The bridge to possible

Quantum Computing in Networks, its Impact and Applications

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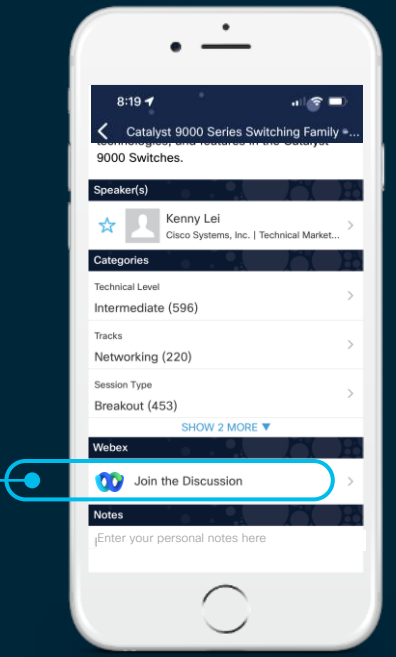

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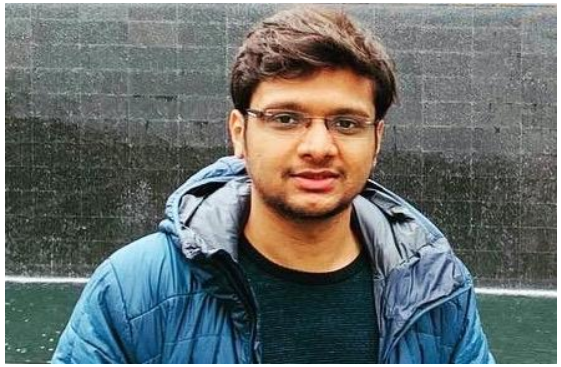
About me

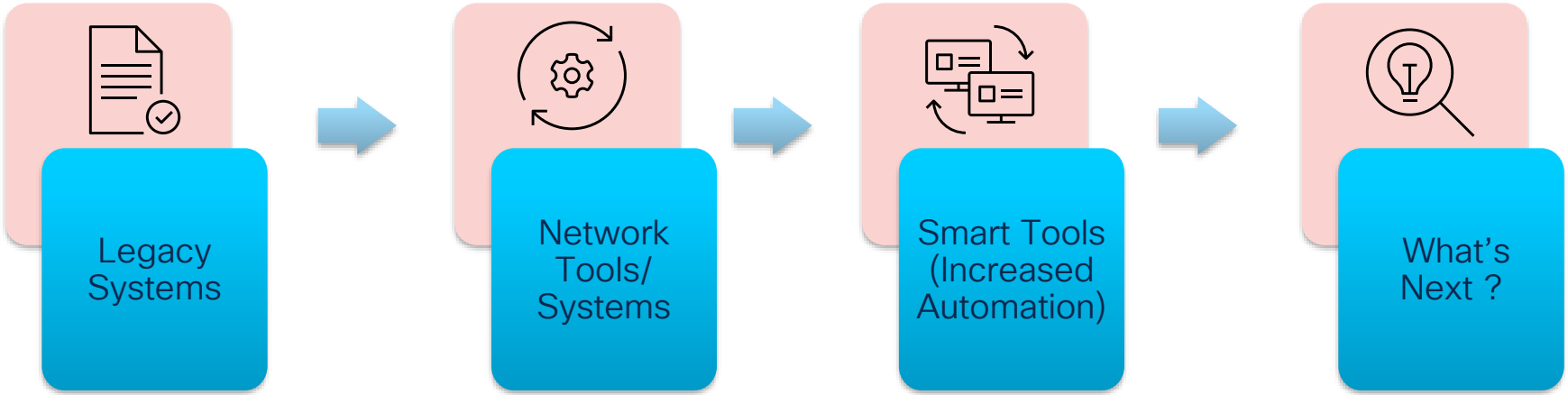


Network Consulting Engineer working at Cisco Systems, where he provides support to Cisco's Service Provider customers. He helps build simulated customer networks to find vulnerabilities, measure, and analyse network metrics to resolve customer issues. He received his engineering degree from Vellore Institute of Technology, Vellore, India. He is a public speaker, an Augmented/Virtual Reality enthusiast , enjoys travelling and a cricket lover.

Agenda

- The Evolution
- Quantum Computing
- Quantum Cryptography
- Quantum Benefits
- Key Takeaways

The Evolution



HISTORY :

"I think I can safely say that nobody understands quantum mechanics" – Richard Feynman

In 1980 – Field of Quantum Computing first introduced by Yuri Manin

In 1982 – Feynman proposed the idea of creating machines based on the laws of quantum mechanics instead of the laws of classical physics.

In 1985 – David Deutsch developed the quantum turing machine, showing that quantum circuits are universal.

In 1994 – Peter Shor came up with a quantum algorithm to factor very large numbers in polynomial time.

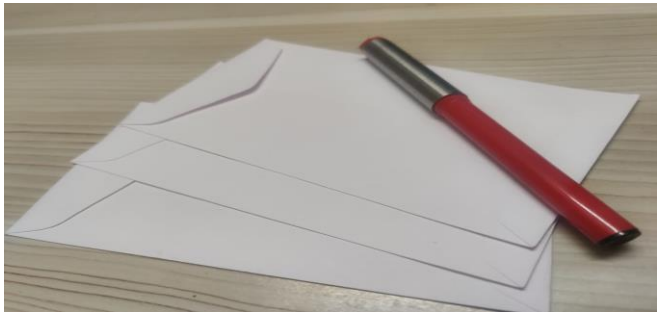
In 1996 – Lov Grover develops a quantum search algorithm with $O(\sqrt{N})$ complexity.

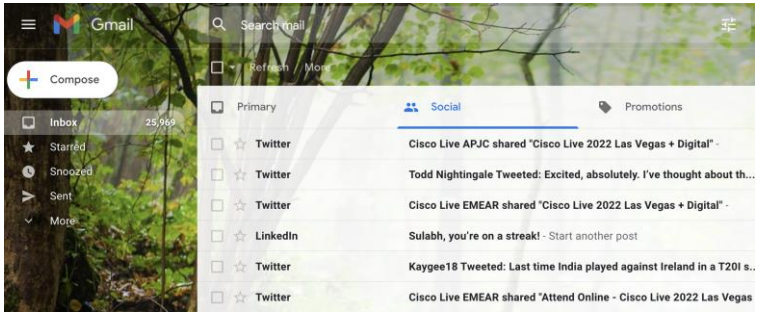
In 2017 – IBM presented the first commercially usable quantum computer with 17 Qubits.

In 2019 – IBM's "Q System One" with 20 Qubits is presented – first to be available as a cloud application from a data center.

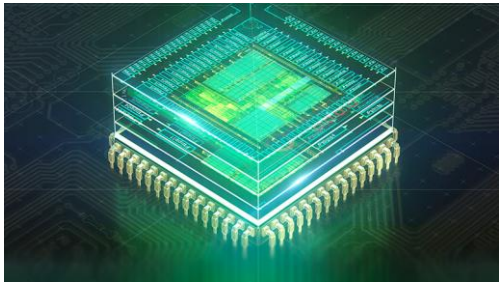
Same year researchers at Google came up with a chip called "Sycamore" which has 53 qubits claiming proof of Quantum supremacy – the quantum superiority over classical computers.

The Analogy

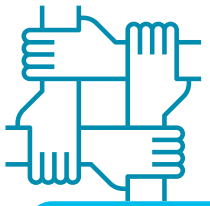




What is Quantum Computing ?



Studies theoretical computation systems (quantum computers) that make direct use of quantum-mechanical phenomena, such as superposition and entanglement, to perform operations on data and solve problems too complex for classical computers



Superposition

Interference

Entanglement

Imagine you are in Vegas and you play the coin game !!

R

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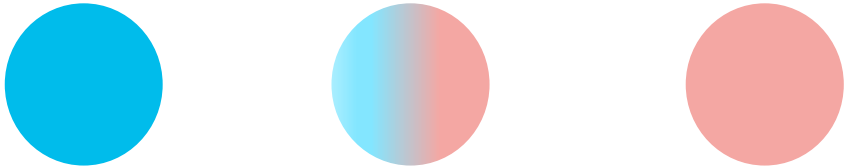

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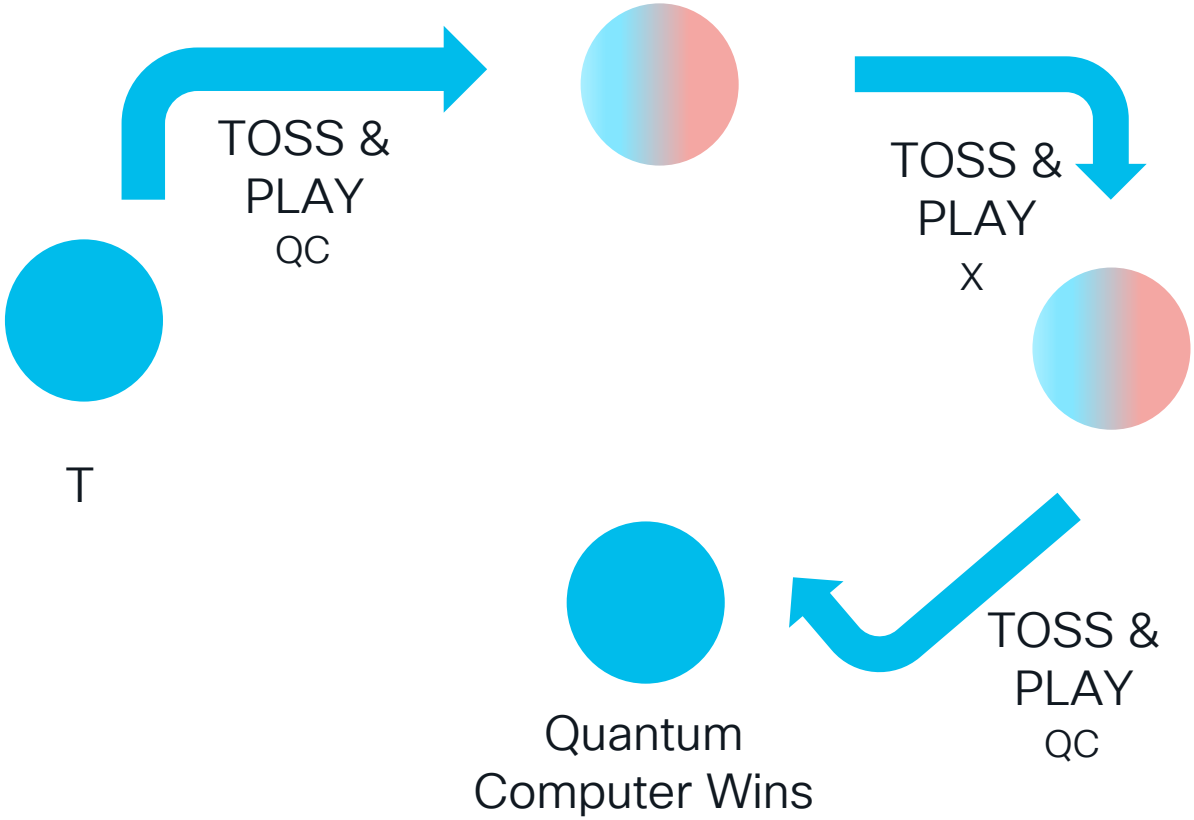
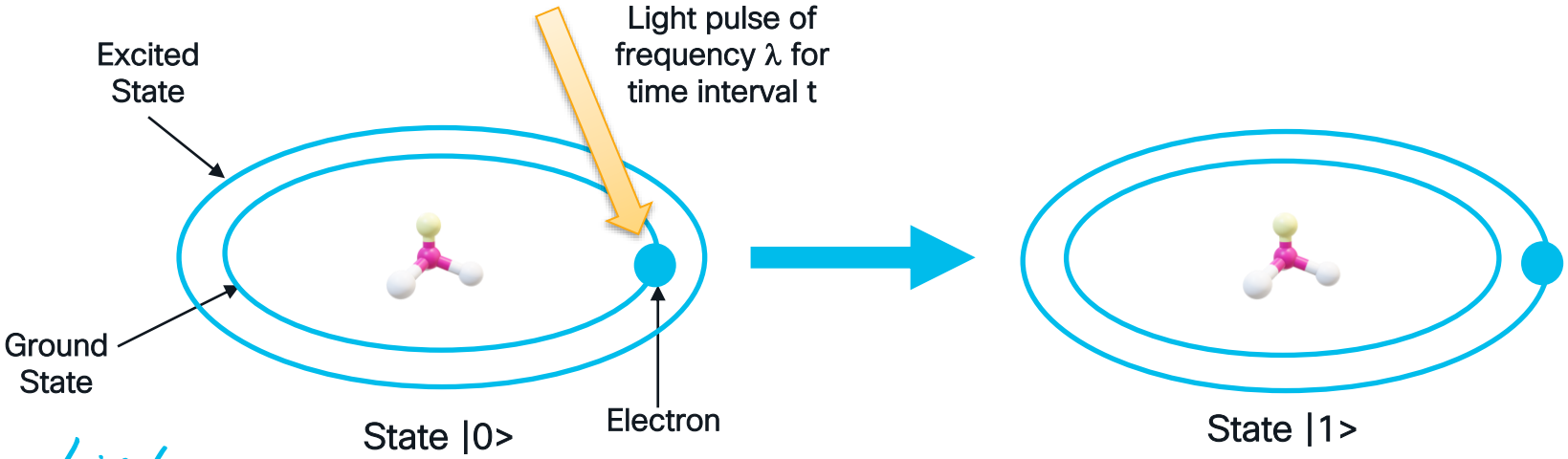
The Quantum Game



Qubits

- Quantum Analogue of the classical bit. Qubits are a two-state quantum mechanical system – that is, they have two distinguishable states, for example 0 and 1, but can also exist in a superposition of both states at the same time.
- A physical implementation of a qubit could use the two energy levels of an atom. An excited state representing |1> and a ground state representing |0>.

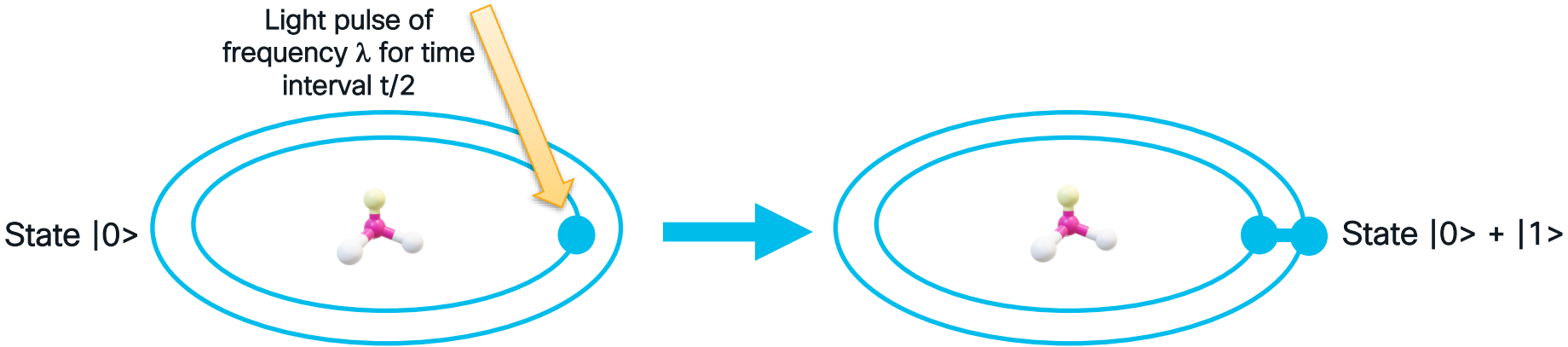


Superposition

- A single qubit can be forced into a superposition of the two states denoted by the addition of the state vectors:

$|\psi\rangle = \alpha 1|0\rangle + \alpha 2|1\rangle$, where $\alpha 1$ and $\alpha 2$ are complex numbers and $|\alpha 1|^2 + |\alpha 2|^2 = 1$

- A qubit in superposition is in both of the states $|1\rangle$ and $|0$ at the same time .

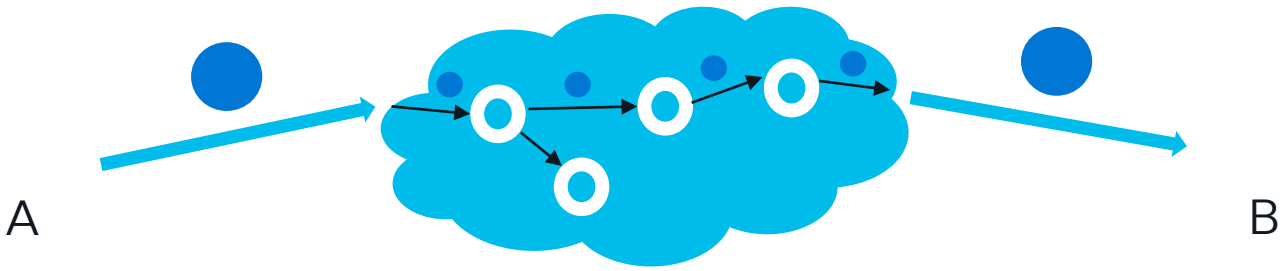


Entanglement

- Entanglement is the ability of quantum systems to exhibit correlations between states within a superposition. A close connection that makes each of the qubits react to a change in the other's state instantaneously, no matter how far they are apart.
- This means when measuring just one entangled qubit, one can directly deduce properties of its partners without having to look.

What is a Quantum Network ??

- A quantum network is a collection of nodes connected over a network so that they can transmit quantum states between themselves.
- A quantum network enables the ability to share entanglement between distant nodes.



Quantum Network

Demo

Quantum Cryptography

- It describes the use of quantum mechanical effects(viz., quantum communication and quantum computation) to perform cryptographic tasks or to break cryptographic systems.

  E.g., Use of quantum communication to exchange a key securely (quantum key distribution)

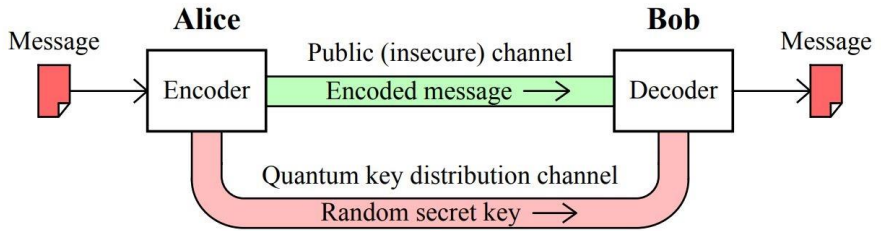
- Quantum computing offers new possibilities for secure communication
  - entanglement
  - teleportation
  - two entangled objects can only be known by their “owners” as entangled

    atoms are like keys.

How can we go about a secured Internet in a Post-Quantum world ??

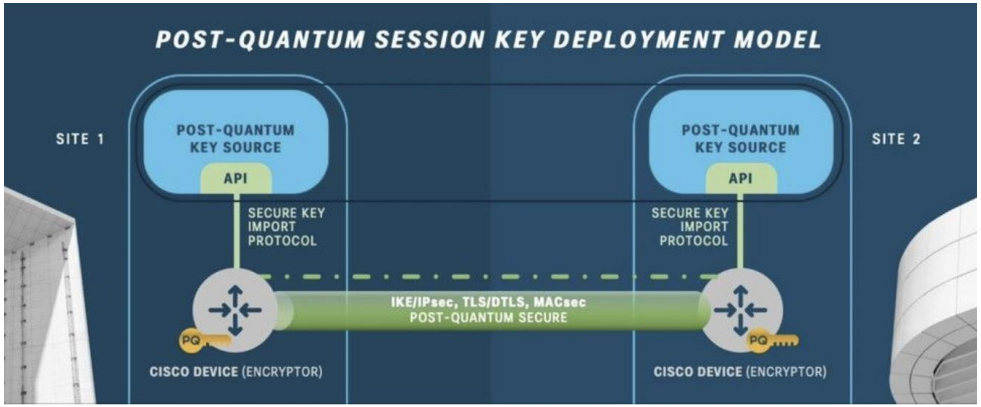
Quantum Key Distribution (QKD)

- QKD describes the process of using quantum communication to establish a shared key between two parties (say A and B) without a third party (C) learning anything about that key, even if C can eavesdrop on all communications between A and B.
- Achieved by A encoding the bits of the key (qubits) as quantum data and sending them to B.
- If C tries to learn these bits, the messages will be disturbed, and A and B will notice.
- Based on Heisenberg's Uncertainty Principle.



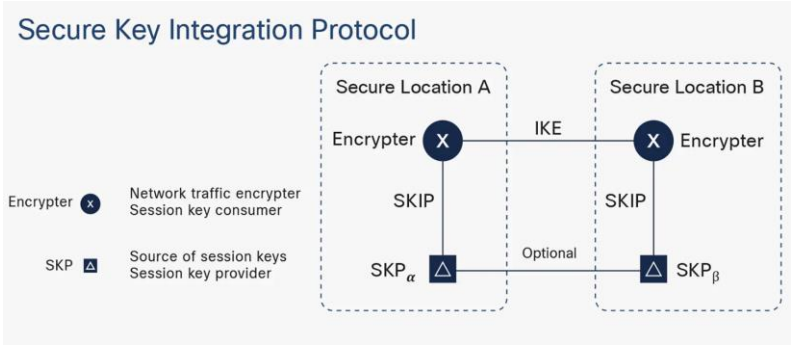
Protecting the Network

- Cisco has built a protocol called Secure Key Integration Protocol (SKIP)
- The protocol enables any Cisco router that supports encryption to use keys that are provided by a quantum distribution system.
- This allows existing Cisco routers to be quantum-ready, with just the addition of an external QKD system.



How SKIP works ??

- When one encryption router wants to communicate with the other encrypting router, it asks its co-located key provider for a secret. It also provides an identifier back to the encrypting router, that router shares it with the other location, and the receiving router asks its own key provider for a key for the corresponding identifier.
- With that solution, you can have existing router-based solutions like MacSEC or IPSec or, in principle, any cryptographic security protocol take advantage of PQ-Secure methods like QKD or preshared keys, or post-quantum-secure methods.
- For more information on SKIP : https://www.cisco.com/c/en/us/products/collateral/optical-networking/solution-overview-c22-743948.html



Quantum Teleportation

- Can be thought either as a kind of transportation, or as a kind of communication. It provides a way of transporting a qubit from one location to another, without having to move a physical particle along with it.

Improved Clock Synchronization
for better positioning systems.

Quantum Cryptography.

HealthCare & Medicine .

QUANTUM BENEFITS

Quantum Internet

Financial Modelling

Logistics Optimization

Computational Chemistry

Key Takeaways

- Quantum computing advances clearly have the potential to disrupt many different industries in potentially significant ways.
- Sustained growth in quantum bits (or 'qubits') and continued technological development are critical to the development of a commercially viable quantum computer.
- As quantum computing becomes more widely used, the incentive to expand its availability and simplicity of use for the entire workforce will grow.

Q&A

Technical Session Surveys

- Attendees who fill out a minimum of four session surveys and the overall event survey will get Cisco Live branded socks!
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