Rateless Forward-Error-Correction for Lossy Mesh Media

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What Rateless FEC Specifies

The transmitter encodes the message into a stream of fragments such that any sufficient subset of fragments enables full message reconstruction. The encoding is rateless — the transmitter can produce arbitrarily many distinct fragments without coordinating with the receiver. The receiver collects fragments until reconstruction succeeds; once it has enough, it stops listening for more.

Fountain codes (Luby Transform codes), Raptor codes, and related rateless erasure codes provide this property. The architecture treats them as a structural element of the wire format: the FEC descriptor in the message header tells the receiver how to combine received fragments into the reconstructed message.

Why Retransmission-Based Protocols Fail in Lossy Mesh

TCP and similar retransmission-based protocols depend on round-trip negotiation between sender and receiver. The sender transmits, the receiver acknowledges or requests retransmission, the sender adjusts and retransmits. The pattern works for the network conditions TCP was designed for; it fails in deeply lossy mesh.

Mesh environments produce loss patterns that retransmission cannot efficiently handle: high baseline loss rate, asymmetric loss between sender and receiver, loss that varies on millisecond timescales, intermittent connectivity that interrupts retransmission negotiation, and one-to-many transmission where retransmission negotiation does not naturally fit. Rateless FEC eliminates the dependency on round-trip negotiation.

How Rateless FEC Composes With Mesh Routing

The transmitter produces an unbounded stream of fragments. Each fragment travels through the mesh independently — relays can forward fragments without reassembling the message, multiple paths can carry different fragments simultaneously, and receivers anywhere in the mesh can begin reconstruction as soon as they have enough fragments.

The architecture composes naturally with hop-history. Each fragment carries its own hop history; the reconstructed message's hop history reflects the diversity of paths the fragments traveled. A receiver gains insight not just into where the message originated but into the topology of the mesh between the origin and itself.

What This Enables for Mesh Operation in Hostile Conditions

Defense mesh radios operating in jammed conditions, satellite-link mesh in deep-fade conditions, expeditionary mesh in temporarily-disrupted environments — all benefit from rateless FEC. The protocol-level resilience reduces the need for application-level retry logic that current architectures depend on.

Wireless mesh in dense urban environments and indoor mesh through structural attenuation gain similar benefits. The patent positions the primitive at the layer

where current mesh deployment encounters the loss-pattern frontier that retransmission-based protocols cannot effectively address.