

Research Review 2021

Quantum Advantage Evaluation Framework

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QIS and DOD



Adam Schultz, Official White House Photo

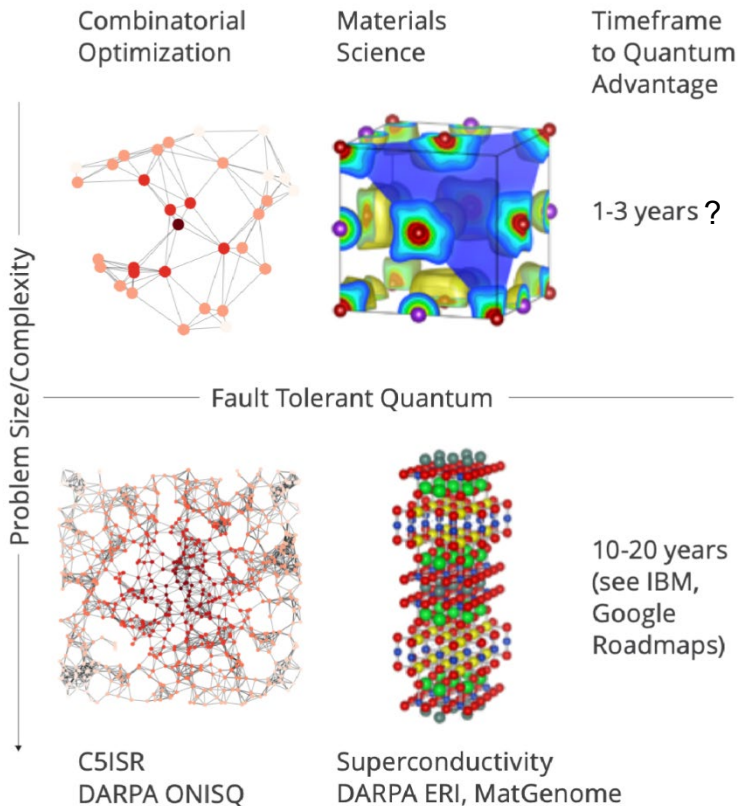
*The future lies in who can, in fact, own the future as it relates to technology, [for example] **quantum computing...***

– President Biden, March 2021

Office of the Under Secretary of Defense, Research, & Engineering (OUSD R&E): SEI to provide research and analysis to “develop and annually update a list of technical problems and research challenges which are likely to be addressable by quantum computers.”

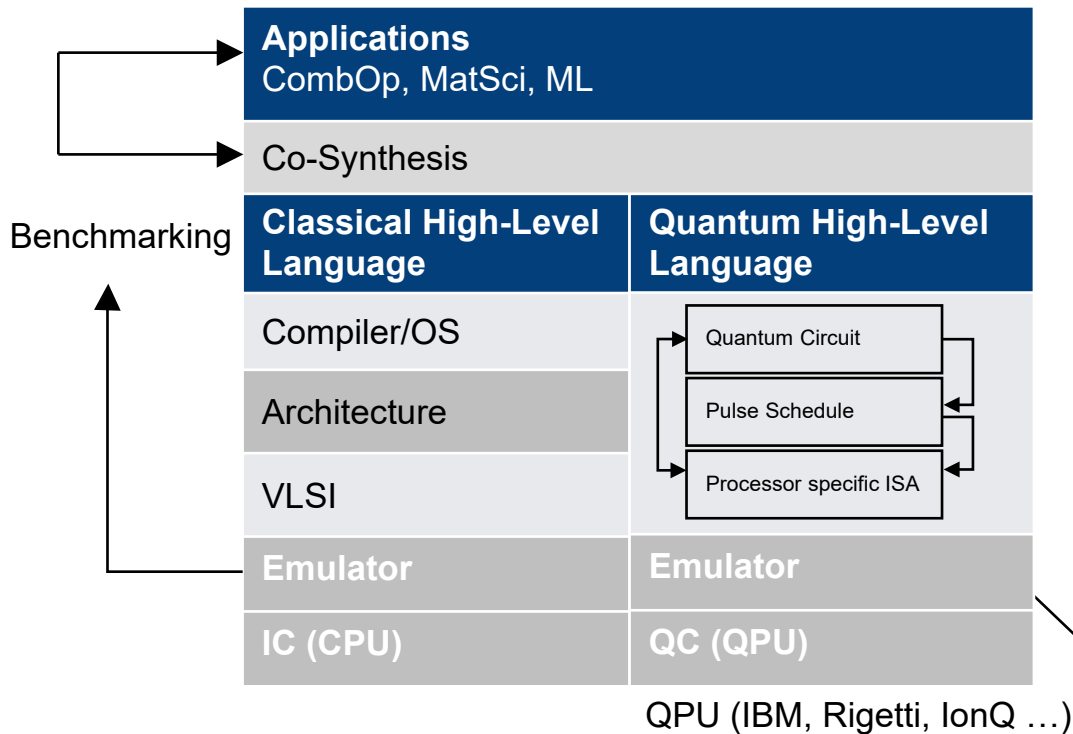
When/where quantum advantage (QA) is to be found = solving some practical DOD problem faster/to higher quality than any other alternatives (e.g., classical State of the Art (SOTA)).

DOD Applications for Quantum Computing

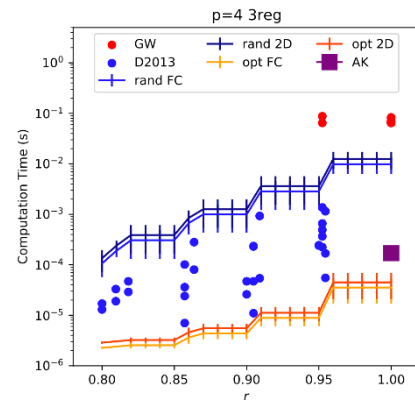


For these **applications**, what are the quantum computing resources necessary for **quantum advantage**?

Quantum Advantage Evaluation Framework (QAEF)

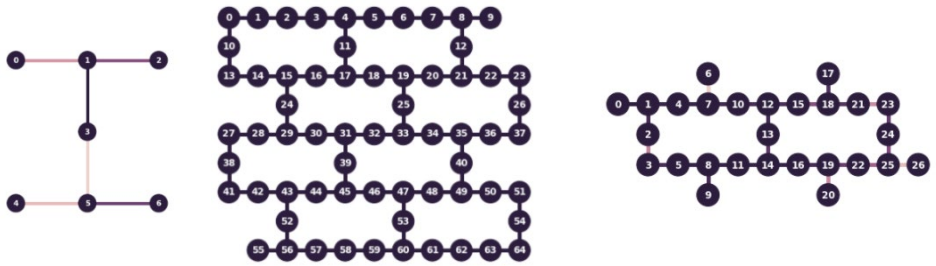
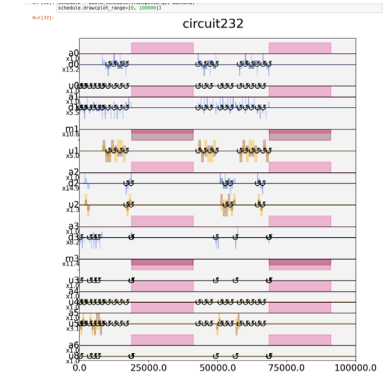
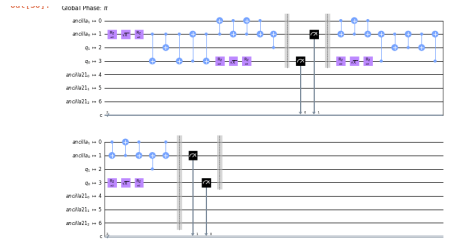
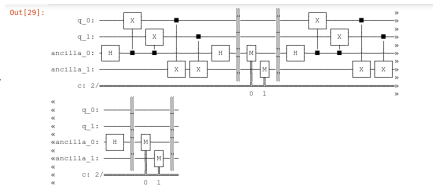
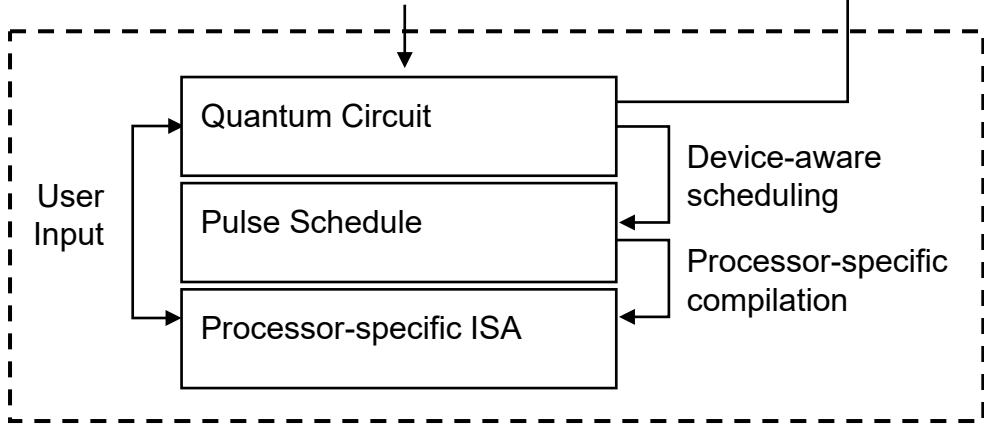


QAEF compares benchmarks for Applications on both quantum and classical SOTA computing to determine quantum advantage.



Example Quantum Computing Full Stack

Applications: CombOp, MatSci, ML



IBMQ Hardware: Right Now

Quantum Error Correction?

Scaling IBM Quantum technology

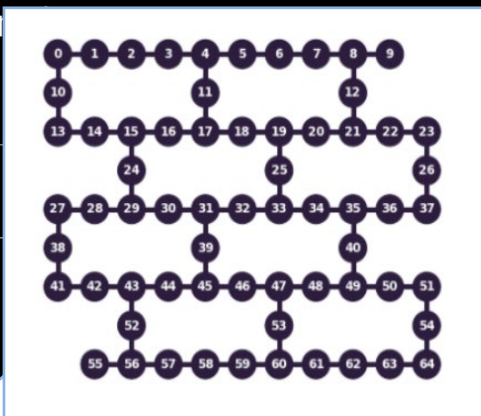


IBM Q System One (Released)

2019 2020

27 qubits
Falcon

65 qubits
Hummingbird

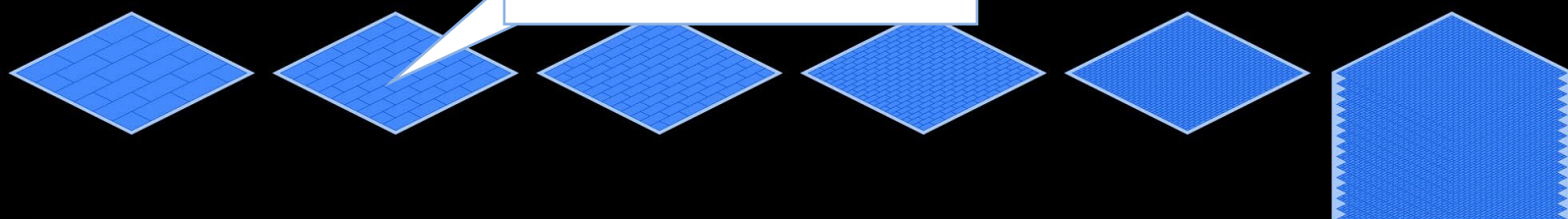


Next family of IBM Quantum systems

2023 and beyond

1,121 qubits
Condor

Path to 1 million qubits
and beyond
Large scale systems



Key advancement

Key advancement

Key advancement

Key advancement

Key advancement

Key advancement

Optimized lattice

Scalable readout

Novel packaging and controls

Miniaturization of components

Integration

Build new infrastructure,
quantum error correction

IBM Research

IBMQ Roadmap

Quantum Systems	Falcon 27 qubits	Hummingbird 65 qubits	Eagle 127 qubits	Osprey 433 qubits	Condor 1121 qubits	Beyond 1K – 1M+ qubits
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IBM Research

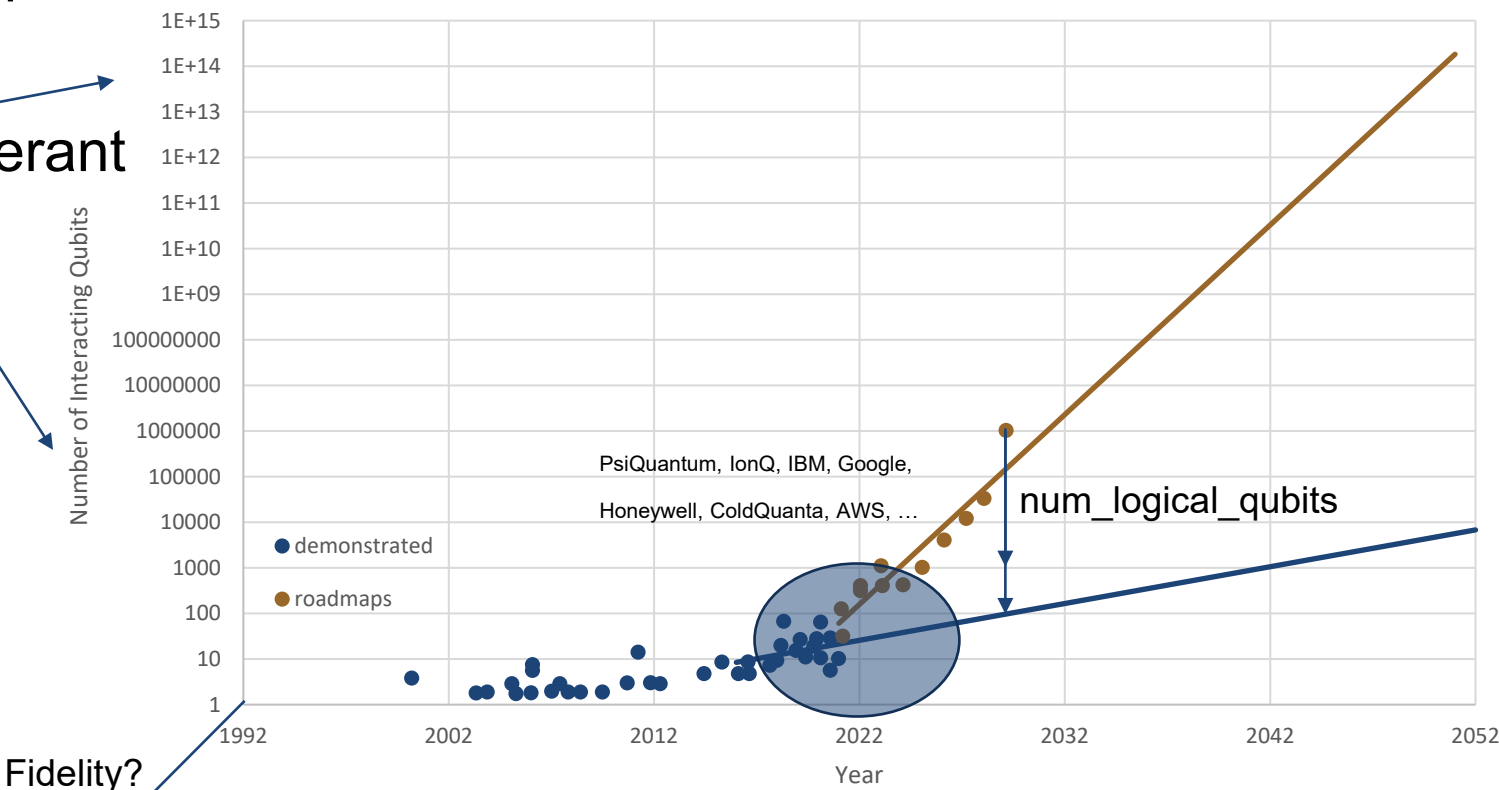


IBM Research

Roadmaps

Fault-Tolerant Apps?

Fidelity?



NISQ Apps??

Summary

Goal: Our Goal is quantum advantage (QA); we want to solve practical DOD problems faster and to higher quality than any other alternatives (e.g., classical SOTA).

Actions: Determine which applications have the best chance of developing QA and when in order to become “quantum ready.”

Collaboration: We are working on QuantumHub at CMU where we have access to quantum software and simulation tools, and a workspace for researchers (contact me for more info).

SEI Team



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