# Problem Statement 14

## Octant-Based IP Geolocation via AIORI Active Measurements

Reference: Anchor on IETF IPPM: framework RFC 2330, one-way delay RFC 7679, loss RFC 7680, RTT RFC 2681; active probes OWAMP/TWAMP/STAMP (RFC 4656/5357/8762); path discovery ICMPv4/v6 & extensions (RFC 792/4443/4884);

**Objective**

Build an **Octant algorithm–driven IP geolocation module** inside **AIORI's Active Measurement Portal** that estimates an IP's physical location by **triangulating network delays** from multiple vantage points and continuously refining the feasible region on the map.

**Background**

Static IP-to-location databases are often stale or coarse. **Active probing (RTT/trace) from diverse vantage points** yields **distance bounds** that, when intersected, can localize an IP with higher accuracy. The **Octant approach** iteratively partitions the search space (sectors/"octants") and prunes regions inconsistent with measured delay constraints, converging to a high-confidence area.

**Problem**

Design and implement a system that:

1. **Collects measurements** from distributed AIORI nodes (ICMP/TCP ping and Paris-traceroute).
2. **Converts RTTs to distance bounds** (calibrated speed-of-propagation + fixed overhead) and **intersects annuli** from ≥3 vantage points.
3. Runs an **Octant solver** that partitions the globe (or regional bounding box) into sectors and iteratively **eliminates infeasible sectors** using:
    - Delay constraints (upper/lower bounds, percentile filtering),
    - Path hints from traceroute (last public hop, IXP/PoP heuristics).
4. **Outputs a geo-estimate** (lat/long) with **confidence region** and **error bars**, and renders it on the Portal map in real time.

**Required Components**

- **Data Plane**
    - Measurement orchestrator (selects vantage sets, rate-limits probes, retries, time-sync sanity).
    - RTT modeling: percentile selection (e.g., P10/P20) to reduce queuing bias; per-link/base-delay calibration.
- **Octant Geolocator**
    - Sectorization & pruning loop (spherical geometry).

    - Constraint intersection (annulus/sector overlap → convex region / polygon).
    - Confidence scoring (region area, constraint consistency, traceroute corroboration).

- **Portal Integration (UI/API)**
    - Map overlay with feasible region, centroid, and confidence radius.
    - Drill-downs: raw probes, traceroute paths, calibration constants.
    - REST/GraphQL endpoint to request a geolocate job and fetch results.

**Data & Validation**

- **Ground truth set**: known servers (RIPE Atlas anchors, campus PoPs, AIORI nodes).
- **Metrics**: median error distance (km), 90p error, time-to-fix (s), probe budget (#/target), stability under load.
- **A/B**: baseline DB lookup vs. Octant estimator; show improvement and failure modes (e.g., satellite paths, CGNAT, anycast).

**Deliverables**

- Containerized **microservice** (collector + solver + API) and a **Portal UI module**.
- **Reproducible dataset** (sample targets + measurements).
- **Report**: methodology, calibration, accuracy, costs, and limitations.

**Evaluation Criteria**

- **Accuracy**: median/90p error vs. ground truth; robust under congestion variance.
- **Efficiency**: probes per estimate; runtime; caching of prior paths.
- **Engineering**: clear code, configs, README; safe rate limits; privacy safeguards.
- **UX**: intuitive map, confidence visuals, explainable results.
- **Insights** (bonus): anycast detection flags; path-aware calibration; regional bias analysis.