Solving the Unsolvable:

How Technology Acceleration Is Transforming Information Processing and Delivering Enabling New Capabilities

Ken Grob, Director, Embedded Technologies,
Embedded Tech Trends 2024

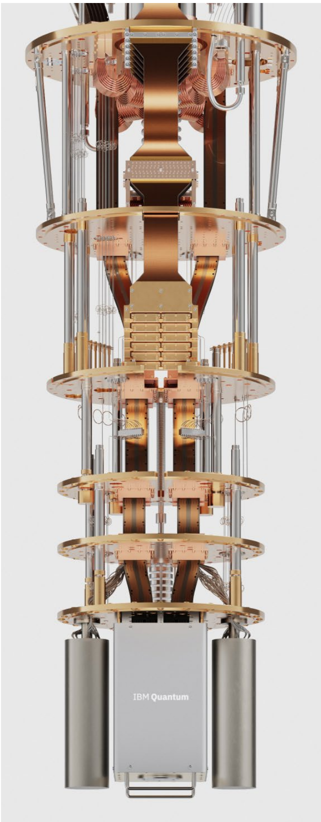


Image sourced from 2023 IBM Quantum Summit

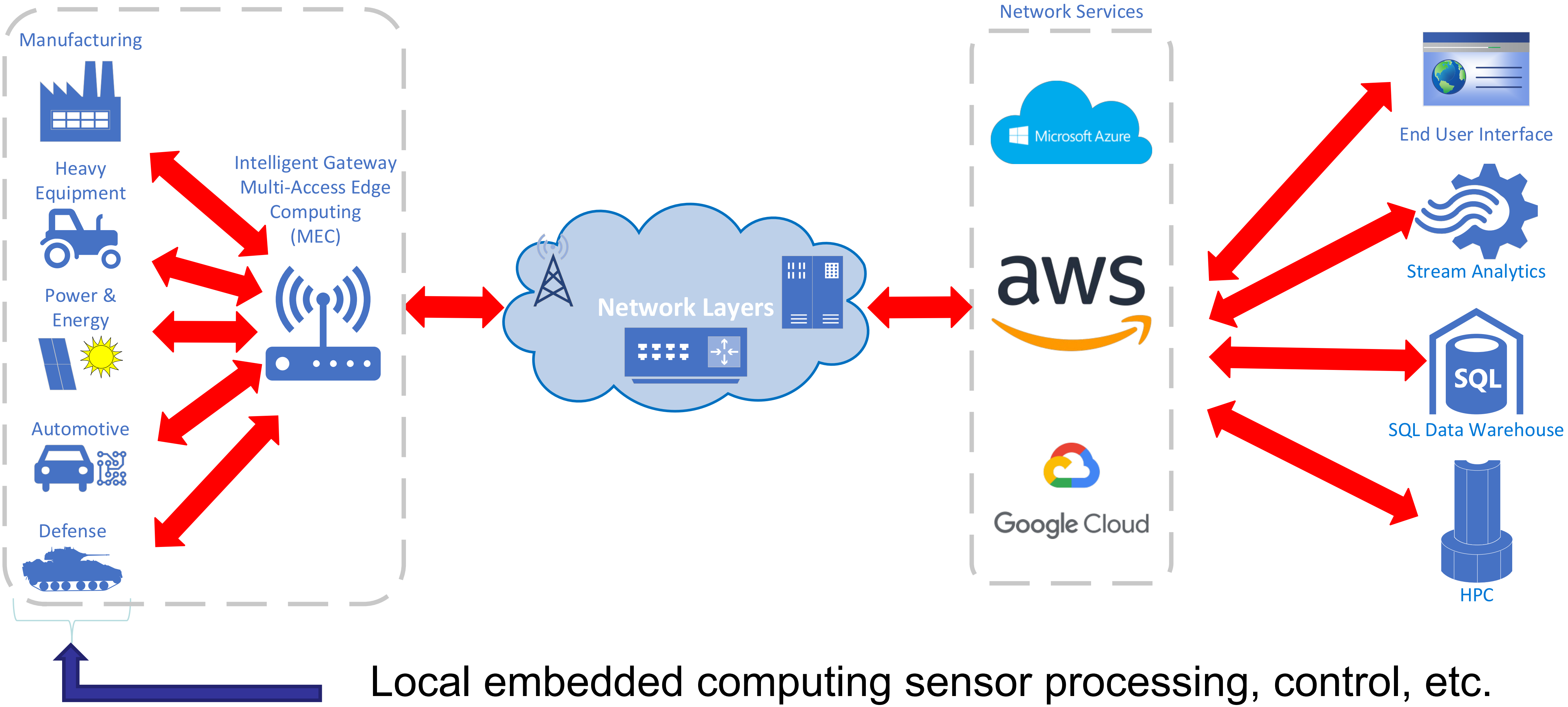
Solving the Unsolvable: A Progression

Trends to Consider

- Rapid increase of compute performance from edge to network to cloud
- Acceleration of new technology like generative or predictive AI that can be distributed through out the end-to-end compute chain
- New security paradigms required to ensure data security up and down; driving the need to plan and implement specific use case security considerations from end-to-end
- Quantum computing, on the horizon and possibly entering with-in a standard business planning window of 5 -7 years adding a transformative and potentially disruptive computing domain.

Modern Edge Computing – Classic

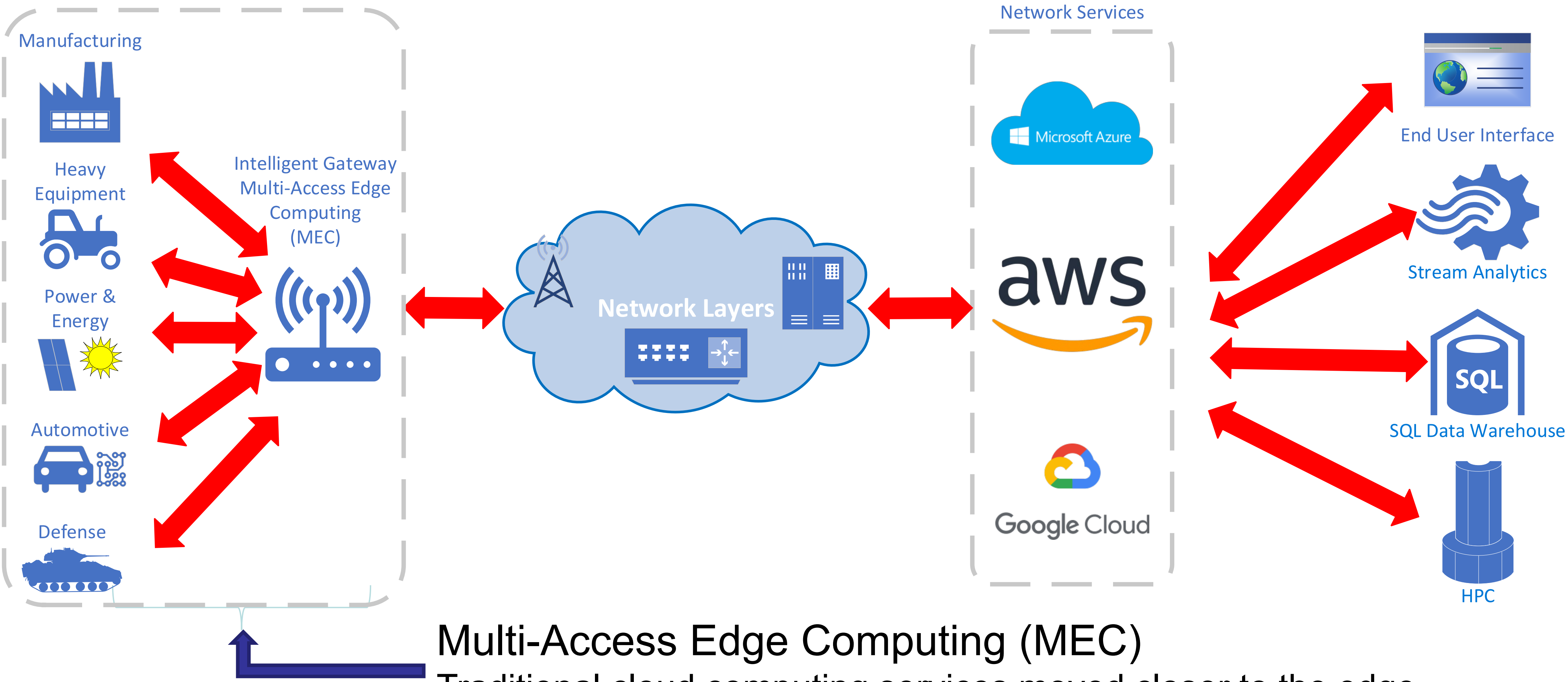
Common model regardless of application



Local embedded computing sensor processing, control, etc.

Modern Edge Computing - Classic

Common model regardless of application

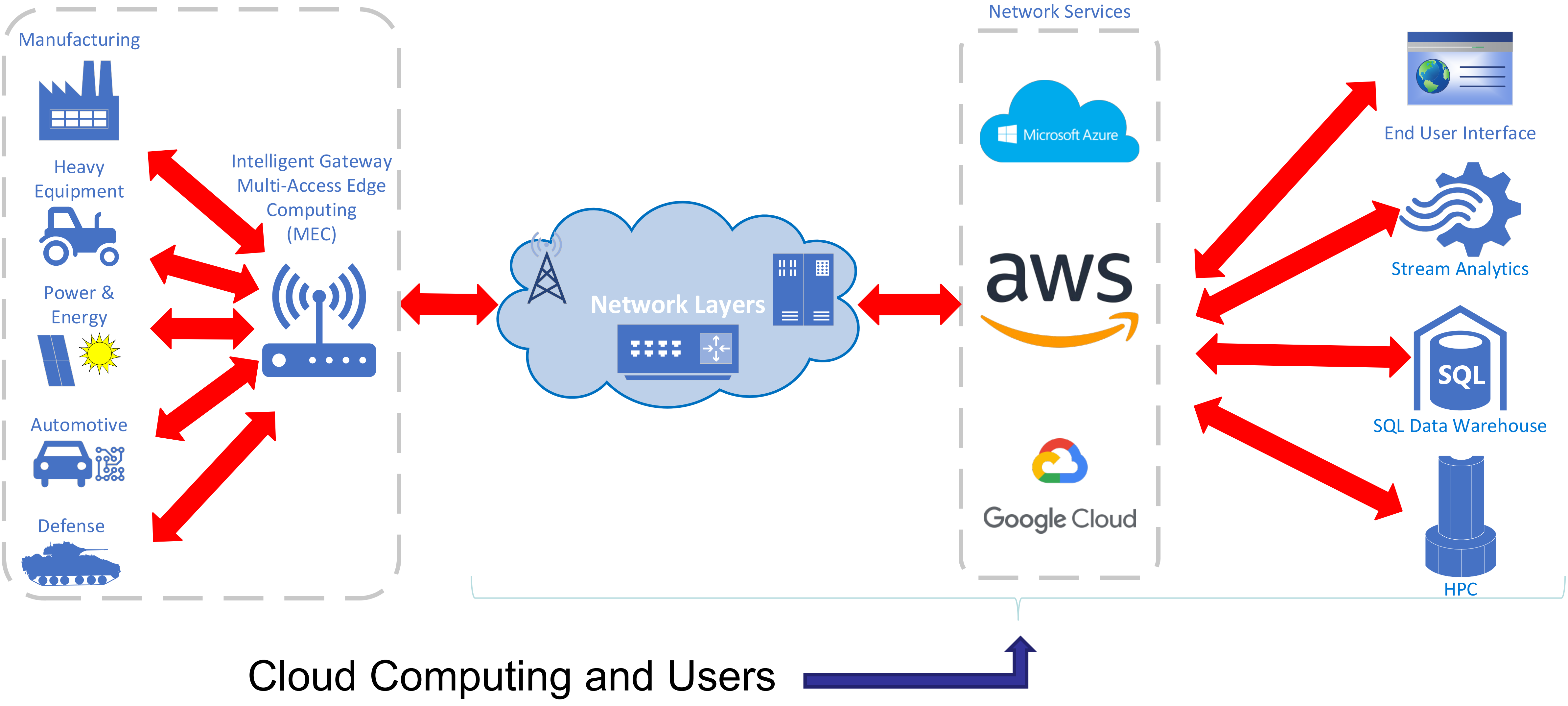


Multi-Access Edge Computing (MEC)

Traditional cloud computing services moved closer to the edge

Modern Edge Computing - Classic

Common model regardless of application



Cloud Computing and Users

MOSA: Applied to the Edge Model

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Reshaping Networks – Network Transformation

- For the DoD, legacy networks must transform rapidly
- Tri-Services are evaluating and taking action to reshape existing network to meet immediate and future needs
- In the Mil/Aero domain, the MOSA approach is mandatory to enable transformation to allow for rapid absorption of new technology to enable the network to evolve
- Characteristics of future networks include resiliency, availability, multiple paths, QoS and determinism regarding the data being transported

Evolving Edge Computing

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Local, high-performance computing for tight-loop, low-latency, stream computing

- Deep learning/AI entering this space

Now

Link upstream to more heavy-lift or specialized processing

- Bandwidth and latency-limited
- Reach Up-Top to access Compute Resources, or access AI services
- Uses containers to transfer application packages, and/or update of local inference models, across the Edge Application Space

Now

Applicable to defense and commercial/industrial applications

- Automotive: Autonomous Vehicles and V2X
- Industrial: Local automated object detection and recognition, with quality and diagnostic data sent upstream as link stability permits

Technologies aligned with SOSA fit in this model

MOSA and SOSA

Considering the Edge Computing Premise around SOSA

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SOSA can be used to implement Edge Compute and AI capabilities

- Use cases are rapidly emerging that will employ Edge Compute, and AI assisted Edge Compute; When is Now
- AI techniques can be implemented between two PICs; a Compute Intensive SBC – Coupled to GPGPU; or via a SOM approach allowing implementation in one PIC.
- Ruggedization in either the Mil/Aero or the Public Sector, or Industrial is required
- Life cycles for the AI component GPGPUs will be short on the order of 3 years or less, prompting and requiring updated; requiring pluggability
- Smaller form factors and SWaPc are of interest; consider VITA 90 VNX+

SOSA Community – What's Going On

Map prior work to new domains and form factors

- i.e. SFF/VNX+, SpaceVPX, VITA 100
- Embracing new missions and modalities, like Directed Energy (DEWs)
- Shows the strength, versatility, and adaptability of the early SOSA work

Integration and centralization of other/prior standards

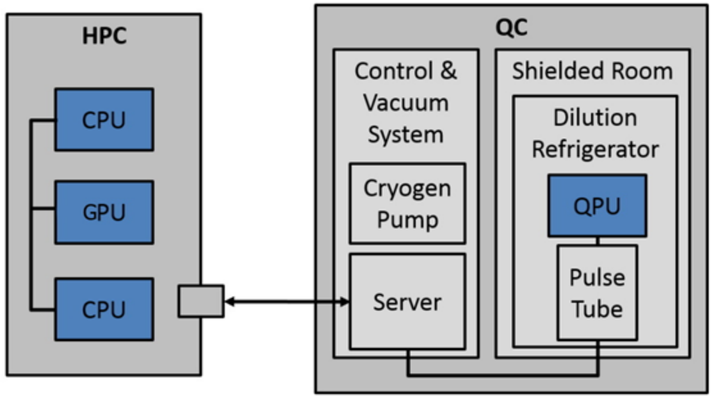
- VICTORY, MORA coming front and center
- Aligns their maintenance and support with the core SOSA/MOSA approach

Applied Middleware emerges around MOSA and OpenVPX, that accelerates development, and deployment

- MORA Ready Development, where frame works are preinstalled within Dev Environments
- AI Ready SOSA Aligned Platforms the funnel available NVIDA technology towards OpenVPX SOSA Aligned platforms that enable rapid re-use, and migration of existing applications

What’s Next: Quantum Emergence Observed

Emergence of unexpected trends and behaviors



2023 closed with some compelling events:

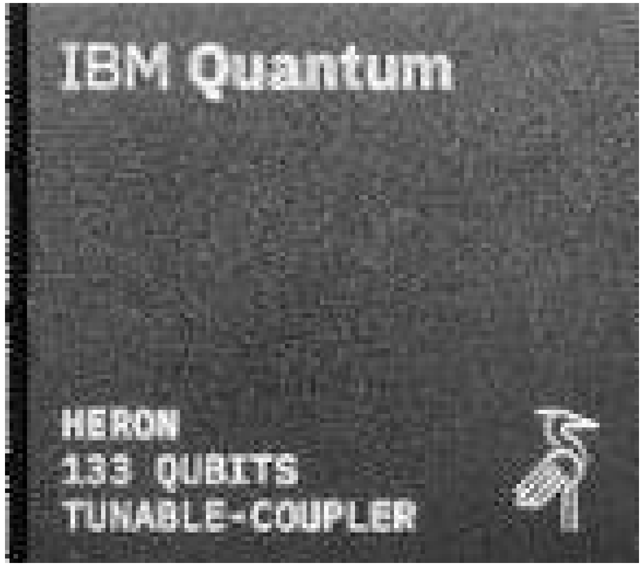
- IBM’s Quantum Summit December 2023 breaks new ground ushering in the era of Quantum Utility, meaning useful calculation can be supported for short bursts
- RPI is the first university to receive an IBM Quantum System One 127 Qubits

IBM Quantum System One at Rensselaer Polytechnic Institute

What's Next: Quantum Emergence Observed

Emergence of unexpected trends and behaviors

- IBM Quantum Summit, December 2023
  - **Establishes a 10 Year Roadmap** with next Quantum Device introduction every year
  - **IBM lays out a bold technical path to produce a practical Quantum Circuit** by introducing a solution to implement error correction feedback to reach stabilized performance in the near term. The plan consists of many innovations.
    - Scientists and Engineers explain the plan, and how to get there -> Reduce Error Rate
      - Expand Qubit Density Gate > 100+
      - Use Tunable Couplers to enhance coherence between gates
      - Implement a new LDPC Parity Code, called the Gross Code to implement Error Correction
      - Utilize multilevel Super Conducting metal layers to reduce connections
      - Design and build for scaling rapidly from 1000 to 4000,… 100,000 Qubits by 2029



  - **Quantum Super Computing:** IBM Quantum System Two Coupled with WatsonX

10 Year Quantum Development Roadmap

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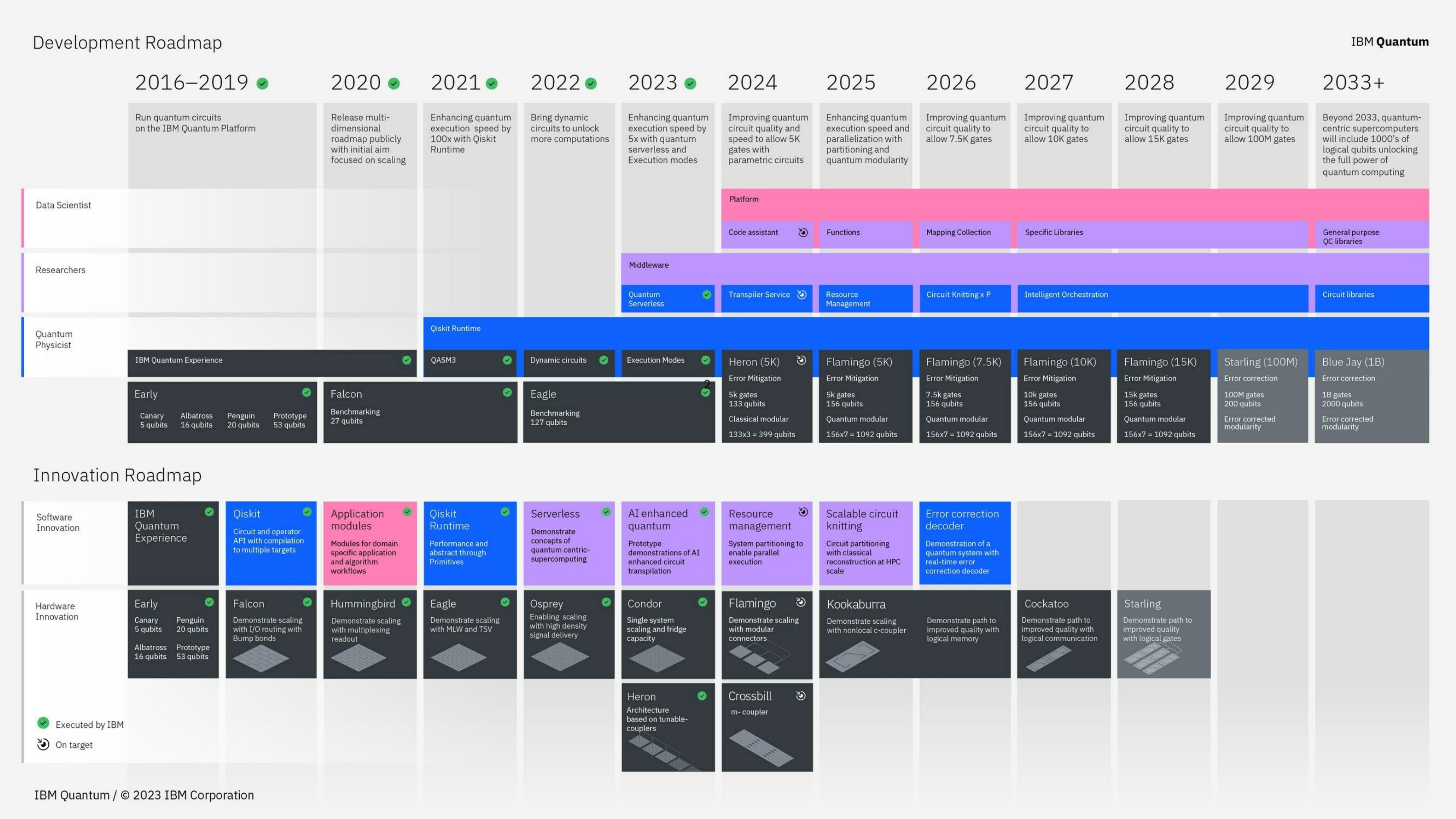

Impact for Researchers or Users

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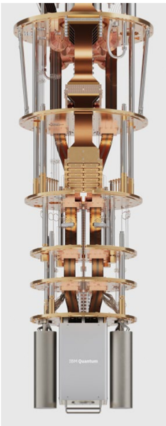
- IBM has established online access to IBM Quantum System Two, for as little as free, or $1.60/second, and as much as $3,000 to buy time without special arrangement
  - This is very early stuff, and limited
  - Code does not need to be optimized for Quantum Processing, the Qiskit SDK abstracts the Quantum Processor from the Classic WatsonX Main Frame. This architecture is called the Quantum QPU, that processes Hybrid Workflows
- **IBM has defined a highly scalable and extensible architecture that if successful** will progressively reveal year on year improvements, until Quantum Stability is reached, allowing today the emergence of the Utility Phase, yielding Quantum processing to Users around the world

IBM Quantum System Two



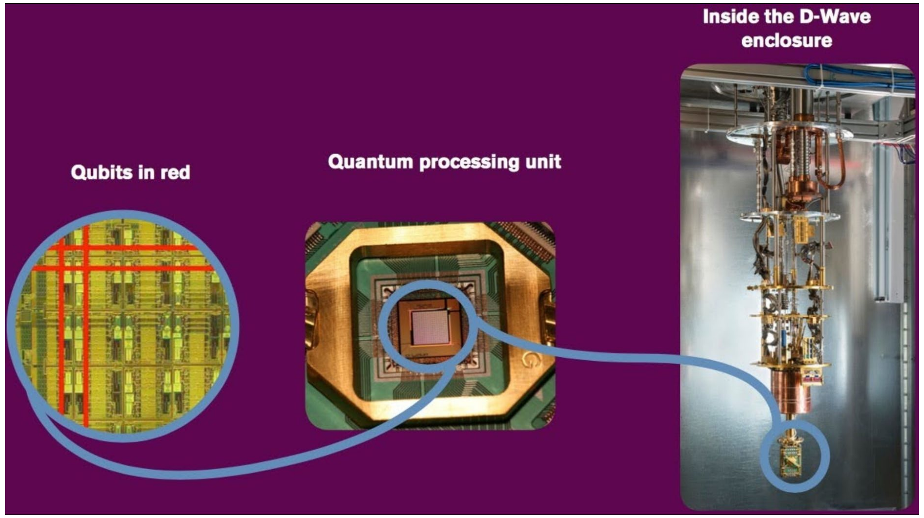
IBM Quantum System Two Processor

What's Next: Quantum Emergence Observed

Emergence of unexpected trends and behaviors

- **December, 2023** – News Program 60 Minutes: releases a piece featuring IBM Yorktown's research & development, and the Opening of the WatsonX Classic Main Frame, coupled thru a Quantum Open SDK called Qiskit 1.0, to a system based on IBM's 133 Qubit Heron Processor referred to as IBM Quantum System Two. **https://www.youtube.com/watch?v=K4ssT6Dzmnw**

Source NVIDIA Blog

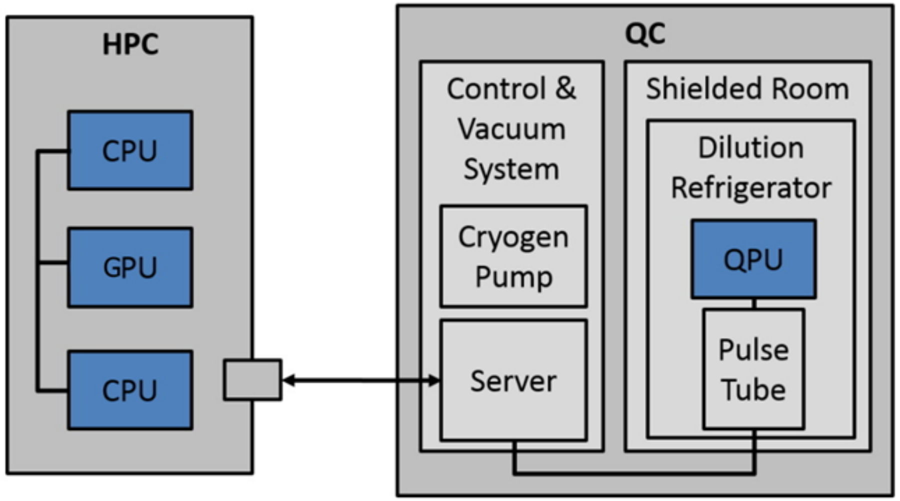


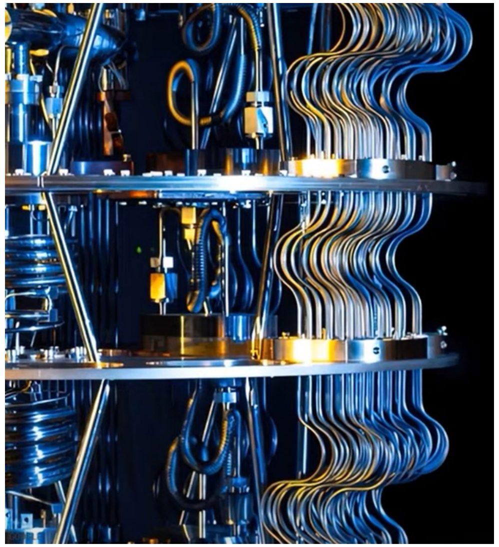
Fridge keeps Quantum Circuit at -273C Near absolute zero

D-Wave has a 5000 Qubit Specialized Processor

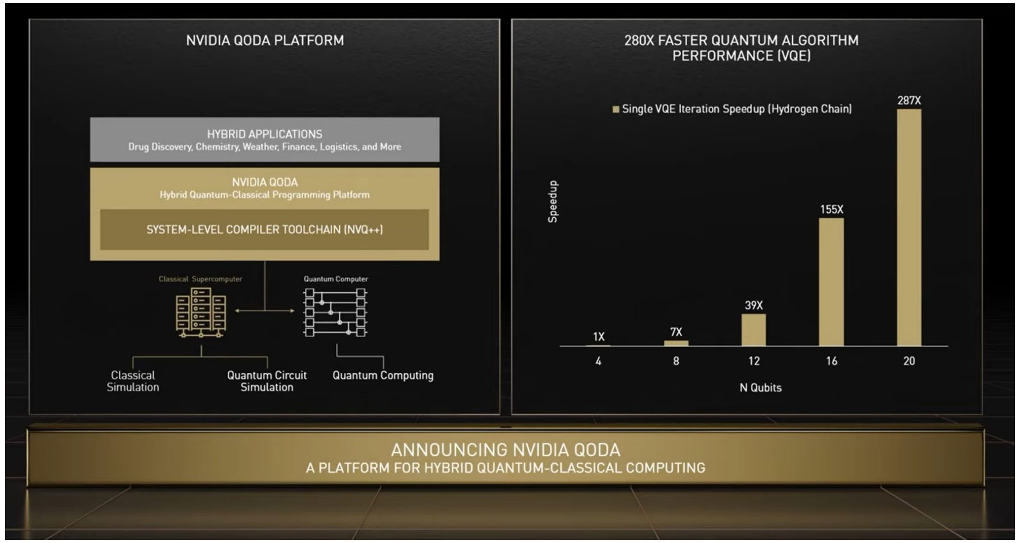
Quantum QPU Basics – Source NVIDIA 2024

NVIDIA DGX Coupled to Quantum





Dilution Fridge



Why is Quantum Compelling

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Two charts demonstrate why this announcement and premise of Quantum computing is compelling

- Moore's Law is still intact, compared to the corollary for Quantum Computing called Rose's Law.
  - Moore's law was established in 1949 and asserts that compute capability doubles every two years, and is still effective and relevant today in 2023.
  - Rose's Law was coined by Steve Jurvetson and established the staring point of 1989, to track Quantum development

Quantum Bits (Qubits)	Equivelant Classical Bits
3	8
10	1024
20	1,048,576
…	…
300	2.037035976…E90

venrock/@ethanjb

Moore's Law Juxtaposed with Rose's Law

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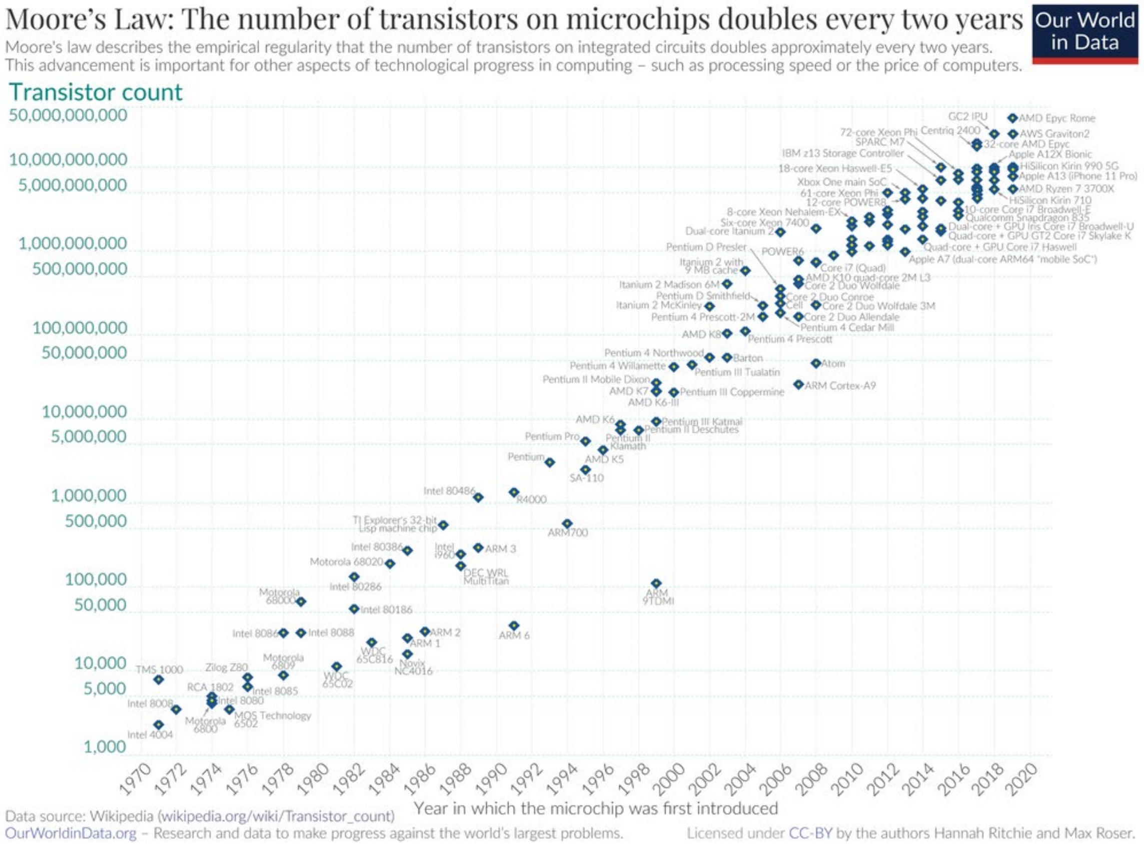
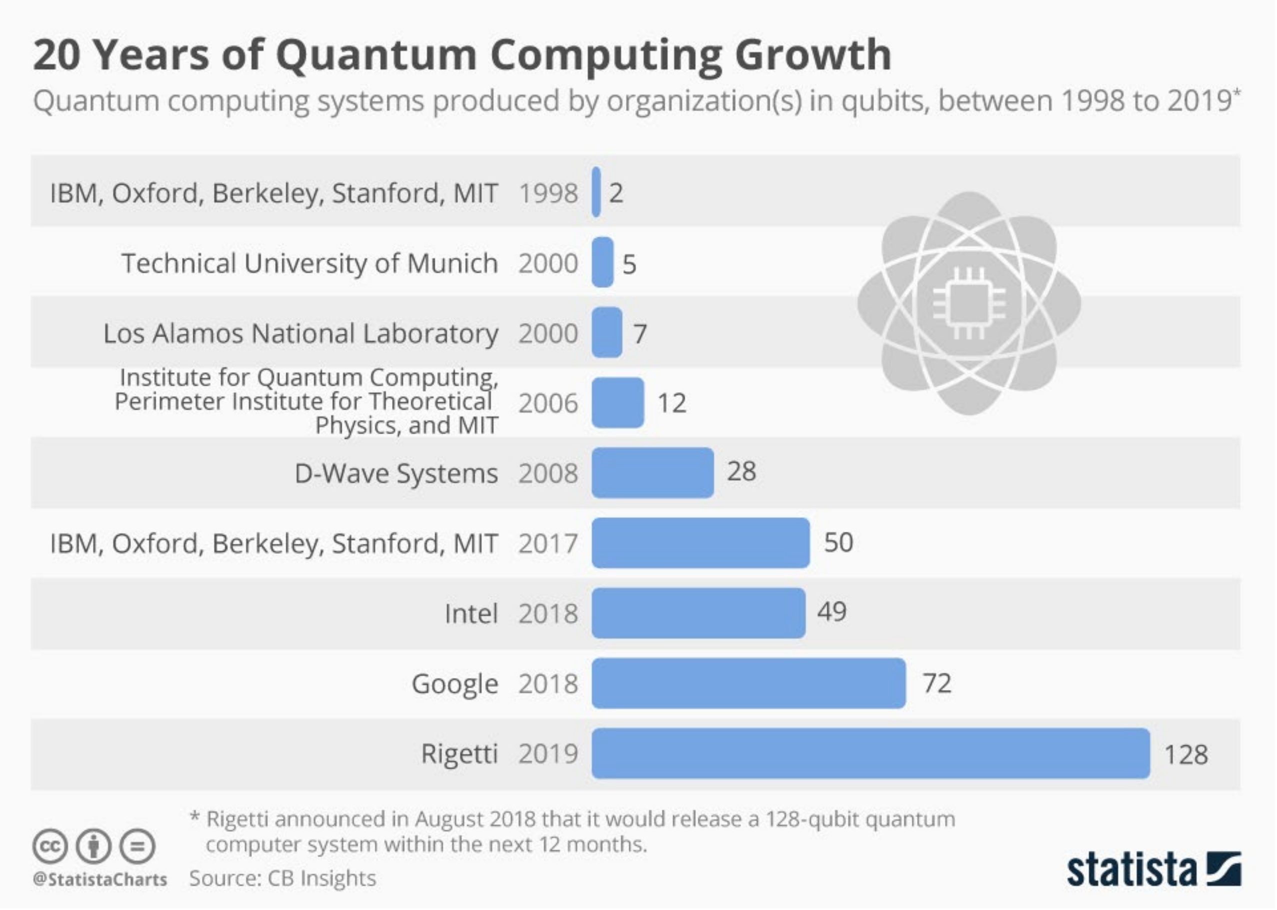
Quantum Computers Calculate All Possibilities of the Input Data Space Presented in One Cycle!



Traditional Moore's Law



To double the power of a Quantum Computer you only need to add 1 Qubit

Moore’s Law Juxtaposed with Rose’s Law

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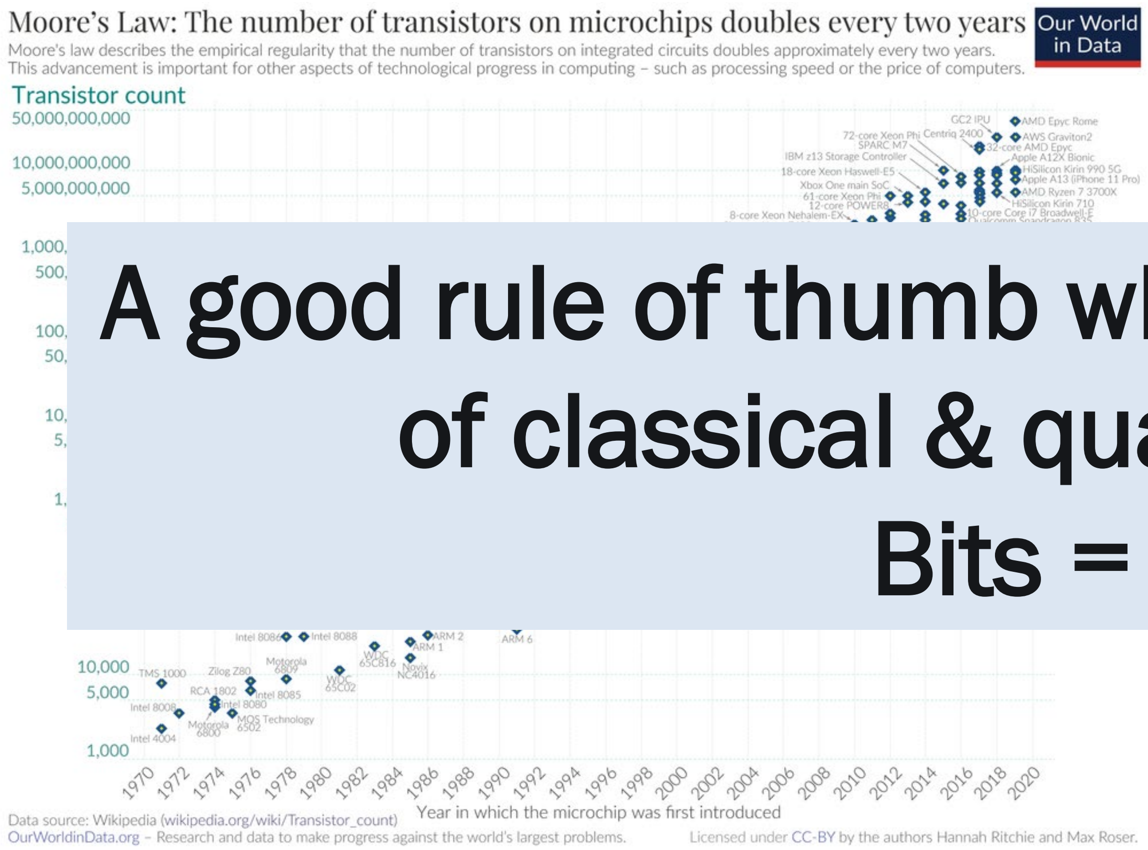
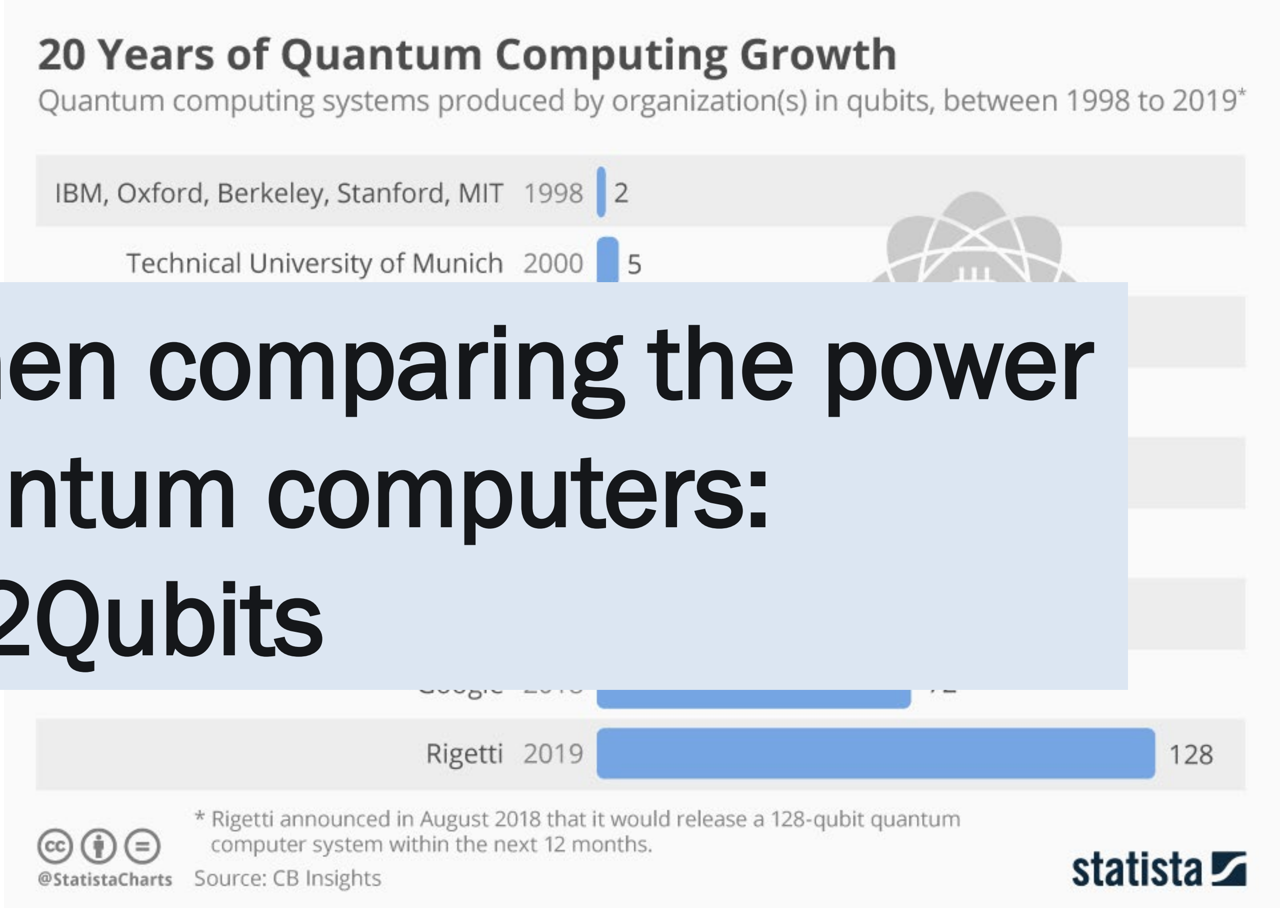
Quantum Computers Calculate All Possibilities of the Input Data Space Presented in One Cycle!





A good rule of thumb when comparing the power of classical & quantum computers:

Bits = 2Qubits

Summary

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- Edge to Network to Cloud Computing is accelerating very rapidly
- Networks are being transformed utilizing faster switches, better routing, emerging AI; connecting ever improving edge SOM and AI devices.
- Multi-path network implementation between terrestrial devices and the Cloud are being improved by layered interconnect that will continue to enable the future of Client/Server computing as we know it.
- Current AI enabled hardware, networks, and Cloud services will continue to accelerate driven by rapidly improving AI devices like NVIDIA's Grace and Hopper, that implement enormous capability to Host AI applications
- Finally, with Quantum Computing Coupled to Existing AI Enabled Compute Complexes, in an Open Way, thru leading approaches like IBM's QisKit, SDK for Quantum, performance increase will be on the order of **trillion x trillion times** an existing classical computer in its early days

Extra Reading

- The Relentless Pursuit of Moore's Law
  - https://semiconductor.substack.com/p/the-relentless-pursuit-of-moores

- Moore’s Law of Moore's Law of Quantum Computing
  - https://nickyoder.com/moores-law-quantum-computer/

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Thank you for your time!