Framework of a Quantum Database

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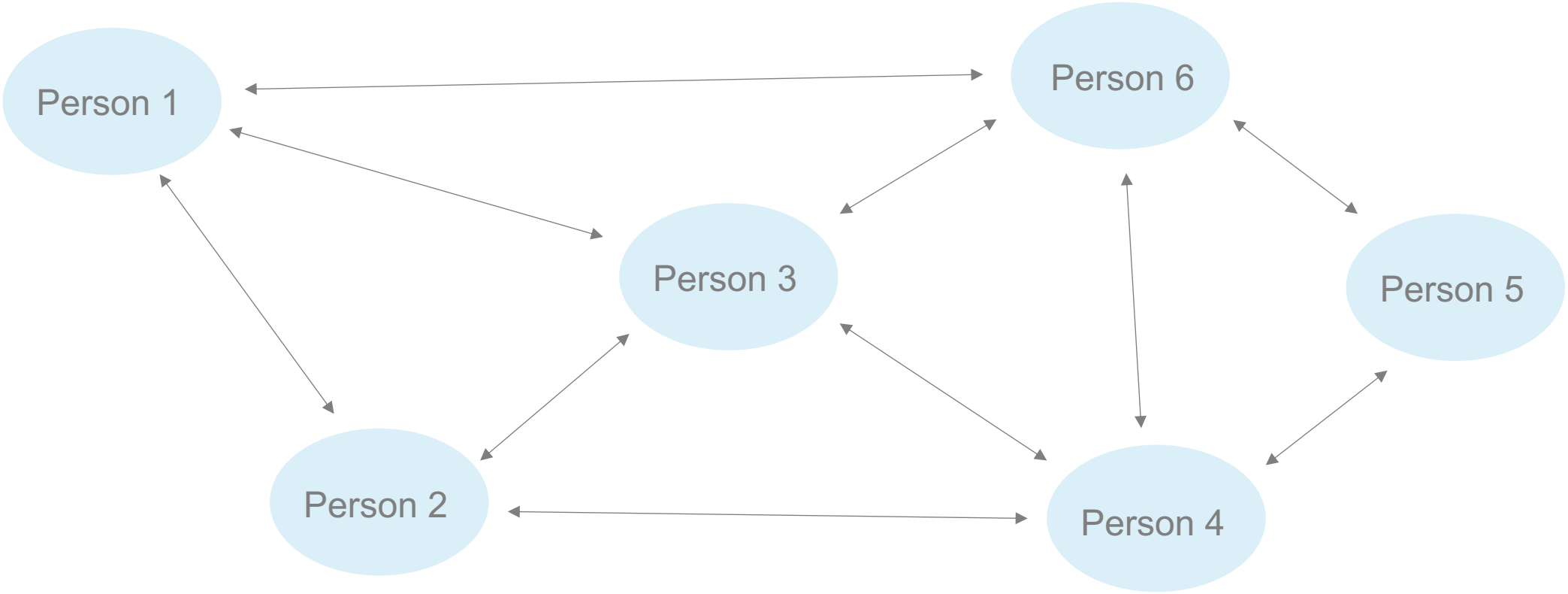
Data and its inherent *structure*



Schematic of a graph database
(e.g., a social network)

Non-classical phenomena in quantum mechanics

$$\frac{1}{\sqrt{2}}(|0\rangle + |1\rangle)$$

superposition

$$\frac{1}{\sqrt{2}}(|00\rangle + |11\rangle)$$

entanglement

Non-classical phenomena in quantum mechanics

$\frac{1}{\sqrt{2}}(|10\rangle + |11\rangle)$

superposition

$\frac{1}{\sqrt{2}}(|00\rangle + |11\rangle)$

entanglement

→ How can quantum mechanical phenomena affect the **structuring** and **processing** of data?

Main research questions

- How can we **organize data** indexed by quantum states?

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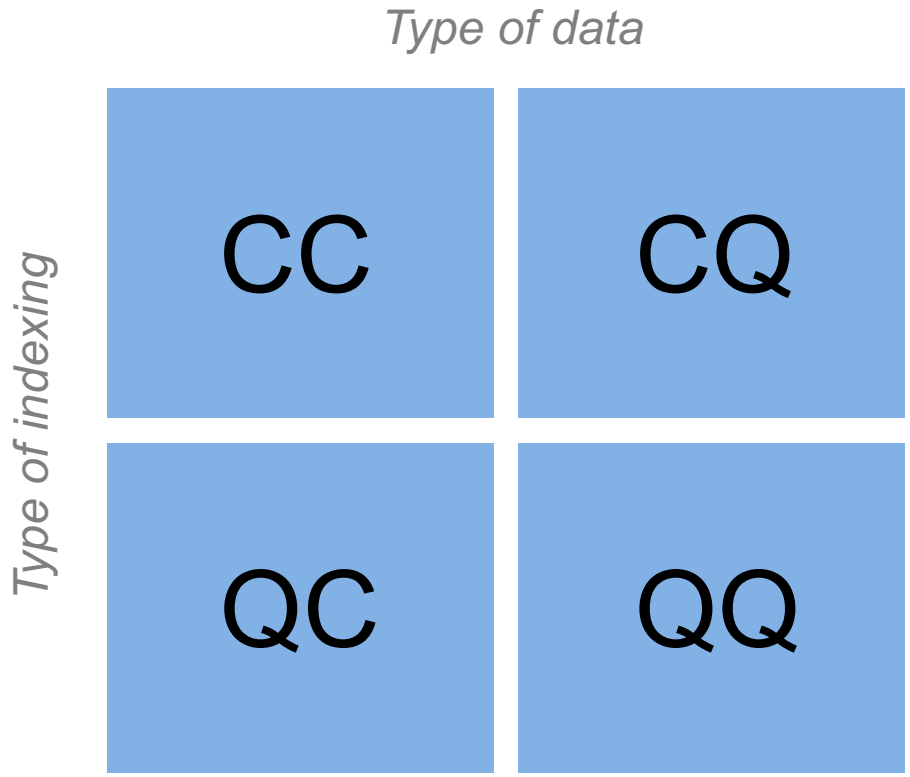
- How can we **organize data** indexed by quantum states?
- How can we store data in a superposition, and what does a **suitable set of operations** on this state looks like?
- What are the **advantages and limitations** of operating on (quantum) data in a superposition state?

The different types of *data* and *indexing*

First letter: index type,
Second letter: data type



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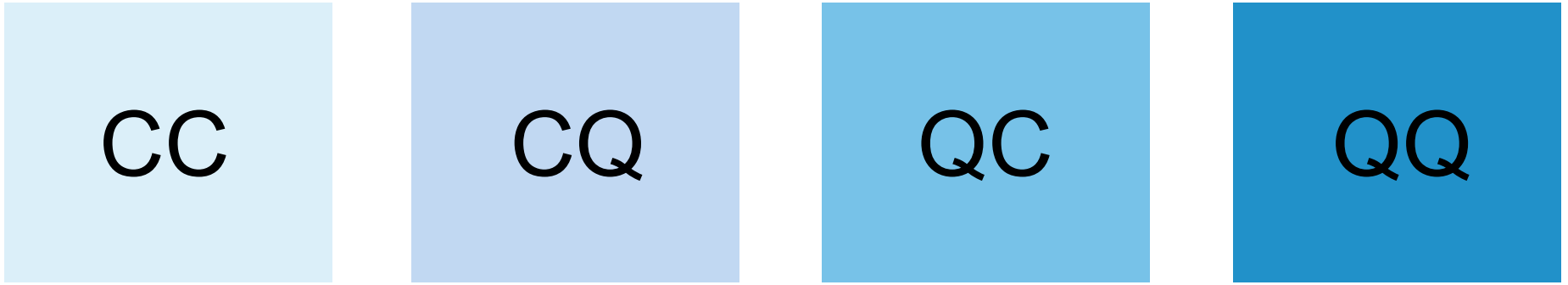

Increasing complexity

Classical scenario:
e.g., classically indexed array

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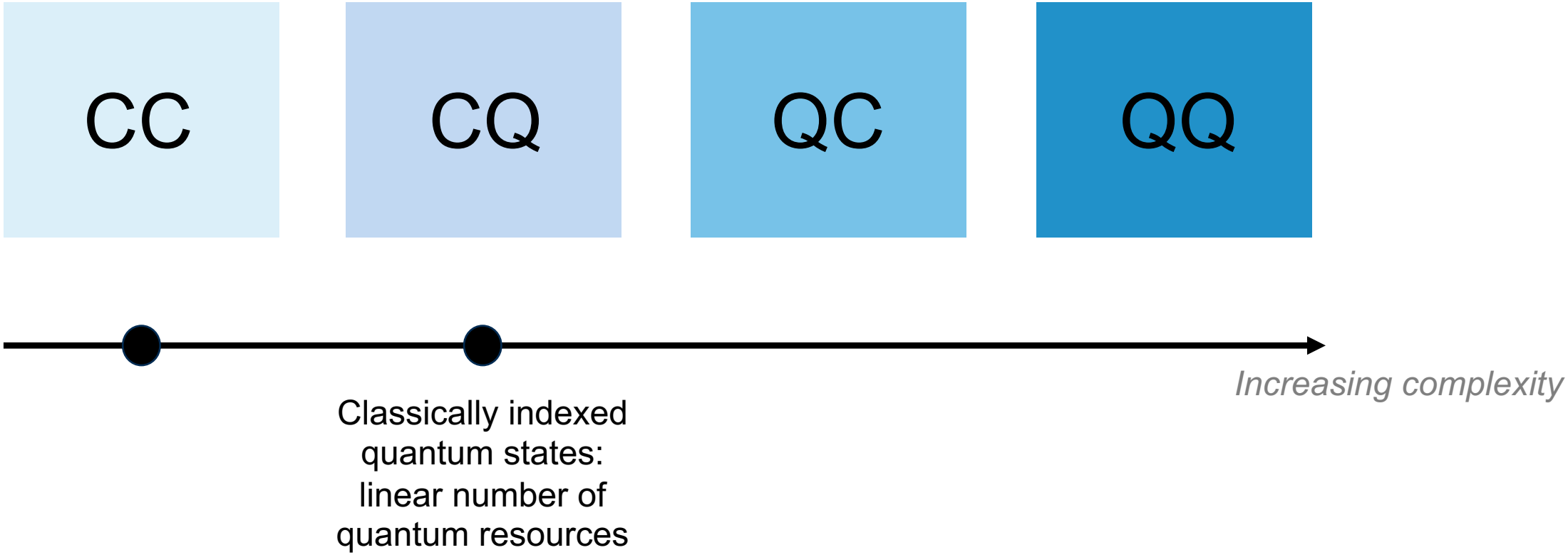

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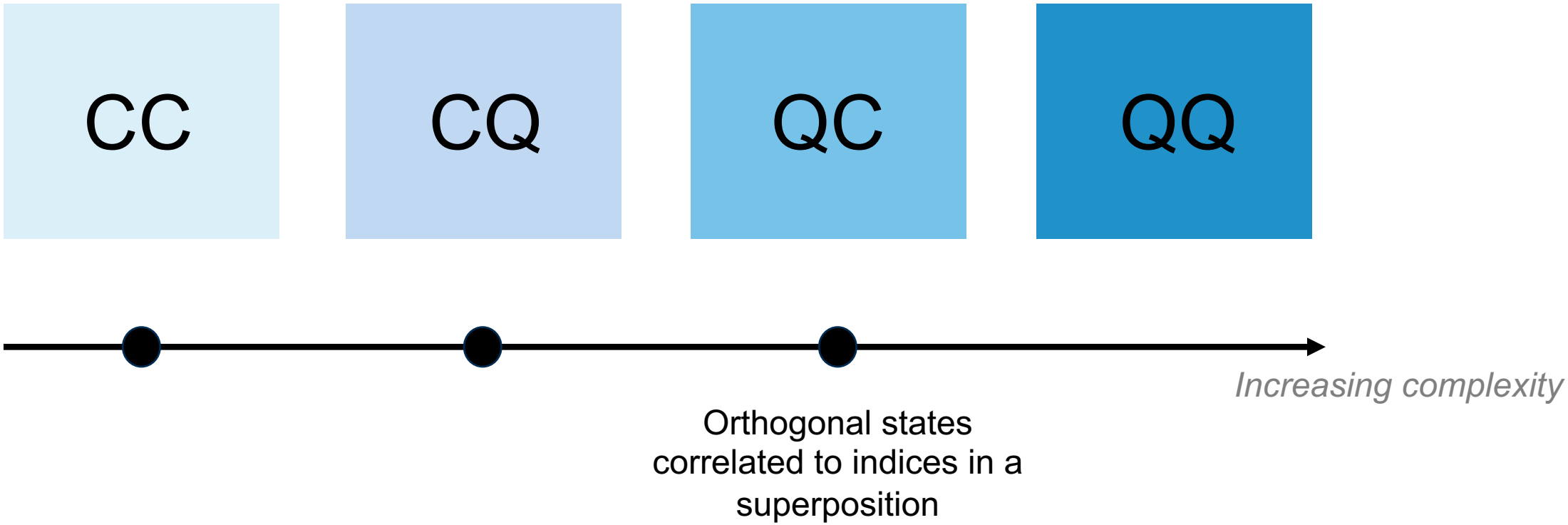

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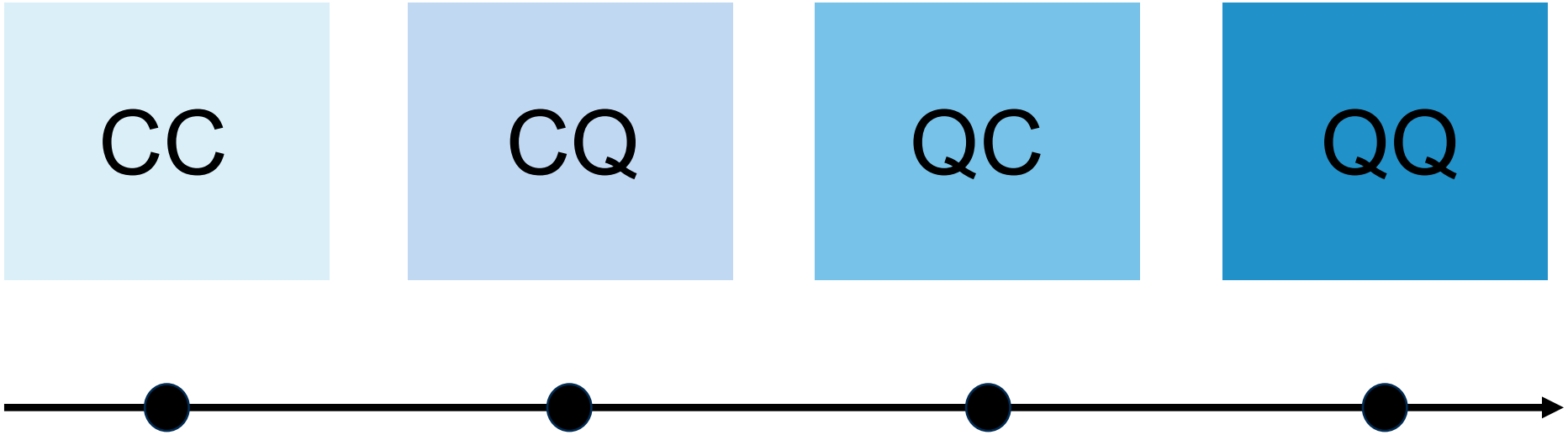

Most general case:
storing quantum data
(non-orthogonal states)
in a superposition

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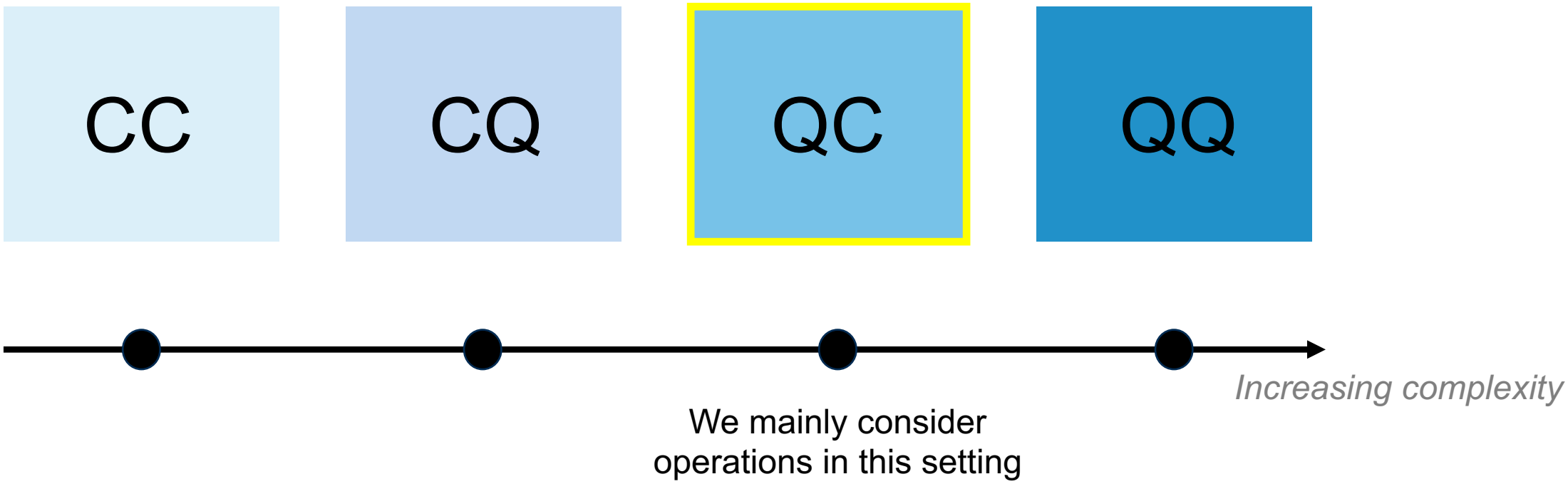
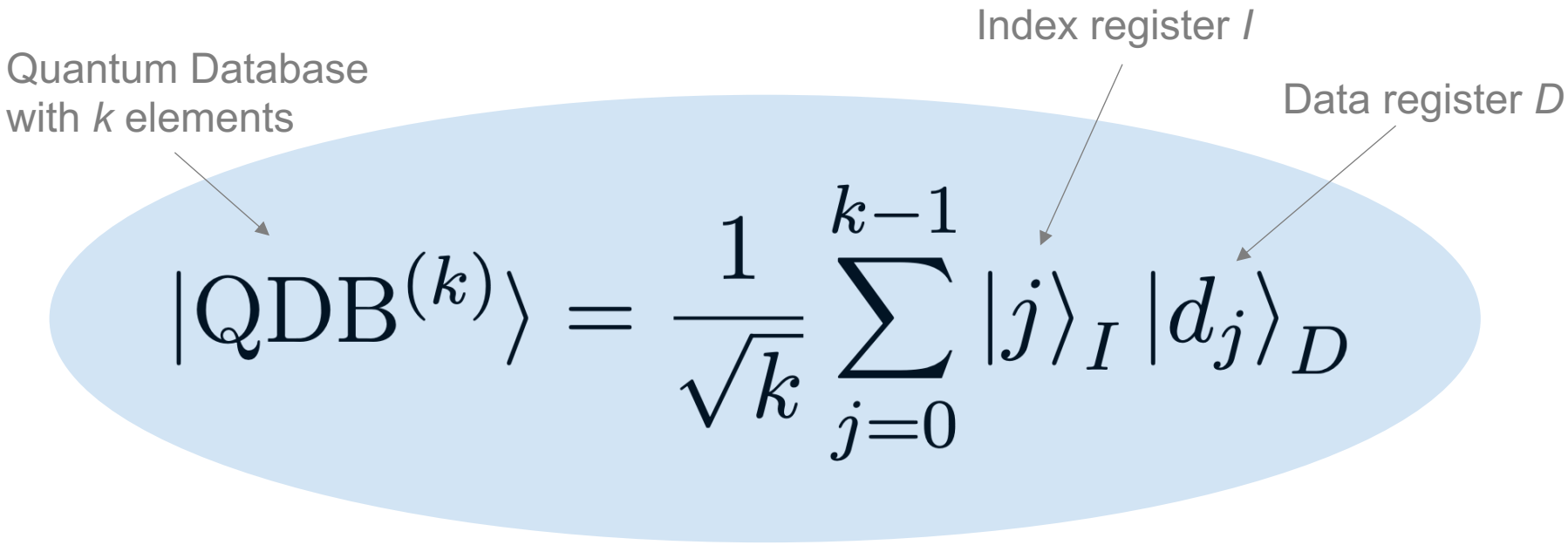
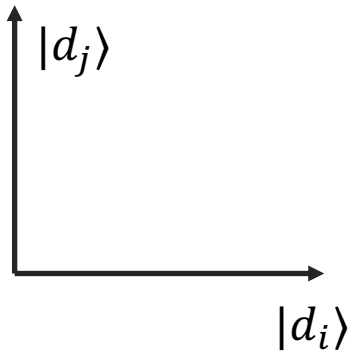


Formal Definition of a Quantum Database

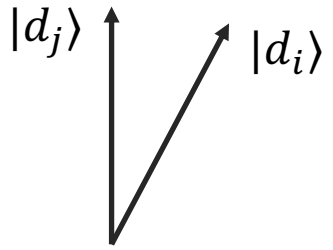


→ **Task:** define operations on this superposition of orthogonal data states $|d_j\rangle$

Formal Definition of a Quantum Database



$$|\mathrm{QDB}^{(k)}\rangle = \frac{1}{\sqrt{k}} \sum_{j=0}^{k-1} |j\rangle_I \, |d_j\rangle_D$$



orthogonal data states*

non-orthogonal data states

Classical data

Quantum data

*The unitary transforming the state to the computational basis must be known.

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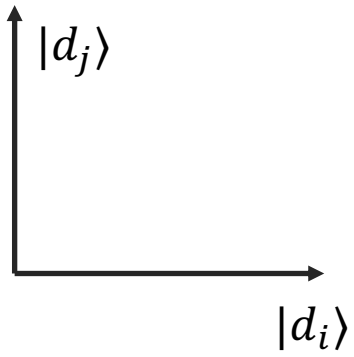

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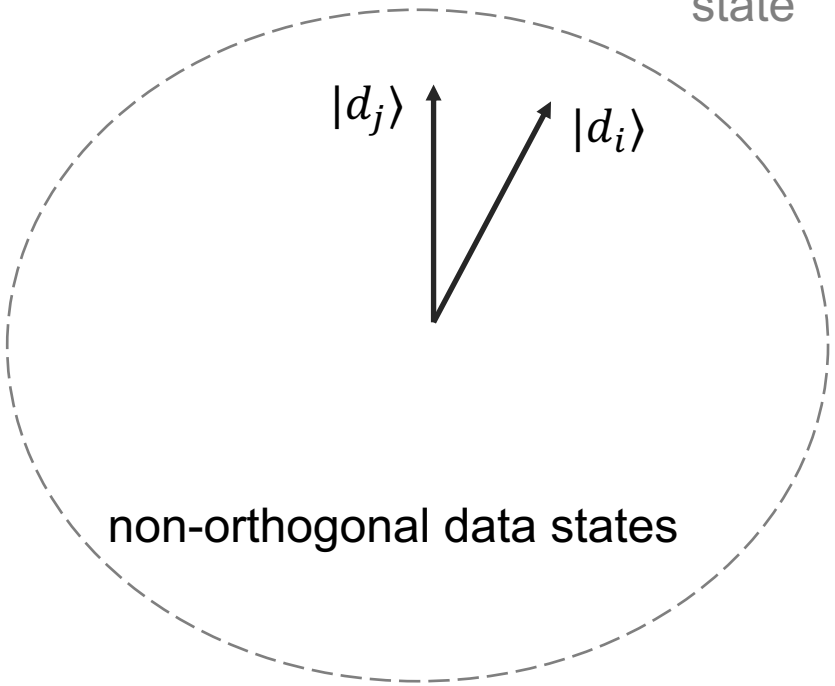
Impossible to create perfect copies for unknown state



non-orthogonal data states

Quantum data

*The unitary transforming the state to the computational basis must be known.

Working on *data* in a superposition - *Outlook*

$$|\mathrm{QDB}^{(k)}\rangle = \frac{1}{\sqrt{k}} \sum_{j=0}^{k-1} |j\rangle_I |d_j\rangle_D$$

The set of operations include:

- Extending the database
- Writing data elements in the database,
- Removing indices from the database
- …

Inherent limitations include:

- No-cloning theorem
- Entanglement of ancilla system and the quantum database
- …

Thank you!

Are there any questions?

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