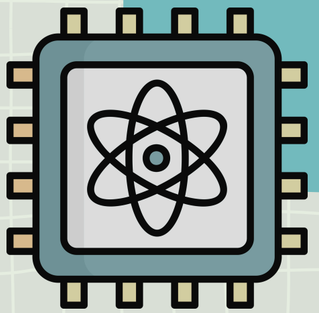
Quantum Voyager



Genetic Algorithms
with Quantum Computing

team: kabanosy

Quantum Computer

uses quantum bits
that represent
probability
between 0 and 1

operates on
circuits consisting
of quantum gates

generates **noise**,
unexpected
outcomes,
as a side-effect

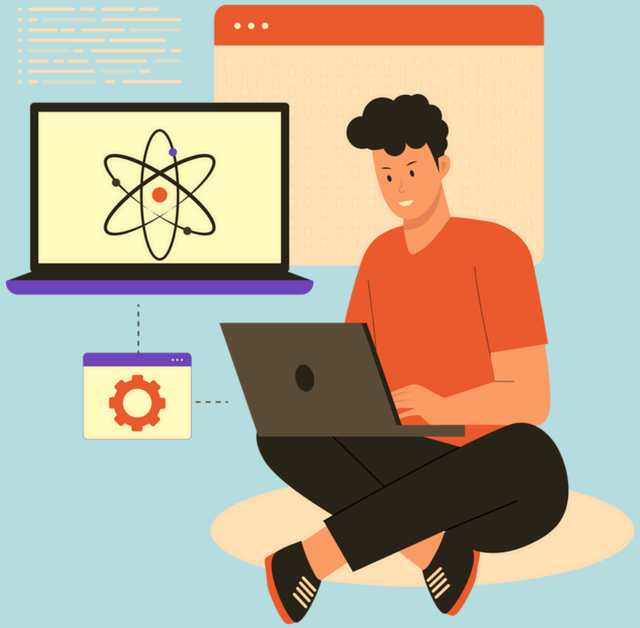
Problem: Travelling Salesman

Find the **shortest path** covering all cities/points without repeating any.

It aims to minimize the total distance or cost of travel, and is **widely used** in logistics, planning, and routing.

How to solve it?

Using **genetic algorithms** enhanced with quantum computers!

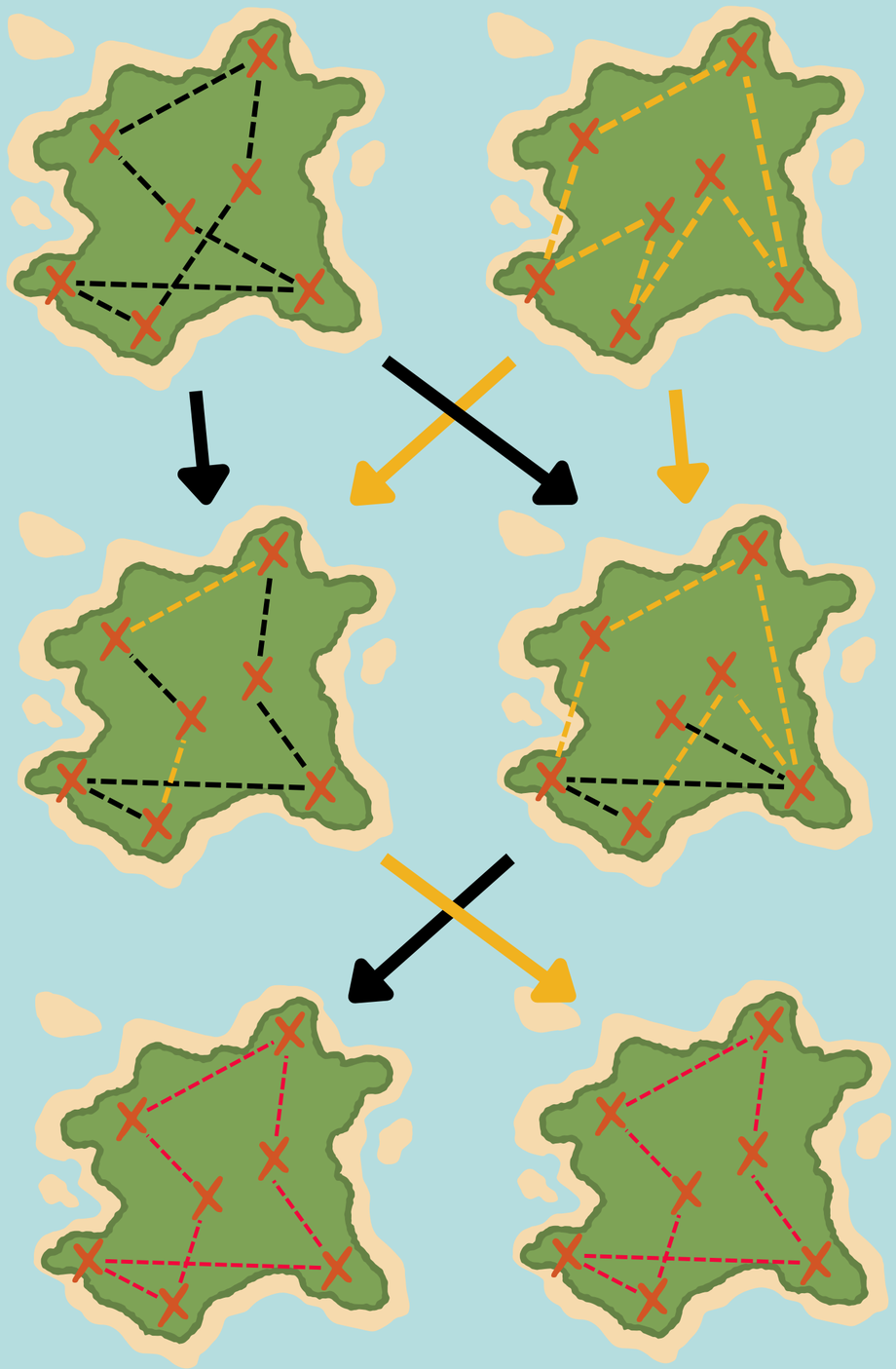


[1] We have a **population** of generated solutions

How do genetic algorithms work?

[2] Solutions change with each **new generation**, mixing and creating **potentially better solutions**

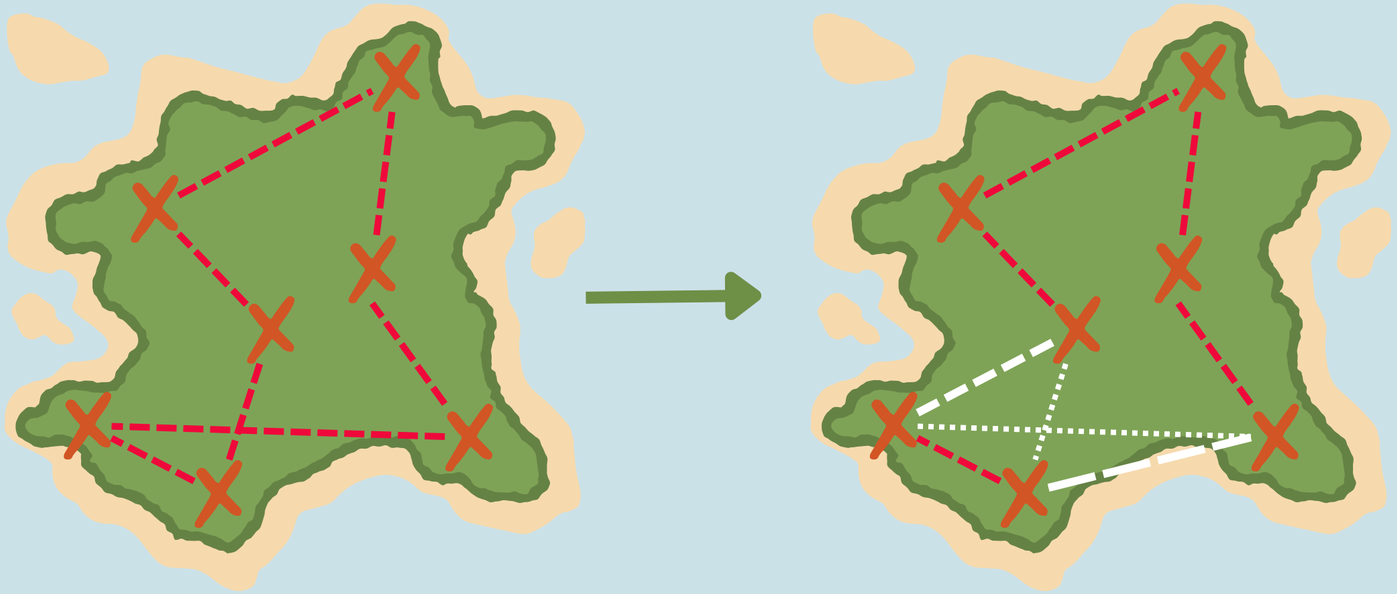
[3] But they can **get stuck** in a local minimum, and **no longer improve** in new generations

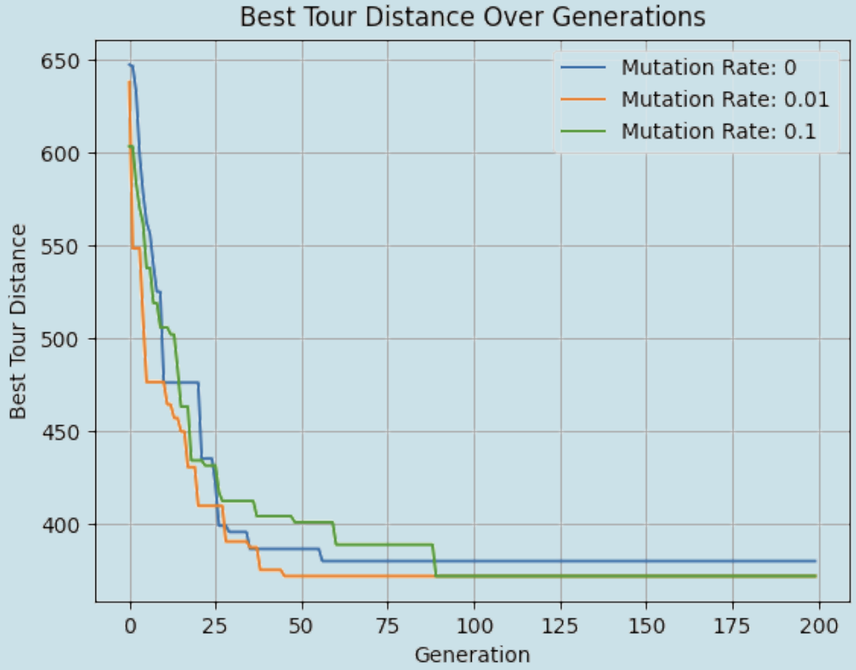


How to “unstuck” ?

We need something **unexpected**, a random change. A **mutation!**

Which we can create with quantum computers and their **noise**!

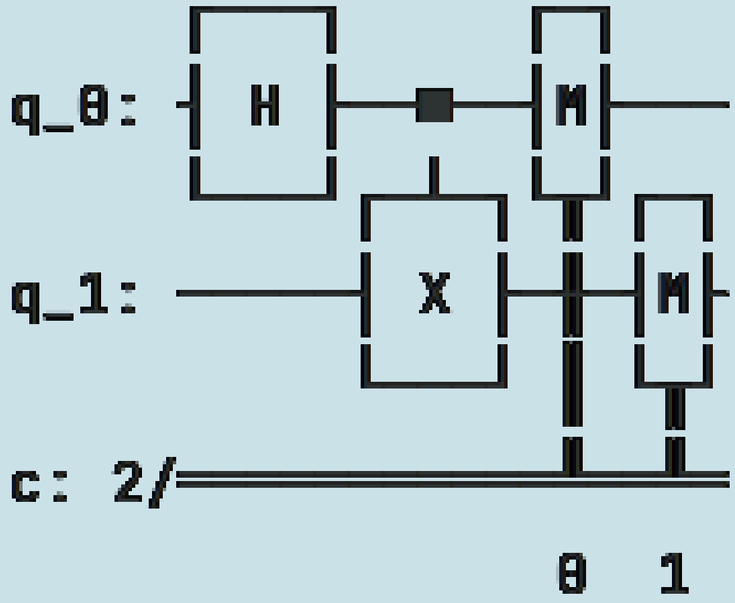




mutations help to achieve better results

Noise effect on quantum cuircut

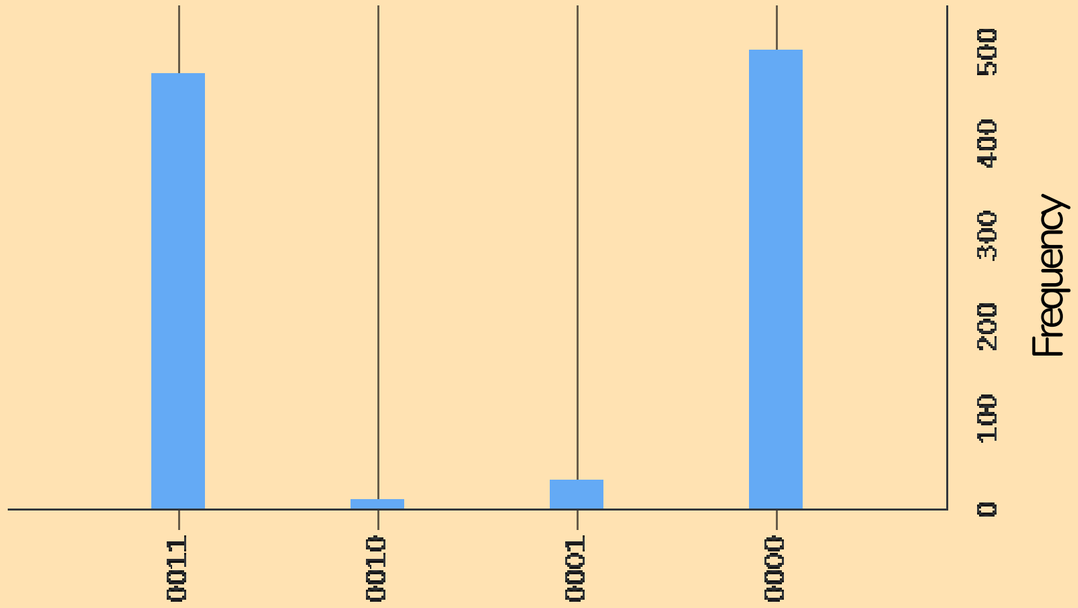
A gate we use has only **two possible** outputs: [00, 11]
But on quantum computers it can generate some **unexpected** outputs.




```qiskit
# create a Quantum Circuit
# with 2 qubits and 2 classical bits
qc = QuantumCircuit(2, 2)
# apply a Hadamard gate on qubit 0
qc.h(0)
# apply a CNOT gate on qubit 0 and qubit 1
qc.cx(0, 1)
# measure the qubits
qc.measure([0, 1], [0, 1])
```

How did we do it?

Noise is a **side-effect,** something unexpected, outcome that “shouldn’t be possible”,



Outcome per 1024 shots on a real **quantum** computer
(on non-quantum computer,
0010 or 0001 would never occur)

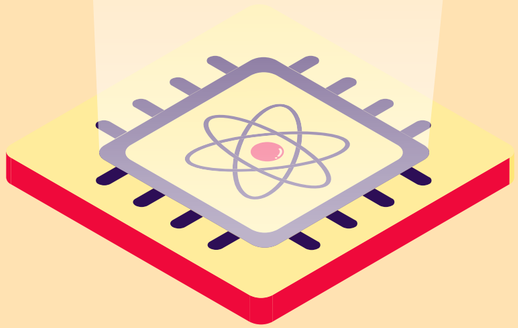
Similarly to **mutation**, it’s an unepxected change that happens randomly.
It’s possible to be received with different frequency, depending on a quantum machine and conditions.

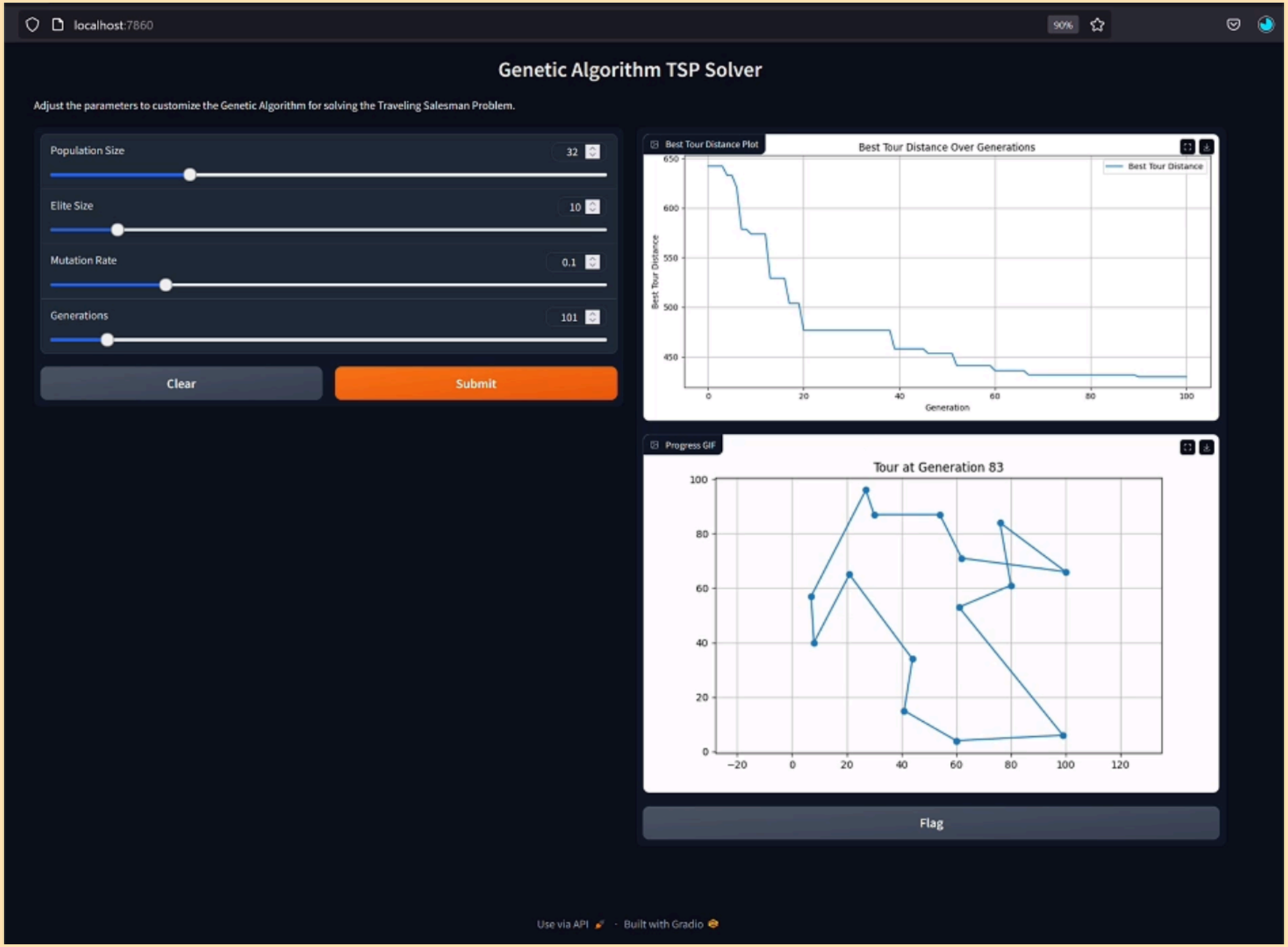
```
# if anomaly occurs, then apply mutation
def should_apply_mutation():
  res = self.qiskit_runtime.run(shots=1)
  return
    res.get('01', 0) > 0
    or
    res.get('10', 0) > 0
```

Wanna try?

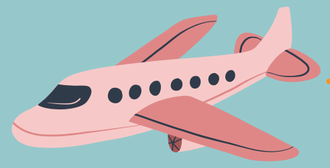
We also created a **platform** where you can **simulate** how this algorithm would work on a quantum computer with a given noise level.

github.com/HackYeahKabanosy/quantum_genetic_algorithm

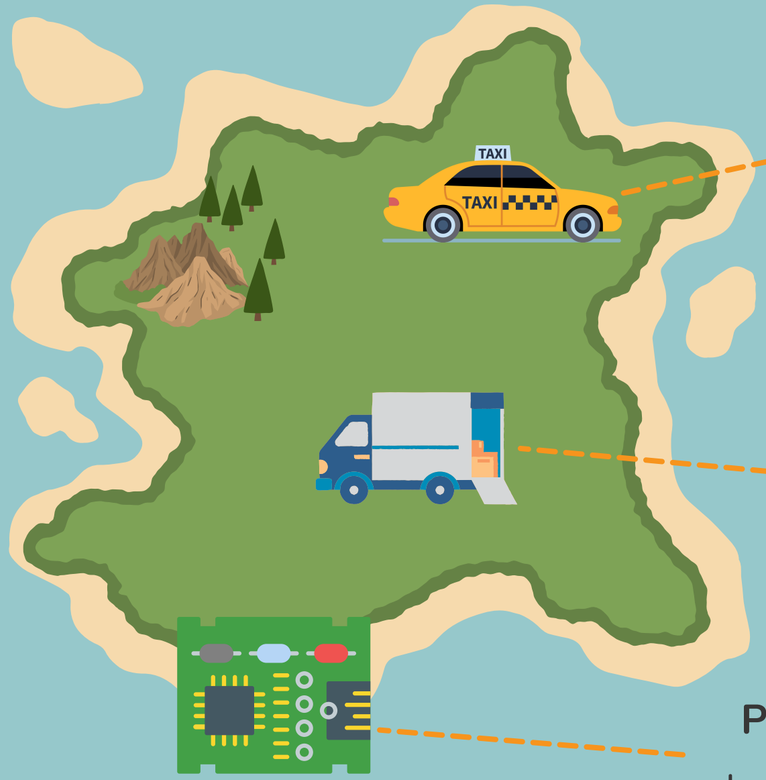




Where Genetic Algorithms are used?



Boeing uses it for finding optimal airplane wings design



Uber and **Lyft** use TSP algorithms to optimize routes for drivers who need to pick up and drop off multiple passengers

FedEx, UPS, or Amazon use Travelling Saleman to find best routes for couriers

PCB manufacturesrs determines the shortest route for circuits on PCB boards

Travelling Salesman is only one of multiple examples. Solutions utilizing Quantum Computres can be used for any other Genetic Algorithm

Thank you!

team kabanosy