Multi-Modal Biometric Continuity Coupling

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What Multi-Modal Continuity Specifies

The continuity validator consumes contributions from multiple biometric modalities simultaneously: cardiovascular (heart rate variability, photoplethysmography, ECG patterns), respiratory (breathing rate, depth, pattern), behavioral (gait, keyboard cadence, mouse-movement patterns, gaze patterns), and remote-sensing (radar-derived presence, thermal signatures observable in facility-deployed sensing). Each modality contributes a credentialed observation; the validator combines contributions into a single continuity attestation.

The combination is not majority voting or sum-of-confidences. It is structural correlation: do the modalities show the consistent evolution that indicates the same biological subject across time, or do they show inconsistencies that indicate spoofing or substitution? The validator produces a graduated continuity score reflecting the cross-modality consistency.

Why Single-Modality Biometrics Have Limits

Single-modality biometric systems (fingerprint readers, facial recognition, iris scanners) have well-documented attack surfaces. Spoofing attacks against

fingerprints, deepfake-driven facial-recognition attacks, and iris-pattern reproduction all bypass single-modality systems with sufficient adversary investment.

The attack-surface response has been to add liveness detection, behavioral confirmation, and multi-factor combinations. The responses help but don't change the architectural pattern: a single modality plus liveness check is still a single-modality system with an additional check. Multi-modal continuity coupling changes the pattern structurally — identity emerges from the cross-modality correlation rather than from any single modality plus check.

How Cross-Modality Correlation Operates

The validator maintains a continuity model for each operating subject: how their cardiovascular signals, respiratory signals, behavioral signals, and remote-sensing signals correlate across time. The model is itself a credentialed observation, signed by the credentialing authority and updated as continuity evidence accumulates.

Each new observation across modalities is evaluated against the model. Consistent observations strengthen the continuity attestation. Inconsistent observations (cardiovascular signals that don't match the subject's typical patterns under behavioral signals that match, or vice versa) weaken it. Sufficiently inconsistent observations trigger continuity break — the validator declares that the observed subject is not, with sufficient confidence, the same biological entity the model represents.

What This Enables for Anti-Spoofing Identity

Adversarial replay attacks across single modalities defeat one channel but not the cross-channel correlation. An attacker who reproduces a fingerprint cannot also reproduce the cardiovascular signals, behavioral patterns, and remote-sensing

observations that the legitimate subject produces. The attack surface expands structurally to require simultaneous multi-modality reproduction.

Continuity-based access control, continuity-based device binding, and continuity-based attestation gain structural anti-spoofing through the architectural primitive rather than through per-deployment liveness-detection retrofits. The patent positions the primitive at the layer where biometric authentication has been struggling against adversarial sophistication for two decades.