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NOV. 28 – DEC. 2, 2022 | LAS VEGAS, NV

CLASSIQ

QTC403

New approaches to implementing quantum algorithms

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Classiq

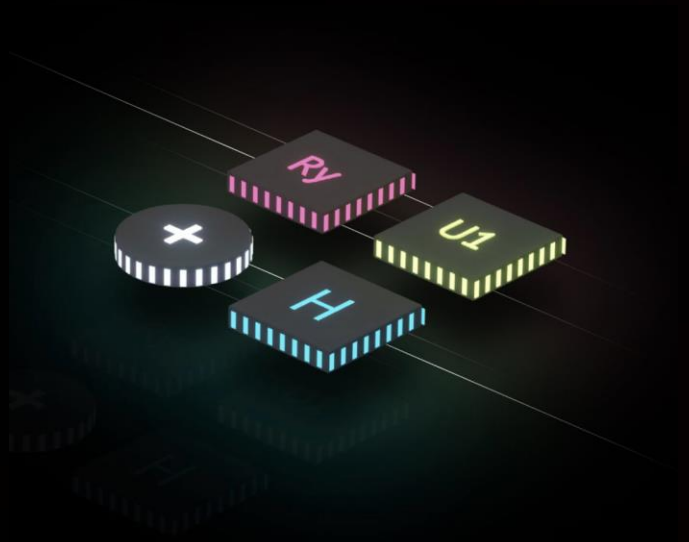
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Partner Development Manager
AWS

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Sr. Manager
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Agenda



- What is a quantum computer?
- Why are financial institutions interested in quantum computing?
- Implementing quantum with NTT and other financial customers utilizing the Classiq platform supported by Amazon Braket
- Challenges in programming quantum computers
- How the Classiq platform addresses these challenges

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About CLASSIQ

- Founded in 2020
- $63M in funding to date
- A world-class team of 40+ quantum engineers
- Substantial patent portfolio
- Customers in various industries and academia



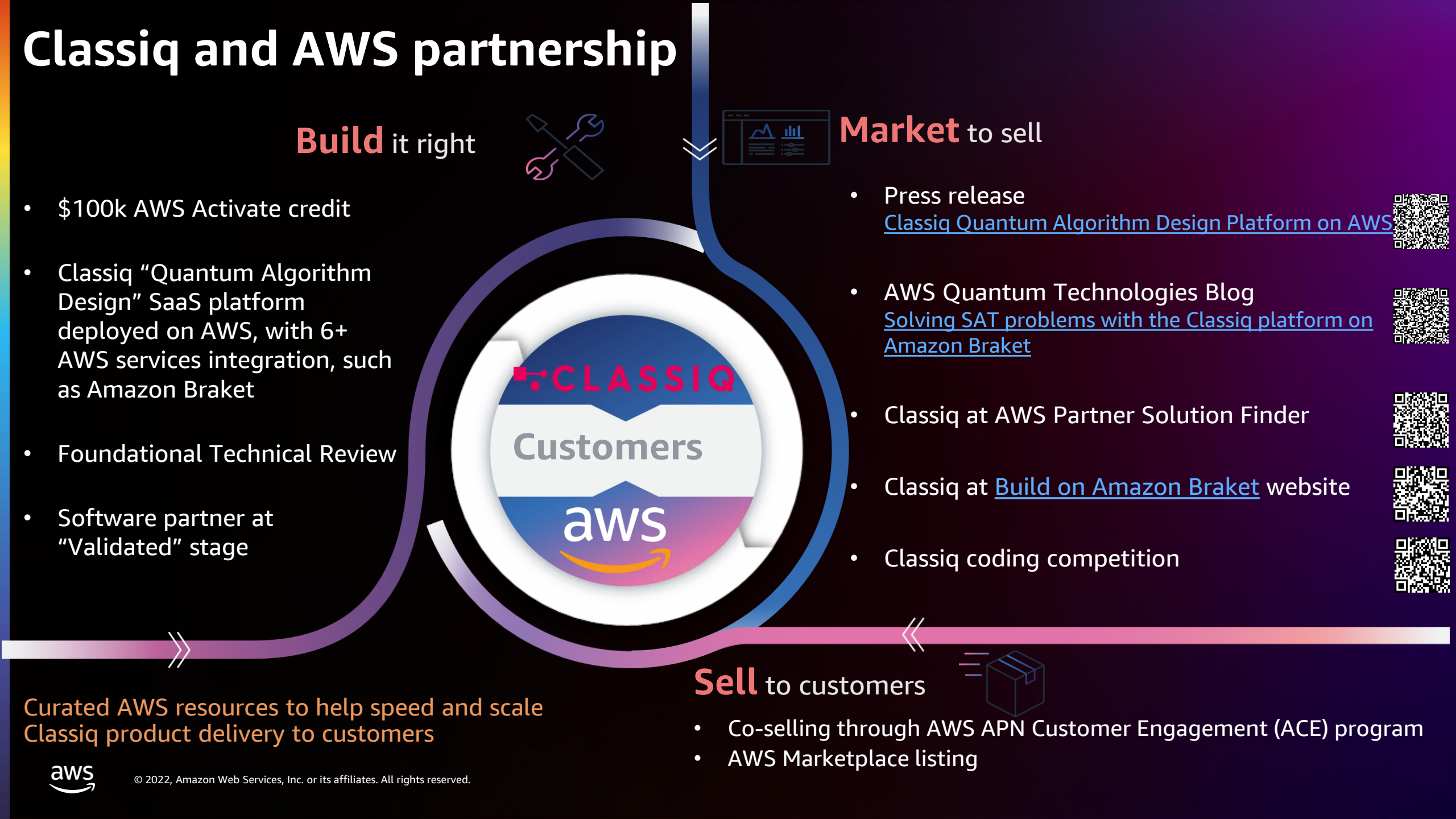


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Classiq and AWS partnership

Build it right

- $100k AWS Activate credit
- Classiq “Quantum Algorithm Design” SaaS platform deployed on AWS, with 6+ AWS services integration, such as Amazon Braket
- Foundational Technical Review
- Software partner at “Validated” stage



Market to sell

- Press release
  Classiq Quantum Algorithm Design Platform on AWS
- AWS Quantum Technologies Blog
  Solving SAT problems with the Classiq platform on Amazon Braket
- Classiq at AWS Partner Solution Finder
- Classiq at Build on Amazon Braket website
- Classiq coding competition

Sell to customers

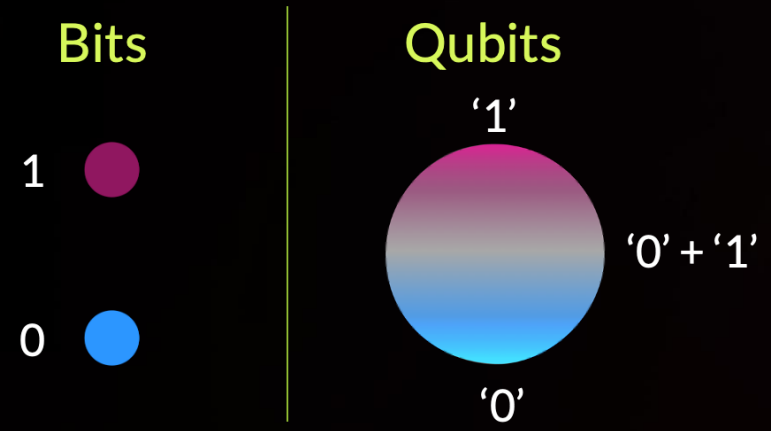
- Co-selling through AWS APN Customer Engagement (ACE) program
- AWS Marketplace listing

Curated AWS resources to help speed and scale Classiq product delivery to customers

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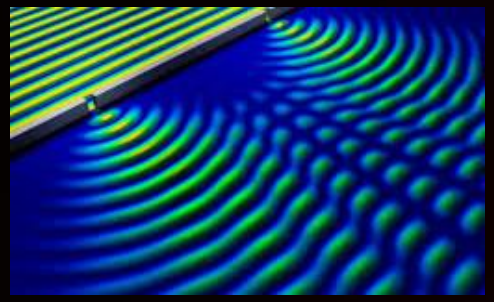
What is a quantum computer?



Superposition

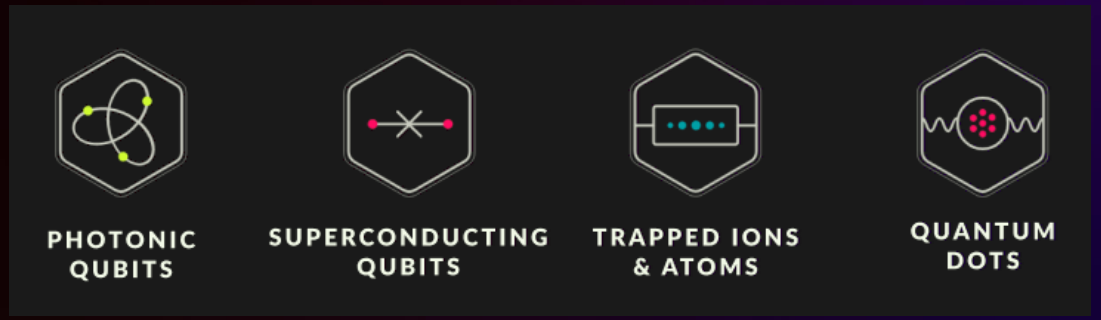


Entanglement



Quantum interference





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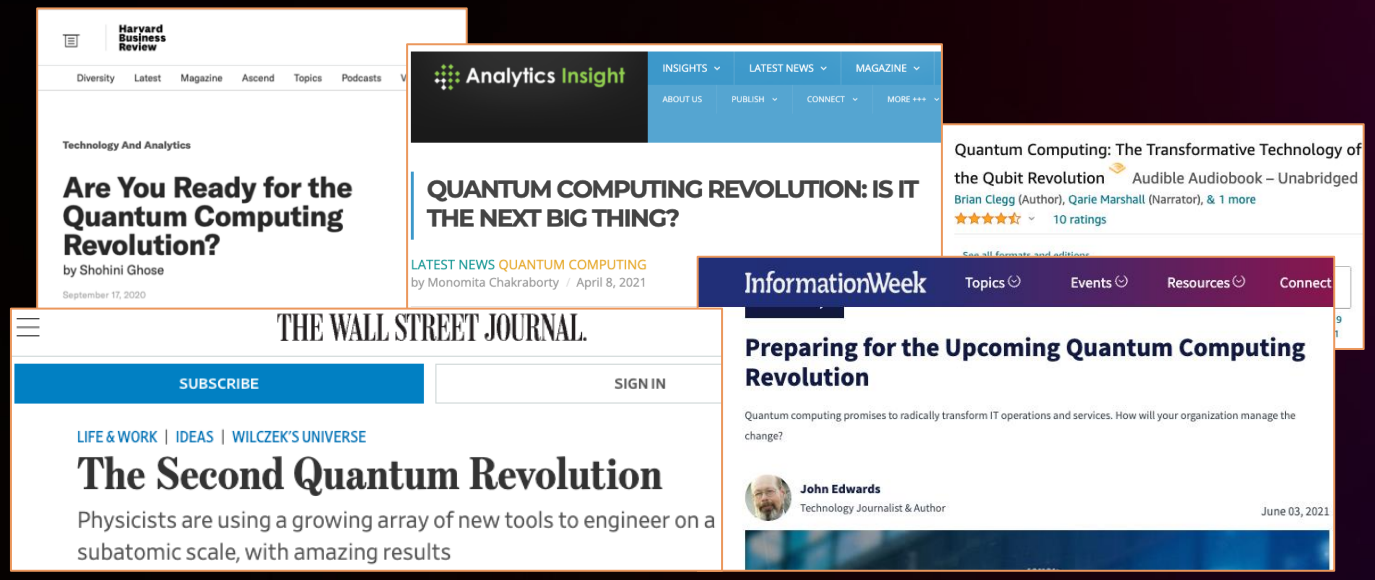
Why are companies interested in quantum computing?

> Quantum computing is a new strategic technology with wide-reaching implications.
>
> Quantum can be a game-changing differentiator when working with huge data sets, models that have numerous variables yet exhibit a high rate of change over time.

ADM Michael Rogers, USN (RET)
Former Director, NSA
Commander, US Cyber Command

Industries quantum will benefit

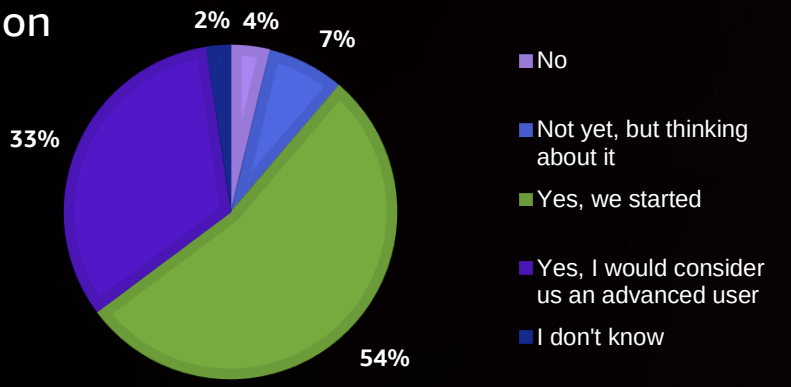
- HEALTHCARE
- CYBERSECURITY
- FINANCE
- ARTIFICIAL INTELLIGENCE
- LOGISTICS
- MANUFACTURING



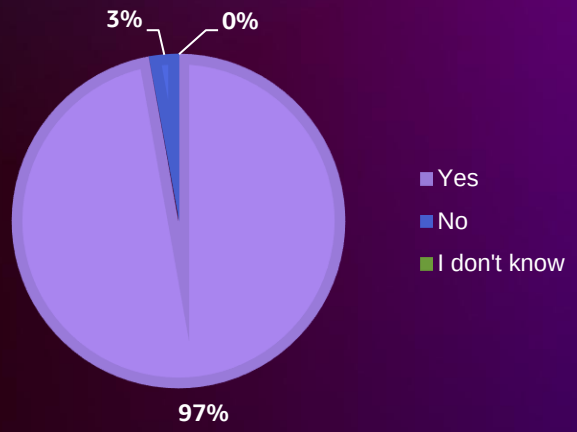
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Financial firms and quantum computing

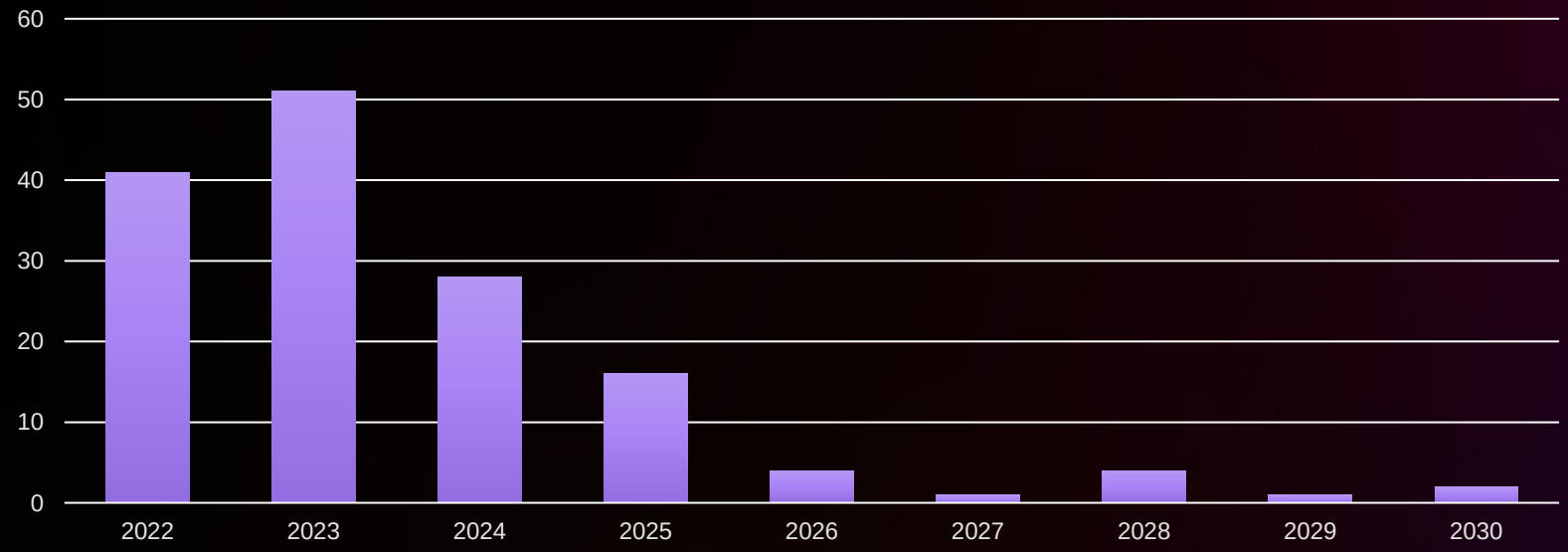
Is your organization investigating quantum computing technologies and/or research?



Do you believe quantum computing technology will someday inform your organization's decision-making on a daily basis, such as staffing, budget, forecasting, or strategy decisions?



When do you believe quantum computing technology will inform your organization's decision-making?



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Source: Sept'22 Classiq Survey

Why is finance interested?

- Monte Carlo simulations – Quantum Amplitude Estimation (QAE)
- Optimization problems- Quantum Approximate Optimization Algorithm (QAOA)
- Machine learning – Amplitude amplification, quantum walks, and others

Applications

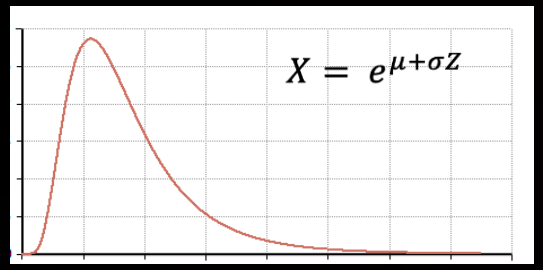
- Risk analysis
- Portfolio optimization
- Optimal trading execution
- Capital allocation
- Asset liability management
- Transaction settlement
- Credit scoring
- Default early warnings
- Fraud detection
- Predictive analytics

NTT DATA

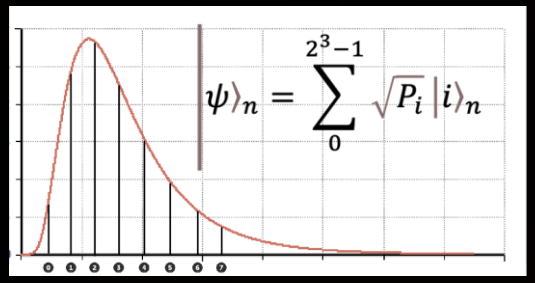
- “We are interested in applying quantum computer technology to financial engineering and believe that the need to compute complex business models will increase in the future. Classiq’s platform enables us to effectively generate and run quantum algorithms for the issues in applying to our supposed use case.” - Shunichi Amemiya, Head of Research and Development HQ, NTT DATA

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How we worked with NTT DATA and others

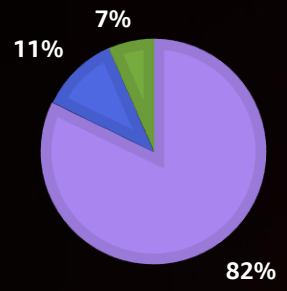


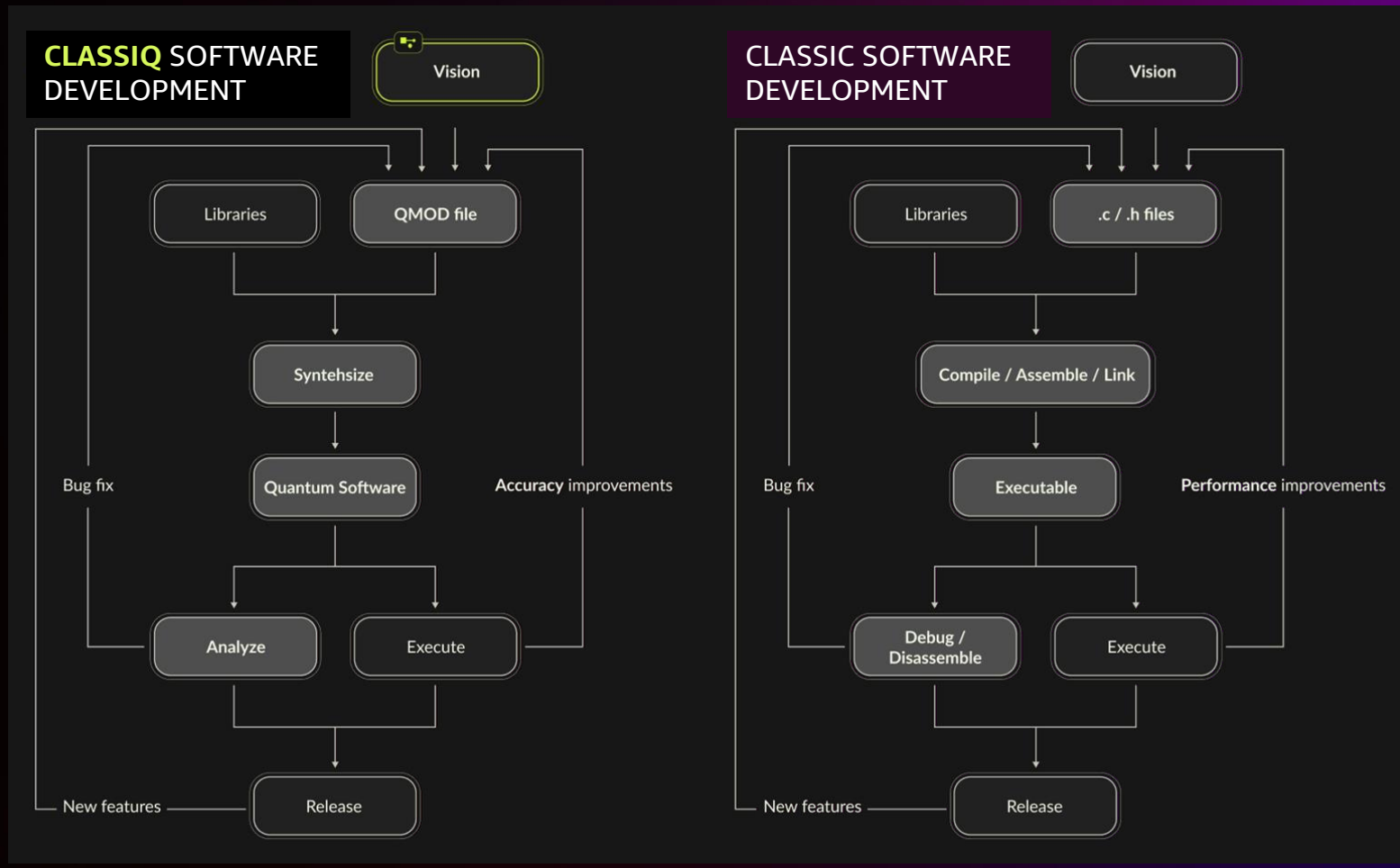
Log-normal distribution



3-qubit approximation

Is your organization currently patenting or does it have plans to patent quantum software-related IP?

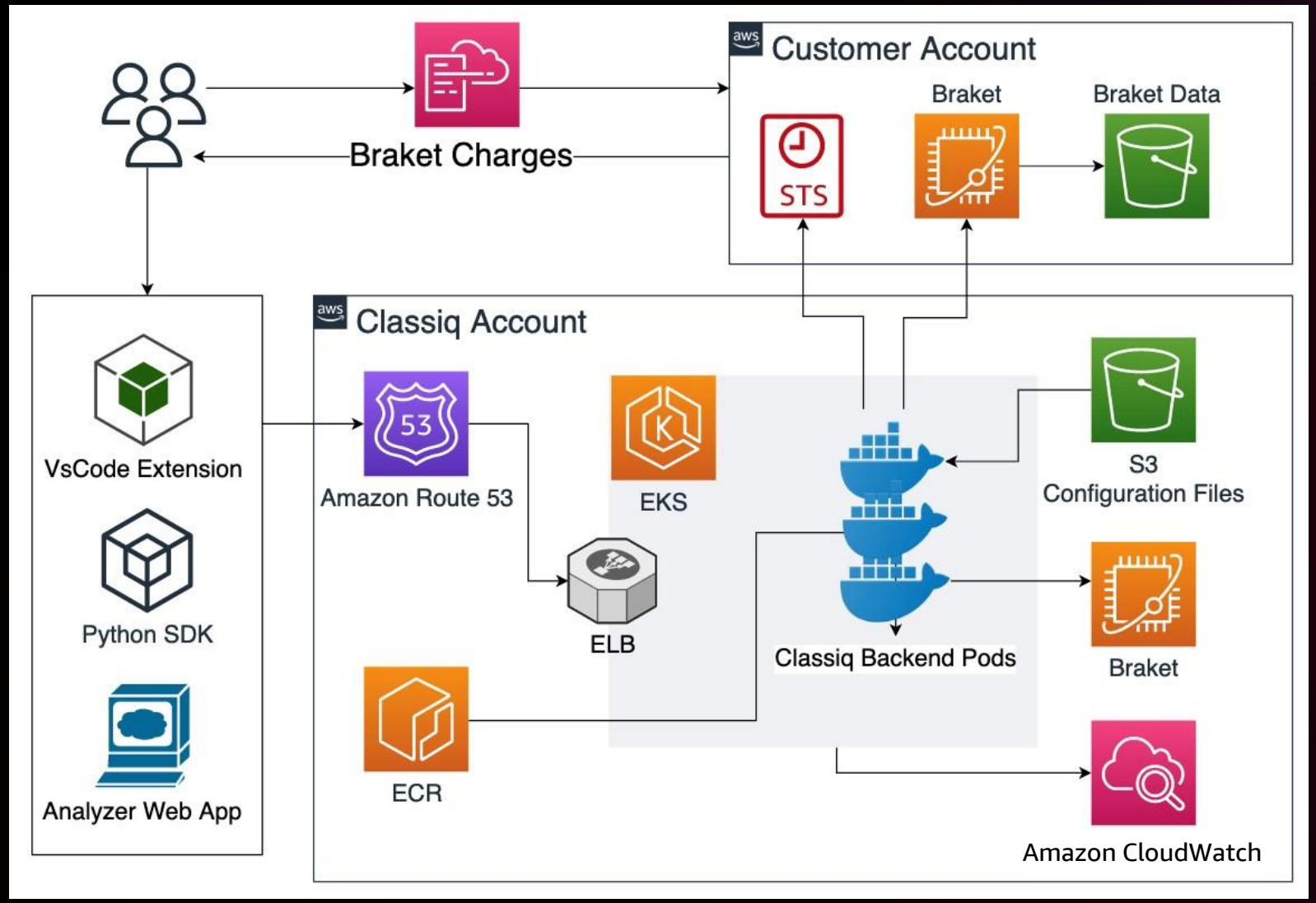




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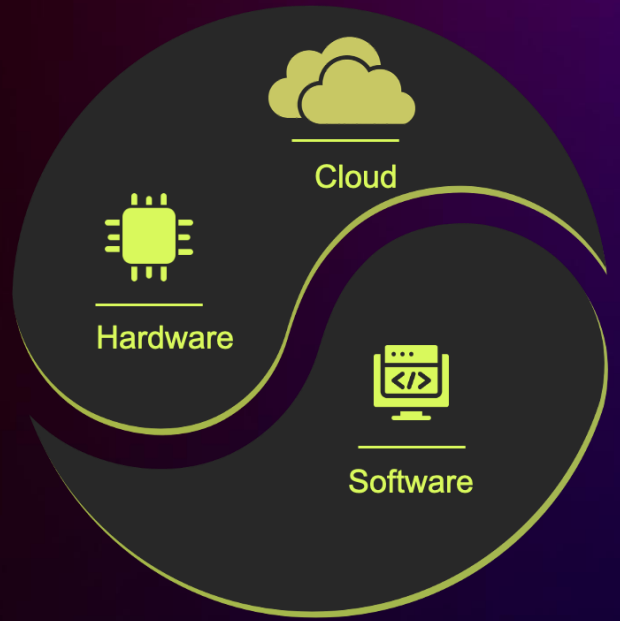
Source: Sept. 2022 Classiq Survey

Classiq cloud architecture on Amazon Braket



Better together

- Fully integrated solution
- Secure infrastructure
- Hybrid classical/quantum



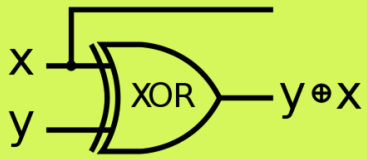
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https://aws.amazon.com/blogs/quantum-computing/solving-sat-problems-with-the-classiq-platform-on-amazon-braket

How do you program a quantum computer?

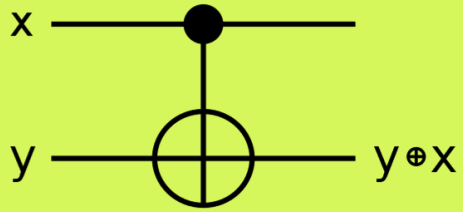
Writing software for quantum computers
is a little bit like electronic design
and a little bit like assembly language

Electronic circuit design



input x	input y	output
0	0	0
0	1	1
1	0	1
1	1	0

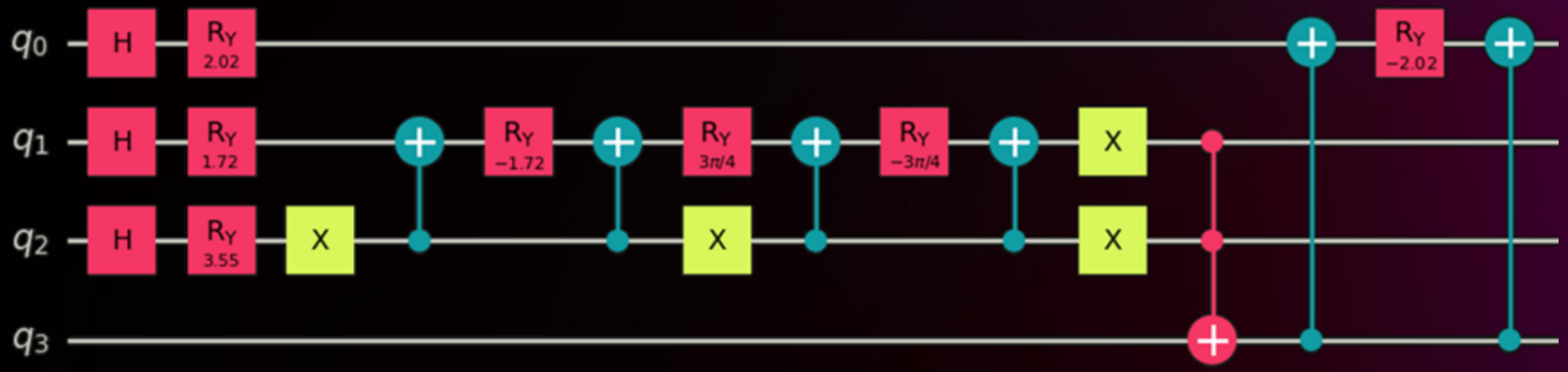
Quantum circuit design



input x	input y	output
$\|0\rangle$	$\|0\rangle$	$\|0\rangle$
$\|0\rangle$	$\|1\rangle$	$\|1\rangle$
$\|1\rangle$	$\|0\rangle$	$\|1\rangle$
$\|1\rangle$	$\|1\rangle$	$\|0\rangle$

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What does quantum software look like?



To create a quantum program, one specifies which qubits (wires) connect to which gates (square blocks)

This is done in quantum assembly language

A classical computer

```
TITLE COOLADDER

    .MODEL SMALL
    .STACK 64


    .DATA
NUMS DB 01H,01H,01H,01H,0A1H,0A1H
SUM DB ?
CC DB ?

    .CODE
MAIN PROC FAR
MOV AX,@DATA
MOV DS,AX
MOV CX,6
MOV BX,OFFSET NUMS
MOV AL,0
```

A quantum computer

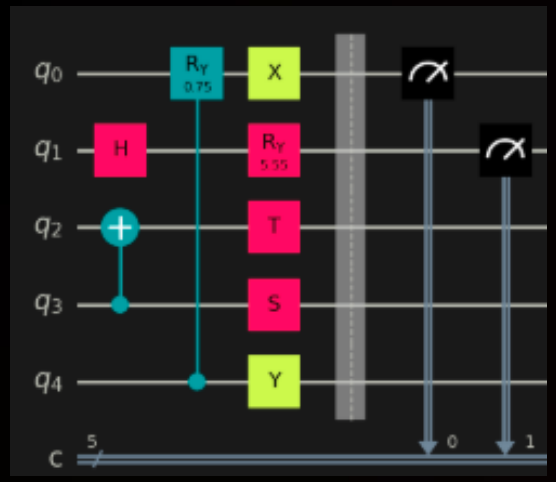
```
1   OPENQASM 2.0;
2   include "qelib1.inc";
3
4   qreg q[2];
5   creg c[2];
6
7   h q[0];
8   ry(pi/4) q[1];
9   cx q[0],q[1];
10  ry(-pi/4) q[1];
```

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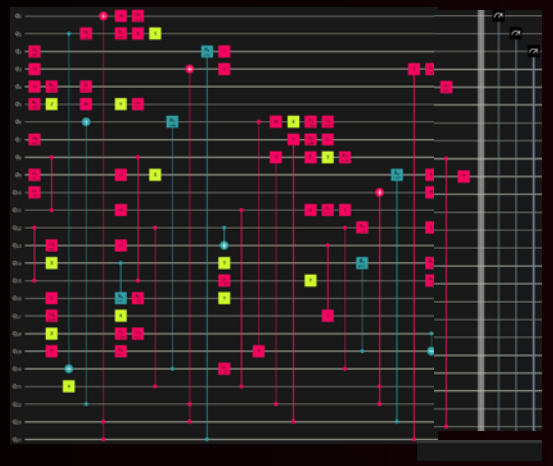
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The quantum software problem

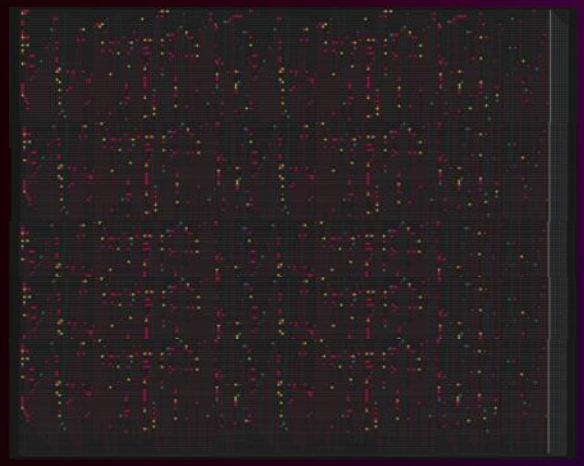
Once the number of qubits (wires) and gates (blocks) increases, it becomes **impossible** to design, debug, and maintain quantum circuits using today's development methods



1998–2017
5 qubits



2018–2021
25 qubits



2022–onward
Thousands or more qubits

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Design challenges

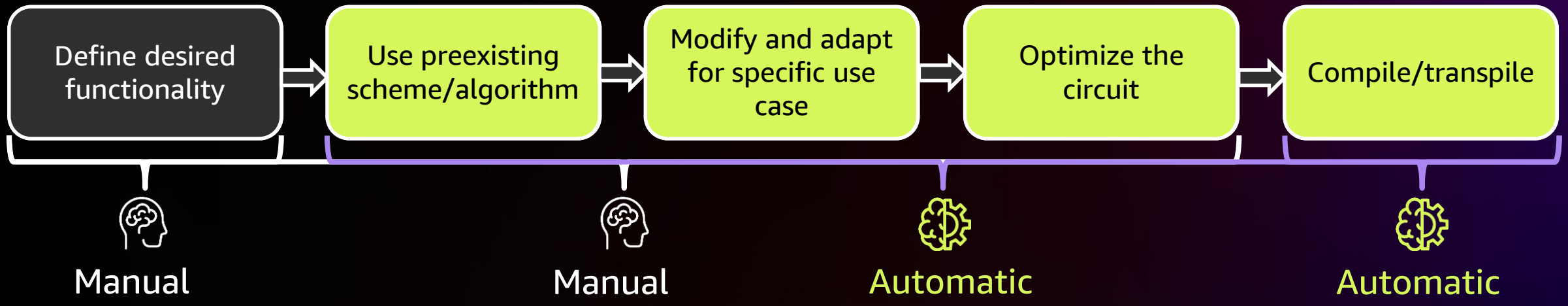
Block-level decisions

- Many possible implementations
- The number of auxiliary qubits
- The appropriate level of accuracy

System-wide constraints

- The number of qubits
- The depth of the circuit
- Resource management and reuse
- The hardware (gate set, noise model, connectivity)

These issues are deeply interconnected!



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The Classiq platform

EASY TO DEFINE, ~~HARD~~ EASY TO IMPLEMENT



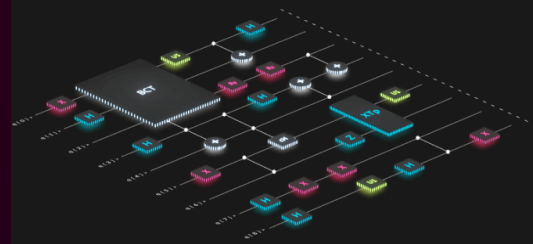
High-level modeling

- Design at a high level
- Specify the constraints



Circuit synthesis

- Automatically generate an optimized circuit
- Easy to port to different hardware platform

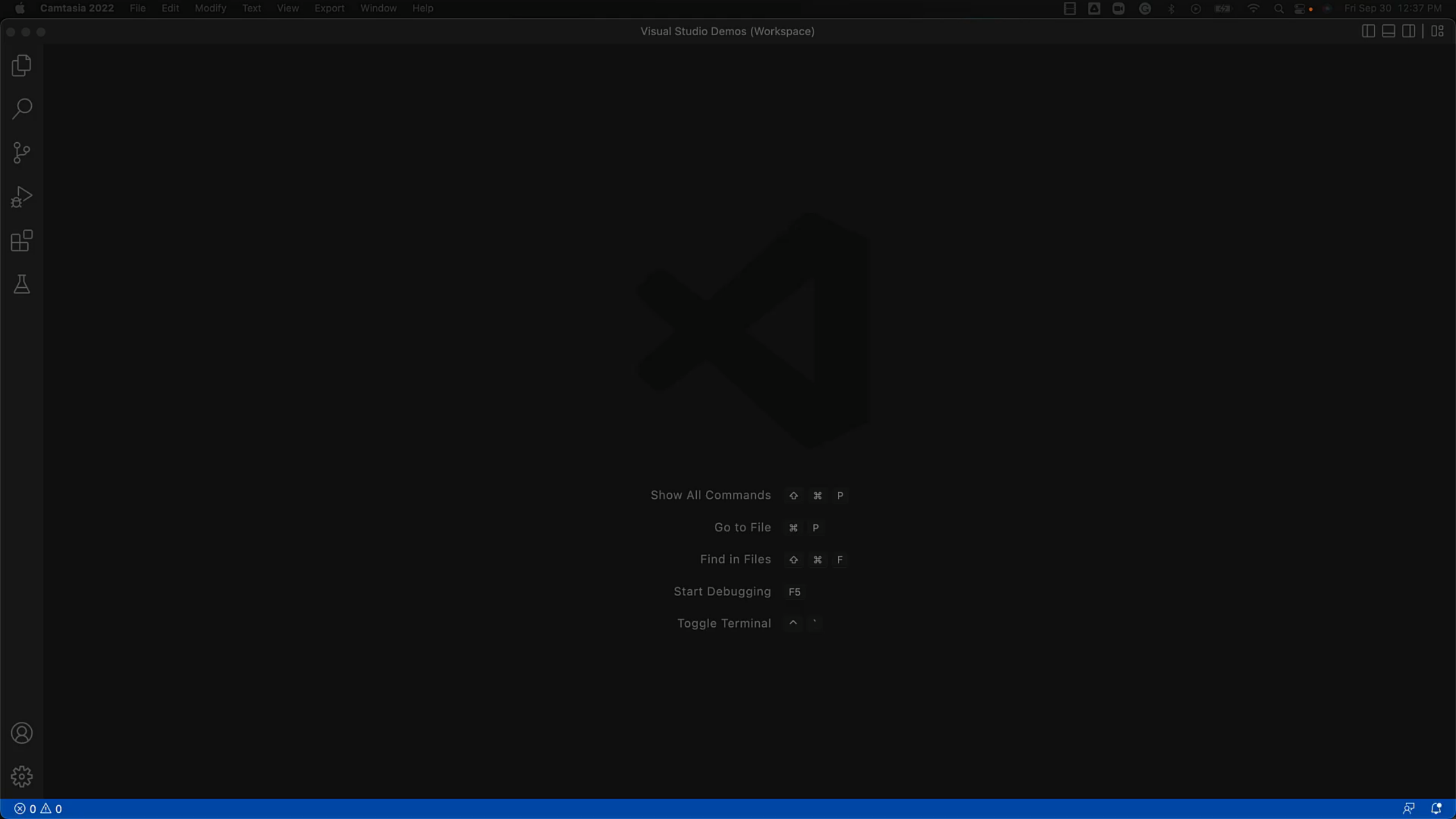


Circuit analysis

- Makes circuits easier to explain, understand, and maintain

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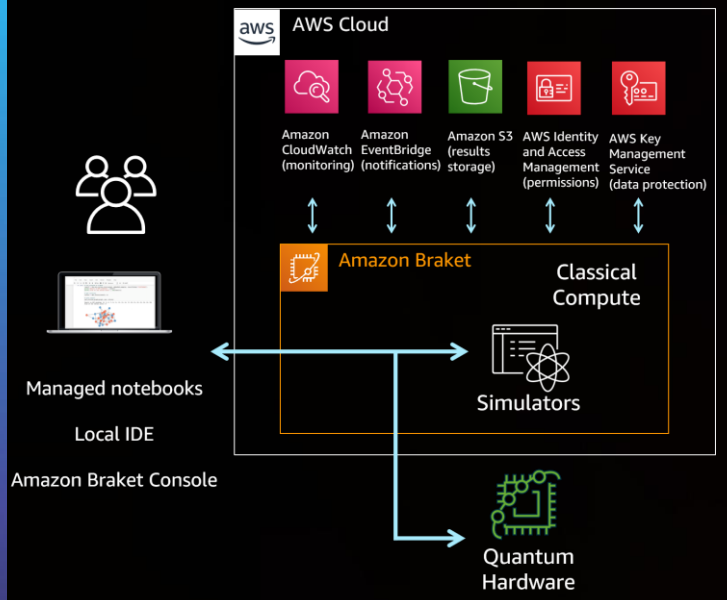

Camtasia 2022 File Edit Modify Text View Export Window Help
Fri Sep 30 12:37 PM
Visual Studio Demos (Workspace)
Show All Commands ⇧ ⌘ P
Go to File ⌘ P
Find in Files ⇧ ⌘ F
Start Debugging F5
Toggle Terminal ^ `
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Amazon Braket: Democratizing quantum computing

A FULLY MANAGED SERVICE THAT MAKES IT EASY FOR SCIENTISTS AND DEVELOPERS TO EXPLORE QUANTUM COMPUTING

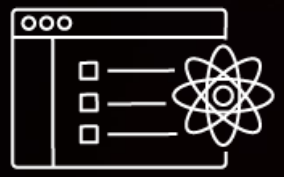
Design

Managed development environments

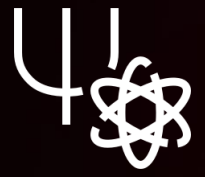


Test

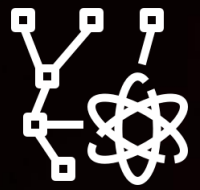
High-performing circuit simulators



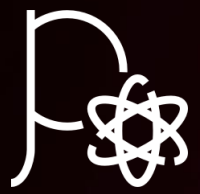
Local simulator



SV1
State Vector



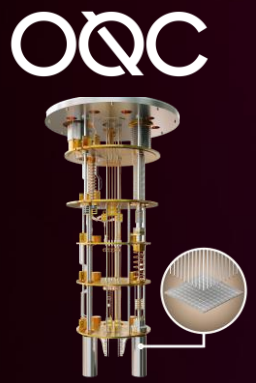
TN1
Tensor Network



DM1
Density Matrix

Run

Hybrid workloads on secure, on-demand quantum hardware







Classiq compatible QPUs

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TAKE YOUR QUANTUM SOFTWARE
TO A HIGHER LEVEL



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Thank you!

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