‘Quantum Computing - Memory & Storage directions & requirements’

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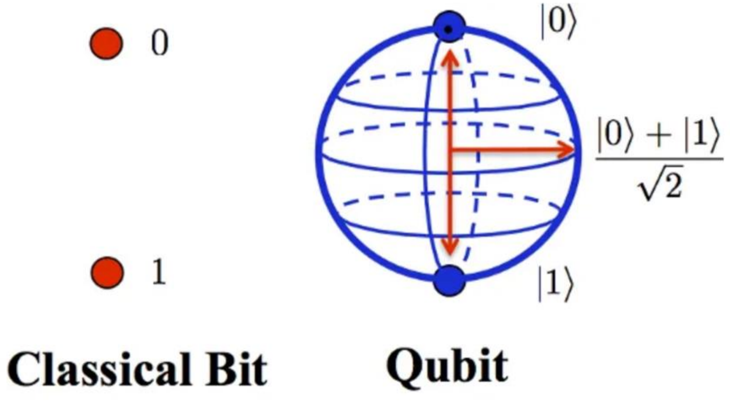
the Future of Memory and Storage

Quantum computing will process massive amounts of information. Workloads could include diagnostic analysis at speeds far greater than classical computing. *But to be fully effective, quantum computing will need to access, analyze and store huge amounts of data.*

Quantum Computing principles

Quantum memory is based on quantum mechanics to store and process information, offering potential for vastly greater storage capacity and computational power compared to classical computers. While still in its early stages, quantum memory utilizes qubits, which can exist in superposition, unlike classical bits, enabling them to hold multiple states simultaneously. Utilize photons or other quantum phenomena to store quantum information – but has short retention times (milliseconds) and is susceptible to errors

Qubits:
Unlike classical bits that can be either 0 or 1, qubits can exist in a superposition of both states simultaneously, significantly increasing storage capacity requirement.



Superposition:
A quantum phenomenon where a qubit can exist in multiple states at once, allowing quantum computers to enable concurrent computations

Entanglement:
A quantum phenomenon where two or more qubits become linked, regardless of the distance separating them, enabling complex computations

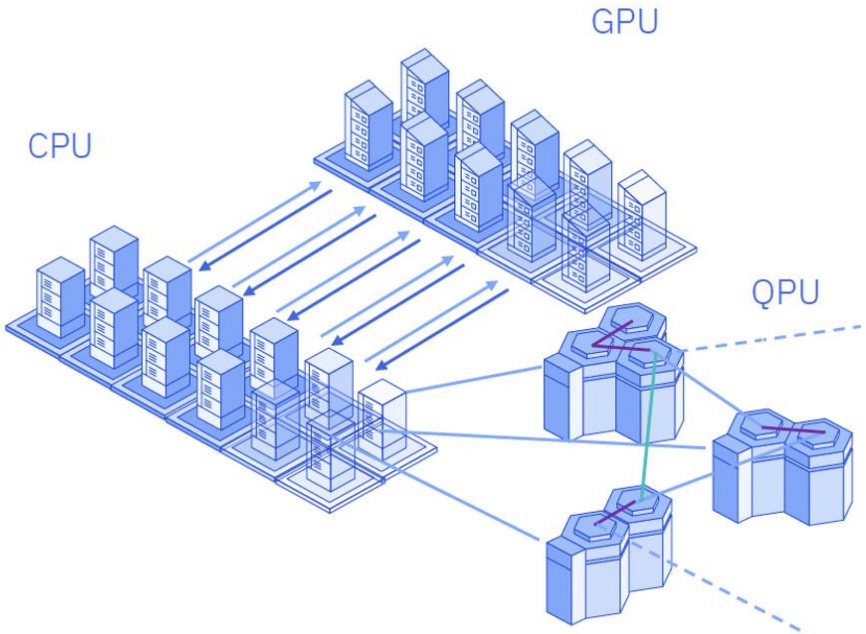
Quantum Memory Research

- **Crystal Defects:** Stores terabytes of classical data within crystals by utilizing individual atomic defects within crystal structure
- **Spin-based storage:** Leverages electron's spin to store data - potential for higher storage density & faster data retrieval rates
- **Quantum Photonic Devices:** Uses photon interaction to enable qubits to exist in multiple energy states simultaneously, enabling faster data processing and storage, & offering potential for efficient nano-scale semiconducting technology with low power consumption
- **Quantum Inspired Algorithms:** Enhance classical data processing by improving data retrieval speeds and optimizing storage. Applied to optimize data compression, potentially offering superior compression rates compared to traditional methods

Challenges of Quantum Memory technology

- **Decoherence:** Qubits are fragile and susceptible to environmental noise, which can cause them to lose their quantum state (decoherence), leading to errors. Decoherence occurs when quantum computing data is brought into existing data storage frameworks and causes qubits to lose their quantum status, resulting in corrupted data and data loss.
- **Stability:** Building large-scale quantum computers with stable and reliable quantum memory is a major technological challenge. Quantum mechanical bits can't be stored for long times as they tend to decay and collapse within a short period (milliseconds)
- **Error Correction:** Quantum computations require sophisticated error correction techniques to mitigate the effects of decoherence & other errors
- **Readout:** Reading out the information stored in a qubit can be challenging and may require destroying the quantum state.

Quantum-centric supercomputing

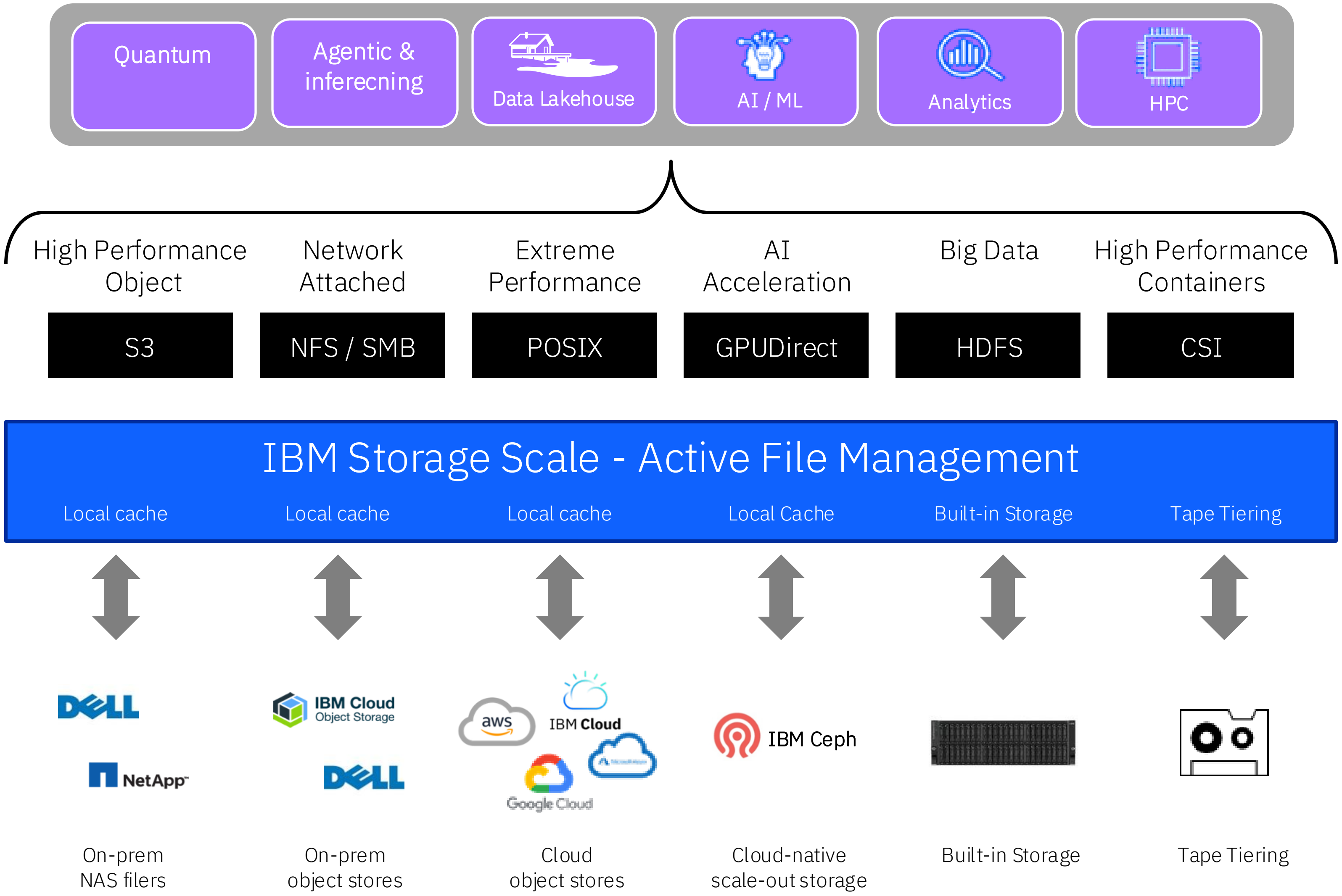


Quantum-centric supercomputing utilizes a modular architecture to enable scaling.

It combines quantum communication and computation to increase the computational capacity of the system and uses a hybrid cloud middleware to seamlessly integrate quantum and classical workflows.

- Data storage for quantum computing will likely need to rely on conventional storage, such as in HPC (High performance compute) system
- The future data center will consist of a Quantum computer, GPU based computer and CPU based computer. Any problems will be assigned to an optimal computing cluster. The data is likely to be shared between multiple computer clusters.
- The optimal storage for hybrid HPC will provide “global data platform” to provide multiple access points for data sharing.

Hybrid HPC Global data platform



Multi-Protocol Support

Simultaneous multi-protocol access including GPUDirect support

Outcome: Enable globally dispersed teams to collaborate on data regardless of protocol, location or format

Storage Acceleration

Automatic, transparent caching of back-end storage systems

Outcome: Accelerates data queries and improves economics by fronting lower performance storage

Storage Abstraction

Single global namespace delivers a consistent, seamless experience for new or existing storage

Outcome: Reduce unnecessary data copies and improve efficiency, security and governance

Summary

1. Quantum computing will process massive amounts of information. Workloads could include diagnostic analysis at speeds far greater than classical computing. *But to be fully effective, quantum computing will need to access, analyze and store huge amounts of data*

2. Quantum memory research focused on crystal defects, spin based storage, photonic device, but significant challenges exists in decoherence, stability, error correction and readout in the near term

3. The future data center will consist of Quantum computer, GPU based computer and CPU based computer- with data is likely to be shared between multiple computer clusters

4. The optimal storage for hybrid HPC will provide “global data platform” to provide multiple access points for data sharing.