sort

Approx. **100x** faster than CPU sort

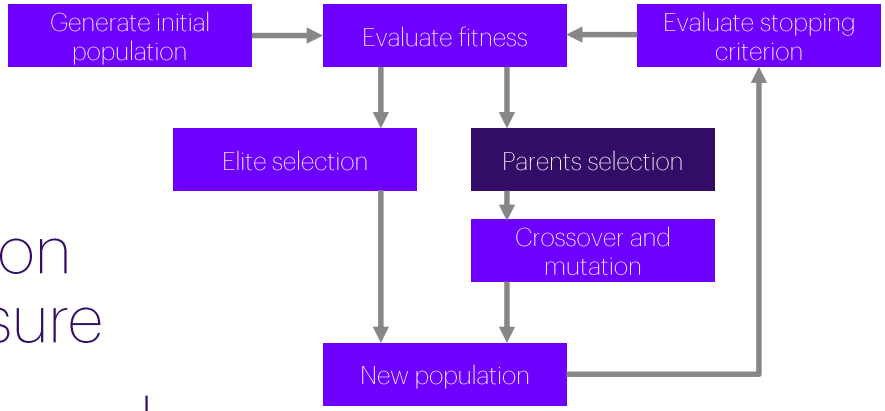
Genetic Algorithm



Selecting small fraction of best chromosomes to go unmodified to new population

Need to balance elite selection and population diversity to **avoid premature convergence**

Genetic Algorithm



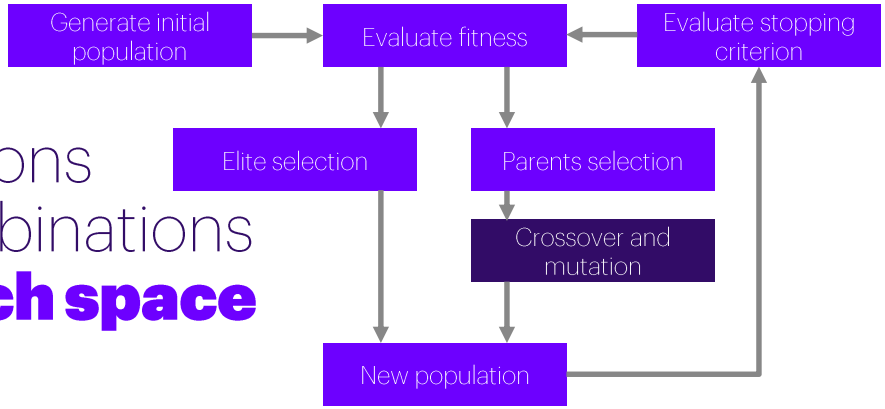
Different selection schemes

Traditional roulette wheel selection suffers from high selection pressure

Rank selection performs better and reduces risk of premature convergence

Use fast GPU scan, approx. 100x faster than CPU scan

Genetic Algorithm

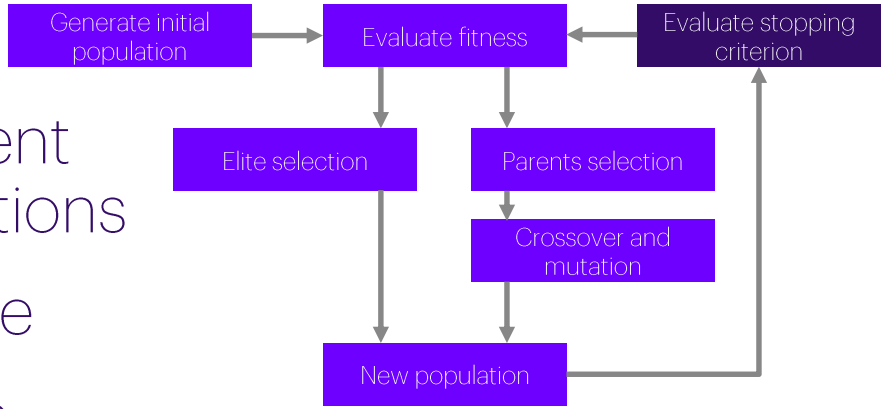


Crossover and mutation operations need to find rare merchant combinations in **astronomically large search space**

Combine two ideas:

- Special crossover and mutation operations inspired from domain specific knowledge
- Crossover relies on geometric construction generating paths between dynamic part and «boundary»

Genetic Algorithm



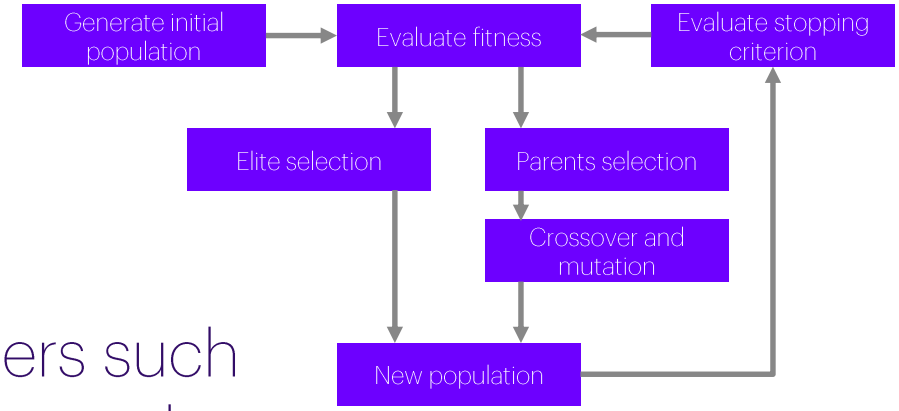
Usually GA stop if no improvement for prespecified number of iterations

→ No guaranteed execution time

Improve termination criteria with extensive testing

- Apply **AI & Machine Learning** to predict probability distribution of deviation from optimal value
- Use this model to select compute budget and number of iterations

Genetic Algorithm

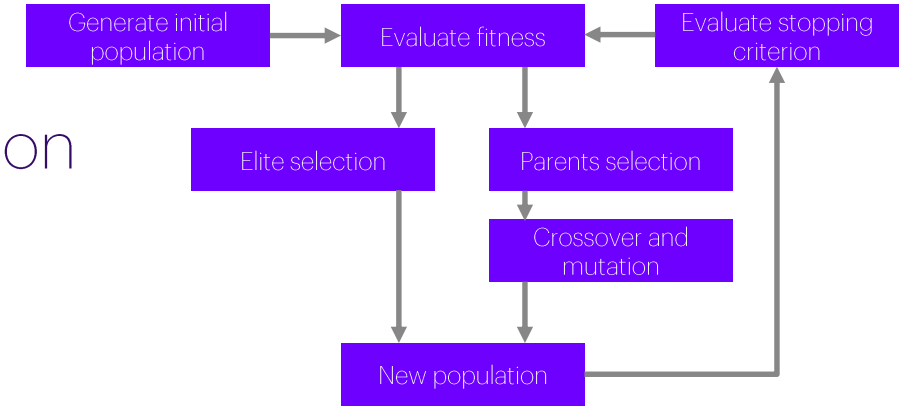


Many ways to configure GA

- Population size
- Values of algorithmic parameters such as mutation rate, elite percentage, etc.
- Selection of GA algorithm features

Rely on **AI & Machine Learning** to identify the ideal GA configuration for a given shopping cart and market offers

Genetic Algorithm

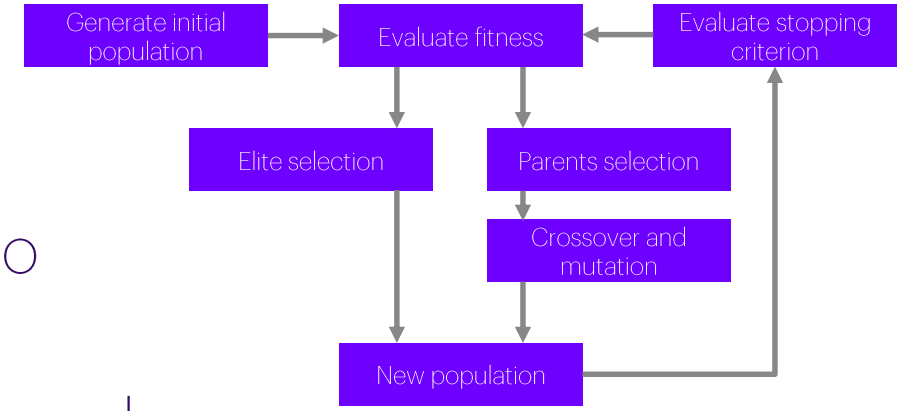


Fast **random number** generation important for performance

Used in

- Initial population creation
- Selection for elitism
- Crossover operations
- Mutation operations

Genetic Algorithm



Statistics

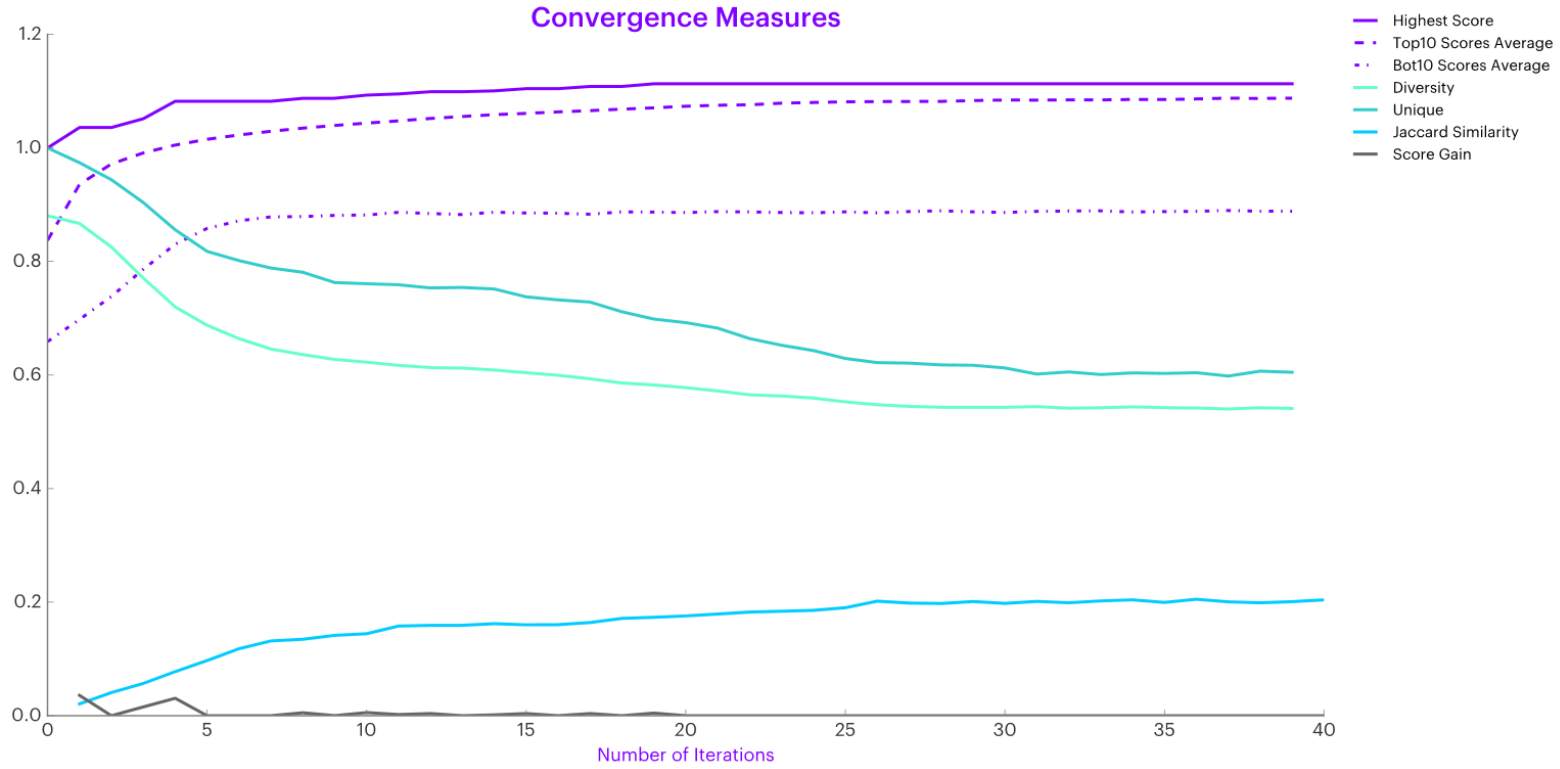
- Pairwise distance calculation to compute population diversity
- Used for quality measurement and detection of premature convergence

Visualization and convergence inspection

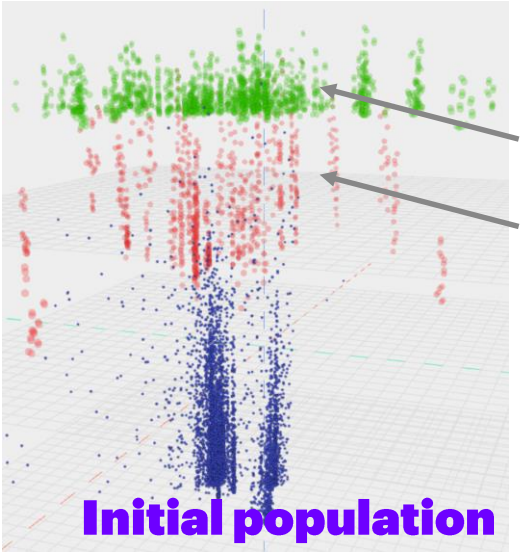
- Nonlinear embedding in 2d and 3d **using TSNE**

Visualization

Convergence Statistics



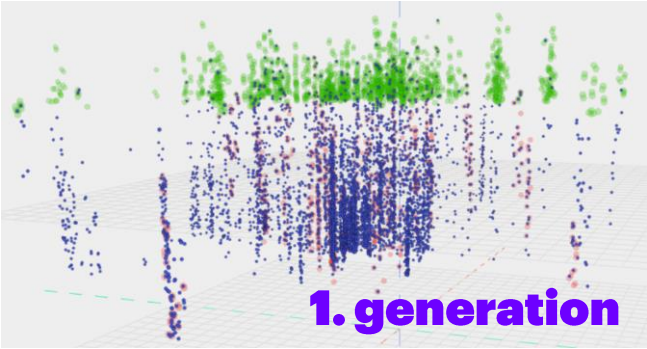
Convergence
Embedding with TSNE

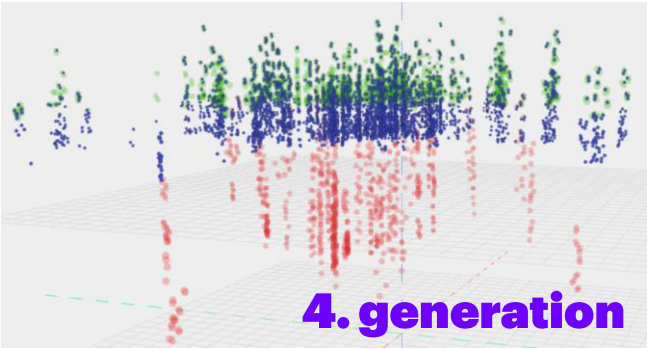


Best part from full search

Special greedy «boundary» points

Score rapidly improves
Catches best points found by full search





Visualization Demo

Implementation & Deployment

Cloud Based
Functional First with F#

Jet platform is fully cloud based

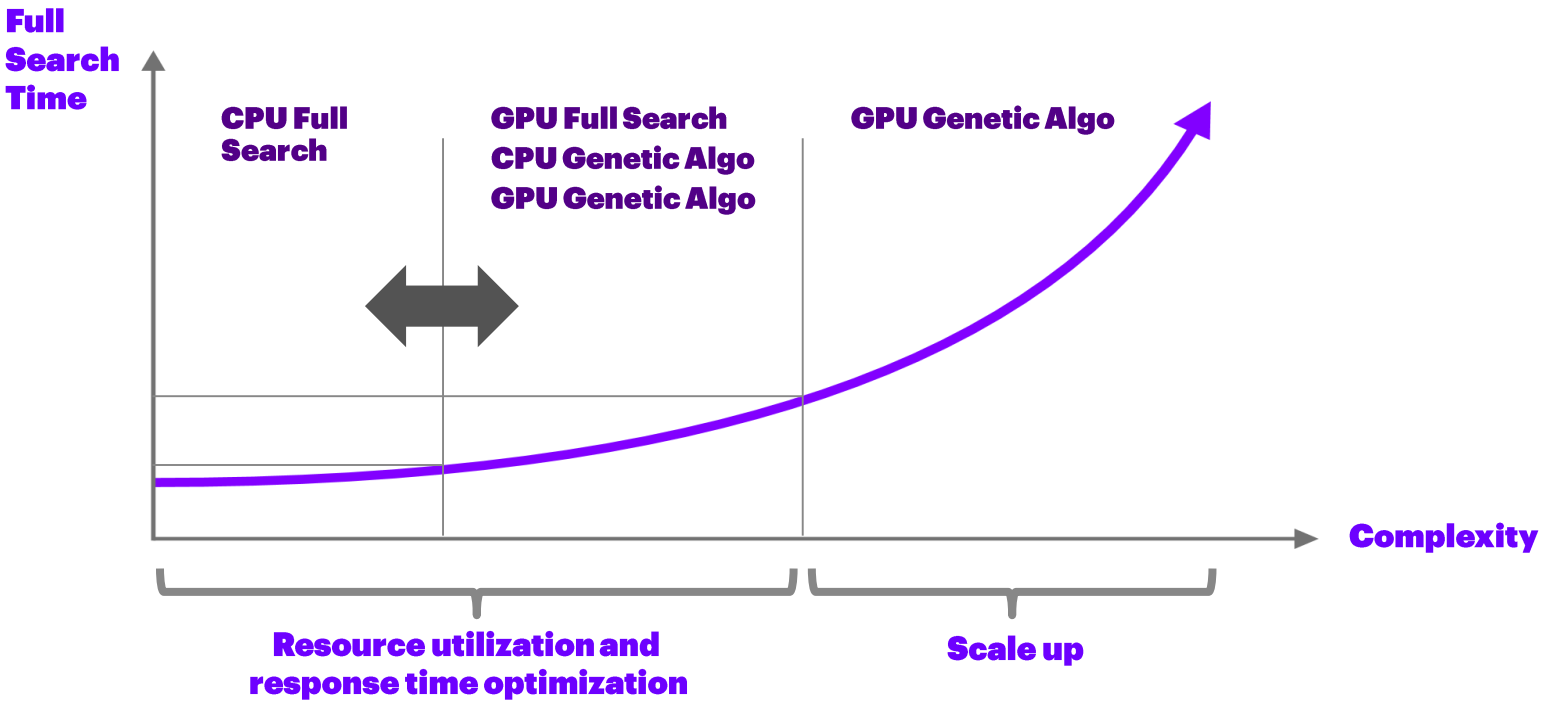
Runs in Microsoft Azure

Use F# as core programming language

Uses Alea GPU from QuantAlea to compile F# to GPU

- Maximal reuse of algorithms for CPU and GPU execution
- Same GPU performance as native CUDA C

Platform Utilization
Dispatch and Optimize with AI

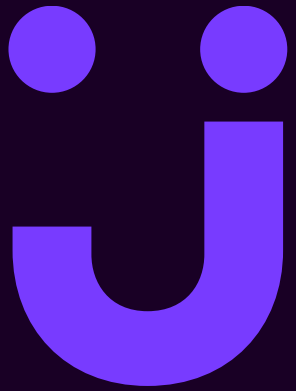


Conclusion

Conclusion

1 Genetic Algorithms + 2 AI & ML + 3 GPUs

Scale up optimal merchant selection to
shopping carts of **unlimited size**
Very **good approximate** solution found in **real time**



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Jet.com/careers

You'd look good in purple

At Jet, our goal is to reshape the landscape of e-commerce forever and make a lasting difference in people's lives. If you want to take on the challenge of building something amazing from the ground up, then this is the place for you.

Take a closer look at life at Jet