TEAM 007

SMART COMMUTE: a Computer Vision Enabled Bus Routing and Scheduling System in Dhahran and Al Khobar

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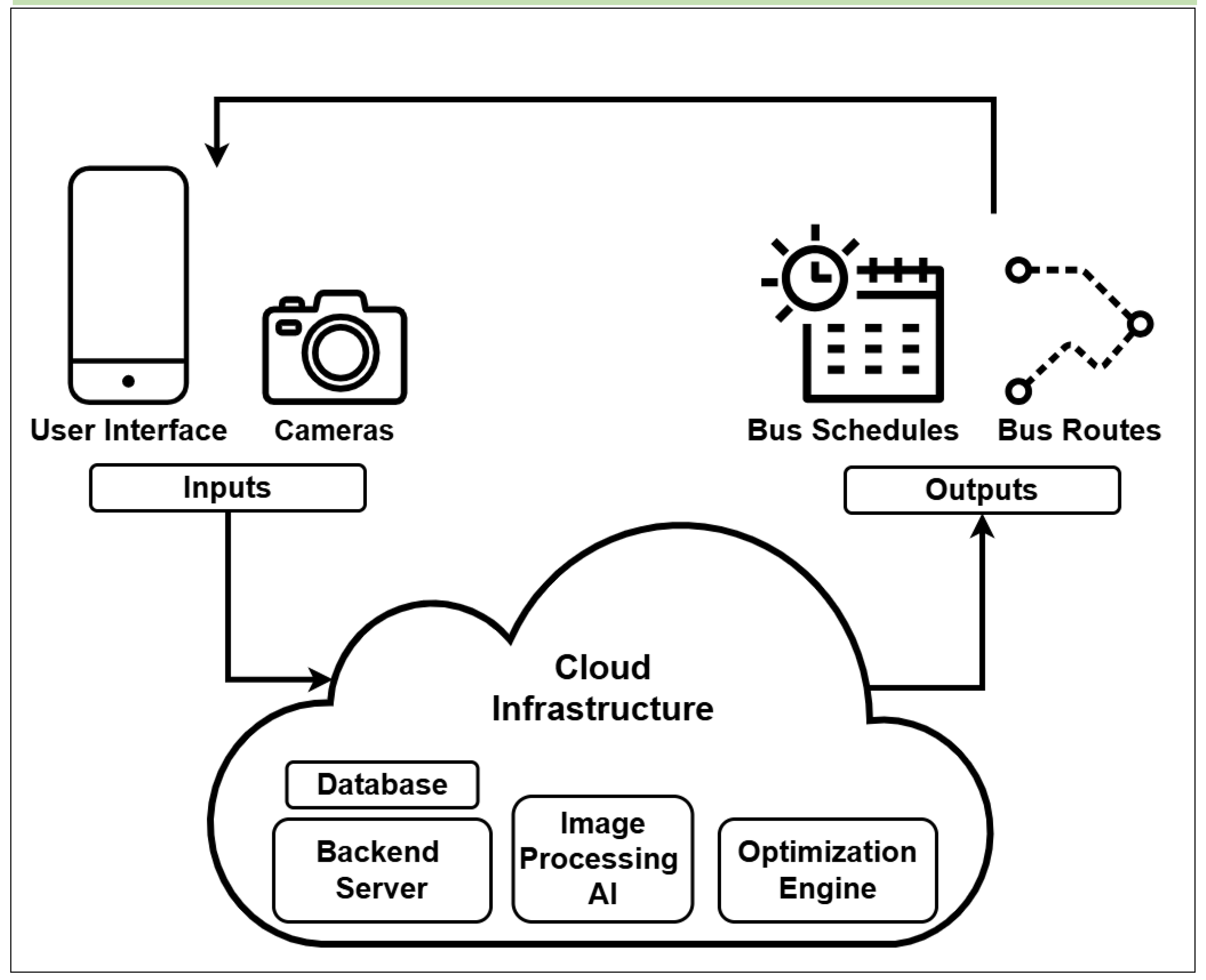
Introduction

Despite major investments, public transportation in Dhahran and Al Khobar remains under-optimized, resulting in long waits, inefficient routes, and low seat utilization. Smart Commute addresses this by uniting computer vision, AI, and mathematical optimization on a secure private cloud to deliver real-time, data-driven routing and scheduling. Riders receive personalized trip recommendations, while agencies gain optimized schedules and fleet allocations—reducing costs, improving service quality, and supporting sustainable mobility.

Prototype Design



Constraints

The system must stay privacy-preserving, inclusive, and responsive while meeting strict limits on time, capacity, and computing resources. It must deliver reliable service across a constrained network, handle model inaccuracies, maintain security through fast token revocation and log retention, and ensure the mobile app performs smoothly on lower-end devices.

Specifications

- Supports 100% resource scaling to expand from a single-host prototype by adjusting parameters.
- Handles 10+ API requests per second without performance degradation.
- Recomputes routes within 10 seconds when new data arrives.
- Uses RBAC + ABAC with authorization latency < 500 ms on average and < 1000 ms at peak.
- Mobile app cold-starts in < 5 seconds and screen transitions in < 500 ms on Android and iOS.
- Object detection model achieves ≥ 75% precision in good lighting and ≥ 65% precision in low-light.
- Weekly re-optimization ensures 80%+ service level under changing conditions.
- Accessibility features expand usability to an additional 5–7% of users.
- 90%+ of services are containerized for portability and easier scaling.
- Mean Time to Recovery (MTTR) is ≤ 30 minutes per node after failure.
- Optimization uses 10+ variables (e.g., time of day, demand, traffic, station sequence).
- Enforces key service constraints: ≤ 30 min wait time, ≤ 30 min travel time, > 10% capacity utilization, and > 90% disabled-seat availability.
- All routing inputs must pass automated validation and refresh every 24 hours to avoid stale data.

Creativity & Novelty

- Benchmarking the Top 100 Cities in the 2024 Oliver Wyman Urban Mobility Rankings: only 2 use CV + modeling + dynamic scheduling, 6 update schedules with AI weekly, and 22 lack AI data.
- Our system is novel by delivering a real-time, fully dynamic schedule, unlike global leaders that use AI only for long-term planning.
- Combines, AI, heuristic optimization, into a unified cloud platform.

Testing & Validation

- Demand Simulation: 1,000 scenarios showed 92% of users waited <15 min, 100% <30 min, with 100% disabled accommodation.
- Computer Vision: YOLOv8 achieved 98.6% accuracy in well-lit scenes and 95% in low-light.
- Optimization Engine: Routing computed in 0.35s, with full API-triggered updates in 150 ms.
- Backend Testing: Sustained 210 req/s with zero errors; authorization averaged 187 ms; full system recovery in 22s.

Conclusion

Testing confirmed that Smart Commute delivers the real-time performance needed to improve transit efficiency: routing updated in under a second, computer vision maintained high accuracy across conditions, the backend handled heavy load reliably, and the mobile app performed smoothly on lower-end devices. These results validate the system's ability to support responsive, data-driven operations that reduce waiting times and improve overall service quality.