QUANTUM COMPUTING

A SURVEY

OPEN SOURCE

- LIQUID(http://stationq.github.io/Liquid/)
- ProjectQ(https://projectq.ch/)
- QBSolv(https://github.com/dwavesystems/qbsolv)
- Quantum Experience (http://www.research.ibm.com/quantum/)
- QCEngine(http://machinelevel.com/qc/)
- Probably a number of others I've missed

VENDORS

- D-WAVE
  - Focused on
    - Optimization problems that can be solved via quantum annealing
    - Training of Boltzman machines and other probabilistic graph based machine learning models
  - Specialized qubit topology “chimera graph”
  - 2K Qubit machine
- IBM
  - Focused on general purpose quantum computing algorithms
  - Gates include Pauli,Hadamard,Conditional,Phase,etc
  - 5 Qubit machine and Simulator
- Rigetti
  - Focused on general purpose quantum computing algorithms
  - Gates include Pauli,Hadamard,Phase,etc
  - Simulator
- Microsoft

PROBLEM DOMAINS IN QUANT FINANCE

- Discrete Optimization Problems using Quantum Annealing
  - Portfolio Construction
  - Balance Sheet Management
- Machine Learning Problems, leveraging interconnected cubits as probabilistic graphs
  - Stat-Arb/Dispersion
  - Trading Pattern Detection (Iceberg, etc)
  - Market Disruption Detection (ie Flash Crash)

A TEN THOUSAND FOOT VIEW

- Quantum Computing leverages the simplest 2-level quantum mechanics model.
- A 2-level quantum mechanics model, generally can be realized in a number of physical mediums (electrons, photon, atomic nucleus, etc)
- Any collection of electrons, photons, nucleus can be used as “qubits”, quantum bits, which are like classical bits
- Except, unlike classical bits, which are in either of two states(ie 0 or 1), qubits are in both states, until the quantum mechanics model is measured. After measurement the qubit collapses into one of two states
- A mathematical description of the system before measurement is built by describing qubit states in probabilistic terms
- Quantum Gates are then defined, also in the context of probabilistic terms.
- Algorithms are written as sets of base settings and then quantum gates applied to qubits.
- Mapping of the theoretical quantum mechanics model onto physical hardware is dependent on vendor implementation

POSSIBLE NEXT STEPS

- A tutorial on linear algebra and complex vector spaces
- A tutorial on basics of quantum mechanics
- Basic systems of qubits
- Quantum Gates
- Review of Quantum Algorithms (http://math.nist.gov/quantum/zoo/)
- Deep dives into vendor implementations and APIs