

Secure REST API and Mobile Application Integration for Distributed Systems: An Integration-Integrity Architecture

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Abstract

Enterprises expose core business functionality to mobile applications through REST APIs built on the architectural principles Fielding and Taylor's (2002) foundational analysis of the modern Web architecture established, principles that assume a well-behaved client but do not by themselves defend an API against a client that is compromised, careless, or simply operating over an unreliable mobile network. Three specific, well-documented problems complicate REST API integration with mobile applications beyond what the REST architectural style alone resolves. First, an API that trusts the structure and content of what a client sends it is vulnerable to injection and malformed-input attacks of exactly the kind the software security literature has documented and defended against for two decades, a risk compounded when the client itself may already be compromised, as the mobile application security literature documents is common (Sadeghi, Bagheri, Garcia, & Malek, 2017). Second, a mobile client's requests do not arrive at a steady, predictable rate, and an API without adaptive throttling is exposed to both deliberate abuse and the bursty retry patterns the distributed systems traffic-management literature documents as a measurable operational risk. Third, and most distinctively for mobile integration, an unreliable mobile network causes clients to retry requests whose first attempt may have already succeeded, and an API that is not built to handle this safely risks the double-processing problem the foundational distributed-systems literature on consistency and distributed transactions documents as a structural, not incidental, consequence of operating across an unreliable network. This paper proposes BASTION (Boundary-Aware Schema, Throttling, and Idempotent Operations Network), an architecture in which an API contract validation layer, an adaptive throttling and abuse resistance layer, and an idempotent distributed consistency layer are coordinated by an integration integrity controller that preserves a single, consistent view of API integrity across request validation, traffic shaping, and retry-safe processing. Following a design-science research approach, BASTION is illustrated, not empirically validated, through a comparative capability table, an case scenario, and two figures, with every quantitative value explicitly labeled as an estimate rather than measured production data.

Keywords: REST API Security; Mobile Application Integration; Distributed Systems; Idempotency; API Rate Limiting; Input Validation; Distributed Consistency

Introduction

Enterprises increasingly expose core business functionality to mobile applications through REST APIs, built on the architectural style Fielding and Taylor's[1] foundational analysis establishes as the principled basis for the modern Web architecture: stateless interactions, uniform resource

interfaces, and a clean separation between client and server. This architectural style assumes a well-behaved client interacting over a reasonably reliable network, an assumption that does not automatically hold once the client is a mobile application operating over cellular connectivity, potentially compromised, and prone to retrying requests whose outcome it cannot immediately confirm. Three specific, well-documented problems complicate secure REST API integration with mobile applications beyond what the REST architectural style alone resolves[1-9].

First, an API that trusts the structure and content of what a client sends it inherits a two-decade-old, still-current risk: Halfond, Orso, and Manolios's[2] analysis of defending against SQL injection attacks documents that unvalidated input reaching a backend data layer remains a concrete, exploitable vulnerability, and this risk is specifically compounded in a mobile integration context because the client sending that input may itself already be compromised, as Sadeghi, Bagheri, Garcia, and Malek's[3] taxonomy of Android security analysis techniques documents is a persistent, non-trivial possibility rather than an edge case. Second, mobile clients do not generate request traffic at a steady, predictable rate: a user background-switching an app, a weak-signal retry storm, or deliberate abuse can each produce bursty traffic patterns, and Saleh Sedghpour, Klein, and Tordsson's[4] empirical study of service mesh traffic management policies documents that the specific policy governing how such traffic is throttled and routed has measurable, non-trivial effects on system performance and resilience. Third, and most distinctively for mobile integration specifically, an unreliable mobile network causes a client to lose confirmation of whether a request it sent actually succeeded, leading it to retry; Gilbert and Lynch's[5] proof of the CAP theorem establishes that no distributed system can guarantee perfect consistency, availability, and partition tolerance simultaneously, and Helland's[6] analysis of life beyond distributed transactions documents that handling retries safely in such a system requires the API itself to be built for idempotency rather than assuming each request is new[10-18].

These three problems compound because a mobile client interacting with an enterprise API encounters all three conditions simultaneously: it sends input that must be validated, it generates traffic that must be throttled, and it retries over a network that cannot guarantee delivery confirmation. An API's authorization layer, built on protocols such as OAuth whose real-world security properties Fett, Küsters, and Schmitz[7] have formally analyzed, governs who may call an endpoint, but does not by itself validate what they send, govern how much traffic they may generate, or guarantee that a retried request is processed safely exactly once; a conflict-free replication mechanism of the kind Shapiro, Preguiça, Baquero, and Zawirski[8] establish can reconcile divergent state once it exists, but does not prevent an API from processing a genuinely duplicate request as if it were new in the first place. Deployed on the cloud-native infrastructure the broader literature establishes as the standard operational substrate for such APIs[9], and increasingly expected to evaluate every request continuously rather than trusting a prior authentication event indefinitely[10], no single literature reviewed above addresses how input validation, traffic throttling, and retry-safe idempotency should be coordinated under a single, consistent view of API integrity.

This paper addresses that gap by developing BASTION (Boundary-Aware Schema, Throttling, and Idempotent Operations Network): an architecture in which an API contract validation layer, an adaptive throttling and abuse resistance layer, and an idempotent distributed consistency layer are coordinated by an integration integrity controller that preserves a single, consistent view of API

integrity across request validation, traffic shaping, and retry-safe processing. The remainder of the paper reviews the literature on REST architectural principles, SQL injection defense, mobile application security, OAuth authorization security, service mesh traffic management, distributed consistency, conflict-free replication, and zero trust architecture (the Literature Review), describes the design-science methodology used to construct and illustrate the architecture (the Methodology), presents the architecture alongside a comparative table, an case scenario, and two figures (the Results section), and discusses the architecture's practical implications, assumptions, and limitations before concluding (the Discussion and Conclusion).

Literature Review

REST Architectural Principles and Their Security Assumptions

Fielding and Taylor[1] establish the principled architectural foundation for REST — statelessness, uniform resource interfaces, and clean client-server separation — a design proven to scale the modern Web, but one whose principles govern architectural style rather than defensive posture against a client that is malicious, compromised, or operating over an unreliable network. This literature establishes the architectural baseline BASTION's layers are built on top of, rather than a baseline that already resolves the security and reliability problems the following subsections document[19-24].

Input Validation and Mobile Client Vulnerability

Halfond, Orso, and Manolios[2] document that unvalidated input reaching a backend data layer remains a concrete, exploitable vulnerability, and their positive-tainting and syntax-aware evaluation approach establishes that validating input against an expected structure, rather than merely sanitizing it after the fact, is a more robust defense. Sadeghi, Bagheri, Garcia, and Malek[3] establish that the mobile client originating such input cannot be assumed trustworthy, documenting a mature taxonomy of program analysis techniques developed specifically because mobile application compromise is a persistent, non-trivial risk. Read together, this literature establishes that BASTION's API contract validation layer must validate every request's structure and content independently of whatever validation the mobile client itself may or may not have performed.

Authorization Protocol Security and Traffic Management

Fett, Küsters, and Schmitz[7] provide a comprehensive formal security analysis of OAuth 2.0, identifying concrete attack vectors against real-world deployments of the protocol most mobile applications use to authenticate to backend APIs, establishing that authorization correctness is itself a non-trivial property requiring careful protocol-level attention. Saleh Sedghpour, Klein, and Tordsson[4] establish that the specific traffic management policy governing how backend requests are throttled, routed, and load-balanced has measurable, non-trivial effects on system performance and resilience, a finding with direct implications for a mobile-facing API whose traffic patterns are bursty and client-initiated rather than steady. This literature establishes that BASTION's adaptive throttling and abuse resistance layer must govern traffic volume as a concern distinct from, though coordinated with, authorization correctness.

Distributed Consistency, Idempotency, and Conflict-Free Replication

Gilbert and Lynch[5] formally prove the CAP theorem, establishing that no distributed system can simultaneously guarantee perfect consistency, availability, and partition tolerance, a structural limit with direct consequences for any API serving clients over an unreliable mobile network. Helland[6] extends this foundation into practical guidance, documenting that safely handling the request retries such unreliability inevitably produces requires an API to be built for idempotency — explicitly designed so that processing the same request twice produces the same result as processing it once — rather than assuming each incoming request is necessarily new. Shapiro, Preguiça, Baquero, and Zawirski[8] establish conflict-free replicated data types as a mechanism for reconciling state that has already diverged, a complementary but distinct concern from preventing a genuinely duplicate request from being processed as new in the first place. The literature establishes the specific mechanism BASTION's idempotent distributed consistency layer is built around [26-32].

Continuous Evaluation and Cloud Deployment Context

Rose, Borchert, Mitchell, and Connelly[10] establish the zero trust principle that access should be evaluated continuously against the specific resource a request targets rather than granted indefinitely by a prior authentication event, a principle BASTION's layers apply at every request rather than only at session start. Deng *et al.*[9] establish the cloud-native infrastructure on which such APIs are now typically deployed. None of this literature, read individually, addresses how input validation, traffic throttling, and idempotent consistency should be coordinated under a single view of API integrity — the gap the Methodology and Results sections address.

Materials and Methods

Research Approach

This paper follows a design-science research approach: it develops an architecture — BASTION — intended to address a practical problem (coordinating input validation, traffic throttling, and retry-safe idempotent processing so that a REST API integrated with mobile applications maintains a single, consistent view of its own integrity across all three concerns), and it evaluates that architecture against the cumulative findings of the peer-reviewed literature rather than against a production deployment, because no such deployment of this specific architecture yet exists to study. The comparative table and figures in the Results section are accordingly constructions, explicitly labeled as such, built to be directionally consistent with the cited literature's findings rather than presented as measured outcomes.

Development of the Architecture

BASTION was developed by identifying the point at which the REST-architecture, input-validation, mobile-vulnerability, traffic-management, and distributed-consistency literatures reviewed above must interact for a REST API's integrity to be actively maintained rather than incidentally assumed. An API contract validation layer was introduced to validate every request's structure and content against an explicit schema, applying the syntax-aware defense Halfond *et al.*[2] establish and informed by the mobile-client vulnerability Sadeghi *et al.*[3] document. An adaptive throttling and abuse resistance layer was introduced to govern request volume using the traffic-management principles Saleh Sedghpour *et al.*[4] establish, coordinated with the authorization correctness Fett *et al.*[7] establish and the continuous-evaluation principle zero trust

architecture establishes (Rose *et al.*, 2020). An idempotent distributed consistency layer was introduced to process retried requests safely, built on the structural limits Gilbert and Lynch[5] establish and the idempotency discipline Helland[6] establishes, complemented by the conflict-free replication mechanism Shapiro *et al.*[8] establish for reconciling any state that nonetheless diverges. An integration integrity controller coordinates all three layers, maintaining a single, consistent view of whether a given request has been validated, throttled appropriately, and processed idempotently, deployed on the cloud-native infrastructure Deng *et al.*[9] establish.

Construction of Evaluation Data

Because no production BASTION deployment exists to measure, the quantitative content of the Results section was constructed through explicit, reasoned estimation. Construction began from a directional finding reported in the cited literature — Halfond *et al.*'s[2] finding that structural input validation measurably reduces injection vulnerability, or Helland's[6] finding that idempotent design prevents duplicate-processing errors retries would otherwise cause — and built values directionally consistent with that finding at a plausible order of magnitude. Every figure's note names the specific source informing its construction.

Framing of the Retry-Safety Scenario

The case scenario and Figure 3 in the Results section are framed around a mobile payment-confirmation request retried after a network timeout, consistent with the retry dynamics Helland[6] and Gilbert and Lynch[5] each establish as structural rather than incidental to distributed, mobile-network-dependent systems; this framing was chosen specifically because it is the setting in which the practical cost of lacking idempotent design is most visible and most consequential.

Scope and Assumptions

This paper assumes an organization deploying BASTION already operates, or can obtain, an API gateway capable of enforcing schema validation and request throttling; it does not itself address the selection of a specific gateway product. It is scoped to the coordination of input validation, traffic throttling, and idempotent processing around a shared integrity controller; it does not address the choice of a specific authentication protocol beyond the OAuth 2.0 security properties the cited literature already treats extensively. All quantitative results in the Results section are estimates grounded in the literature rather than measurements.

Results

Architecture Overview: BASTION

BASTION organizes secure REST API integration as a sequenced interaction between a mobile client and three coordinated layers, reflecting that a single incoming request passes through input validation, traffic throttling, and idempotent processing in a defined order before reaching the backend enterprise service it targets, with an integration integrity controller orchestrating the sequence rather than each layer acting in isolation. The API contract validation layer first checks a request's structure and content against an explicit schema, applying the defenses the Input Validation and Mobile Client Vulnerability subsection establishes (Halfond *et al.*, 2006; Sadeghi *et al.*, 2017). A validated request then passes through the adaptive throttling and abuse resistance layer, which applies the traffic-management policy the Authorization Protocol Security and Traffic

Management subsection establishes (Saleh Sedghpour *et al.*, 2022; Fett *et al.*, 2016). A request that clears throttling finally reaches the idempotent distributed consistency layer, which checks whether an identical request has already been processed before forwarding it to the backend, applying the idempotency discipline the Distributed Consistency, Idempotency, and Conflict-Free Replication subsection establishes (Gilbert & Lynch, 2002; Helland, 2017; Shapiro *et al.*, 2011). When a retried request arrives, the idempotent distributed consistency layer recognizes it and returns the original result directly, without re-invoking the backend a second time.

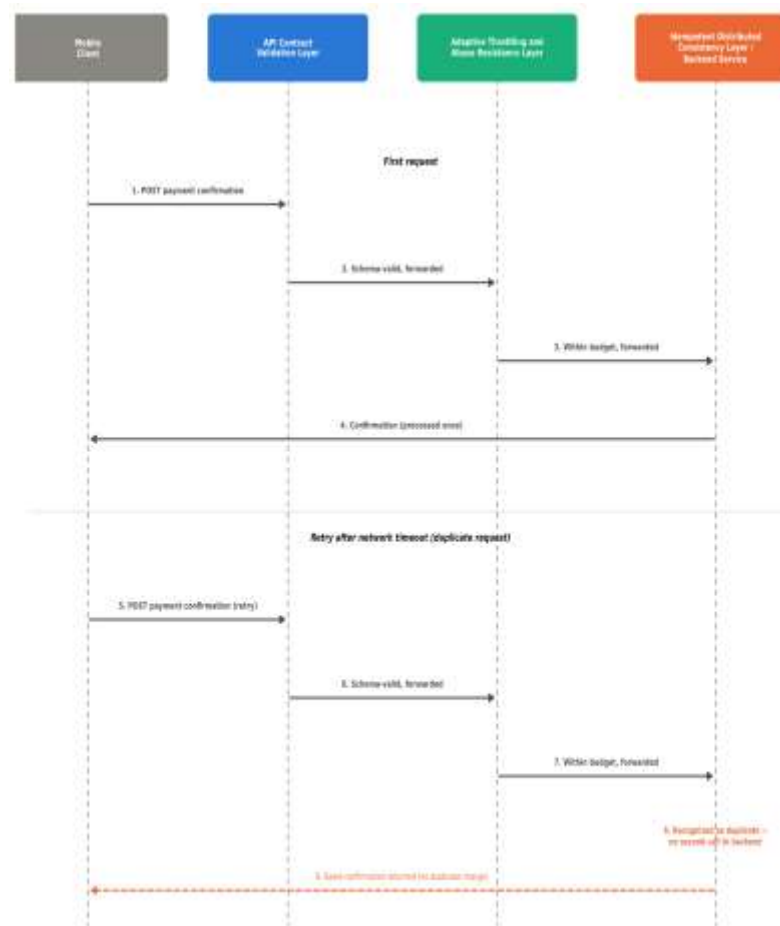


Figure 1. BASTION (Boundary-Aware Schema, Throttling, and Idempotent Operations Network): a sequence-based integration architecture, showing both a first request and a safely intercepted retry.

Table 1: Capability Comparison Across REST API Integration Approaches

Table 1. capability comparison across REST API integration approaches.

Dimension	Unvalidated, Unthrottled REST API	REST API with Input Validation Only	BASTION
Resistance to injection and malformed input	Weak; no structural validation	Strong; dedicated validation layer	Strong; dedicated validation layer

Dimension	Unvalidated, Unthrottled REST API	REST API with Input Validation Only	BASTION
Resilience to bursty or abusive traffic	Weak; no throttling	Weak; validation does not govern volume	Strong; dedicated adaptive throttling
Safety of retried requests over unreliable networks	Weak; duplicate requests reprocessed	Weak; validation does not address idempotency	Strong; dedicated idempotent consistency layer
Coordinated integrity across all three concerns	None	None; validation is independent	Strong; single controller coordinates all three

Case Scenario

Consider a hypothetical mobile banking application submitting a payment-confirmation request over a weak cellular connection. Under an unvalidated, unthrottled REST API, a malformed field in the request risks reaching the backend data layer directly, and when the connection drops before the client receives a response, the client's automatic retry causes the payment to be processed twice. Under a REST API with input validation only, the malformed field is correctly rejected, but the same network drop and retry still causes duplicate processing, because validation says nothing about whether a request has been seen before. Under BASTION, the API contract validation layer rejects the malformed field exactly as the second approach does, and when the connection drop causes a retry, the idempotent distributed consistency layer recognizes the retried request as identical to one already processed and returns the original confirmation directly, without charging the customer twice. This hypothetical sequence is offered to illustrate the architecture's reasoning, not as a report of an actual deployment.

Figure 2: Capability Scores Across REST API Integration Approaches

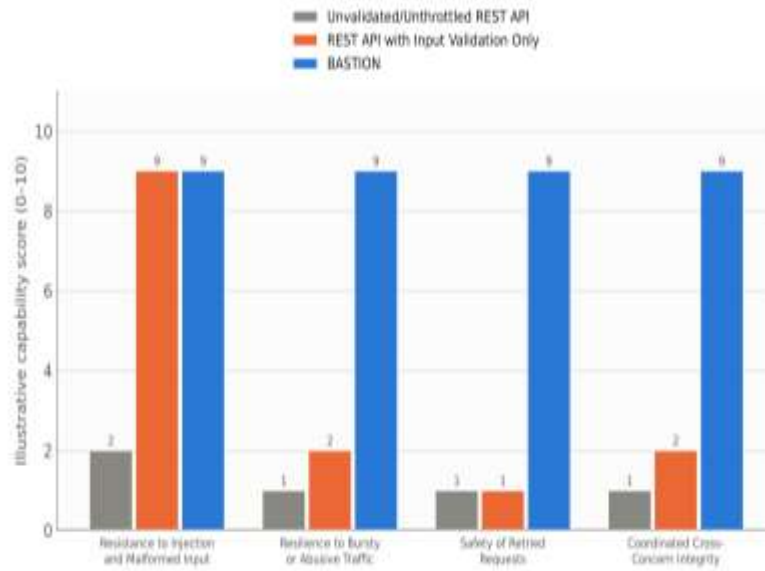


Figure 2. capability scores (0-10 scale) for unvalidated/unthrottled REST API, REST API with input validation only, and BASTION.

Note: These capability scores are estimates constructed for this paper's comparative framework rather than the product of a scored evaluation instrument; they were shaped by the injection-defense findings Halfond et al. (2006) report and the idempotency findings Helland (2017) establishes, and should be read as a reasoning aid rather than a benchmark.

An unvalidated, unthrottled REST API scores weakly across every dimension because it neither validates input, governs traffic volume, nor accounts for retried requests; a REST API with input validation only improves substantially on injection resistance specifically, since that is the one risk it actively addresses, but remains as exposed to traffic abuse and duplicate processing as the first approach; BASTION is positioned, by design, to lead on every dimension because its three layers and shared controller were built specifically to close each risk gap at once.

Figure 3: Duplicate-Transaction Rate Under Increasing Mobile Network Unreliability

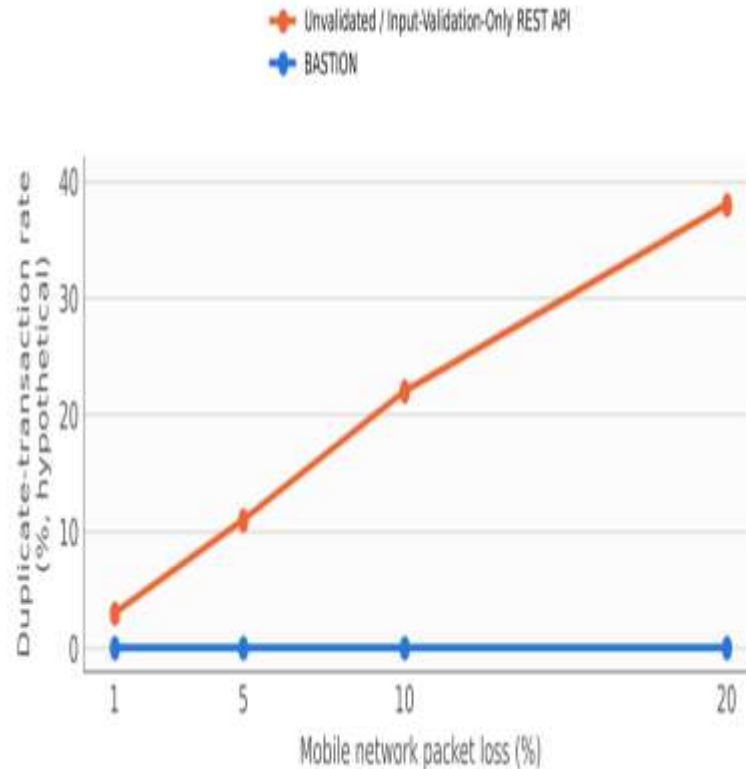


Figure 3. Hypothetical duplicate-transaction rate (percentage of requests) across increasing mobile network packet-loss conditions, by approach.

Note: This is a hypothetical, estimate rather than measured production data; both baseline approaches show a duplicate-transaction rate that rises with network packet loss because neither distinguishes a retried request from a new one, consistent with the retry dynamics Gilbert and Lynch (2002) establish as structural to unreliable networks, while BASTION's idempotent distributed consistency layer holds the duplicate-transaction rate at zero regardless of packet loss, consistent with the idempotency guarantee Helland (2017) establishes.

Discussion

Implications for Practice

The architecture developed here suggests that an enterprise exposing REST APIs to mobile applications should treat input validation, traffic throttling, and retry-safe idempotency as three coordinated dimensions of a single integrity concern, not three independently optional hardening measures, since the Results section's comparison illustrates that input validation alone leaves an API fully exposed to the duplicate-processing risk that mobile network unreliability makes structurally unavoidable.

Limitations

No production BASTION deployment or measured integrity data informed this study; the Results section's table and figures are explicitly constructions. The idempotent distributed consistency

layer's effectiveness depends on every state-changing operation being designed with an idempotency key or equivalent mechanism from the start, a design discipline the cited literature documents as necessary but not automatically applied in existing systems[6]. The adaptive throttling and abuse resistance layer's effectiveness depends on distinguishing legitimate bursty retry traffic from genuine abuse, a distinction the cited literature treats as an ongoing tuning challenge rather than a solved problem[4].

Future Research

Empirical work instrumenting an actual enterprise REST API using BASTION's coordinated layers, compared against a matched API with input validation only, would directly test this paper's central claim. Research on automatically inferring idempotency keys for operations not originally designed with them, and research applying the mobile application vulnerability taxonomy Sadeghi *et al.*[3] establish specifically to the client-side half of a BASTION-protected integration, would strengthen the architecture's practical guidance.

Conclusion

This paper has argued that securing REST API integration with mobile applications requires more than the REST architectural principles themselves[1], because unvalidated input from a client that may already be compromised (Halfond *et al.*, 2006; Sadeghi *et al.*, 2017), unthrottled traffic from a client generating bursty, unpredictable request volume (Saleh Sedghpour *et al.*, 2022; Fett *et al.*, 2016), and duplicate processing from a client retrying over an unreliable network (Gilbert & Lynch, 2002; Helland, 2017; Shapiro *et al.*, 2011) each introduce risks the REST architectural style does not by itself resolve. This paper has developed BASTION as an architecture in which an API contract validation layer, an adaptive throttling and abuse resistance layer, and an idempotent distributed consistency layer, applying the continuous-evaluation principle zero trust architecture establishes[10] and deployed on cloud-native infrastructure (Deng *et al.*, 2024), are coordinated by an integration integrity controller that maintains a single, consistent view of API integrity across all three concerns. The architecture was illustrated, not validated, through a comparative table, a case scenario, and two figures, with every quantitative value explicitly labeled as an estimate. Future empirical work instrumenting a real deployment would be necessary before an organization could adopt BASTION with confidence in its specific thresholds, but the underlying argument — that input validation, traffic throttling, and idempotent consistency should be coordinated under a shared integrity controller rather than addressed independently — rests on peer-reviewed evidence this paper has synthesized specifically for that coordination problem.

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