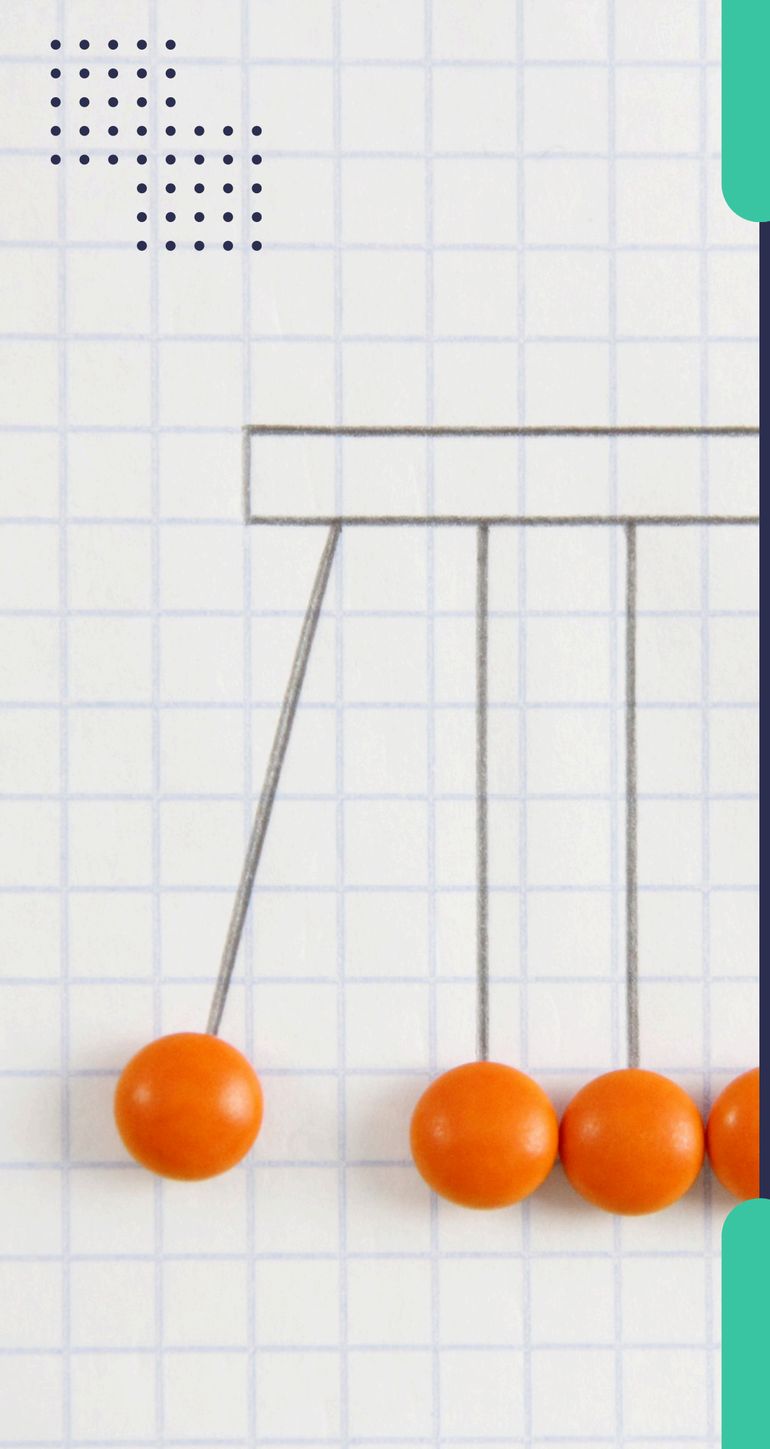

Quantum networks and Distributed Quantum Computing

Presentation by **Maria Gragera Garces**

bqb Quantum Youth | 2024

Who am I?

- Bsc Physics, University of Bath
- Cisco Quantum
- IBMQ EMEA Community
- Open sourcerer
  - Qiskit
  - Error correction library (Google Summer of Code 2022)
  - Quantum Hackathons
- PhD in Distributed Quantum Computing, University of Edinburgh

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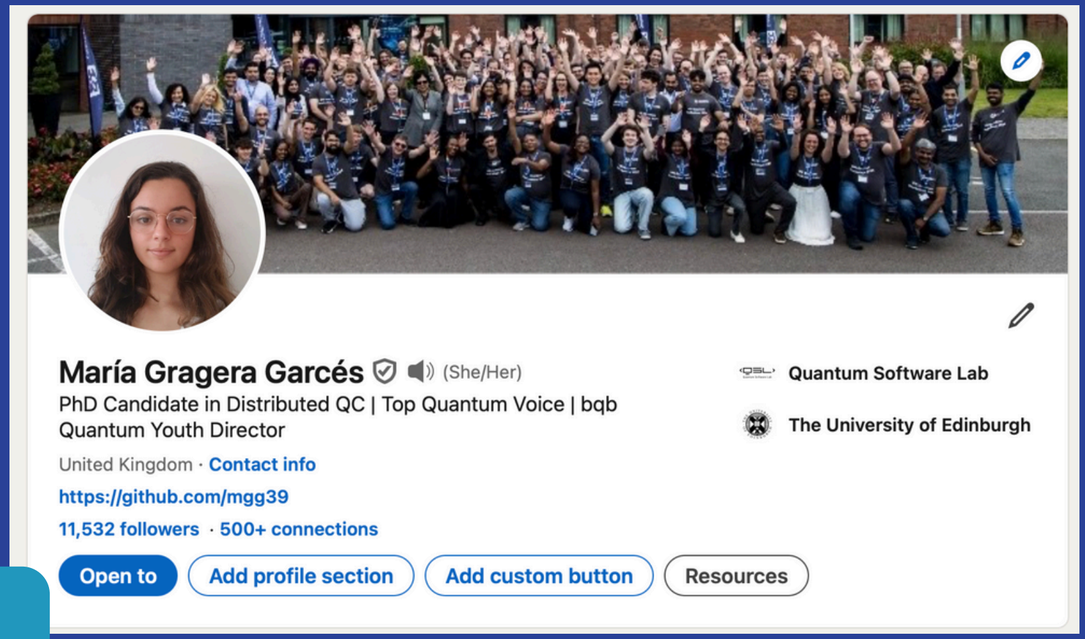

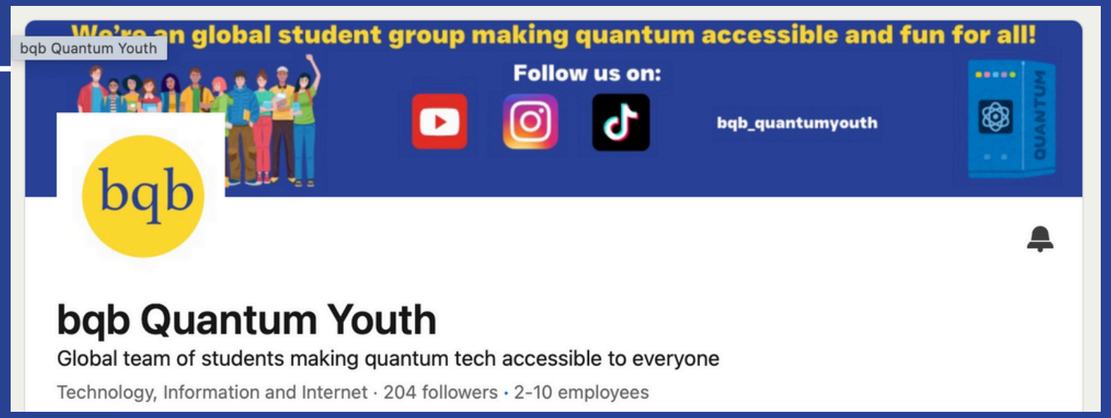

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What will be covering today

1 **What are quantum networks?**

2 **Why would we think about distributing quantum computation with quantum networks?**

3 **Current hardware bottlenecks: why does no one do this yet?**

Quantum networks

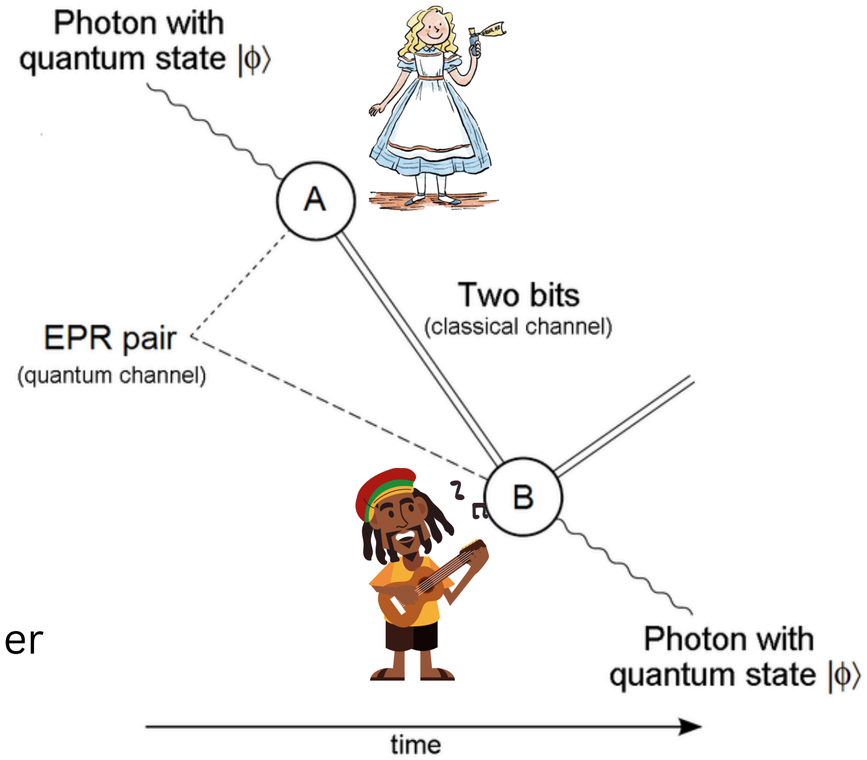
-> facilitate the transmission of information in the form of qubits, between physically separated quantum processors

Quantum Teleportation

- No cloning theorem
- EPR pair -> entangled pair of qubits

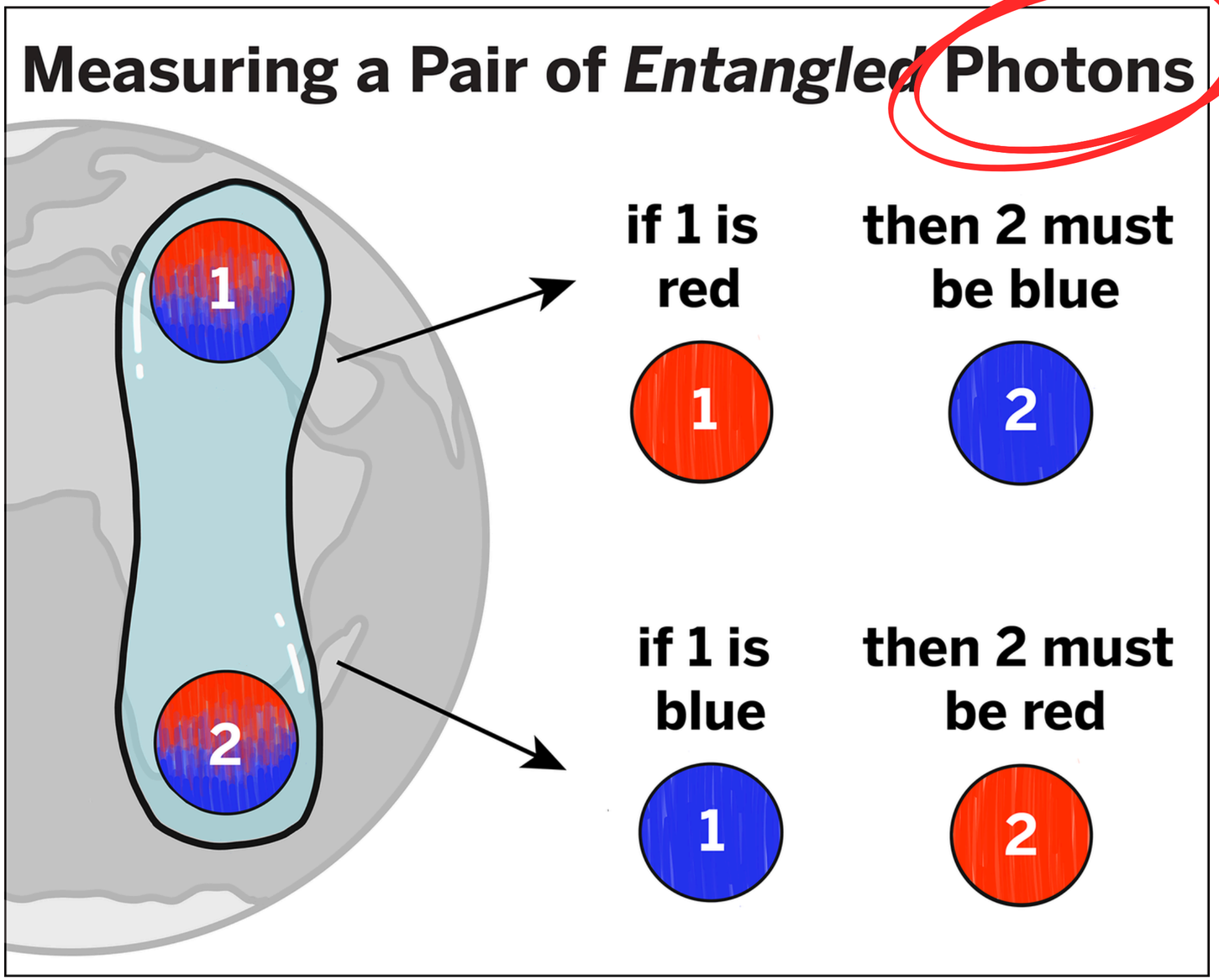
$$\frac{1}{\sqrt{2}}(|\uparrow\rangle_A|\downarrow\rangle_B + |\downarrow\rangle_A|\uparrow\rangle_B)$$

measuring one particle instantly defines the state of the other



''Teleporting an Unknown Quantum State via Dual Classical and Einstein-Podolsky-Rosen Channels'', Charles H. Bennett, Gilles Brassard, Claude Crépeau, Richard Jozsa, Asher Peres, and William K. Wootters Phys. Rev. Lett., 1993 '

$$\frac{1}{\sqrt{2}}(|\uparrow\rangle_A|\downarrow\rangle_B + |\downarrow\rangle_A|\uparrow\rangle_B)$$



Quantum networks

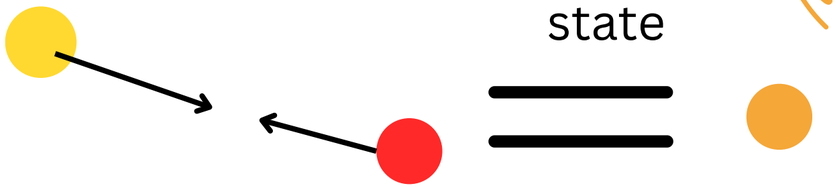
-> facilitate the transmission of information in the form of qubits, between physically separated quantum processors

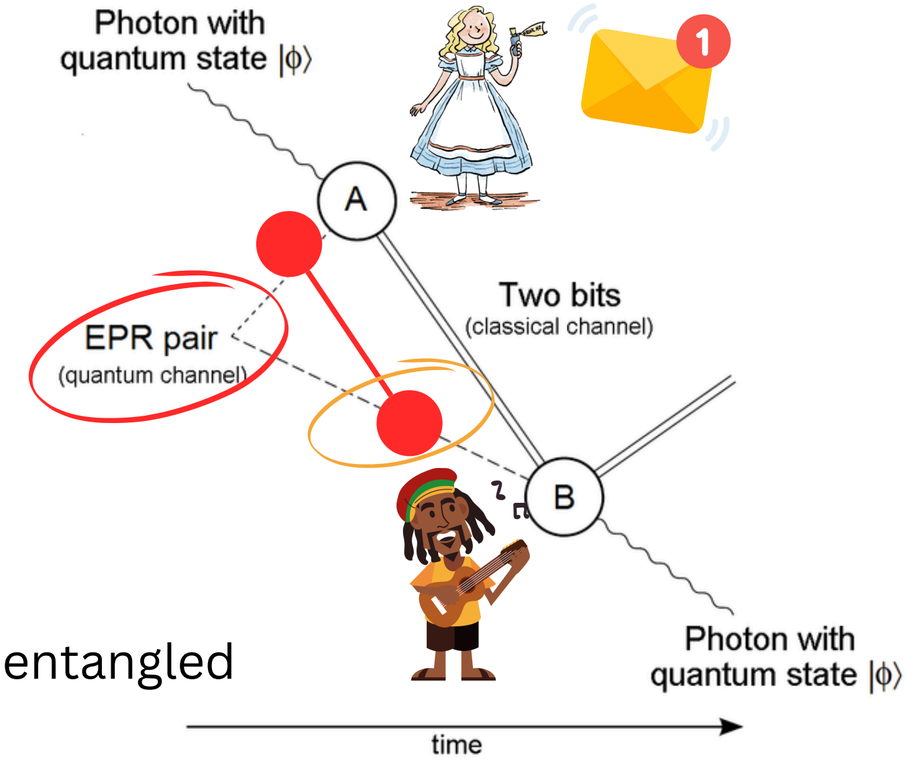
Quantum Teleportation

- No cloning theorem
- EPR pair -> entangled pair of qubits

Alice wants to send a message to Bob


She will combine her message state and her shared entangled state





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WHY?

Quantum networks

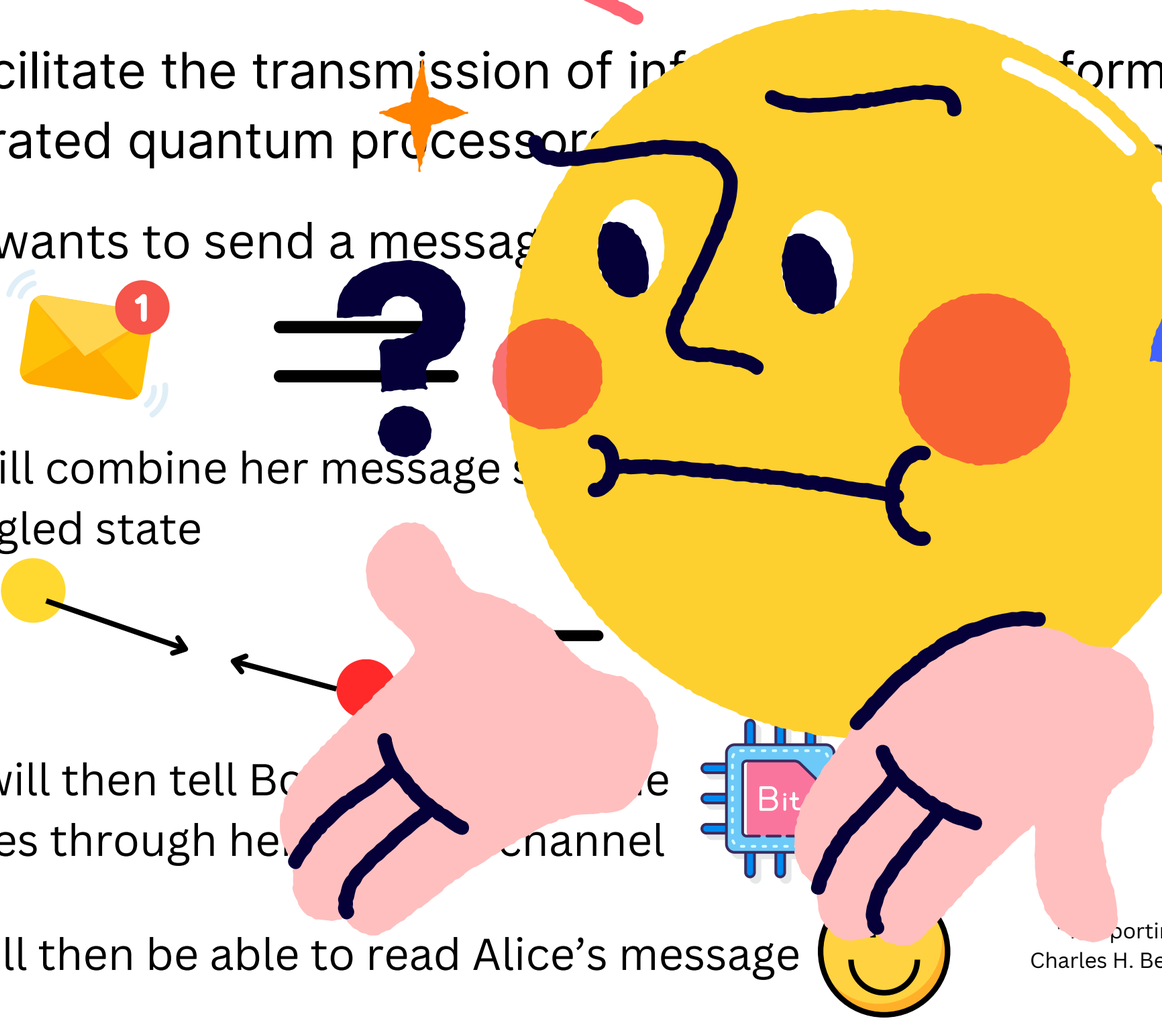
-> facilitate the transmission of inf form of qubits, between physically separated quantum processor

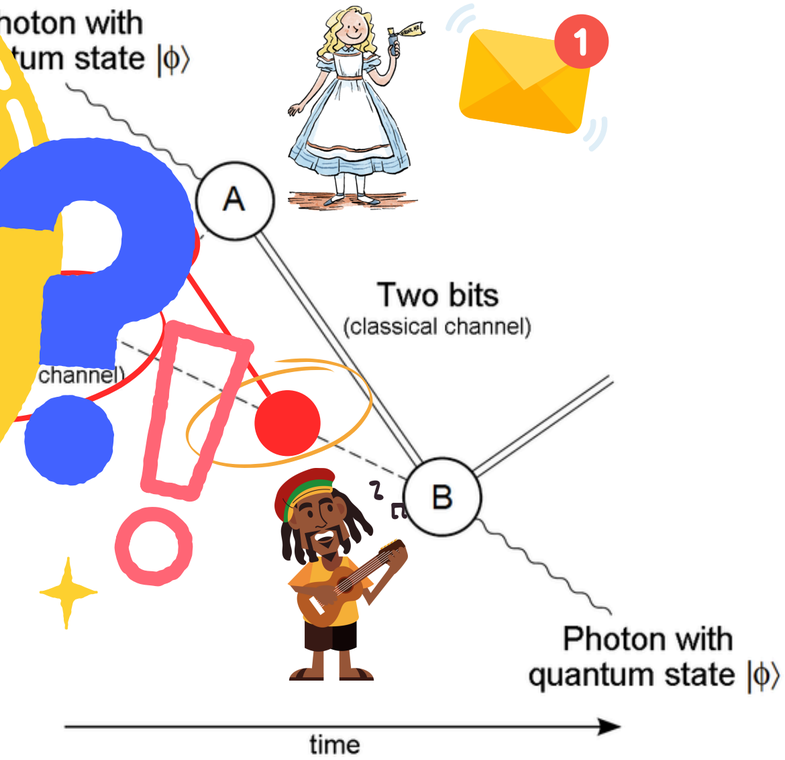
Alice wants to send a messag

She will combine her message s entangled state

Alice will then tell Bo e changes through he hannel

Bob will then be able to read Alice’s message





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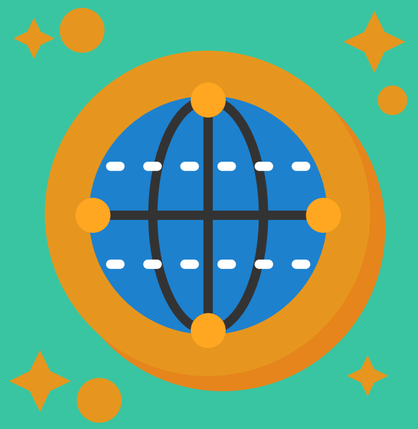
Quantum networks

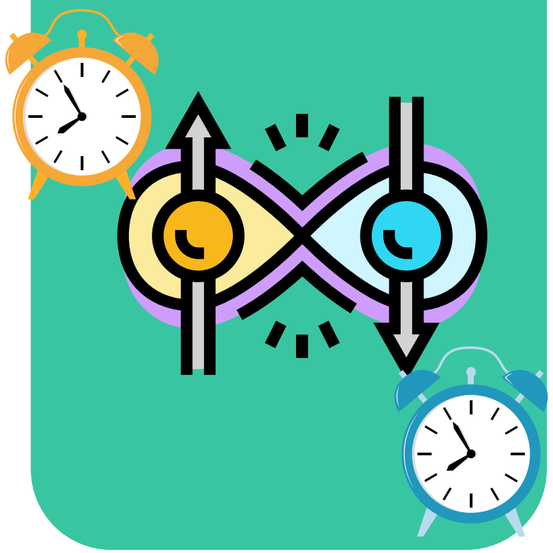
Transmission “pure” quantum data



Reduction communication complexity

Security

Clocks



etc.

Substituting Quantum Entanglement for Communication

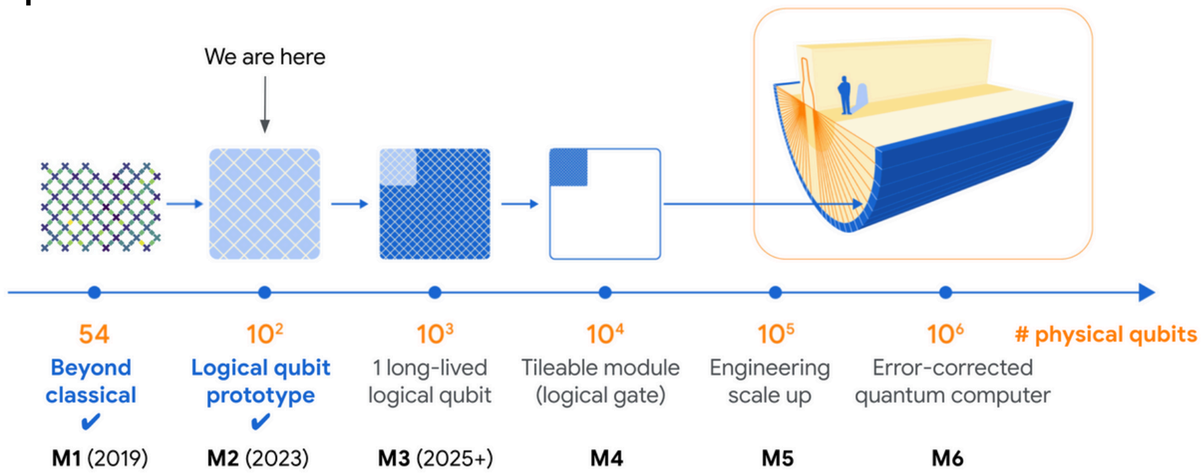
Richard Cleve[1]* and Harry Buhrman[2]**
[1] *Department of Computer Science, University of Calgary, Calgary, Alberta, Canada T2N 1N4*
[2] *CWI, P.O. Box 94070, 1090 GB Amsterdam, The Netherlands*

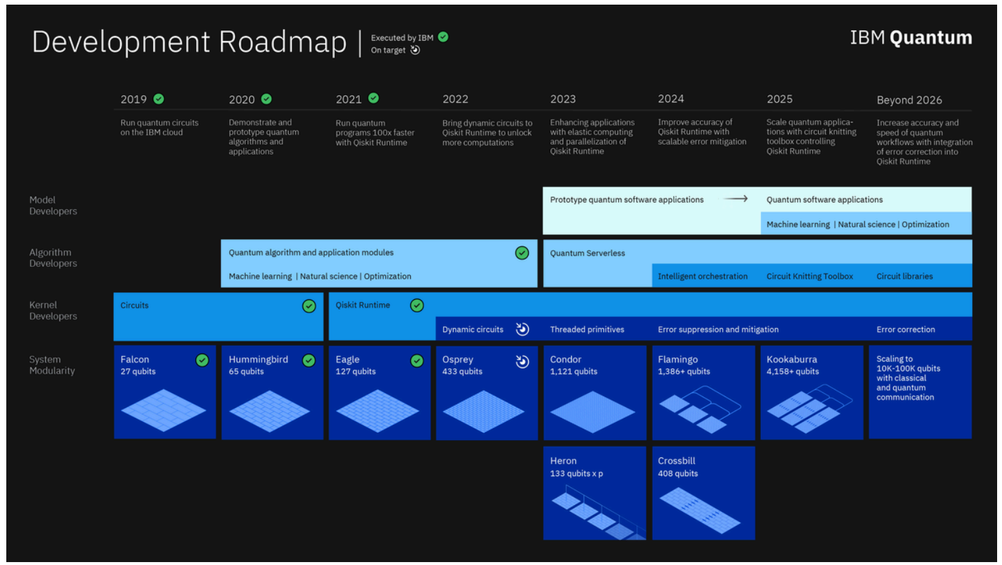
We show that quantum entanglement can be used as a substitute for communication when the goal is to compute a function whose input data is distributed among remote parties. Specifically, we show that, for a particular function among three parties (each of which possesses part of the function’s input), a prior quantum entanglement enables one of them to learn the value of the function with only two bits of communication occurring among the parties, whereas, without quantum entanglement, three bits of communication are necessary. This result contrasts the well-known fact that quantum entanglement cannot be used to simulate communication among remote parties.

PACS numbers: 03.65.Bz, 89.70.+c

Why would we think about distributing quantum computation?

- “Big” applications of qc such as computational catalysis or RSA require **millions of physical qubits**
- Given current projections it will be **challenging** for individual quantum processors to achieve such qubit numbers





- > argument from: “Distributed Quantum Computing with QMPI” by Thomas Häner, Et. al

Why would we think about distributing quantum computation?

Classical networks

VS

Quantum networks

Qiskit

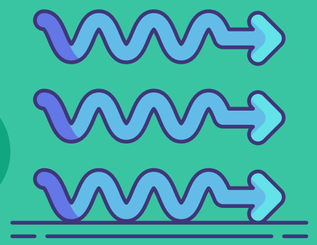
PENNYLANE

Cirq

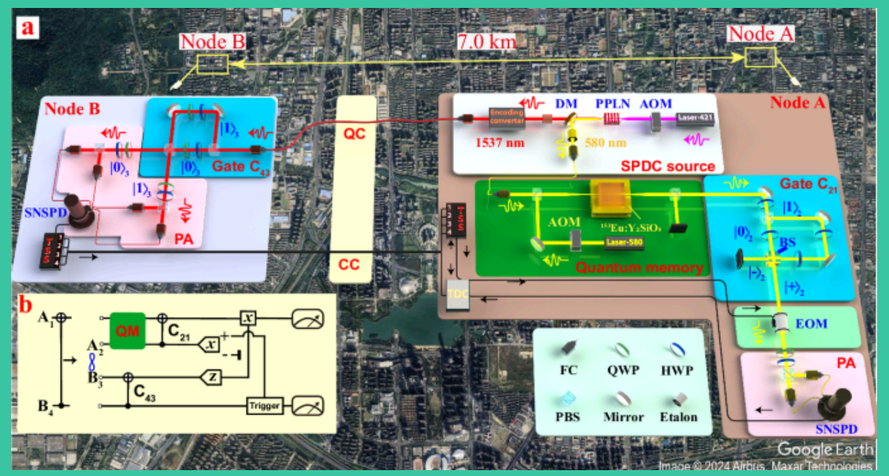
simulate coms!

Current hardware bottlenecks

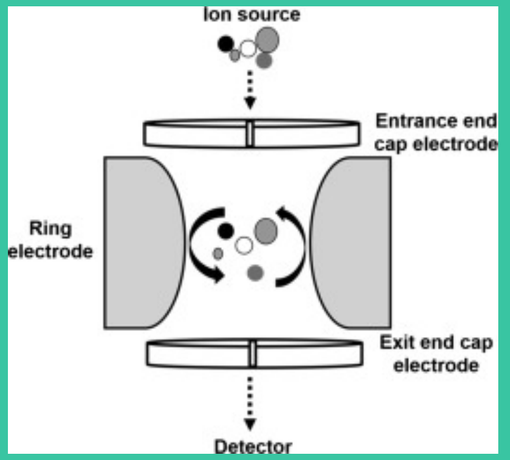
Photons



- Photons & Ion traps
- Quantum transducers?



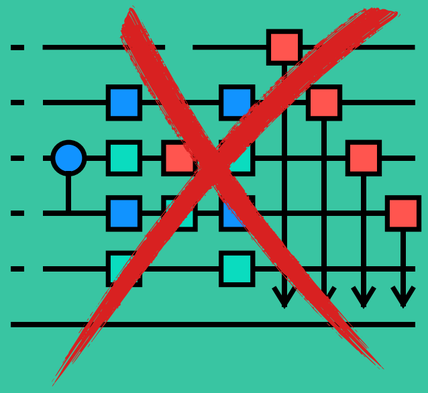
Nonlocal photonic quantum gates over 7.0 km (Nature)



Quadrupole Ion Trap (Metabolomics Perspective)

QC models

- Circuit model
- Measurement based quantum computing (fusion gates)
- Higher dimensional quantum computing
- Quantum walks



Who?

Thank You So Much!

Presentation by **Maria Gragera Garces**

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