

User Story 9: Question Queue Feature

- Story: "As a user, I want a clear visual indicator when someone raises their hand or asks a question so that I can acknowledge all participants in a timely manner."
- What it's about: Helping meeting facilitators manage participation by making it obvious when attendees need attention, preventing people from being overlooked.

Header

Feature Name: Raised-Hand & “Has a Question” Indicator

Version: 1.0

Date: September 22, 2025

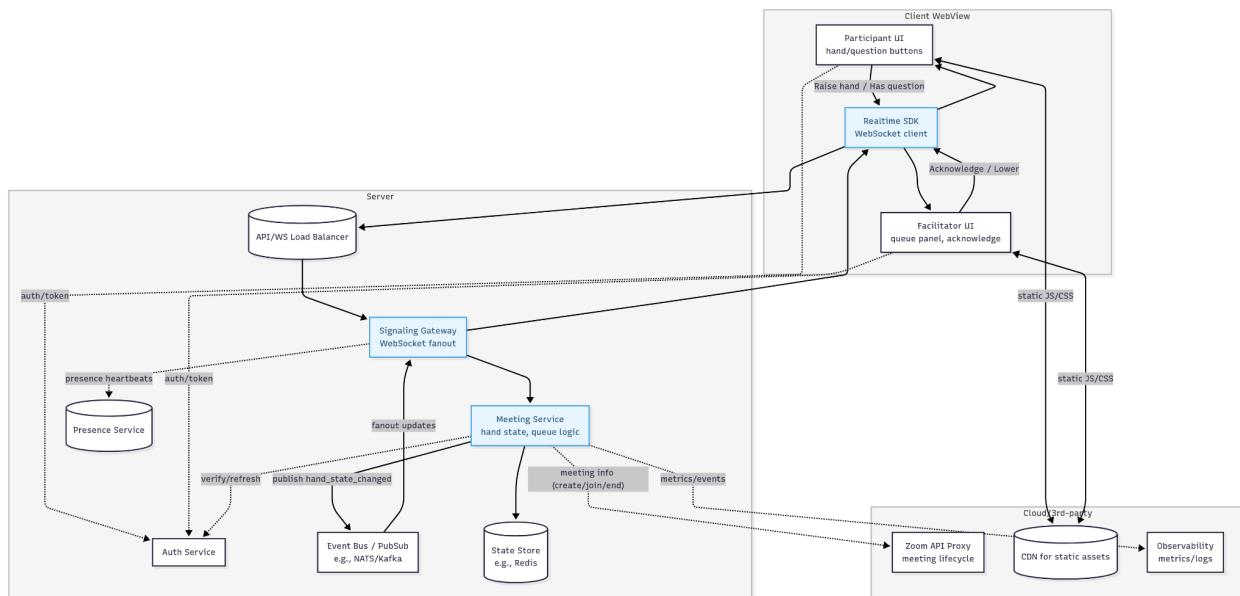
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Role: Software Engineer

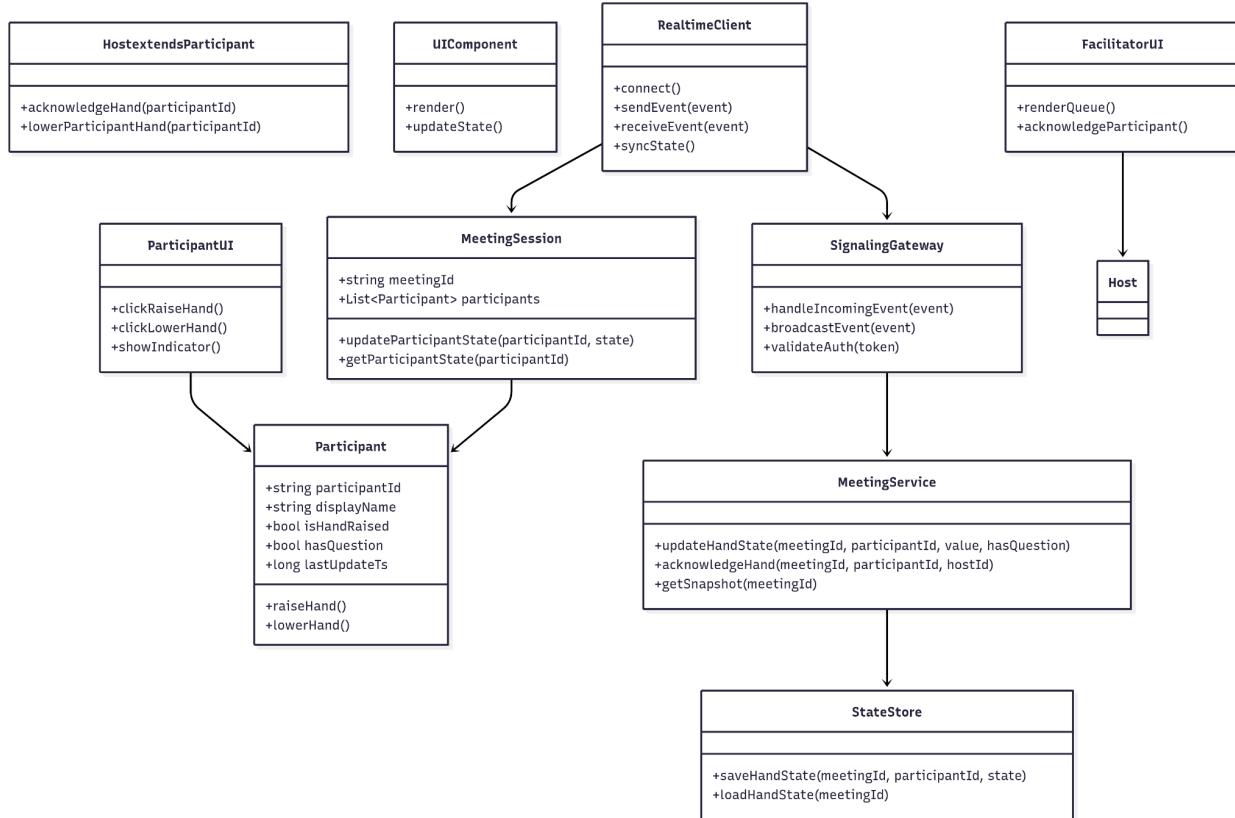
Priority: High

Estimated Development Time: 2-3 sprints

Architecture Diagram



Class Diagram



List of Classes

Client-Side Classes

- **Participant**
Represents an attendee in the meeting.
 - **Attributes:** `participantId`, `displayName`, `isHandRaised`, `hasQuestion`, `lastUpdateTs`.
 - **Methods:** `raiseHand()`, `lowerHand()`.

- **Host (extends Participant)**
Special role with moderation privileges.
 - Methods: `acknowledgeHand(participantId)`, `lowerParticipantHand(participantId)`.
 - **UIComponent (abstract)**
Base class for visual components.
 - Methods: `render()`, `updateState()`.
 - **ParticipantUI (extends UIComponent)**
UI elements for participants to raise/lower hand or ask question.
 - Methods: `clickRaiseHand()`, `clickLowerHand()`, `showIndicator()`.
 - **FacilitatorUI (extends UIComponent)**
Host-facing UI for managing raised hands/questions.
 - Methods: `renderQueue()`, `acknowledgeParticipant()`.
 - **MeetingSession**
Local representation of meeting state.
 - Attributes: `meetingId`, `participants`.
 - Methods: `updateParticipantState()`, `getParticipantState()`.
 - **RealtimeClient**
Manages WebSocket connection and event sync.
 - Methods: `connect()`, `sendEvent(event)`, `receiveEvent(event)`, `syncState()`.
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Server-Side Classes

- **SignalingGateway**
Entry point for client WS connections.
 - Methods: `handleIncomingEvent(event)`, `broadcastEvent(event)`,
`validateAuth(token)`.

- **MeetingService**

Business logic for hand/question state changes.

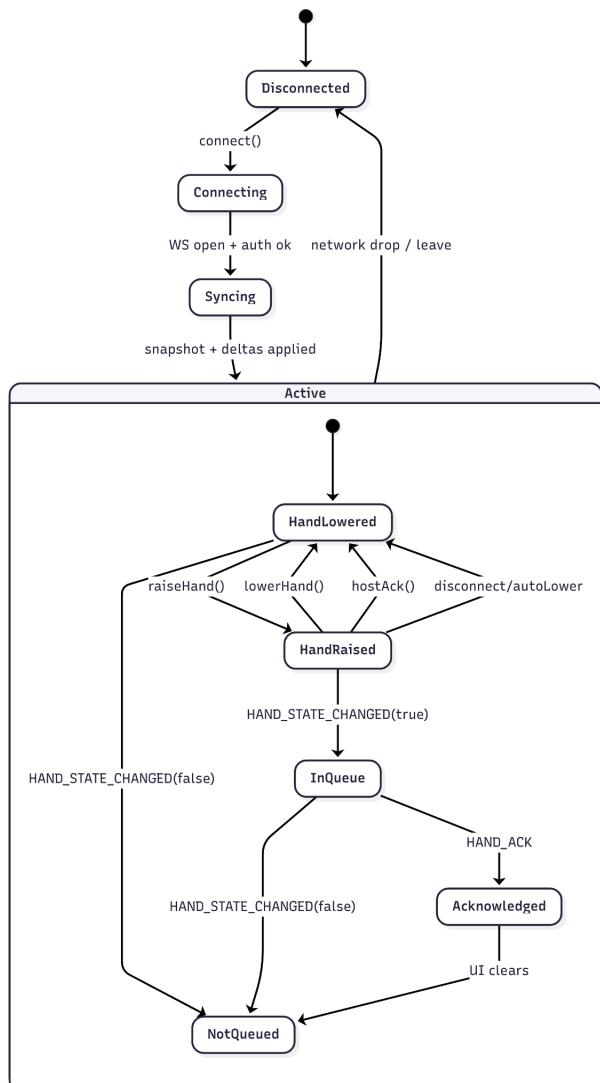
- **Methods:** `updateHandState(meetingId, participantId, value, hasQuestion)`,
`acknowledgeHand(meetingId, participantId, hostId)`,
`getSnapshot(meetingId)`.

- **StateStore**

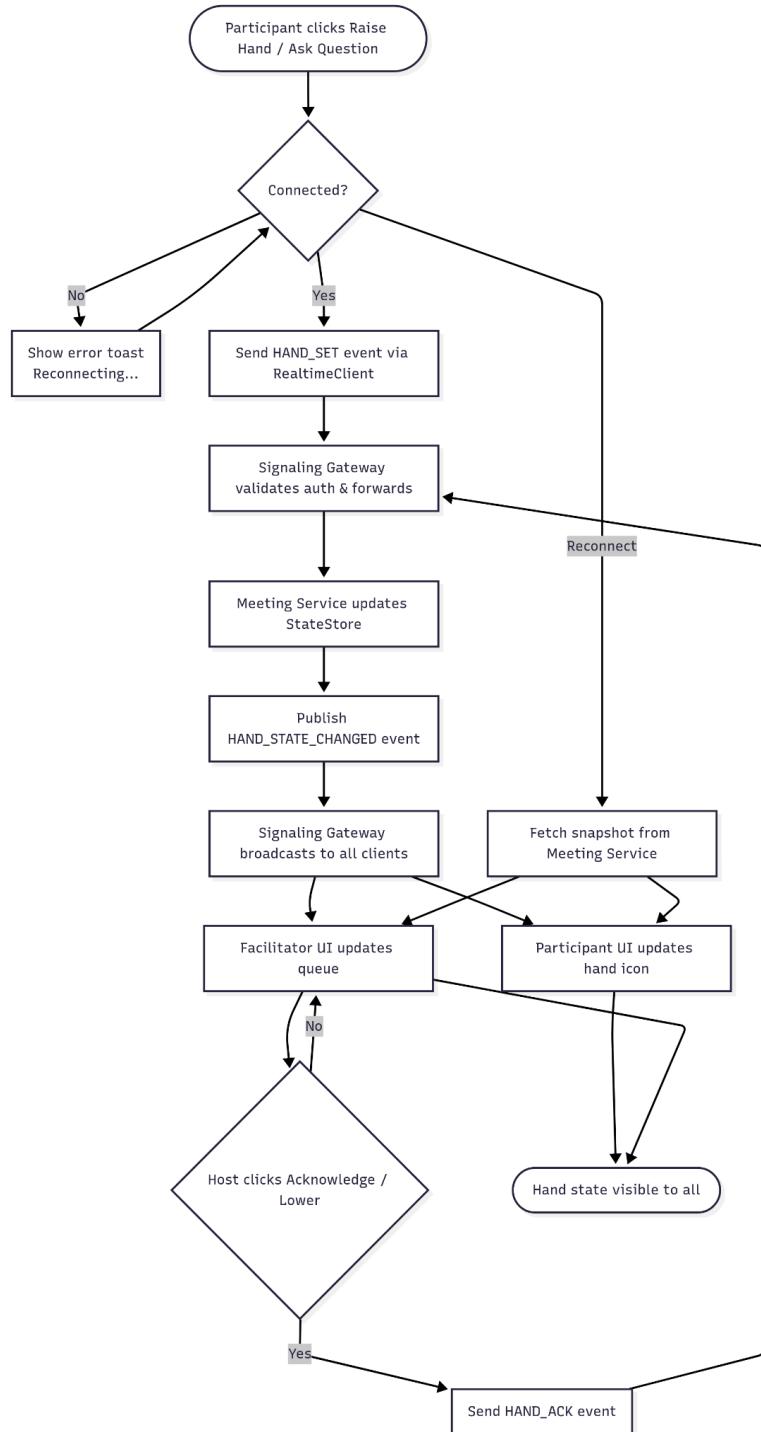
Persists and retrieves hand/question states.

- **Methods:** `saveHandState(meetingId, participantId, state)`,
`loadHandState(meetingId)`.

State Diagrams



Flowcharts



Development Risks and Failures Analysis

Client Layer Component Risks

ParticipantUI / FacilitatorUI

- UI Latency: Indicator updates may appear delayed if rendering is not optimized (e.g., re-rendering entire participant grid instead of diff updates).
- Accessibility Gaps: Missing ARIA live regions or keyboard shortcuts could exclude participants with disabilities.
- Inconsistent UX Across Devices: WebView differences (desktop vs. mobile) may cause mismatched behavior (e.g., tap gestures vs. click).
- Event Storming: Rapid toggling (raise/lower repeatedly) could overwhelm the UI or cause flickering indicators if debouncing is missing.

MeetingSession (local state)

- State Drift: If missed deltas are not reconciled properly during reconnect, a participant's hand state may be wrong until manually refreshed.
- Memory Leaks: Stale participant objects not pruned after disconnects could degrade performance in large meetings.

RealtimeClient

- Connection Drops: Flaky network can leave UI in inconsistent state if retries or snapshot syncs fail.
- Duplicate Events: If retry logic is not idempotent, user may see ghost indicators (e.g., two hands raised for the same participant).
- Cross-Version Compatibility: Older clients may not interpret new event fields (`hasQuestion`, `ackedBy`) correctly, leading to partial functionality.

Server Layer Component Risks

SignalingGateway

- Scaling Bottlenecks: If a single gateway node handles too many concurrent WS sessions, broadcast latency could exceed SLA.
- Auth Validation Lag: Extra auth calls on each event may cause raised-hand signals to delay beyond target latency.
- Fanout Failure: Partial broadcast failures could cause only a subset of clients to receive state updates.

MeetingService

- Ordering Guarantees: If sequence numbers are not strictly monotonic, clients may mis-order events and show wrong queue order.
- Business Logic Errors: Incorrect handling of `HAND_ACK` could leave participant hand stuck in raised state after acknowledgment.
- Snapshot Staleness: If StateStore is not updated atomically, reconnecting clients may receive outdated hand states.

StateStore

- Single Point of Failure: If Redis (or chosen store) fails, the service cannot persist or reload hand states.
- Write Contention: High-frequency raise/lower events could cause race conditions unless updates are atomic.
- TTL Misconfigurations: If states expire too early, raised hands may disappear prematurely.

Event Bus / PubSub

- At-Least-Once Semantics: Duplicate messages can occur without deduplication, leading to repeated hand-raise notifications.
- Dropped Messages: Network partitions between MeetingService and Gateway may silently drop events unless retry logic is robust.

Technology Stack

Client Layer

- **WebView Front-End**
 - **Framework:** React (for rendering participant grid, indicators, and queue panels).
 - **State Management:** Redux or Context API for hand/question state per participant.
 - **Accessibility:** ARIA live regions, keyboard bindings, high-contrast mode.
 - **Transport:** WebSockets via RealtimeClient for event delivery.
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Server Layer

- **SignalingGateway**
 - **Runtime:** Node.js or Go for handling high-concurrency WebSocket connections.
 - **Load Balancer:** Nginx / Envoy for distributing WS sessions.
 - **Protocol:** Secure WebSockets (WSS) with OAuth2 token validation.
- **MeetingService**
 - **Runtime:** Java / Go / Node.js microservice for event processing.
 - **Framework:** gRPC or REST endpoints for control ops; WS events for real-time state.
 - **Logic:** Maintains queue ordering, enforces host permissions, manages acknowledgments.
- **StateStore**
 - **DB Choice:** Redis (in-memory, low-latency) for hand/question state keyed by meetingId.
 - **Schema:** `hand_state:{meetingId} → {participantId, value, hasQuestion, ts}`.

- **Durability:** RDB/AOF persistence enabled to survive restarts.
 - **Event Bus / PubSub**
 - **Option A:** NATS for lightweight, low-latency fanout.
 - **Option B:** Kafka for stronger persistence & replay (if at-scale needed).
 - **Responsibility:** Ensures ordered fanout of HAND_STATE_CHANGED events.
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Cloud & Integration

- **CDN:** CloudFront / Akamai for delivering front-end assets.
- **Auth:** OAuth2 / OpenID Connect provider (used for validating WS tokens).
- **Zoom API Proxy:** Wraps Zoom-like APIs for meeting lifecycle; not extended here.
- **Monitoring:** Prometheus + Grafana for metrics (latency, error rates, event throughput).
- **Logging:** ELK stack (Elasticsearch, Logstash, Kibana) for auditing host actions (e.g., acknowledgments).

APIs

WebSocket Events (Realtime Channel)

Client → Server

1. **HAND_SET**

```
JSON
{
  "type": "HAND_SET",
  "meetingId": "m_123",
```

```
"participantId": "p_456",
  "value": true,           // true = raised, false = lowered
  "hasQuestion": true,    // optional, indicates question intent
  "ts": 1737783000123,
  "idempotencyKey": "hash123"
}
```

2. HAND_ACK (Host only)

```
JSON
{
  "type": "HAND_ACK",
  "meetingId": "m_123",
  "targetParticipantId": "p_456",
  "hostId": "h_789",
  "ts": 1737783000456,
  "idempotencyKey": "hash124"
}
```

Server → Client

1. HAND_STATE_CHANGED

```
JSON
{
  "type": "HAND_STATE_CHANGED",
  "value": true,           // true = raised, false = lowered
  "hasQuestion": true,    // optional, indicates question intent
  "ts": 1737783000123,
  "idempotencyKey": "hash123"
}
```

```

"meetingId": "m_123",
"participantId": "p_456",
"value": true,           // current state
"hasQuestion": false,
"ackedBy": null,        // or hostId if acknowledged
"reason": null,          // "offline" | "manual"
"seq": 1042,
"ts": 1737783000150
}

```

2. SNAPSHOT (on join/reconnect)

```

JSON
{
  "type": "SNAPSHOT",
  "meetingId": "m_123",
  "seqHead": 1042,
  "handState": [
    {"participantId": "p_1", "value": true, "hasQuestion": false, "ts": 1737782999000},
    {"participantId": "p_2", "value": false, "hasQuestion": false, "ts": 1737782998000}
  ]
}

```

REST / gRPC APIs (Server Control Plane)

1. **GET /meetings/{meetingId}/handState**
 - Returns full snapshot of current hand/question states.
 - Used for debug/admin or fallback if WS fails.
 2. **POST /meetings/{meetingId}/participants/{participantId}/hand**
 - Body: { "value": true, "hasQuestion": false }
 - Updates participant's hand/question state (non-realtime path).
 3. **POST /meetings/{meetingId}/participants/{participantId}/ack**
 - Body: { "hostId": "h_789" }
 - Host acknowledgment; clears participant's raised hand.
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Auth & Security

- **All WS events** must include OAuth2 bearer token on connect; validated against meetingId.
- **Host-only actions (HAND_ACK)** require role claim `role: host|cohost`.
- **Rate Limits:**
 - Max 5 raise/lower events per 10 seconds per participant.
 - Host ACK limited to 10 per second.

Public Interfaces

Client-Facing Interfaces

1. Participant UI Controls

- **Button:** *Raise Hand / Lower Hand*

- Toggle control bound to `raiseHand()` / `lowerHand()`.
 - Visible state: icon highlighted when active.
- **Button:** *Ask Question* (optional variant of raise hand)
 - Sets `hasQuestion = true` along with raised state.
- **Indicator:**
 - Hand icon or badge shown on participant's tile.
 - Tooltip: "Raised hand" or "Has a question."
- **Accessibility:**
 - Keyboard shortcut: `Alt+Y` (toggle).
 - ARIA live region: " raised hand."

2. Facilitator (Host) UI Controls

- **Queue Panel:**
 - Ordered list of participants with raised hands.
 - Metadata: participant name, time raised, question flag.
 - **Actions:**
 - *Acknowledge* → clears raised hand, optional toast shown.
 - *Lower Hand* → force clears state.
 - **Indicator:**
 - Count badge (e.g., "3 hands raised").
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Server-Facing Interfaces

1. WebSocket Endpoints

- `wss://<gateway>/realtime?token=<auth>`
 - Input: `HAND_SET`, `HAND_ACK` messages.
 - Output: `HAND_STATE_CHANGED`, `SNAPSHOT` messages.

2. REST Endpoints (optional fallback / admin)

- `GET /meetings/{meetingId}/handState` → JSON snapshot.
 - `POST /meetings/{meetingId}/participants/{id}/hand` → set state.
 - `POST /meetings/{meetingId}/participants/{id}/ack` → host ack.
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External Interfaces

- **Zoom API Proxy**
 - Provides meeting lifecycle (join/leave, auth validation).
 - Not extended for hand-raise logic; only ensures participant/host roles.
- **Monitoring / Logging Dashboards**
 - Prometheus metrics exposed:
 - `hand_event_latency_ms` (p95, p99)
 - `hand_event_error_rate`
 - `active_hands_count` per meeting
 - Logs include: participant actions, host acknowledgments, error traces.

Data Schemas

1. In-Memory / StateStore Schema

Key: hand_state:{meetingId}

Value: Hash/Map of participant hand states

JSON

```
{  
  "participantId": "p_123",  
  "isHandRaised": true,  
  "hasQuestion": false,  
  "ackedBy": null,  
  "lastUpdateTs": 1737783000123  
}
```

- **participantId:** Unique ID of the participant in meeting.
- **isHandRaised:** Boolean flag for raised hand.
- **hasQuestion:** Boolean flag if participant indicates a question.
- **ackedBy:** Host/co-host ID if acknowledgment cleared the hand.
- **lastUpdateTs:** Server-side timestamp of last state change.

2. Event Schema (PubSub / WS Broadcasts)

HAND_STATE_CHANGED Event

JSON

```
{  
  "type": "HAND_STATE_CHANGED",  
  "meetingId": "m_123",  
  "participantId": "p_123",  
  "isHandRaised": true,  
  "hasQuestion": false,  
  "ackedBy": null,
```

```
"reason": null,  
"seq": 1042,  
"ts": 1737783000150  
}
```

SNAPSHOT Event

JSON

```
{  
  "type": "SNAPSHOT",  
  "meetingId": "m_123",  
  "seqHead": 1042,  
  "handState": [  
    {  
      "participantId": "p_123",  
      "isHandRaised": true,  
      "hasQuestion": false,  
      "ackedBy": null,  
      "lastUpdateTs": 1737782999000  
    },  
    {  
      "participantId": "p_456",  
      "isHandRaised": false,  
      "hasQuestion": false,  
      "ackedBy": null,  
      "lastUpdateTs": 1737782998000  
    }  
  ]  
}
```

3. Audit Log Schema (for compliance / debugging)

Stored in persistent DB or log pipeline (not user-facing).

JSON

```
{  
  "logId": "uuid-123",  
  "meetingId": "m_123",  
  "actorId": "h_789",  
  "targetParticipantId": "p_123",  
  "action": "HAND_ACK",  
  "result": "success",  
  "ts": 1737783000456
```

}

4. API Response Schema (REST Fallback)

GET /meetings/{meetingId}/handState

JSON

```
{  
  "meetingId": "m_123",  
  "seqHead": 1042,  
  "participants": [  
    {  
      "participantId": "p_123",  
      "isHandRaised": true,  
      "hasQuestion": false,  
      "ackedBy": null,  
      "lastUpdateTs": 1737782999000  
    },  
    {  
      "participantId": "p_456",  
      "isHandRaised": false,  
      "hasQuestion": false,  
      "ackedBy": null,  
      "lastUpdateTs": 1737782998000  
    }  
  ]  
}
```

Security and Privacy

Authentication & Authorization

- **OAuth2 Access Tokens:**
 - All WebSocket connections require a valid bearer token.
 - Token must include `meetingId`, `participantId`, and `role`.

- **Role Enforcement:**
 - Regular participants can only raise/lower their own hand.
 - Hosts/co-hosts can acknowledge or lower other participants' hands.
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Data Integrity

- **Idempotency Keys:** Prevent duplicate event processing during retries.
 - **Sequence Numbers:** Ensure consistent ordering of `HAND_STATE_CHANGED` events across all clients.
 - **Replay Protection:** Events older than the last known `seq` are discarded by clients.
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Transport Security

- **Encrypted Channels:** All signaling runs over WSS (WebSockets over TLS 1.2+).
 - **HSTS / CSP:** Front-end enforces HTTPS with strong headers to prevent downgrade attacks.
 - **Certificate Management:** Automated rotation (e.g., via Let's Encrypt or internal PKI).
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Privacy Considerations

- **Minimal PII:** Events carry only `participantId` and display name (from existing meeting roster).
- **Ephemeral States:** Hand/question indicators are transient, tied to active meeting only.
- **Audit Logs:** Host acknowledgments are logged with `actorId` and `targetParticipantId` for accountability.

- **Data Retention:** Hand state logs expire after 30 days (configurable), unless retained for compliance.
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Threat Mitigation

- **Flood Control:** Per-participant rate limits (e.g., max 5 hand raises per 10 seconds).
- **Spoofing Prevention:** Tokens signed by Auth service; cannot forge hand events for other participants.
- **Replay Attacks:** Each event timestamp (`ts`) and sequence number (`seq`) validated; stale or duplicate events rejected.
- **Denial of Service:** Gateway enforces connection caps and per-IP throttling.

Risks to Completion

Technical Risks

- **Realtime Reliability:** Achieving sub-500 ms end-to-end latency under load may require careful tuning of WebSocket fanout and Redis writes.
 - **Ordering Guarantees:** Ensuring strict monotonic sequence numbers across distributed meeting service instances could introduce complexity.
 - **Reconnect Sync:** Edge cases in snapshot + delta recovery may leave clients with stale or inconsistent hand states.
 - **Cross-Client Compatibility:** Older or partially updated clients may not recognize `hasQuestion` or `ackedBy` fields, causing divergent UI behavior.
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Integration Risks

- **Dependency on Auth Service:** Delays or failures in OAuth2 token validation can block event flow.
 - **Interaction with Zoom API Proxy:** If participant roles are not synced correctly, a user may gain or lose acknowledgment privileges incorrectly.
 - **Event Bus Backpressure:** If PubSub queues lag, broadcasts may be delayed or dropped.
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Delivery Risks

- **Limited Testing at Scale:** Without large test meetings (100–300 participants), concurrency bugs may only surface in production.
 - **Mobile WebView Variability:** Differences in how Android/iOS handle WebSocket reconnections could cause inconsistent experience.
 - **Accessibility Gaps:** If ARIA live regions or shortcuts are not fully tested, feature may fail accessibility audits.
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Resource & Timeline Risks

- **Redis Persistence Tuning:** Enabling durability may affect latency; requires dedicated ops time.
- **Operational Overhead:** Additional monitoring and alerting pipelines may not be ready by release.
- **Team Familiarity:** If the team lacks prior experience with high-concurrency WS systems, learning curve may extend delivery.

LLM Chat Log: <https://chatgpt.com/share/68d47b28-bc90-800b-84ec-279a63113a33>