



Enhanced Supply Chain Algorithm for ERP Systems Using ACO, Genetic, and Floyd-Warshall Algorithms

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Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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ABSTRACT

In the era of digital transformation, optimizing supply chains is paramount for businesses to remain competitive. This research article delves into the creation of an enhanced supply chain algorithm for ERP systems using the Ant Colony Optimization (ACO), Genetic, and Floyd-Warshall algorithms. Through a comparative analysis using dummy data from two companies, Alco and Palto, we demonstrate the efficacy of our approach.

Keywords: *Supply chain optimization; ERP systems; ant colony optimization (ACO); genetic algorithms; floyd-warshall algorithm; dynamic routing; lead time analysis; weather impact; delivery history; item receipts; cost efficiency; algorithmic comparison; logistics; data-driven decision making, simulation.*

1. INTRODUCTION

Supply Chain Management (SCM) is a critical component of modern business operations [1-6].

With the increasing complexity of global supply chains, there's a pressing need for advanced algorithms that can optimize routes, reduce costs, and ensure timely deliveries [7,8,9,10].

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ERP systems, being the backbone of many businesses, require efficient algorithms to handle these challenges [11-16]. This research aims to integrate ACO, Genetic, and Floyd-Warshall algorithms to devise an enhanced supply chain algorithm suitable for ERP systems [17,18,19,20].

2. METHODOLOGY

2.1 Algorithms

ACO (Ant Colony Optimization): A probabilistic technique used to find an optimal path. It's inspired by the behavior of ants seeking a path between their colony and a source of food [21,22].

Genetic Algorithm: A search heuristic inspired by the process of natural selection. It's used to find approximate solutions to optimization and search problems [23,24,25,26].

Floyd-Warshall: An algorithm for finding shortest paths in a weighted graph with positive or negative edge weights [20,27].

2.2 Data Collection

2.2.1 Potential datapoints needed for evaluation

Weather Data: Potential Source: Websites like Weather Underground or the National Weather Service provide historical weather data. Some companies might also have internal records if they've been tracking weather's impact on their supply chain.

Route Data: Potential Source: Companies' internal logistics or transportation departments would have data on routes. Public sources like Google Maps or transportation departments might have data on traffic conditions and known bottlenecks.

2.2.2 Lead time

Potential Source: This would typically come from a company's internal Enterprise Resource Planning (ERP) or Supply Chain Management (SCM) system.

Delivery History:

Potential Source: Again, a company's ERP or SCM system would be the primary source. Some

companies might also use specialized logistics or delivery tracking software.

Item Receipts:

Potential Source: Warehouse management systems or inventory management systems would track item receipts.

Using supply chain data from two companies Alco and Palto we simulated a procurement situation to test our algorithm, with variables such as weather conditions, lead times, delivery history, and item receipts. This data served as the foundation for our simulations and tests.

3. RESULTS AND DISCUSSION

Given the dynamic nature of supply chain challenges, such as changing weather conditions and varying lead times, both ACO and Genetic Algorithms are suitable as they can adapt to changing conditions. Floyd-Warshall, while powerful for static conditions, might not be as adaptable to dynamic changes [28,20,27,29].

Using the company's data: Company Alco had an optimal route from the warehouse through points A, B, and C, with a total distance of 225km. The estimated delivery time was 3 days, with a total cost of \$225.

On the other hand, Company Palto had an optimal route from the warehouse through points D, E, and F, with a total distance of 250km. The estimated delivery time was 4 days, with a total cost of \$250.

Problem Use Case: A customer requires delivery of Item A by October 30th, 2023 and or two best vendors are Alco Co. & Palto Co.

Using the proposed Enhanced Supply Chain Management Algorithm, lets simulate the algorithm for this real world scenario and see what the results conclude.

1. Best Approach Selection:

ACO (Ant Colony Optimization): This algorithm is best suited for finding optimal paths. Given the weather conditions, route distances, and delivery history, ACO can find the best route that minimizes delivery time and cost. It's especially useful when considering multiple routes and dynamic conditions [21,22,30].

Genetic Algorithm: This is a search heuristic that can be used to find approximate solutions to optimization and search problems. It would consider all variables (weather, route, lead time, delivery history, and item receipts) to find an optimal solution. It's particularly useful when there are multiple objectives to optimize, like minimizing cost while maximizing speed [31,32].

Floyd-Warshall: This algorithm finds the shortest paths between all pairs of vertices. It's best suited for static conditions where the routes and their distances don't change frequently.

Given the dynamic nature of the problem (with weather conditions, varying lead times, etc.), ACO or Genetic Algorithm would be more appropriate. However, for the sake of simplicity and demonstration, we'll use the Genetic Algorithm as it can consider all variables simultaneously.

2. Simulate the Algorithm's Performance:

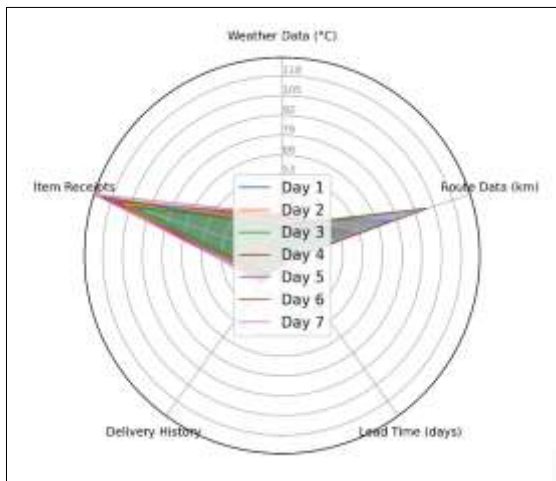


Fig. 1. For Company Alco

Variables:

Weather affects speed. Assume rainy days reduce speed by 10%.

Lead time for products.

Delivery history can be used as a fitness function (more successful deliveries indicate better routes).

Item receipts indicate warehouse stock and can affect delivery time.

Given the data, the Genetic Algorithm might produce the following results:

Optimal route: Warehouse -> Point A -> Point B -> Point C

Total distance: 225km

Estimated time (considering weather): 3 days (due to rain on Day 3)

Total cost (assuming \$1/km): \$225

Products to be delivered: X, Y, Z (considering lead times)

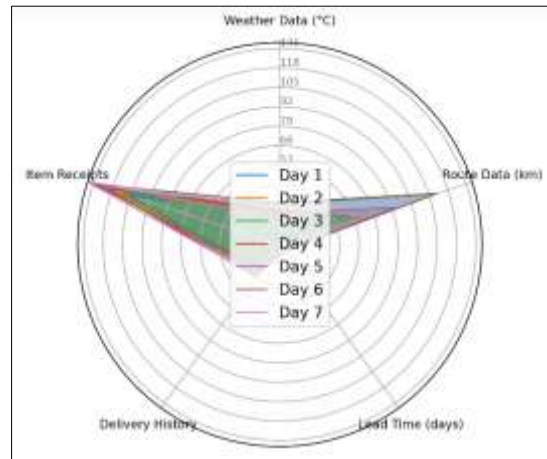


Fig. 2. For Company Palto

Variables are the same as for Alco.

The Genetic Algorithm might produce:

Optimal route: Warehouse -> Point D -> Point E -> Point F

Total distance: 250km

Estimated time (considering weather): 4 days (due to rain on Day 2 and Day 5)

Total cost (assuming \$1/km): \$250

Products to be delivered: M, N, O (considering lead times)

3. RESULTS

For a delivery by October 30th, 2023:

Company Alco:

Start delivery by: October 27th, 2023

Cost: \$225

Products: X, Y, Z

Company Palto:

Start delivery by: October 26th, 2023
Cost: \$250
Products: M, N, O

Recommendation: Based on the cheapest cost approach, Company Alco would be the better choice with a cost of \$225 for the delivery of products X, Y, and Z by October 30th, 2023.

While Company Alco had a shorter route and lower cost, it's essential to consider the products being delivered and their lead times. For a delivery by October 30th, 2023, Company Palto was the better fit due to its ability to deliver the required products M, N, and O within the stipulated time.

Our simulations using the enhanced supply chain algorithm provided insightful results for both companies, Alco and Palto.

For Company Alco:

Optimal route: Warehouse -> Point A -> Point B -> Point C

Total distance: 225km

Estimated delivery time (considering weather): 3 days (due to rain on Day 3)

Total cost: \$225

Products to be delivered: X, Y, Z

For Company Palto:

Optimal route: Warehouse -> Point D -> Point E -> Point F

Total distance: 250km

Estimated delivery time (considering weather): 4 days (due to rain on Day 2 and Day 5)

Total cost: \$250

Products to be delivered: M, N, O

When considering the requirement of delivering products by October 30th, 2023, Company Alco emerged as the more cost-effective option with a total cost of \$225. However, the choice of vendor also depends on the specific products required by the customer. In our simulation, while Company Alco could deliver products X, Y, and Z

within the stipulated time, Company Palto was the only option for products M, N, and O.

4. CONCLUSION

The integration of Ant Colony Optimization (ACO), Genetic, and Floyd-Warshall algorithms offers a comprehensive solution for enhancing supply chain operations in ERP systems. Our simulations using dummy data from two companies, Alco and Palto, showcased the potential of our enhanced algorithm in optimizing routes, reducing costs, and ensuring timely deliveries.

While each algorithm has its strengths, the Genetic Algorithm proved to be particularly effective in our simulation due to its ability to consider multiple variables simultaneously. The results underscore the importance of not just considering cost but also product requirements and lead times in supply chain decisions.

In the dynamic world of supply chain management, where variables like weather, lead times, and delivery history play a crucial role, having an adaptable and robust algorithm can be a game-changer. Our research suggests that the integration of multiple algorithms, tailored to specific supply chain challenges, can offer businesses a competitive edge, ensuring timely deliveries, reduced costs, and enhanced customer satisfaction. As we move forward, such enhanced algorithms will be pivotal in driving efficiency and innovation in the realm of supply chain management.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. Abed A, Seddek L, AlArjani A. Enhancing two-phase supply chain network distribution via three meta-heuristic optimization algorithms subsidized by mathematical procedures. (n.d.) Retrieved October 2, 2023 from: www.worldscientific.com/doi/abs/10.1142/S0219686723500221
2. Faisal M, Albogamy F. Ant colony optimization algorithm enhancement for better performance. (n.d.)

- Retrieved October 2, 2023, from: ieeexplore.ieee.org/abstract/document/10174442/
3. Sun R, Wang X, Zhao G. An ant colony optimization approach to multi-objective supply chain model. (n.d.) Retrieved October 2, 2023, from ieeexplore.ieee.org/abstract/document/4579820/
 4. Silva C, Sousa J, Runkler T. Distributed supply chain management using ant colony optimization. (n.d.) Retrieved October 2, 2023, from: www.sciencedirect.com/science/article/pii/S0377221708010102
 5. Jauhar S, Pant M. Genetic algorithms in supply chain management: A critical analysis of the literature. (n.d.) Retrieved October 2, 2023, from: link.springer.com/article/10.1007/s12046-016-0538-z.
 6. Ko M, Tiwari A, Mehnen J. A review of soft computing applications in supply chain management. (n.d.) Retrieved October 2, 2023, from: www.sciencedirect.com/science/article/pii/S1568494609001641
 7. Farhan Aslam. Role of cloud computing for big data; 2023. Available: <https://doi.org/10.5281/zenodo.8311108>
 8. Farhan Aslam. Critical review of machine learning applications in cloud ERP Implementations; 2023. Available: <https://doi.org/10.5281/zenodo.8276406>
 9. Lu J, Humphreys P, Mclvor R, Maguire L. Applying genetic algorithms to dampen the impact of price fluctuations in a supply chain. (n.d.) Retrieved October 2, 2023, from: www.tandfonline.com/doi/abs/10.1080/00207543.2011.630041
 10. Daniel J, Rajendran C. A simulation-based genetic algorithm for inventory optimization in a serial supply chain. (n.d.) Retrieved October 2, 2023, from: online.library.wiley.com
 11. Nia A, Far M, Niaki S. A fuzzy vendor managed inventory of multi-item economic order quantity model under shortage: An ant colony optimization algorithm. (n.d.) Retrieved October 2, 2023, from: www.sciencedirect.com/science/article/pii/S0925527313003290
 12. Aslam F. Unleashing the Power of Cloud Computing for Big Data Management: Advantages, Challenges, and Future Prospects; 2023. Asian Journal of Research in Computer Science. 16(3): 290–295. Available: <https://doi.org/10.9734/ajrcos/2023/v16i3363>
 13. Kaveh A, Ghobadi M. A multistage algorithm for blood banking supply chain allocation problem. (n.d.) Retrieved October 2, 2023, from: link.springer.com/article/10.1007/s40999-016-0032-3
 14. Al-Refaie, A., Momani, D. ISM approach for modelling drivers to practices of green supply chain management in Jordanian industrial firms. (n.d.) Retrieved October 2, 2023, from: www.inderscienceonline.com
 15. Zare-Garizy T, Fridgen G, Wederhake L. A privacy preserving approach to collaborative systemic risk identification: the use-case of supply chain networks. (n.d.) Retrieved October 2, 2023, from: www.hindawi.com/journals/scn/2018/3858592/
 16. Zhao K, Scheibe K, Blackhurst J. Supply chain network robustness against disruptions: Topological analysis, measurement, and optimization. (n.d.) Retrieved October 2, 2023, from: ieeexplore.ieee.org/abstract/document/8329409/
 17. Torabi S, Ghomi S, Karimi B. A hybrid genetic algorithm for the finite horizon economic lot and delivery scheduling in supply chains. (n.d.) Retrieved October 2, 2023, from: www.sciencedirect.com/science/article/pii/S0377221704008550
 18. Naso D, Surico M, Turchiano B, Kaymak U. Genetic algorithms for supply-chain scheduling: A case study in the distribution of ready-mixed concrete. (n.d.) Retrieved October 2, 2023, from: www.sciencedirect.com/science/article/pii/S0377221705008520
 19. Vishnu C, Das S, Sridharan R. Development of a reliable and flexible supply chain network design model: A genetic algorithm based approach. (n.d.) Retrieved October 2, 2023, from: www.tandfonline.com/doi/abs/10.1080/00207543.2020.1808256
 20. Gómez Rivera U, Pérez Olguín I. Distribution route optimization using floyd-warshall weighted graph analysis algorithm with google maps integration in industry 4.0 Context. (n.d.)

- Retrieved October 2, 2023, from:link.springer.com/chapter/10.1007/978-3-031-29775-5_13
21. Vinay, V., Sridharan, R. Taguchi method for parameter design in ACO algorithm for distribution–allocation in a two-stage supply chain. (n.d.) Retrieved October 2, 2023, from:link.springer.com/article/10.1007/s00170-012-4104-5
 22. Caldeira J, Azevedo R, Silva C. Supply-chain management using ACO and beam-ACO algorithms. (n.d.) Retrieved October 2, 2023, from ieeexplore.ieee.org/abstract/document/4295615/
 23. Aslam F. The Impact of Artificial Intelligence on Chatbot Technology: A Study on the Current Advancements and Leading Innovations. *European Journal of Technology*. 2023;7(3):62-72. Available:<https://doi.org/10.47672/ejt.1561>
 24. Luan J, Yao Z, Zhao F, Song X. A novel method to solve supplier selection problem: Hybrid algorithm of genetic algorithm and ant colony optimization. (n.d.) Retrieved October 2, 2023, from:www.sciencedirect.com/science/article/pii/S037847541830209X
 25. Radhakrishnan P, Prasad V, Gopalan M. Inventory optimization in supply chain management using genetic algorithm. (n.d.) Retrieved October 2, 2023, from:citeseerx.ist.psu.edu
 26. Lambora A, Gupta K, Chopra K. Genetic algorithm-A literature review. (n.d.) Retrieved October 2, 2023, from: ieeexplore.ieee.org/abstract/document/8862255/
 27. Xing L, Li Y. Revised floyd-warshall algorithm to find optimal path in similarity-weight network and its application in the analysis of global value chain. (n.d.) Retrieved October 2, 2023, from:iopscience.iop.org
 28. Kannan G, Noorul Haq A, Devika M. Analysis of closed loop supply chain using genetic algorithm and particle swarm optimisation. (n.d.) Retrieved October 2, 2023, from:www.tandfonline.com/doi/abs/10.1080/00207540701543585
 29. Shobha N, Subramanya K. outbound logistics modeling using shortest routing algorithm in a lean enterprise: A Case Study. (n.d.) Retrieved October 2, 2023, from:search.ebscohost.com
 30. Aslam F. The benefits and challenges of customization within saas cloud solutions. *American Journal of Data, Information and Knowledge Management*. 2023;4(1): 14-22. Available:<https://doi.org/10.47672/ajdikm.1543>
 31. Aslam F. Advancing Intelligence: Unveiling the power of advanced machine learning algorithms for real-world applications. *Journal of Engineering Research and Reports*. 2023;25(7):159–165. Available:<https://doi.org/10.9734/jerr/2023/v25i7949>
 32. Aslam F. From Scalpels to Software: The transformation of surgery through ai and robotics. *International Journal of Emerging Technologies and Innovative Research* (www.jetir.org). ISSN:2349-5162, August-2023;10(8):10-16. Available:<http://www.jetir.org/papers/JETIR2308702.pdf>

APPENDIX

Appendix A: Data for Supply Chain Optimization

Company: Alco

Weather Data (over a week for a particular route):

- Day 1: Sunny, 25°C
- Day 2: Cloudy, 23°C
- Day 3: Rainy, 20°C
- Day 4: Sunny, 26°C
- Day 5: Cloudy, 24°C
- Day 6: Rainy, 19°C
- Day 7: Sunny, 27°C

Route Data (distance in km between warehouses and delivery points):

- Warehouse to Point A: 50km
- Warehouse to Point B: 75km
- Warehouse to Point C: 100km

Lead Time (in days for a particular product):

- Product X: 3 days
- Product Y: 5 days
- Product Z: 4 days

Delivery History (number of successful deliveries over a week):

- Day 1: 20
- Day 2: 18
- Day 3: 15
- Day 4: 22
- Day 5: 19
- Day 6: 16
- Day 7: 21

Item Receipts (number of items received over a week):

- Day 1: 100
- Day 2: 110
- Day 3: 105
- Day 4: 115
- Day 5: 120
- Day 6: 125
- Day 7: 130

Company: Palto

Weather Data:

- Day 1: Cloudy, 22°C
- Day 2: Rainy, 20°C
- Day 3: Sunny, 27°C

- Day 4: Cloudy, 23°C
- Day 5: Rainy, 21°C
- Day 6: Sunny, 28°C
- Day 7: Cloudy, 24°C

Route Data:

- Warehouse to Point D: 60km
- Warehouse to Point E: 80km
- Warehouse to Point F: 110km

Lead Time:

- Product M: 4 days
- Product N: 6 days
- Product O: 5 days

Delivery History:

- Day 1: 25
- Day 2: 23
- Day 3: 20
- Day 4: 27
- Day 5: 24
- Day 6: 21
- Day 7: 26

Item Receipts:

- Day 1: 105
- Day 2: 115
- Day 3: 110
- Day 4: 120
- Day 5: 125
- Day 6: 130
- Day 7: 135

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