ABSTRAK

Abstrak—Traveling Salesman Problem (TSP) menghadirkan tantangan komputasi signifikan akibat ekskalasi eksponensial ruang pencarian. Penelitian ini mengevaluasi performa algoritma *Branch and Bound* (B&B) berbasis *Reduced Cost Matrix* (RCM) yang dikombinasikan dengan strategi *Least Cost Search* (LCS) untuk memitigasi ledakan kombinatorial. Melalui metodologi *stress testing*, efektivitas mekanisme *pruning* dianalisis pada berbagai dimensi kota. Hasil simulasi menunjukkan bahwa integrasi RCM dan LCS berhasil mencapai solusi optimal global dengan efisiensi pemangkasan yang menekan eksplorasi ruang status hingga $0{,}000005\%$ pada skala $n = 17$. Secara empiris, penelitian ini mengidentifikasi bahwa skalabilitas metode eksak tersebut terkendala oleh limitasi memori fisik (*hardware-bound limitation*) dalam mengelola *Priority Queue*, yang menyebabkan saturasi sistem saat mencapai skala $n = 17$. Temuan ini menegaskan bahwa batas skalabilitas praktis metode deterministik tidak hanya bergantung pada ketajaman fungsi *bounding*, melainkan juga pada kapasitas *resource* komputasi dalam mengakomodasi *live nodes*. Penelitian ini memberikan kontribusi berupa parameterisasi limitasi algoritma dalam optimasi rute berskala makro.

Kata Kunci: *Branch and Bound*, *Reduced Cost Matrix*, *Least Cost Search*, Ruang Pencarian, Efisiensi Algoritma, Kapasitas Komputasi.

ABSTRACT

Abstract—The Traveling Salesman Problem (TSP) presents a significant computational challenge due to the exponential escalation of its search space. This research evaluates the performance of the *Branch and Bound* (B&B) algorithm, utilizing a *Reduced Cost Matrix* (RCM) combined with a *Least Cost Search* (LCS) strategy to mitigate combinatorial explosion. Through a stress-testing methodology, the effectiveness of the algorithm's pruning mechanism is analyzed across various city dimensions. Simulation results demonstrate that the integration of RCM and LCS consistently achieves global optimal solutions, with pruning efficiency suppressing status space exploration to 0.000005% at the $n = 17$ scale. Empirically, this study identifies that the scalability of this exact method is constrained by hardware-bound memory limitations in managing the *Priority Queue*, leading to system saturation at the $n = 17$ scale. These findings confirm that the practical scalability limit of deterministic methods is determined not only by the acuity of the bounding function but also by the computational resource capacity to accommodate live nodes. This study provides a precise parameterization of algorithmic limitations for macro-scale route optimization.

Keywords: *Branch and Bound*, *Reduced Cost Matrix*, *Least Cost Search*, Search Space, Algorithmic Efficiency, Computational Capacity.