SECTION 11.
INFORMATION TECHNOLOGIES AND SYSTEMS

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ONLINE ROUTE REPLANNING UNDER CHANGING CONSTRAINTS AND PRIORITIES IN DYNAMIC TRANSPORT ENVIRONMENTS

Real-time transport routing systems depend on constant changes such as link failures, demand spikes, vehicle failures, regulatory restrictions, and the activation of priority tasks that render prior plans invalid [1]. Complete re-optimization from scratch is inefficient computationally for large networks operating in very tight time windows, and simple local repair heuristics give us solutions far away from optimal because a knock-on effect works its way into interdependent routes [2]. Towards this end, an online replanning scheme was introduced in this work to promptly update a route system that already contains existing components when scenarios change dynamically based on real-time data, with the goal of doing replanning 10–50 × faster than full replanning per solution with solution quality within 4% of the global optimum [3].

Dynamic events influencing transport routing have various features and call for variable replanning strategies. Disruptions to the links (like road closures and capacity reductions) also necessitate affected vehicles rerouting while allowing unaffected segments intact. Task shuffling across vehicles due to demand changes of new requests and cancellations. Vehicles state changes, such as mechanical failures, lead to decreased fleet capacity and a redistribution of load. New constraints introduced by regulatory changes may be limiting current routes [5]. Different event types must be recognized by the replanning framework, with specialized detection, impacts and response generators.

The following replanning architecture uses a hierarchical event processing pipeline in prioritizing the incoming events based on immediate urgency and scope

[6]. In emergency conditions with immediate response, reactive replanning is generated using pre-computed contingency plans within seconds. Tactical events with responsiveness windows of minutes use incremental optimization whereby affected route segments are altered while the unaffected segment is amended; an optimization process with 10–50 times faster than complete re-optimization will be obtained. Strategic events with longer horizons may launch background enhancements without disturbance in operations that can be performed by using strategic events with longer-horizon [7]. Aggregation batches for events aggregate in batches of closely-spaced events to prevent oscillatory replanning behavior.

Dependency analysis with incremental constraint processing allows the minimal range of routes to be identified as affected with regards to dependent on each related subset which has some aspect and a reduced amount of system problem space to handle the loss of affected segments and then re-optimize them [8]. Priority management assigns numerical scores based on urgency, economic value, and safety criticality, with automatic escalation as deadlines approach. Stability mechanisms including solution distance penalties, commitment horizons, and hysteresis thresholds reduce unnecessary plan changes by 65% while sacrificing only 2.1% of theoretical optimality [9].

Experimental validation on a 3000-node network with 200 vehicles processing an average of 15 events per minute demonstrates average solution quality within 3.8% of offline optimal with replanning latency of 340 milliseconds [10]. When compared to the periodical full re-optimization at 5-minute intervals, the realized performance shows 11% better. Stress testing to burst scenarios as well as to 50+ simultaneous disruptions verifies graceful degradation, where the latency increases to 1.2 seconds but the feasibility is preserved.

This research shows online replanning enables effective real-time adaptation of routing solutions with hierarchical event processing and incremental constraint management in dynamic transport environments. Compared to the re-optimization, the proposed framework allows replanning speed 10–50x faster, while keeping the solution quality and operational stability of near-optimal results, establishing online replanning as critical aspect of an automated routing decision system for the large-scale dynamic transport networks.

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