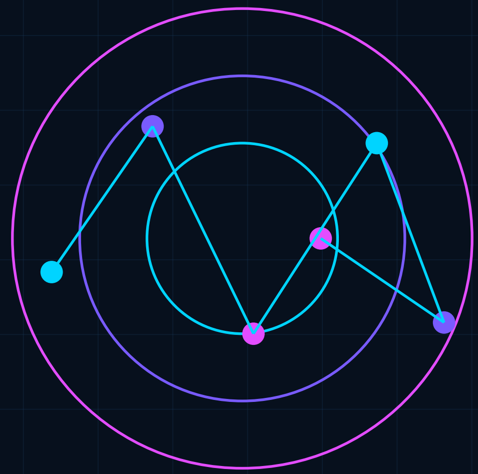
MYTHOS SYSTEMS

TECHNICAL LIBRARY / RESEARCH INTELLIGENCE

QUANTUM NETWORKING

Photonic Quantum Networking & Entanglement Distribution

Current-source review, evidence-bounded adoption decision, explicit limitations, reproducibility controls, and preserved source research note.



PERMANENT ID	EVIDENCE	ADOPTION	FRESHNESS
RES-033	A-	RESEARCH ONLY	STABLE WATCH

Freshness review: 2026-09-17 / Next scheduled review: 2027-03-16

RESEARCH CONTROL SURFACE

Required Research Fields

Each field remains independently reviewable; evidence strength does not imply production authority.

EVIDENCE GRADE — **A-**

Strength of the retained source set and technical basis.

SOURCE AUTHORITY — **3 registered authorities**

RFC 9340 - Architectural Principles for a Quantum Internet; RFC 9583 - Application Scenarios for the Quantum Internet; ETSI Quantum Key Distribution Technical Committee

FRESHNESS — **STABLE WATCH**

Reviewed 2026-09-17; dynamic sources require event-driven revalidation.

CONFLICTS — **VISIBLE / NOT SILENT**

Differences between specification, vendor behavior, research claims, and reproduced evidence must remain explicit.

LIMITATIONS — **EXPLICIT**

No certification, procurement approval, legal conclusion, or unbounded production claim is created by this report.

REPRODUCIBILITY — **REQUIRED**

Material claims require exact versions, representative data, failure cases, artifacts, and repeatable acceptance criteria.

ADOPTION POSTURE — **RESEARCH ONLY**

Maintain photonic quantum networking and entanglement distribution as a research horizon. Separate QKD deployment from general quantum-internet capability and track repeater, memory, loss, and interoperability evidence.

REVIEW TRIGGER — **2027-03-16**

Scheduled at 180 days; earlier on material source, vulnerability, implementation, or contradictory-evidence change.

SOURCE AUTHORITY / FRESHNESS

Authority Register and Freshness Delta

Primary-source lineage is preserved; current-source changes are separated from unperformed implementation claims.

AUTHORITY 01

RFC 9340 - Architectural Principles for a Quantum Internet

https://www.rfc-editor.org/rfc/rfc9340

AUTHORITY 02

RFC 9583 - Application Scenarios for the Quantum Internet

https://www.rfc-editor.org/rfc/rfc9583

AUTHORITY 03

ETSI Quantum Key Distribution Technical Committee

https://www.etsi.org/committee/qkd

2026-09-17 FRESHNESS DELTA

Primary-source register retained and freshness controls advanced to the current review date. No new product or laboratory performance claim is introduced without reproduced evidence.

Freshness policy: scheduled review + immediate review on source supersession, material release, vulnerability, retraction, or contradictory evidence.

Evidence Must Survive Contact With Reality

SOURCE authority — **CLAIM** bounded — **TEST** representative — **EVIDENCE** retained — **DECISION** conditional

- Source authority is not implementation evidence. Product behavior, scale, security, interoperability, and operator fit remain environment-specific.

- Conflicting evidence is recorded rather than averaged away. Specification behavior, vendor implementation, preprint results, and production observations are separate evidence classes.

- Quantitative claims are informative until reproduced under documented hardware, software, data, topology, load, and failure conditions.

- Adoption posture is reversible. A stronger source set can coexist with a pilot-only or research-only recommendation when maturity, safety, economics, or operability remain unresolved.

Decision Gate and Validation Plan

ADOPTION POSTURE

RESEARCH ONLY

Maintain photonic quantum networking and entanglement distribution as a research horizon. Separate QKD deployment from general quantum-internet capability and track repeater, memory, loss, and interoperability evidence.

1 / SOURCE	Pin exact versions, publication state, retrieved artifacts, and source hashes.
2 / PROTOTYPE	Demonstrate the core mechanism with representative data and instrumented execution.
3 / FAILURE	Exercise malformed input, dependency loss, stale state, overload, recovery, rollback, and misuse.
4 / BASELINE	Compare against an incumbent, classical, or simpler architecture using the same workload.
5 / ACCEPT	Record acceptance criteria, residual limitations, owner, expiration, and revalidation triggers.

EXPIRATION / REVIEW TRIGGER

Next scheduled review: 2027-03-16 (180-day cadence). Review sooner after material source revision, breaking implementation release, critical vulnerability, retraction, benchmark contradiction, changed workload, or changed legal/safety boundary.

8. Complete Source Research Note

SOURCE-LINEAGE NOTICE

The following material preserves the complete original source note, excluding only the conversational wrapper and outer Markdown fence. Legacy status labels and absolute language are retained for traceability and do not override the candidate status, limitations, or adoption decision in this edition.

Document ID: RES-033 Version: 1.0.0 (Definitive Registry Edition) Status: Published Research Note Classification: Public Organization: Mythos Systems (MYTHOS AI) Owner: Aaron Stovall Effective Date: 2026-07-16 Applies To: Quantum network engineers, optical physicists, cryptographic architects, and sovereign infrastructure specialists designing the Quantum Internet, quantum key distribution (QKD) meshes, and distributed quantum computing fabrics Companion Standards: MYTHOS-QTC-0002 (Quantum Network Technologies, Architecture, & Security), MYTHOS-QTC-0003 (Quantum Key Distribution & Entanglement Networking), MYTHOS-QTC-0001 (Quantum Computing Benchmark), MYTHOS-SEC-0001 (Post-Quantum Cryptography)

The architecture of global quantum networking has failed. Organizations attempt to build Quantum Key Distribution (QKD) networks by pushing single photons through standard optical fiber. Because of the No-Cloning Theorem, quantum states cannot be amplified by classical Erbium-Doped Fiber Amplifiers (EDFAs). As a result, photon loss in fiber causes the quantum signal to decay exponentially; point-to-point QKD is physically capped at roughly 100 kilometers.

To build a global Quantum Internet—one capable of linking distributed quantum computers and providing physically guaranteed encryption—this distance limit must be shattered.

This research note defines the architectural dynamics of Photonic Quantum Networking. It dissects the mechanics of utilizing matter-based and all-photonic quantum repeaters to perform entanglement swapping across mesh topologies. It details the extreme physical constraints of maintaining quantum coherence (decoherence) over legacy fiber, and the classical control plane orchestration required to synchronize Bell State Measurements (BSMs). Understanding these dynamics is a prerequisite for building the sovereign, fault-tolerant quantum fabrics mandated by the Mythos Quantum Standards.

To understand quantum networking, we must move from copying data (classical) to teleporting state (quantum). A quantum network does not route payloads; it distributes entanglement.

1.1 Entanglement Swapping (The Quantum Handshake)

To entangle Node A and Node B, who are 1,000 km apart, the network does not send a photon from A to B.

- The Mechanic: Node A creates an entangled pair (A1, A2). Node B creates an entangled pair (B1, B2). A2 is sent to a midpoint Repeater; B2 is sent to the same Repeater. The Repeater performs a Bell State Measurement (BSM) on A2 and B2, projecting them into an entangled state.
- The Teleportation: Because A1 was entangled with A2, and B1 was entangled with B2, the BSM at the repeater mathematically causes A1 and B1 to become entangled, despite never having interacted or traversed the full distance.

1.2 The Matter-Based Quantum Repeater

The first generation of quantum repeaters utilize matter qubits (e.g., trapped ions, NV centers in diamond, or superconducting transmons) as temporary memory.

- The Architecture: The repeater receives a photon, transfers its quantum state onto a stationary matter qubit, holds it in memory until the second photon arrives, and then performs the BSM.
- The Constraint: This requires deterministic photon-to-matter interfaces, which are notoriously inefficient and suffer from short memory coherence times (microseconds to milliseconds).

1.3 The All-Photonic Quantum Repeater

The breakthrough paradigm eliminates matter entirely, utilizing only light.

- The Architecture: Based on the KLM (Knill-Laflamme-Milburn) scheme and photonic cluster states. The repeater node receives flying photons and performs a linear-optics BSM using beam splitters and phase shifters.
- The Advantage: No cryogenic matter memory is required. The network operates at room temperature (though single-photon detectors still require cooling) and scales far more easily across standard telecom infrastructure.

While entanglement swapping theoretically allows infinite distances, the physical implementation over standard optical fiber introduces extreme physical constraints.

2.1 The No-Cloning Theorem & Exponential Loss

In classical networks, if a signal gets weak, an amplifier boosts it. In quantum networks, measuring a state destroys it (wavefunction collapse), and the No-Cloning Theorem forbids copying an unknown quantum state.

- The Flaw: Standard single-mode fiber (SMF) loses roughly 0.2 dB of signal per kilometer at 1550nm. After 100 km, the signal is 20 dB weaker (1% of original power). After 1,000 km, it is 200 dB weaker (10^-20 of original power). Sending a single photon 1,000 km through fiber yields virtually zero probability of arrival.
- The Mitigation: Quantum repeaters must be spaced every 50-100 km. Entanglement is established hop-by-hop, and then swapped end-to-end.

2.2 Decoherence and Mode Mismatch

Entanglement swapping requires the two photons arriving at the repeater (A2 and B2) to be completely indistinguishable.

- The Flaw: As photons travel through fiber, changes in temperature, physical vibration, and chromatic dispersion alter their phase, polarization, and arrival time. If A2 and B2 are not identical when they hit the beam splitter, the BSM fails or produces unentangled noise.
- The Mitigation: The architecture MUST implement active phase stabilization. Classical "pilot tones" (laser pulses at a different wavelength) are sent alongside the quantum photons to continuously monitor and correct phase drift in real-time.

2.3 The Synchronization Ceiling

To perform a BSM, the two photons must arrive at the repeater's beam splitter within picoseconds of each other.

- The Constraint: This requires sub-nanosecond clock synchronization across the entire network. Standard NTP or PTP is insufficient. The network requires White Rabbit (sub-nanosecond) or optical frequency comb synchronization.

To overcome the probabilistic nature of photon loss and BSM success rates, the architecture must scale horizontally.

3.1 Space-Division Multiplexing (SDM)

The success rate of a linear-optics BSM is at best 50% per photon pair received. To make entanglement distribution practically useful, the network must attempt thousands of BSMs simultaneously.

- The Mechanic: Utilizing multi-core fiber (MCF) or space-division multiplexing, a single fiber cable carries dozens of independent spatial channels. The repeater processes thousands of photons in parallel, drastically reducing the time required to successfully establish an end-to-end entangled link.

3.2 Quantum Mesh Routing (The Path Selection Problem)

In a classical mesh, routing algorithms (like BGP or OSPF) find the shortest path. In a quantum mesh, the "best" path is not the shortest, but the one with the highest probability of entanglement survival.

- The Mechanic: The routing protocol evaluates the fidelity of entanglement at each hop. If a node is experiencing high decoherence or detector dark counts, the routing algorithm dynamically selects an alternative path through the mesh, optimizing for end-to-end quantum state fidelity rather than raw latency.

The fundamental shift of a global entanglement mesh is the enablement of technologies physically impossible on classical networks.

- Distributed Quantum Computing: Two 100-qubit quantum computers in different cities can be entangled via the photonic mesh, effectively functioning as a single 200-qubit machine. This allows the scaling of quantum intelligence without requiring a single, massive, impossibly complex cryogenic refrigerator.
- Device-Independent QKD (DI-QKD): The highest security tier of quantum cryptography. By utilizing entanglement swapping, the sender and receiver can mathematically prove (via Bell inequality violations) that their cryptographic key has not been intercepted, without having to trust the physical hardware of the repeaters in between.
- Quantum Sensor Networks: Atomic clocks and gravitational wave detectors can be entangled across continents, creating a global, ultra-precise sensing array for navigation and physics research.

To deploy photonic quantum networking in production, the Mythos Architecture enforces strict classical/quantum plane separation and physical security boundaries.

5.1 The Ultra-Low-Latency Classical Control Plane

Quantum repeaters cannot operate autonomously. When a BSM succeeds, the repeater must instantly send a classical message (a "heralding" signal) to the end nodes so they know the entanglement was established.

- The Mitigation: The classical control plane MUST operate on a physically separate, ultra-low-latency network (SRv6 over InfiniBand). The latency of the classical control plane mathematically bounds the throughput of the quantum network. If the classical signal is delayed, the quantum state decoheres before the application can use it.

5.2 Trusted Node Abolition (The End-to-End Mandate)

First-generation QKD networks used "Trusted Nodes" at the 100km mark. The node would decrypt the quantum key, read it, and re-encrypt it for the next hop. This means the node knew the key, creating a massive insider threat.

- The Mitigation: A Mythos-compliant quantum network MUST abolish Trusted Nodes. Entanglement swapping ensures the end-to-end key is never present at the intermediate repeaters. The repeaters only perform BSMs; they are mathematically blind to the resulting entangled state.

5.3 Physical Fiber Tap Detection

Because quantum states cannot be observed without being disturbed, a fiber tap on a quantum channel is instantly detectable as a spike in the Quantum Bit Error Rate (QBER).

- The Mitigation: The network monitoring plane MUST continuously monitor QBER. If the QBER spikes above the baseline noise floor, the routing protocol instantly quarantines that physical fiber link, rerouting entanglement distribution through an alternative path, and alerts the physical security team to a potential fiber interdiction.

The strategy of pushing single photons through lossy fiber and hoping they arrive is a prototype, not an architecture. The global Quantum Internet requires a paradigm shift from signal amplification to entanglement distribution. By utilizing all-photonic repeaters, space-division multiplexing, and ultra-low-latency classical control planes, we overcome the exponential loss of standard fiber. We transform the optical network from a pipe carrying data into a mesh weaving quantum reality, unlocking distributed quantum computing and physically guaranteed cryptographic sovereignty.

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A classical network routes data; a quantum network routes entanglement.
An EDFA amplifier is a classical crutch; a BSM is a quantum bridge.
A trusted node is a spy; entanglement swapping is a blind matchmaker.
A photon lost is a state destroyed; a mesh path is a guarantee.
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The fiber is lossy; the entanglement is absolute.

> Distances may be physical.
> Quantum coherence must be absolute.
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End of Research Note RES-033

9. Source Register

Source	Authority and Status	Freshness Control
RFC 9340 - Architectural Principles for a Quantum Internet https://www.rfc-editor.org/rfc/rfc9340	Primary architecture RFC Informational RFC Published: 2023	Validated: 2026-07-22 Review on material revision, withdrawal, supersession, or scheduled report review.
RFC 9583 - Application Scenarios for the Quantum Internet https://www.rfc-editor.org/rfc/rfc9583	Primary use-case RFC Informational RFC Published: 2024	Validated: 2026-07-22 Review on material revision, withdrawal, supersession, or scheduled report review.
ETSI Quantum Key Distribution Technical Committee https://www.etsi.org/committee/qkd	Primary standards body Active program Published: Living	Validated: 2026-07-22 Review on material revision, withdrawal, supersession, or scheduled report review.

10. Lineage, Review, and Publication Record

Record	Value
Original source file	RES-033_Photonic_Quantum_Networking_Entanglement_Distribution.md
Original source words	1635
Upgrade type	Enterprise research report; source and freshness validation; limitations; adoption decision; reproducibility plan
Generated on	2026-07-22
Current status	Candidate Research Report
Publication authority	Formal Mythos approval not yet recorded
Next review	180 days or event-driven trigger, whichever occurs first