# Design and Prototype of an Asynchronous Entanglement Distribution Protocol for Satellite Quantum Networks

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**Abstract**: We design an asynchronous protocol for the distribution of entanglement in a quantum network with high latencies not relying on a central controller. The protocol is validated via simulation.

Entanglement distribution protocols for quantum networks typically rely on synchronous time-slotted execution of operations [1], often regulated by a centralized network controller, but this approach is unfeasible with large classical signalling delays, such as we have in satellite-based networks. To overcome this limitation, we build on the concept of an asynchronous Quantum Network Protocol (QNP) proposed in [2], which we extend by enabling the concurrent distribution of end-to-end entangled bits (ebits) between multiple applications in the network over partially overlapping paths. In our system model, we assume that every node has quantum memory cells that can absorb incoming flying qubits from Entangled Photon Source Generators (EPSGs) and store them until they are used or discarded by overwriting the cell with a new qubit. One key design aspect is that, inspired by [3], we assign groups of quantum memory cells to the various incoming/outgoing links of a node, which allows us to define a procedure that proceeds hop-by-hop from the initiator of an ebit establishment procedure to the intended end-node peer in the quantum network, as illustrated in Figure 1. A prototype of the protocol has been implemented in an event-drive simulator for validation and performance evaluation.

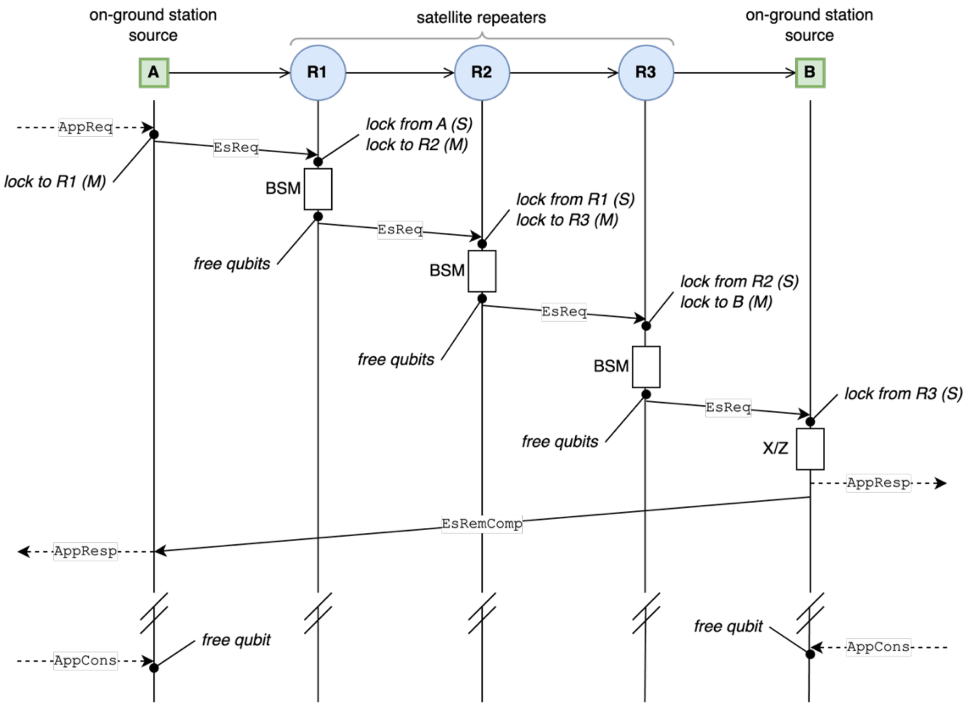


**Fig. 1** Example of a successful ebit establishment between end-nodes A and B via quantum repeaters R1, R2, and R3. The procedure is started by A when there is an internal request (`AppReq`) from an application, which is translated into the message `EsReq` sent to its successor R1 along the path. At every intermediate node, one qubit from the memory is locked as Slave (S) from the predecessor and a corresponding one as Master (M) toward its successor; an entanglement swapping is performed between the two qubits via Bell State Measurement (BSM) until the intended destination is reached, which performs X/Z corrections based on the BSM outcomes embedded hop-by-hop in the `EsReq` messages.

## References

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