Section 8. Entanglement as Network-Level Code Coupling

This section reformulates quantum entanglement in the language of QIA. Instead of treating entanglement as an abstract mathematical feature of tensor-product Hilbert space, QIA interprets it as a physical coupling of wave-pattern codewords distributed across multiple nodes of a lossless entropic network. The key principle is that entangled systems do not carry independent local codes; they share a joint encoding that must remain routing-consistent across the network.

8.1 Definition of entanglement in QIA: shared code across nodes

In QIA, entanglement is defined as shared wave-pattern code across distinct nodes. Two nodes A and B are entangled when their effective codewords cannot be decomposed into independent local encodings. Instead, the physically relevant information is a joint codeword whose correlation tensor links the nodes as a single distributed encoding object. In this sense, the network stores one shared code rather than two separate codes.

$$codeword\_AB \neq codeword\_A \otimes codeword\_B$$

8.2 Nonlocal correlation as routing consistency

Nonlocal quantum correlations arise naturally under the shared-code definition. If a joint codeword is distributed across nodes, then any valid routing update must preserve the internal consistency of that code. Correlations therefore appear “nonlocal” because the network enforces code-consistency globally, not because classical messages are exchanged faster than light. QIA describes this as routing-consistency nonlocality: the distributed code constrains allowed joint outcomes across separated nodes.

$$\textit{Nonlocal correlation} \approx \textit{global consistency constraint on shared code routing}$$

8.3 Bell/CHSH from routing: violation of classical locality without signaling

From a routing viewpoint, Bell/CHSH violations occur because classical locality assumes independent local hidden variables. QIA does not assume independent local codes. Instead, the hidden variables are not purely local; they include shared routing degrees of freedom carried by the joint codeword. As a result, the correlation structure of the shared code can exceed classical bounds, producing CHSH violations. Nevertheless, no-signaling is preserved because observers cannot control the routing-consistency constraint to transmit a message. The marginal statistics at each node remain invariant under remote measurement choice.

$$CHSH > 2 \ \textit{possible because shared} - \textit{code routing variables are nonlocal, while signaling remains forbidden}$$

8.4 Monogamy and distributed constraints

Entanglement monogamy is interpreted in QIA as a distributed constraint on code coupling. A joint codeword cannot be maximally coupled to arbitrarily many independent nodes, because routing consistency would become over-constrained. In other words, the network cannot maintain perfect shared-code coupling simultaneously across multiple incompatible links. Monogamy therefore reflects capacity and compatibility constraints of distributed encoding rather than a mysterious quantum rule.

8.5 Multipartite cases: GHZ/W states as code-coupling topology

For multipartite entanglement, QIA emphasizes topology. GHZ-type and W-type states represent qualitatively different architectures of shared-code coupling. GHZ correlations correspond to a highly global coupling topology in which consistency is enforced across all nodes simultaneously, producing strong all-or-nothing constraints. W states correspond to a more distributed and robust topology in which pairwise couplings are weaker but redundancy preserves entanglement under loss of one node. Therefore, QIA treats multipartite entanglement as a classification of network encoding topologies rather than merely a list of Hilbert-space vectors.