

A complex network diagram occupies the left and center of the page. It features a dense web of blue and red nodes connected by thin lines, with several prominent, thicker, wavy lines in blue and red that flow from the network towards the right side of the page. The nodes are small circles, and the lines represent connections between them.

# Quantum Computing Talent Ecosystem Analysis

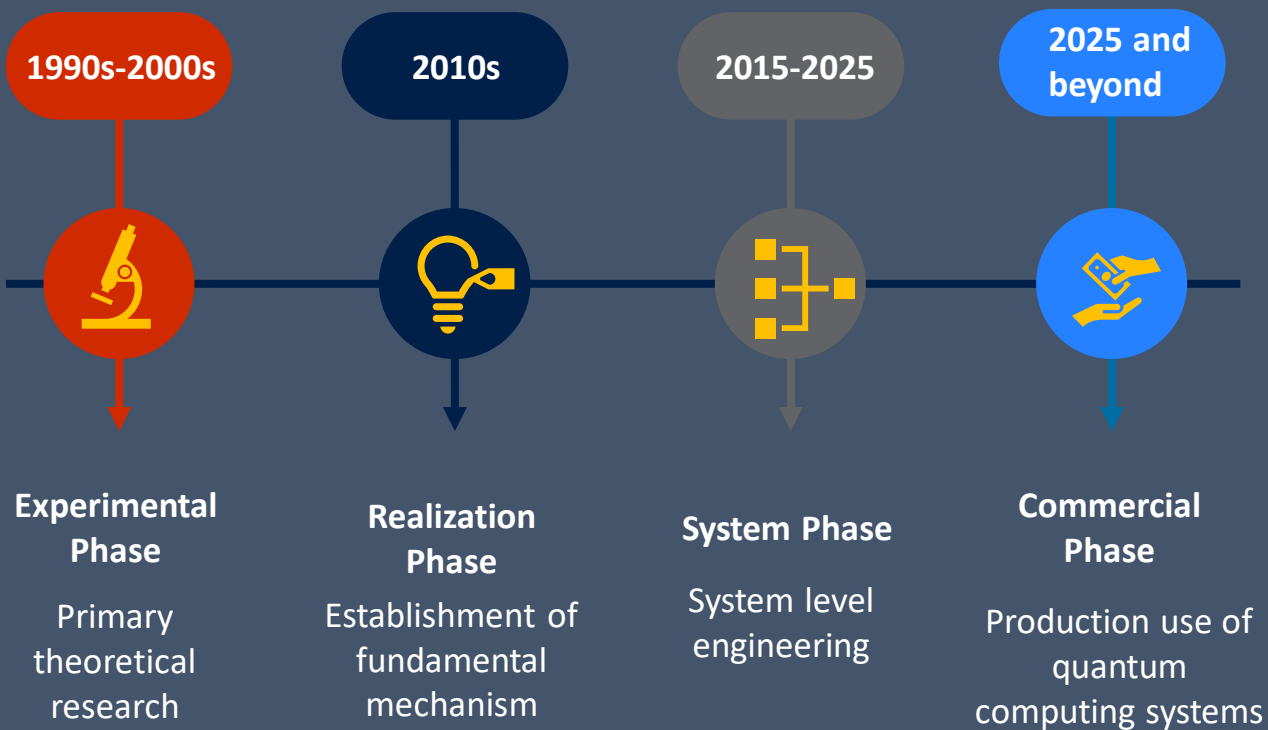
**Conceptualized and Developed: November – 2020**

The objective of the document is to provide a comprehensive analysis of possible Quantum Computing use cases across industries and how companies are leveraging global Quantum computing talent ecosystem to build Quantum computers and it's use cases

Serial Nos.	CONTENTS
01	Quantum Computing Evolution – Timeline Map
02	Quantum Computing Use-Cases (Industry Specific)
03	Quantum Computing – Job Openings, Growth Rate, Roles Taxonomy, Skills & Workloads
04	Quantum Computing – Global Hotspot Locations Mapping & USA Major Hotspot Locations Analysis
05	Quantum Computing – A deeper understanding

Quantum Computing technology is based on the principles of Quantum Mechanics with potential to perform calculations billions of times faster than a silicon-based computer

## Quantum Computing Timeline Map



### Classical Computing V/S Quantum Computing

Point of comparison	Classical Computing	Quantum Computing
<b>Representation</b>	Bit either 0 or 1	Qubit: a superposition of 0 & 1
<b>Calculation</b>	Moving bits through logic gates	Altering states of atom
<b>Information Delivered</b>	Can be copied without being distributed	Cannot be copied or read without being distributed
<b>Information behavior</b>	Single direction	Multiple direction
<b>Noise tolerance</b>	High	Low
<b>Security</b>	Low	High
<b>Computational cost</b>	High	Low

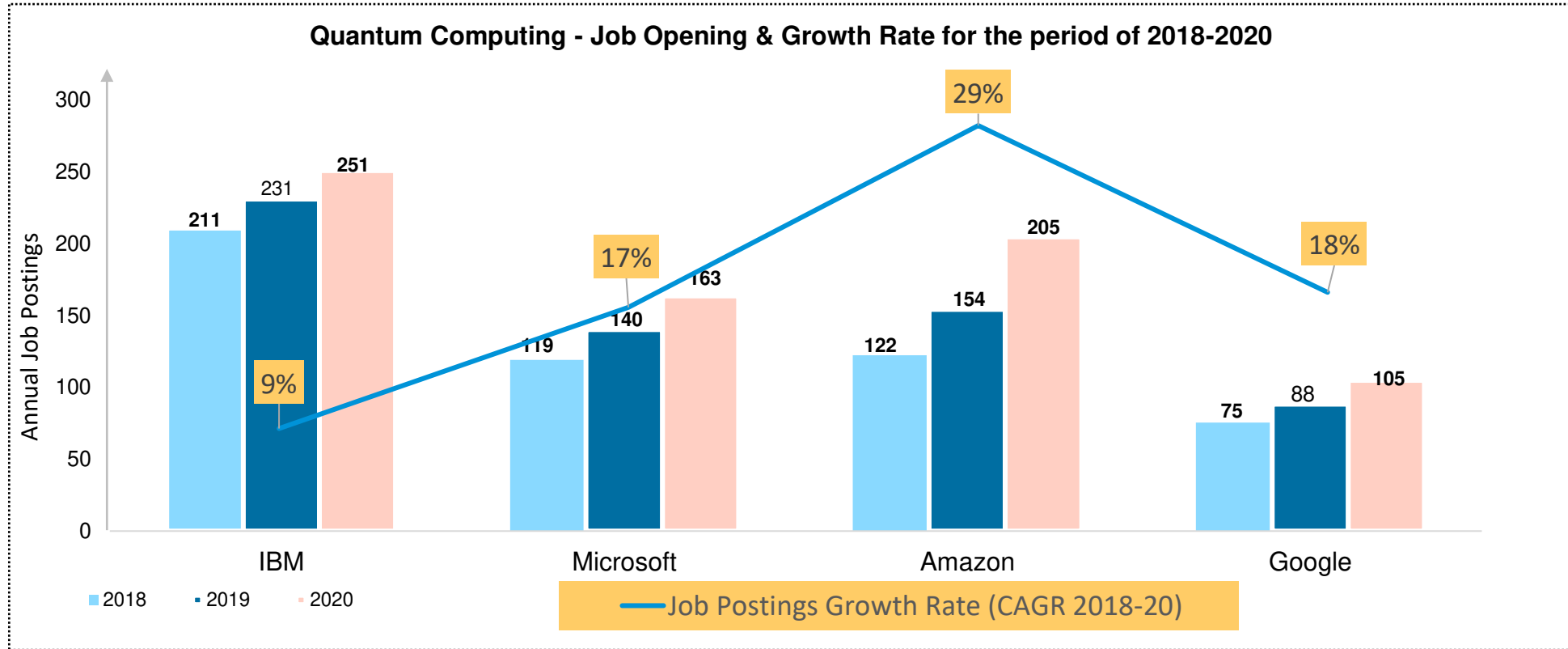
Quantum computing will enable researchers & end-users to find highly specific use-cases across industries including , but not limited to, Automotive, BFSI, Manufacturing, Pharmaceuticals, Energy/Utilities, Media, and Aerospace & Defence



Automotive	BFSI Industry	Manufacturing	Pharmaceuticals	Energy & Utilities	Media & Entertainment	Aerospace & Defence
Traffic Flow Optimization	Targeting and Forecasting	Supply Chain Optimization	Rapid Drug Discovery	Load Monitoring & Balancing	Advertisement Scheduling	Faster Aircraft Design
Vehicle Routing	Risk Profiling	Risk Modelling	Pharmacogenomic Testing & Genome Sequencing	Oil Well Optimization	Personalized Recommendation	Advanced Software Debugging
Powerful & Efficient E-Vehicle Batteries	Trading Optimization	Production Planning	Drug Interaction Prediction	Energy Distribution	Ad Revenue Maximization	Cryptographic Algorithm Optimization
Logistical Planning	Asset Pricing	Fault Analysis	Protein Modelling & Protein Folding	Utilization Prediction	AI based Image Classification	Reduction in Aircraft Design Turnaround Time
Autonomous Driving	Portfolio Optimization	Design Optimization	Diagnostic Capability Improvement	Expanding Reservoir Production		Network Planning Optimization
	Anti-Money Laundering		Catalyst & Enzyme Designing	Grid Optimization		Computational Fluid Dynamics
	Customer Behavioural Data			Network Design & Routing		
	Customer Onboarding					



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- Amazon has highest Y-o-Y average growth rate (29%) followed by Google(18%) and Microsoft(17%) for the Quantum Computing Job roles
- Highest number of Job openings were recorded for Quantum Computing relevant roles in 2020 :
  - IBM – 251
  - Amazon – 205
  - Microsoft – 163

After analysing the Top 15 companies from the global Quantum Computing Ecosystem, Draup has identified that typically all relevant Job Roles can be mapped & structured across 5 unique Job Clusters



## JOB ROLES TAXONOMY

HARDWARE ENGINEERING	SOFTWARE ENGINEERING	RESEARCH SCIENCE	PRODUCT & PROGRAM MANAGEMENT	TECHNICAL CONSULTING
Cryogenic Integrationn Engineer – Quantum Hardware	Software Development Engineer – Quantum	Theoretical Physicist – Quantum Solutions	Product Manager, Quantum Computing	Industry Quantum Consultant
Design Verification Engineer	Quantum Full Stack Developer	Quantum Science Researcher	Technical Program Manager - Quantum Hardware	Solutions Architect - Quantum
FEOL / BEOL Fabrication Engineer-Quantum Computing	Front/Back End Developer – Quantum Software & Tools	Quantum Computing Scientist	Azure Quantum Research Program Manager	Quantum Computing Technical Expert
Signal & Power Integrity Engineer – Quantum Computing	Quantum Software Engineer, Test and Measurement	Quantum Research Scientist – Design & Simulation	Principal Theory and Simulation Program Manager	
Quantum Device Fabrication Engineer	Quantum Software Security Engineer	Quantum Data Scientist	Technical Program Manager	
Quantum Hardware Development Engineer	Software QA Engineer	Research Scientist (Quantum Algorithms and Applications)		
Quantum Test Engineer	Embedded Software Engineer			
Quantum Control Engineer				

Job Clusters

Job Roles

High Priority Job Roles

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# Skills & Workloads for Quantum Computing job roles are highly advanced and require prior experience in programming language(s) along with working knowledge or research on Quantum Computing topics

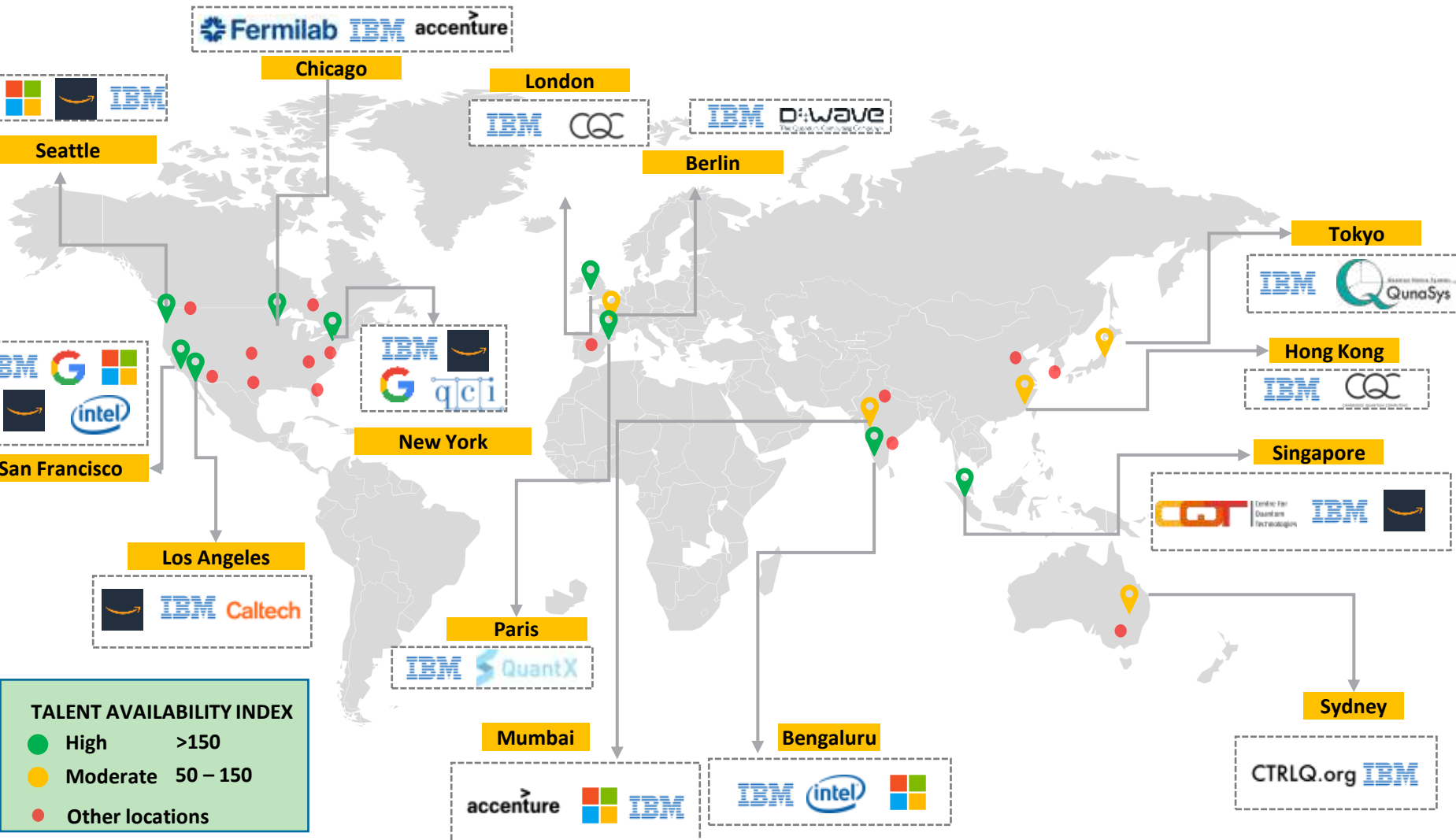


High Demand Quantum Computing Job Roles	Job Clusters	Technical Skills	Workloads
<ul style="list-style-type: none"> <li>• Software Development Engineer - Quantum</li> <li>• Embedded Software Engineer</li> <li>• Quantum Software Engineer, Test and Measurement</li> </ul>	<b>Software Engineering</b>	<ul style="list-style-type: none"> <li>• <b>Skills:</b> C, C++, Java, Python, Spring, MATLAB, HTML, Simulink, PostgreSQL, Julia, software scripting for hardware interfaces</li> </ul>	<ul style="list-style-type: none"> <li>• Advancing the entire quantum computing technology stack &amp; full stack architecture.</li> <li>• Exploring applications to make quantum broadly usable and accessible</li> </ul>
<ul style="list-style-type: none"> <li>• Cryogenic Integration Engineer</li> <li>• Design Verification Engineer</li> <li>• Signal Integrity Engineer - Quantum</li> <li>• Quantum Device Fabrication Engineer</li> <li>• Quantum Test Engineer</li> </ul>	<b>Hardware Engineering</b>	<ul style="list-style-type: none"> <li>• <b>Skills:</b> C, C++, Java, Python, Spring, MATLAB, Hardware Interface Programming, Cryogenic Operations, Device Fabrication (Lithography)</li> </ul>	<ul style="list-style-type: none"> <li>• Solve problems related to the fabrication and characterization of novel quantum processors</li> <li>• Assemble &amp; test complex electrical/ mechanical systems, cryogenic systems, microwave electronics to develop quantum hardware</li> </ul>
<ul style="list-style-type: none"> <li>• Quantum Scientist</li> <li>• Quantum Data Scientist</li> <li>• Quantum Research Scientist</li> <li>• Quantum Science Researcher</li> <li>• Applications Research Scientist</li> </ul>	<b>Research Science</b>	<ul style="list-style-type: none"> <li>• <b>Skills:</b> C, C++, Java, Python, Spring, MATLAB, HTML, Simulink, PowerBI, Tableau, Qlik, Quantum Mechanics, Theoretical Physics</li> </ul>	<ul style="list-style-type: none"> <li>• Responsible for architecting compiler optimizations in the Quantum Information Science Kit (Qiskit)</li> <li>• Thought leadership in quantum algorithms and/or quantum architecture research</li> </ul>
<ul style="list-style-type: none"> <li>• Technical Product Manager</li> <li>• Principal Theory and Simulation Program Manager</li> <li>• Technical Program Manager - Quantum Hardware</li> </ul>	<b>Product &amp; Program Management</b>	<ul style="list-style-type: none"> <li>• <b>Skills:</b> C, C++, R, Python, STATA, SAS, SPSS, Adobe Design, Cloud Services, Product Roadmap, User Stories, Wireframes, UI/UX</li> </ul>	<ul style="list-style-type: none"> <li>• Define and drive an organization-wide strategy for Quantum Computing</li> <li>• Engage with customers direct to identify new capabilities, product features for the use of Quantum Computing to achieve end goals.</li> </ul>
<ul style="list-style-type: none"> <li>• Solutions Architect (Quantum)</li> <li>• Industry Quantum Consultant</li> <li>• Quantum Computing Technical Expert</li> </ul>	<b>Technical Consulting</b>	<ul style="list-style-type: none"> <li>• <b>Skills:</b> Python, HPC, ML/DL algorithms, Cloud Computing, SOA, Server-less Architecture, GPUs, Linear Programming, Qiskit, Quantum Consulting</li> </ul>	<ul style="list-style-type: none"> <li>• Develop solution reference archt. aligned to business needs &amp; evolving capabilities of emerging tech</li> <li>• Design technical solutions that take advantage of the Cloud platform &amp; Quantum Computing services.</li> <li>• Provide Consumer, Retail, &amp; Agri-business industry-specific thought leadership &amp; advisory services</li> </ul>


Draup has analysed all the major hotspots of Quantum Computing globally ; US is the largest hotspot of Quantum Computing because of focus on quality Research & Development & presence of HQs of Global Tech Giants



IBM is actively present at all major Quantum Computing hotspots globally that have high access to relevant talent & technical infrastructure needed for its research & development



### Case Studies

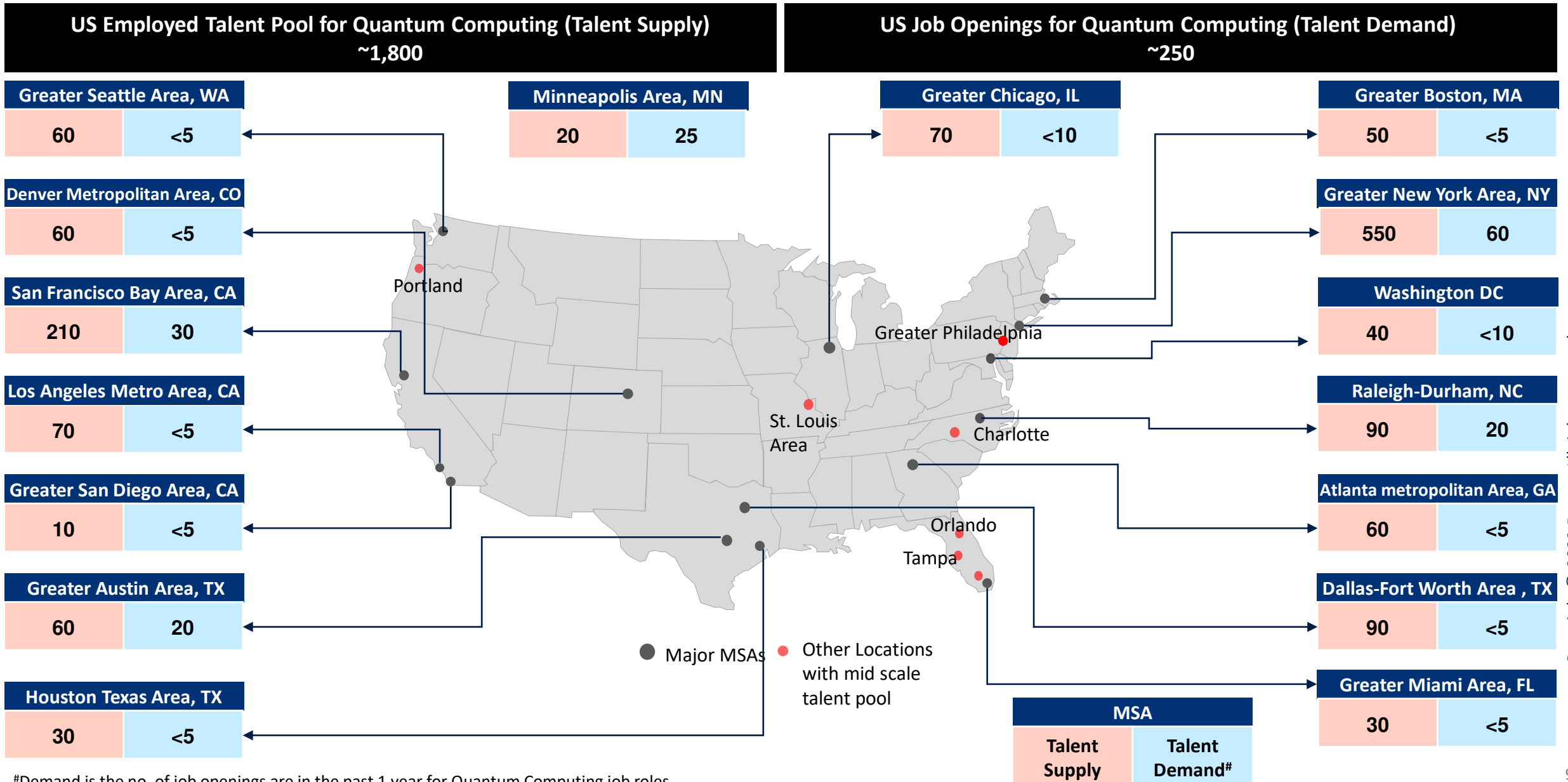
- 
- Cambridge Quantum Computing Partners With IBM to Expand Industry Engagement in Quantum
  - CQC will expand membership of the network with cloud-based access to the IBM Quantum Computation Center, which now includes 20 of the most-advanced quantum computers commercially available to explore practical applications for business and science

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DRAUP's proprietary talent module was used to find relevant talent pool assessment. All the locations were analyzed for talent availability across all job roles specified in the taxonomy



US has a talent pool of approximately 1,800 Quantum Computing professionals ; Greater New York Area, San Francisco Bay Area are the Top 2 hotspot locations in the US based on Talent Pool availability



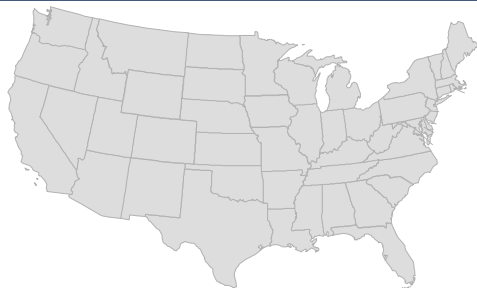
#Demand is the no. of job openings are in the past 1 year for Quantum Computing job roles

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Home to Quantum Computing pioneers, US has a great Fresh Talent Supply & Installed Talent Quality and has access to world-class universities for Computer Science Research such as Stanford and MIT



### Overall assessment: United States



Talent Availability	✓
Fresh Talent	✓
Talent Quality	✓
Talent Growth	⚠
Median Cost	✗
Ease of Hiring	⚠
Regulatory Cost	✓
Infrastructure Cost	✗
Location Characteristics	✓
Start up Index	✓

Early findings raise no concerns  
 Limited concerns, likely not significant  
 Early findings raise significant concerns

### Location Characteristics

Demographics	Population	~330M
	Annual population growth	0.6%
Quality of Life	Cost of Living Index*	70.95
	Local Purchasing Power Index*	119.1
	Avg. Commute Time (one way)	27 min

### Key Employers

IBM	Accenture
Google	Intel
Microsoft	Accenture
AWS	Cisco

### Top Universities

Universities	*Total Relevant Graduates
Stanford University	1,600+
TEXAS The University of Texas at Austin	1,200+
MIT Massachusetts Institute of Technology	650+
UC San Diego	500+
Berkeley UNIVERSITY OF CALIFORNIA	480+
HARVARD UNIVERSITY	230+

### Talent Concentration



\*Data referenced from worldpopulationreview.com

Source: University Websites

\*Graduation degrees includes: Electrical and Electronics, Computer Science, Mathematics and Physics

# Draup identified the most favoured locations of Quantum Computing in the US based on Overall Rating Score measured across 6 Talent-based parameters



Parameters	Greater Chicago Area	Greater New York Area	San Francisco Bay Area	Raleigh-Durham Area	Austin, Metropolitan Area
Talent Availability	Yellow	Green	Green	Green	Yellow
Fresh Talent Supply	Green	Green	Green	Yellow	Yellow
Median Talent Cost	Yellow	Orange	Orange	Orange	Orange
Ease of Hiring	Green	Green	Green	Yellow	Yellow
Talent Quality	Green	Green	Green	Green	Green
Talent Growth	Green	Yellow	Yellow	Green	Yellow
<b>Overall Rating</b>	<b>High</b>	<b>High</b>	<b>High</b>	<b>Mid</b>	<b>Mid</b>

DRAUP'S LOCATION ASSESSMENT FRAMEWORK	
Research from over 100+ DRAUP projects and discussions with multiple Industry Leaders, we have identified the critical metrics for any Location Strategy analysis	
<b>TALENT AVAILABILITY</b>	<ul style="list-style-type: none"> <li>No. of installed talent pool in the given roles.</li> <li>Higher the number of relevant talent pool, higher the favourability</li> </ul>
<b>FRESH TALENT SUPPLY</b>	<ul style="list-style-type: none"> <li>No. of installed talent pool in Number of graduates with software and computer science background</li> <li>Higher the fresh graduates with relevant degree, higher the favourability of location</li> </ul>
<b>MEDIAN TALENT COST</b>	<ul style="list-style-type: none"> <li>No. of installed talent pool in the given roles.</li> <li>Higher the number of relevant talent pool for 6 roles, higher the favourability</li> </ul>
<b>EASE OF HIRING</b>	<ul style="list-style-type: none"> <li>Ratio of available talent to no. of job openings (available talent supply -demand ratio) for the given roles</li> <li>High Talent/Demand ratio is considered as a favourable factor</li> </ul>
<b>TALENT QUALITY</b>	<ul style="list-style-type: none"> <li>The % of Total Talent that has more than 5 years of relevant work experience</li> <li>Higher the Talent Quality, higher the favourability of location</li> </ul>
<b>TALENT GROWTH</b>	<ul style="list-style-type: none"> <li>Increase or decrease of Talent Pool in a particular year calculated across a span of 5 years (CAGR)</li> <li>Higher the Talent Growth, higher the favourability of location</li> </ul>

• The top 5 MSAs in the US were rated across several factor that are important for hiring with Talent Availability, Median Talent Cost and Ease of Hiring being the most important ones

• San Francisco Bay Area, Chicago and New York are among the highest rated locations in US because of strong talent growth, and ease of hiring

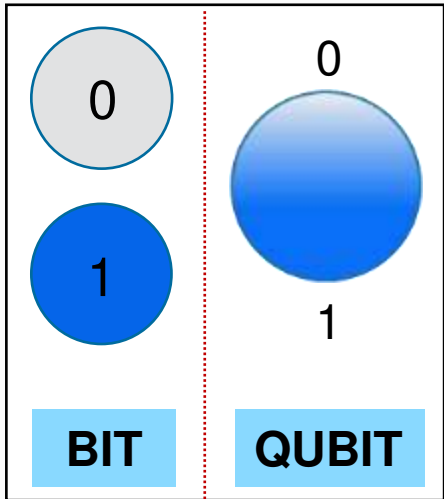
Favorable
Moderate
Unfavorable

Benchmarks are relative within a Parameter

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- Principles of Quantum Computing
- Quantum Computing Market Ecosystem
- Quantum Computing Collaborations, Investments and Outlook

Qubit can also exist in the superpositions of 0 state and 1 state, thus enabling quantum computers to store more information & perform multiple complex calculations parallelly



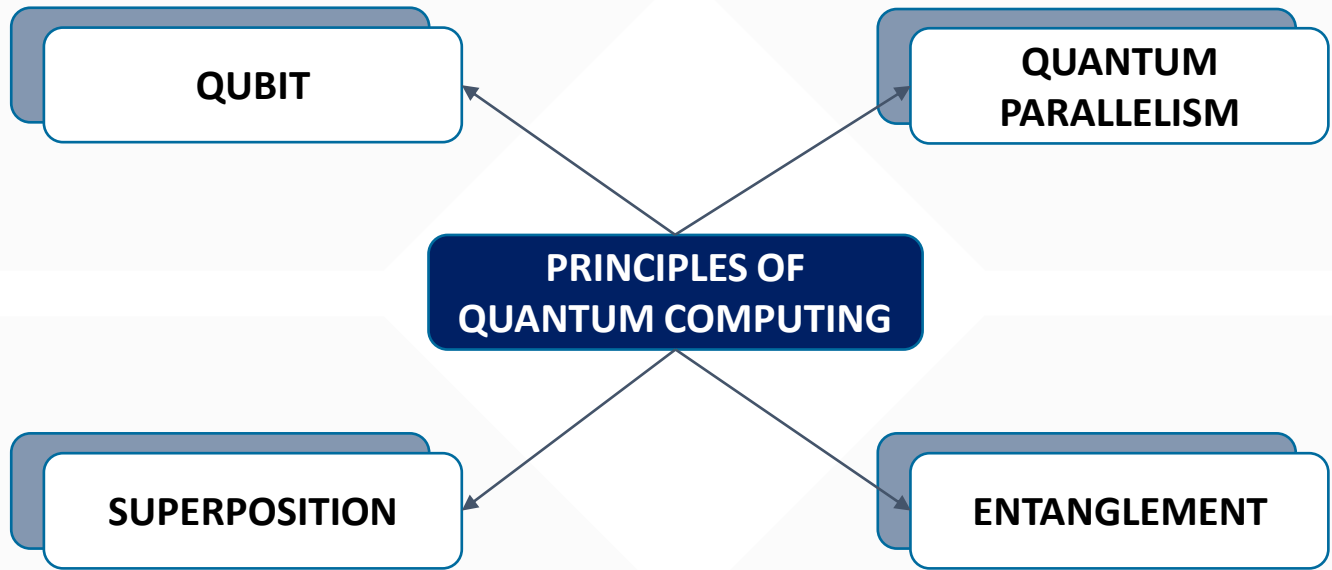
- Quantum computers use a more sophisticated data representation known as a qubit or quantum bit.
- Each qubit can exist in state 1, 0, or simultaneously occupy both states with varying probability

- A quantum computer's sequence of qubits can be present in every possible combination of 1s and 0s
- This allows the computer to test every possible solution simultaneously & perform complex calculations faster

**BITS**  
 101 → 5 (Decimal)  
 111 → 7 (Decimal)  
 In case of 3 Bits, a classical computer can be in just one of those 8 (2<sup>3</sup>) states at a given time

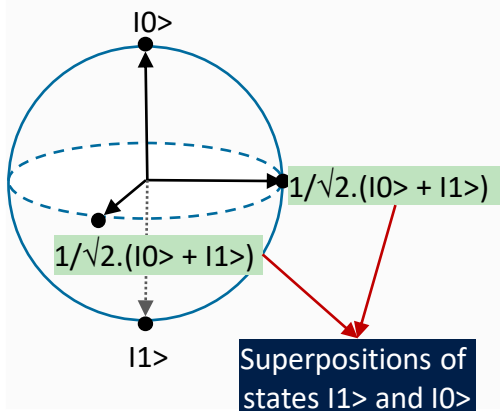
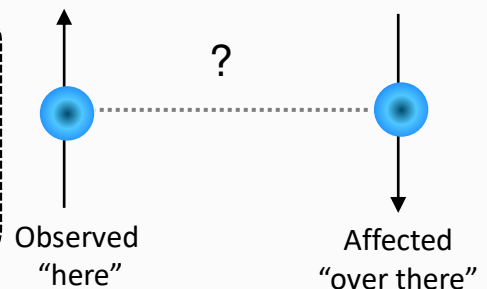
**QUBITS**  
 000 001 010 011  
 100 101 110 111  
 Can occupy all of them in parallel with varying probability... one calculation contains all 8 states

**PRINCIPLES OF QUANTUM COMPUTING**



- Ability of the quantum systems to be in multiple states at the same time (other than 0 & 1)
- This enables quantum computers to look at multiple variables & scenarios at the same time

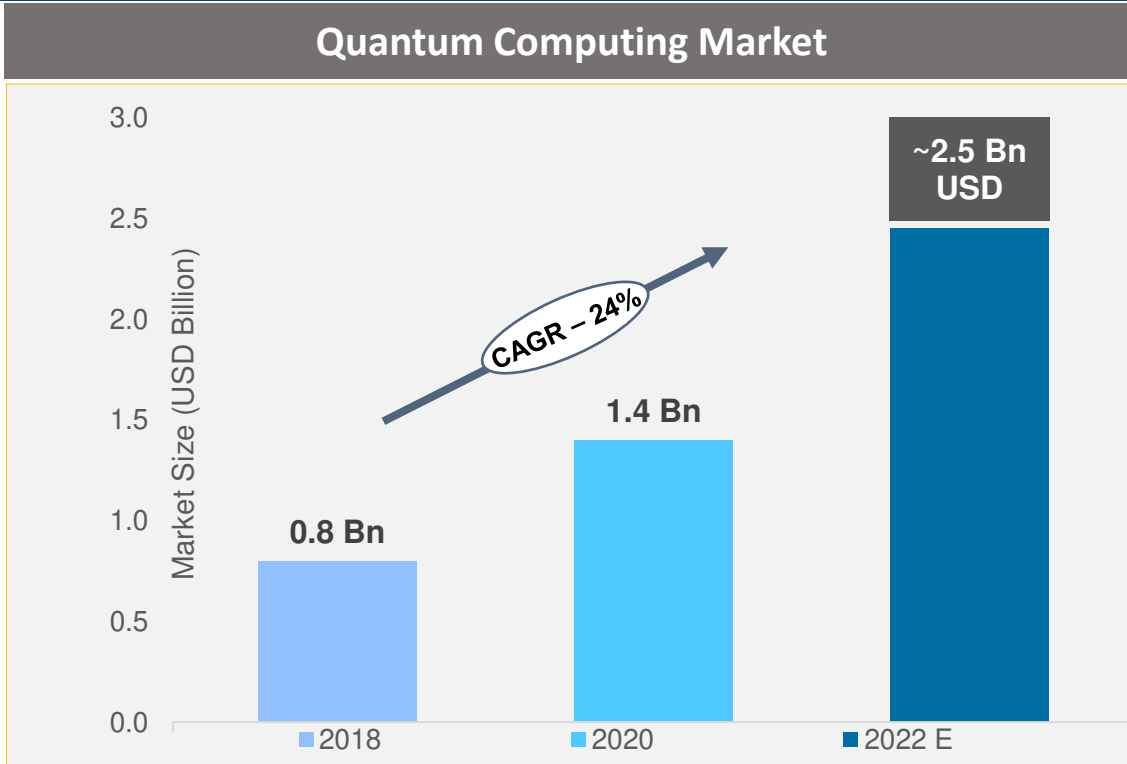
- State of an n-qubit system cannot be written as the state of its individual components because of Entanglement
- It states that the measurement of one qubit is always correlated to the measurement of the other qubit



Quantum Computing is one of the most disruptive technologies of today with huge potential across all Industries that require superfast computational speed to solve its complex problems in real time



The Market of Quantum Computing is growing at a CAGR of nearly 25% YoY and is estimated to be a \$2.5Bn USD Market by the end of 2022; The high growth is driven by the increasing demand from relevant players serving the entire spectrum of solutions across the Quantum Computing Ecosystem



### Quantum Computing Ecosystem

End to End Solution Providers	Hardware and Systems Providers	Software and Services Providers	Quantum Computing Specialists
IBM	IONQ	Xanadu	TELLUS MATRIX GROUP
Google	intel	QCC (Cambridge Quantum Computing)	QCI (Quantum Circuits Inc)
rigetti	QTech	RIVER LANE RESEARCH	AQT
Microsoft	BraneCell	QCWARE	Silicon Quantum Computing
QILIMANJARO	qci	Q*Branch	PsiQ
Honeywell	TUNDRASYSTEMS GLOBAL LTD	IQBit	QBITLOGIC





### Technology Trends impacted by Quantum Computing

- **ML/AI:** Quantum algorithms help in artificial neural network optimization for ML/AI to speed up ML-based complex problems
- **Cybersecurity:** Quantum Cryptography leverages individual particles- photons for the development of a cryptosystem to provide unbreakable security
- **5G:** The upcoming increase in connected devices & sensors after 5G network roll-out will force companies to leverage quantum-safe solutions to protect personal data from breaches and theft

Source: Primary interviews with DRAUP's SME's, industry professionals, and insights from customer engagement

# Tech Giants such as IBM, Microsoft, & Amazon are collaborating by investing in various start-ups to solve their computational & optimization problems, leading to a further acceleration of the Quantum Computing market



Collaborations	Investments/New Projects	Impact & Outlook
	<ul style="list-style-type: none"> <li>IBM to host quantum computing systems that cross the <b>QV32</b> performance threshold. They are <b>27-qubit Falcons</b> and <b>5-qubit Canaries</b>. IBM is also investing in <b>Cambridge Quantum Computing</b>.</li> </ul>	<ul style="list-style-type: none"> <li>Inspire the next generation of devices and further research.</li> <li>Commercialization of quantum technologies</li> </ul>
	<ul style="list-style-type: none"> <li>Microsoft invested <b>\$215M</b> in <b>photonic</b> quantum computer start-up <b>PsiQuantum</b>, also preparing its Azure cloud computing service to offer access to <b>three prototype quantum computers</b>, from <b>Honeywell</b> and, <b>IonQ</b> and <b>QCI</b>.</li> </ul>	<ul style="list-style-type: none"> <li>Development of quantum computer that uses photons as qubits, thus facilitating computation.</li> </ul>
	<ul style="list-style-type: none"> <li>AWS unveiled a new service called <b>Amazon Braket</b> to facilitate Quantum Computing in the Cloud in <b>collaboration</b> with <b>IonQ</b>, <b>Rigetti Computing</b> and <b>D-Wave</b>.</li> </ul>	<ul style="list-style-type: none"> <li>Build quantum algorithms and test them on simulated quantum computers.</li> </ul>
	<ul style="list-style-type: none"> <li><b>QuTech</b> (a collaboration between TU Delft and TNO) and <b>Fujitsu</b> signed a collaboration agreement to combine efforts in a multi-year research project</li> </ul>	<ul style="list-style-type: none"> <li>The aim of the project is to develop the building blocks for a modular quantum computer based on diamond spin qubits.</li> </ul>

Source: Tactical signals from Draup platform, Press releases, and annual reports of the companies

# About DRAUP



Draup uses Machine learning models to perform prior analysis and can replicate it on a broader level for any job roles/skills across functions



## Draup Capabilities & Data Assets



## EMPOWERS DECISION MAKING IN

Recruitment

Strategic Workforce Planning

Peer Intelligence

Diversity & Inclusion

Learning & Development

Compensation & Benefits

University Relations

Mergers and Acquisitions

and diverse other use cases...

**Draup for Location Intelligence:** Draup analyses 4,500+ job roles across 2,500+ locations to help companies understand talent ecosystem with insights around talent cost, required skills, job demand, and peer companies



**50M+**

DIGITAL AND DIGITALLY  
INFLUENCED  
PROFESSIONALS

**4.5K+**

JOB ROLES

**300K+**

PEER GROUP  
COMPANIES

**33**

INDUSTRIES

**65M+**

JOB  
DESCRIPTIONS

**100K+**

COURSES

**2.5K+**

LOCATIONS

**7K+**

UNIVERSITIES

**4M+**

CAREER PATHS  
ANALYZED

**30K**

SKILLS

**7K+**

DIGITAL TOOLS &  
PLATFORMS

**30K+**

UNIVERSITY PROFESSORS

**52**

MACHINE LEARNING  
MODELS DEVELOPED

**10M+**

DAILY DATA POINTS  
ANALYZED

**100+**

LABOR STATISTICS  
DATABASES

**1000+**

CUSTOM TALENT  
REPORTS



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