Chapter 21. Order Picking Systems

21.1. Introduction

Reasons for Order Picking

Buffer Between Production and Demand

Consolidation of Products into a Single Shipment

Exploitation of Transportation Cost Differentials

Response Time Reduction

Order Picking Characteristics

Most Expensive Component of Warehousing

Increased Throughput, Storage, Response Times, and Accuracy Requirements

50 % of Picking Time is Traveling time

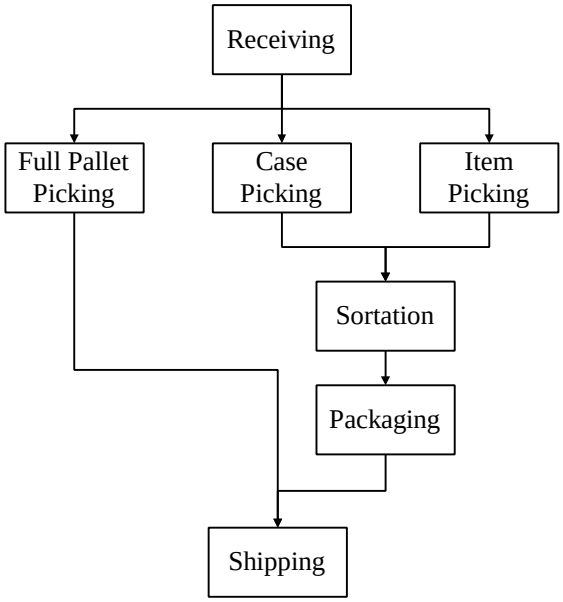

Figure 21.1. Order Picking Systems Schematic

Order Picking Equipment Classes

Automatic

- A Frame

Picker-To-Part

- Bin Shelving, Gravity Flow Rack, Drawers
- Person-Aboard, Order Picking Truck

Part-To-Picker

- Carousel (Horizontal and Vertical)
- Miniload

Figure 21.2. Automatic Order Picking A-Frame
(Picture courtesy of Electrocom)

Figure 21.3. Manual Order Picking from Bin Shelves (Picker-To-Part)
(Photo Courtesy of John Bartholdi)

Figure 21.4. Order Picking Carousel (Part-To-Picker)

21.2. Order Picking in the Aisle

Introduction to Order Picking in the Aisle

Figure 21.5. Order Picking in the Aisle Example

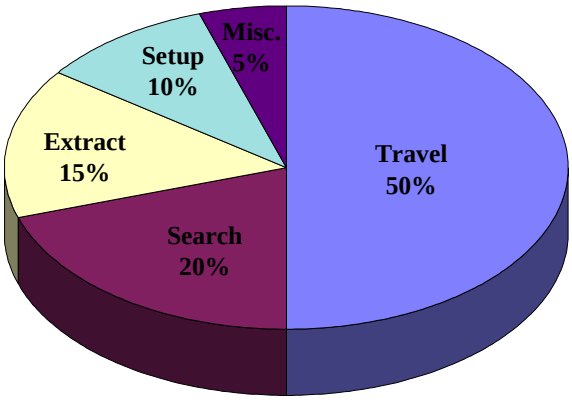

Figure 21.6. Order Picking in the Aisle Cost Breakout

Order Picking in the Aisle Characteristics

Person-To-Part

Walking Time Dominant

Determine Picking Sequence

Objective = Maximal Throughput

Within an Aisle and Between Aisles

Figure 21.7. Quantity LED Displays on Shelves (Pick-To-Light) (Photo Courtesy of AutoPick)

Picking Density

The ratio of the number of locations to be visited for this order divided by the total number of locations in the aisle

Order Picking in Ladder Warehouses

Ladder Warehouse Characteristics

Figure 21.8. Bin Shelving in a Ladder Arrangement

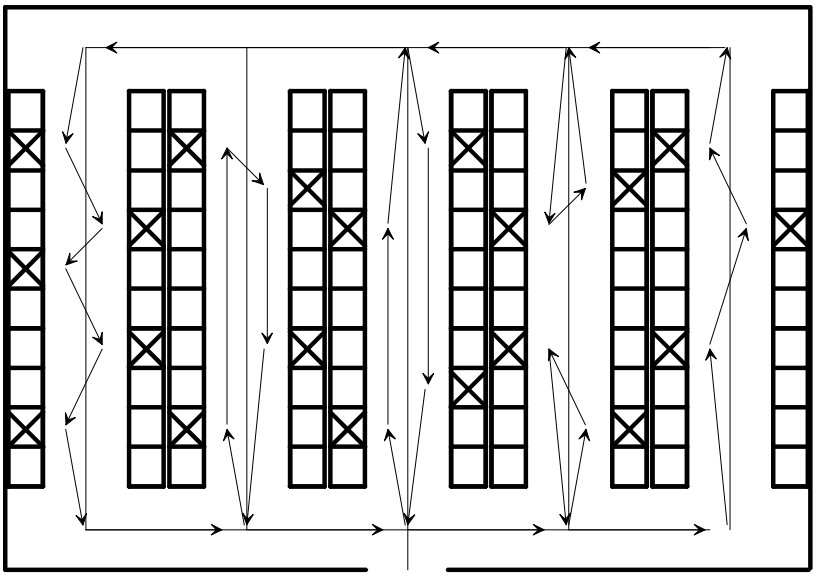

Figure 21.9. Ladder Warehouse Schematic

Set of Parallel Aisles

All Aisles Have Equal Length

Bottom and Top Cross Aisles

Multiple Ladder Blocks

Ladder Warehouse Tour Types

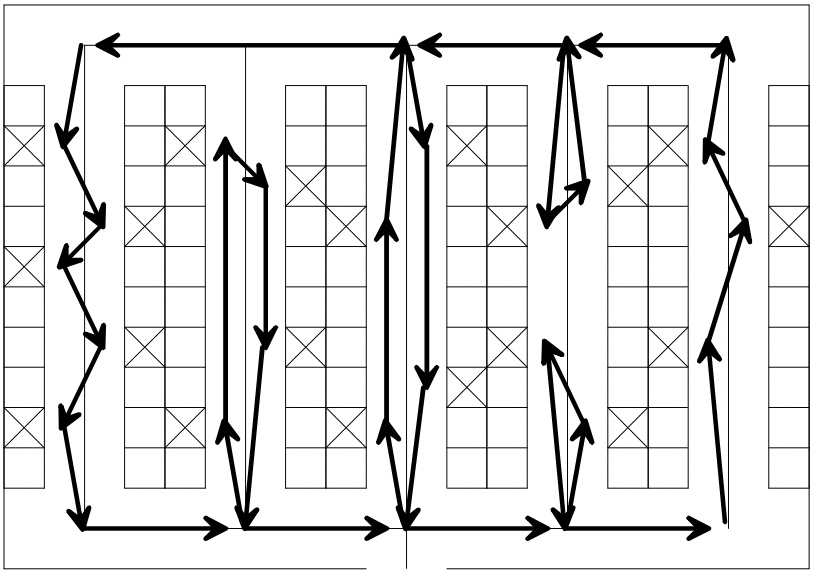

Figure 21.10. Tour Types in a Ladder Warehouse

Traversal

Return (Top or Bottom)

Split Traversal

Split Return

Z-Pick Tour Pattern

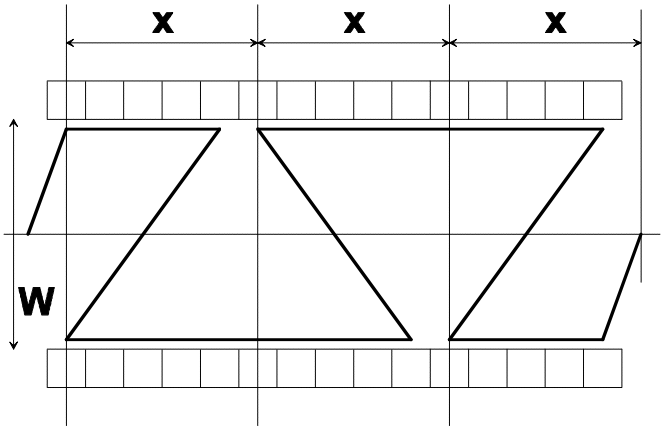

Figure 21.11. Z-Pick Travel in an Aisle Schematic

Variable

- Shorter Travel Time
- Always Different Paths

Fixed

- Longer Travel Time
- Constant Picking Path

Optimal Z-Pick Pattern

$$z^* = \frac{w^2 + 1}{2} \tag{21.1}$$

Aisle Order Picking Conclusions

In the Aisle Conclusions

Z-Pick is 12 % Longer

Best Return is 23 % Longer

Use Traversal Unless

- Picking Density > 50 %
- Turnover Based Storage

Between the Aisle Conclusions

Optimal Mix of Traversal and Return

All Traversal

- Random Storage
- Narrow Aisles
- 2 % Error unless Very Sparse

All Return

- Strongly Turnover Based Storage

Combined In and Between the Aisle Conclusions

Very Low Order Densities

- Optimal Between Aisles
- Mixed Traversal and Return

Very High Densities of Strong ABC

- All Return Between Aisles
- Bottom Return

Intermediate Order Densities

- All Traversal Between Aisles
- In Wide Aisles Use Z-Pick

21.3. Clustering Order Picking Items in the Aisle to a Vehicle

Introduction

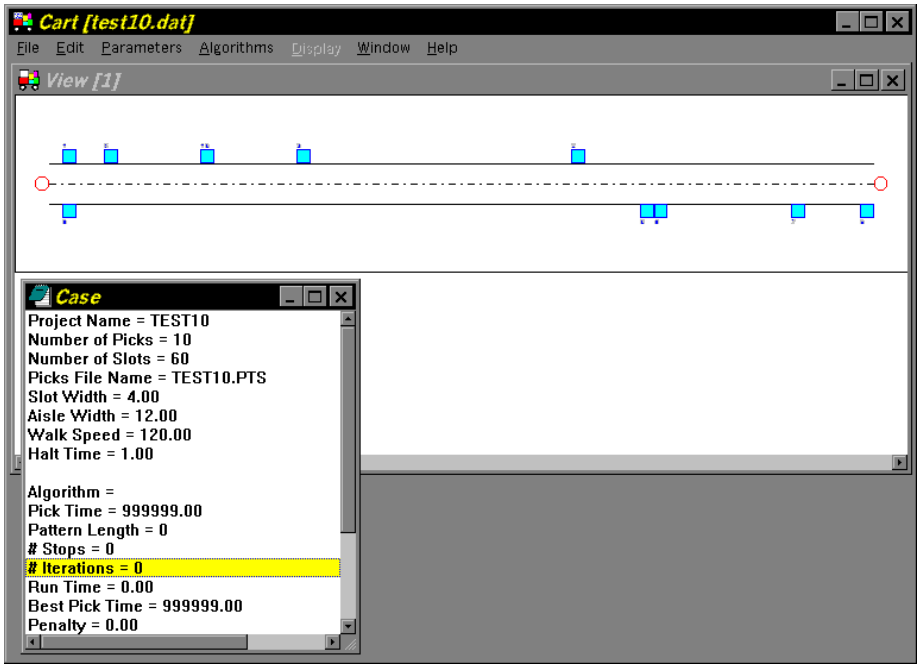

Figure 21.12. Clustering to a Vehicle Example Data

Single Stop Schematic

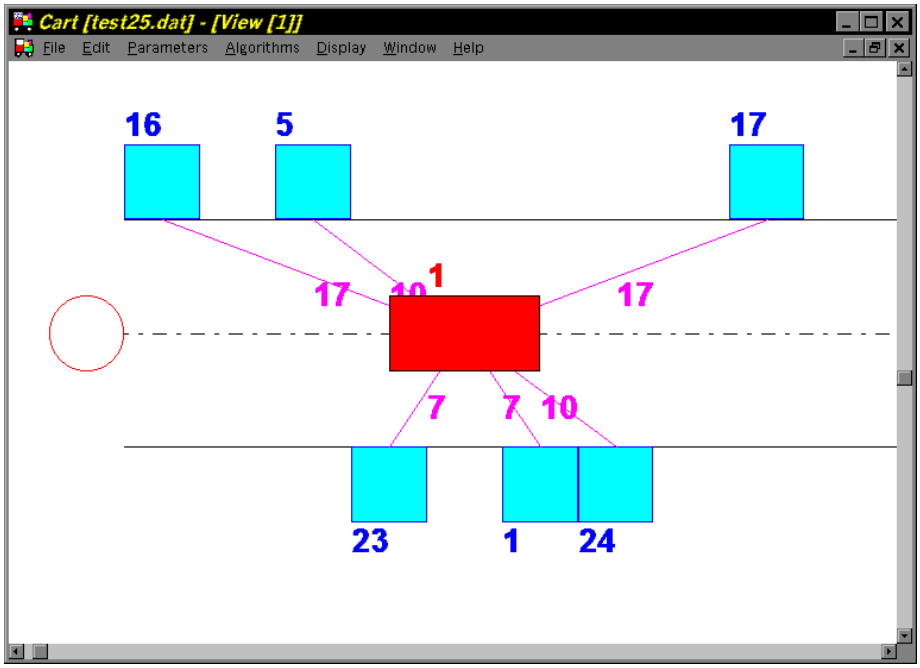

Figure 21.13. Clustering to a Vehicle Single Stop Schematic

Characteristics

Items on Both Sides of the Aisle

Vehicle Drives on Center Line

Walking Time versus Stopping Time

Number, Location, and Allocation of Stops

Figure 21.14. Typical Vehicles for Clustering Items in an Aisle

Figure 21.15. Order Picking in the Aisle to a Vehicle Example

Figure 21.16. Example of Order Picking in the Aisle to a Vehicle with Double Pallet Trailer

Order Picking Patterns

Fixed versus Variable Patterns

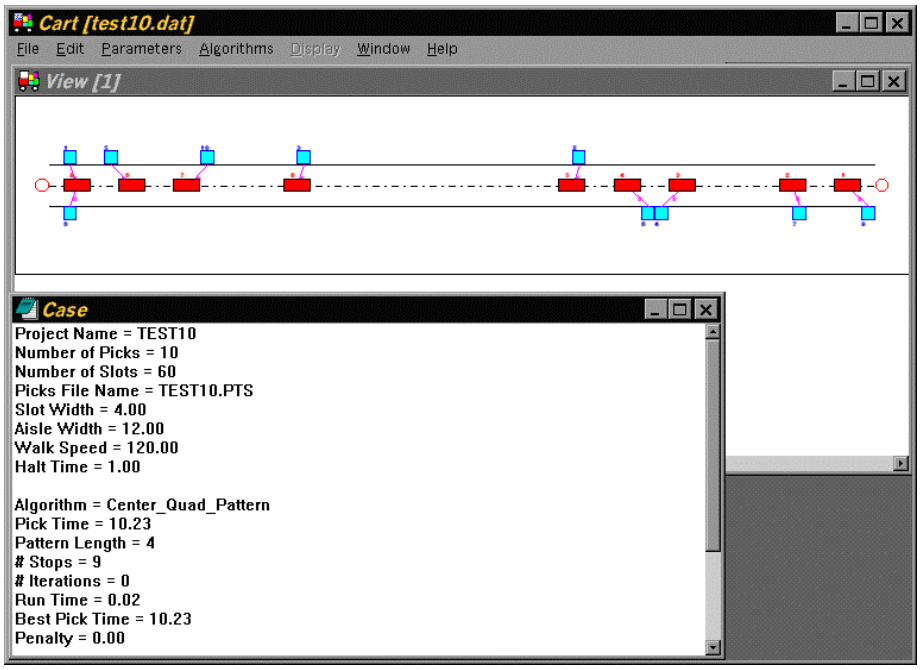

Figure 21.17. Clustering to a Vehicle Quad Pattern Stops

Pattern = All Locations for One Stop

Variable Pattern

- Shorter Picking Time
- Always Changing

Fixed Pattern

- Constant for All Orders
- Optimal Pattern for a Density

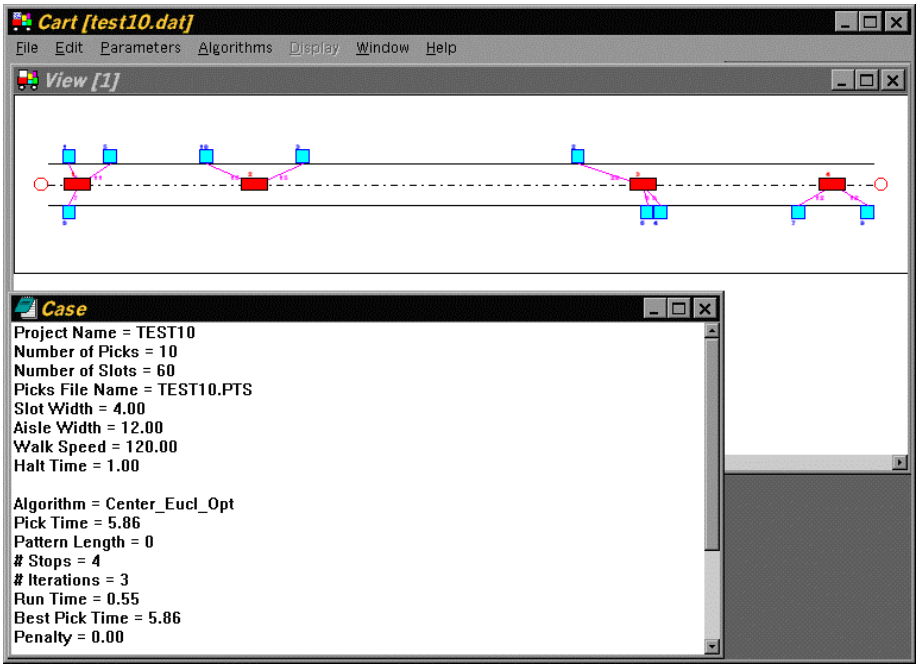

Figure 21.18. Clustering to a Vehicle Optimal Euclidean Stops

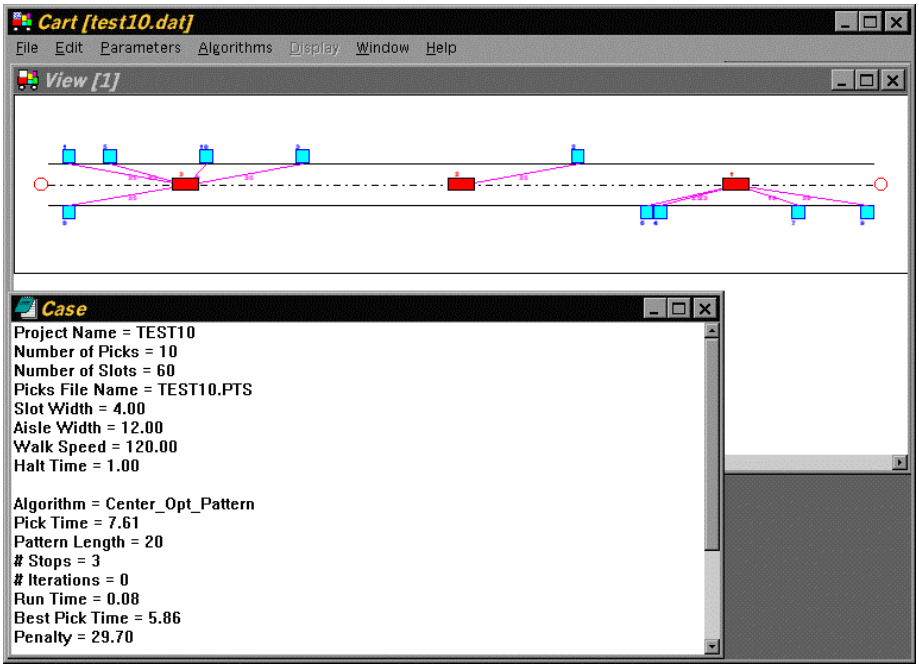

Figure 21.19. Clustering to a Vehicle Optimal Pattern Stops

Comparison of Patterns

Optimal Fixed Pattern is 13 % Longer

Quad Pattern is 48 % Longer

Clustering Conclusions

Quad Pattern Too Many Stops

Optimal Fixed Pattern Good for Constant Density

Variable Pattern Good For

- Computer Controlled
- Variable Density

21.4. Person-Aboard Order Picking

Introduction

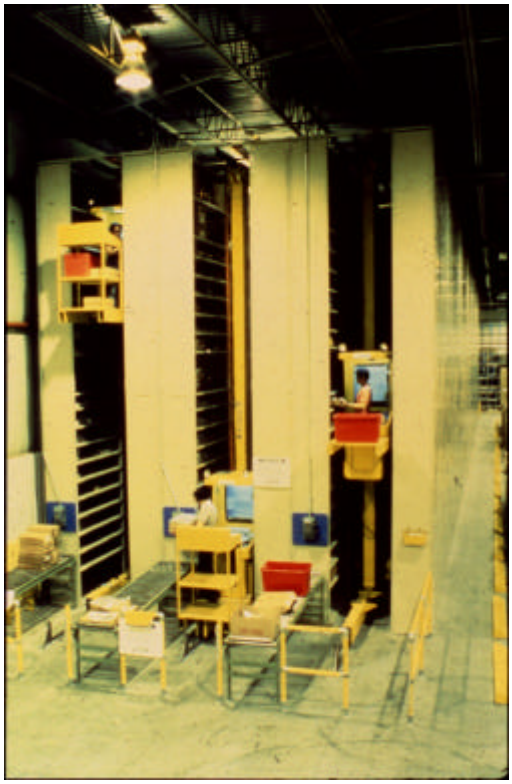

Figure 21.20. Person-Aboard Example

Figure 21.21. Person-Aboard Inside the Aisle View

Figure 21.22. Person-Aboard Order Picking Truck Example

Single Aisle

Simultaneous or sequential travel with Chebyshev or rectilinear travel time, respectively.

$$t^C = \max\left\{\frac{\Delta_x}{v_x}, \frac{\Delta_y}{v_y}\right\} \tag{21.2}$$

$$t^R = \left|\frac{\Delta_x}{v_x}\right| + \left|\frac{\Delta_y}{v_y}\right| \tag{21.3}$$

$$S = \max\left\{\frac{L}{v_x}, \frac{H}{v_y}\right\} \tag{21.4}$$

$$b = \frac{\min\left\{\frac{L}{v_x}, \frac{H}{v_y}\right\}}{S} \tag{21.5}$$

"Square-In-Time" are racks with a shape factor b equal to one.

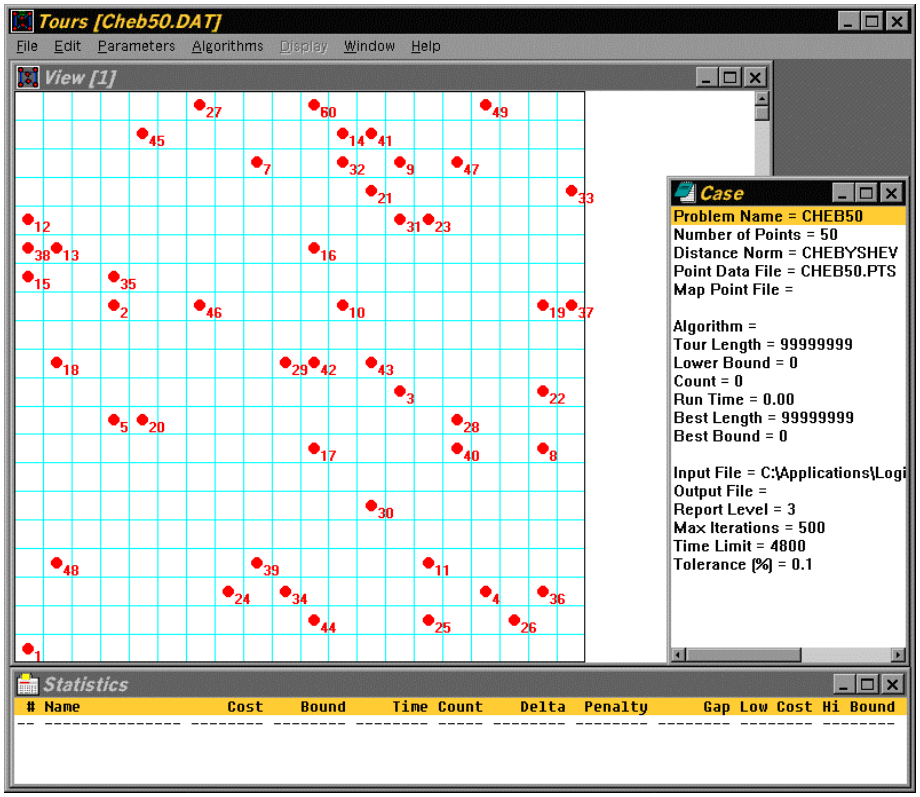

Figure 21.23. TOURS Person-Aboard Example Problem

Order Picking Tours

Common Tour Types

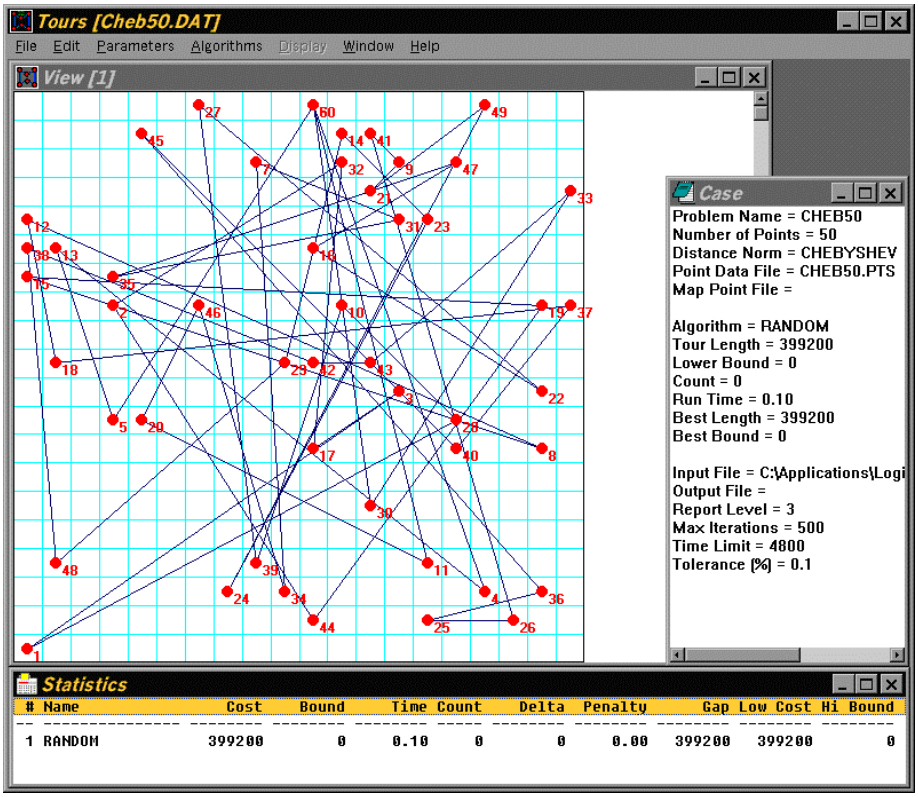

Figure 21.24. TOURS Random Sequence Tour Illustration

Out and Back (2 Strip)

Nearest Neighbor

Exchange Improvement

- 2 Opt
- 3 Opt

Convex Hull

Band

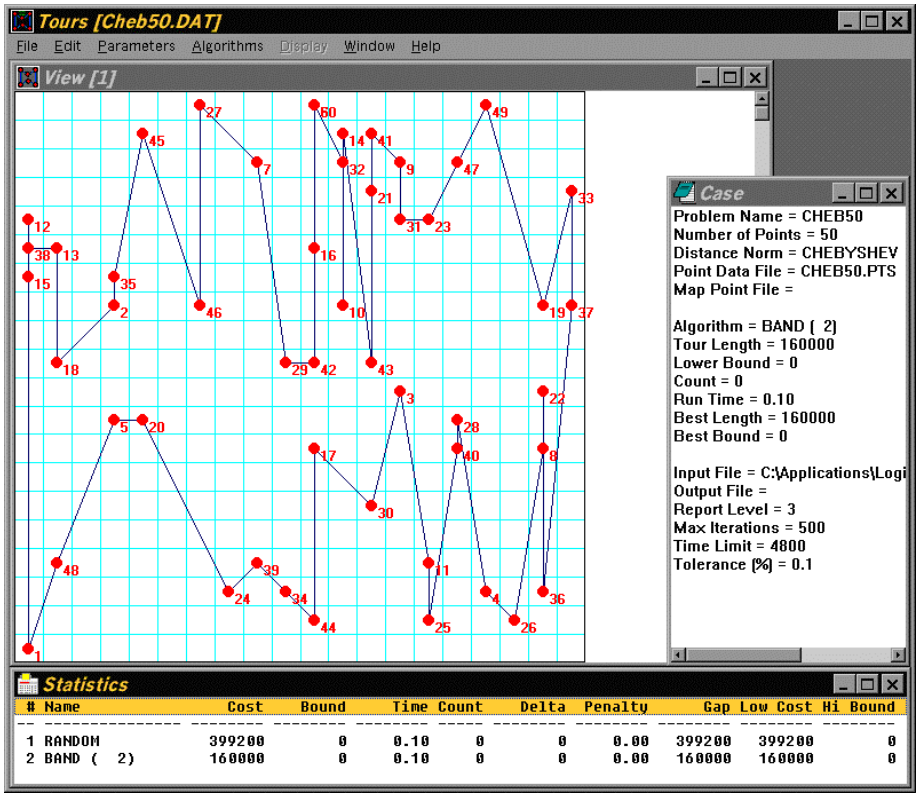

Figure 21.25. TOURS 2 Band or Out-and-Back Sequence Tour Illustration

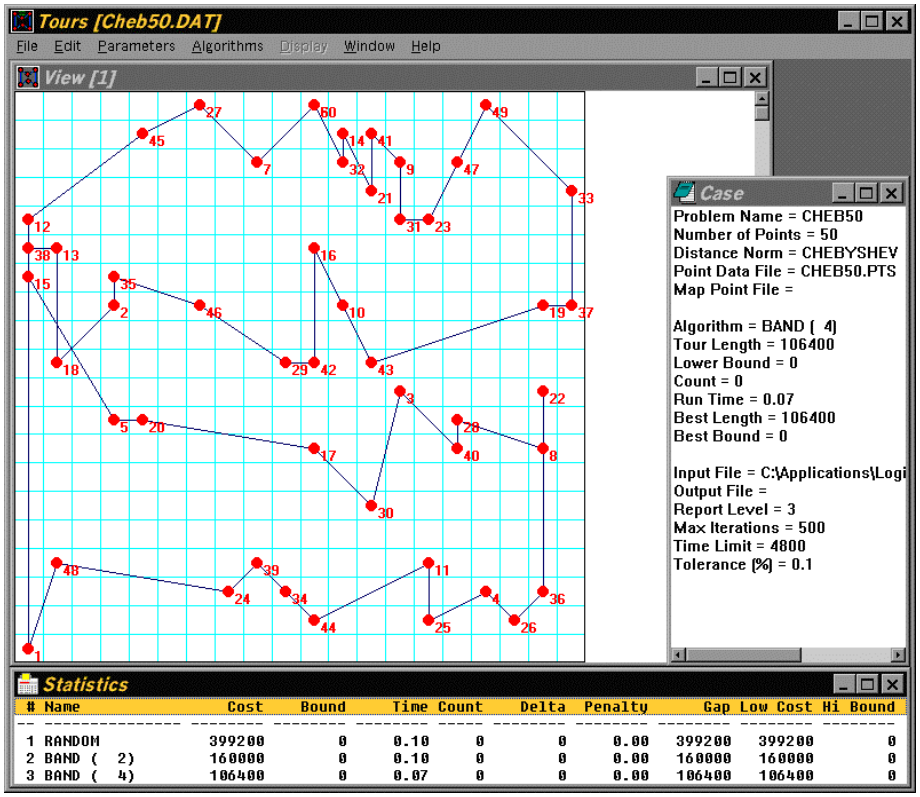

Figure 21.26. TOURS 4 Band Sequence Tour Illustration

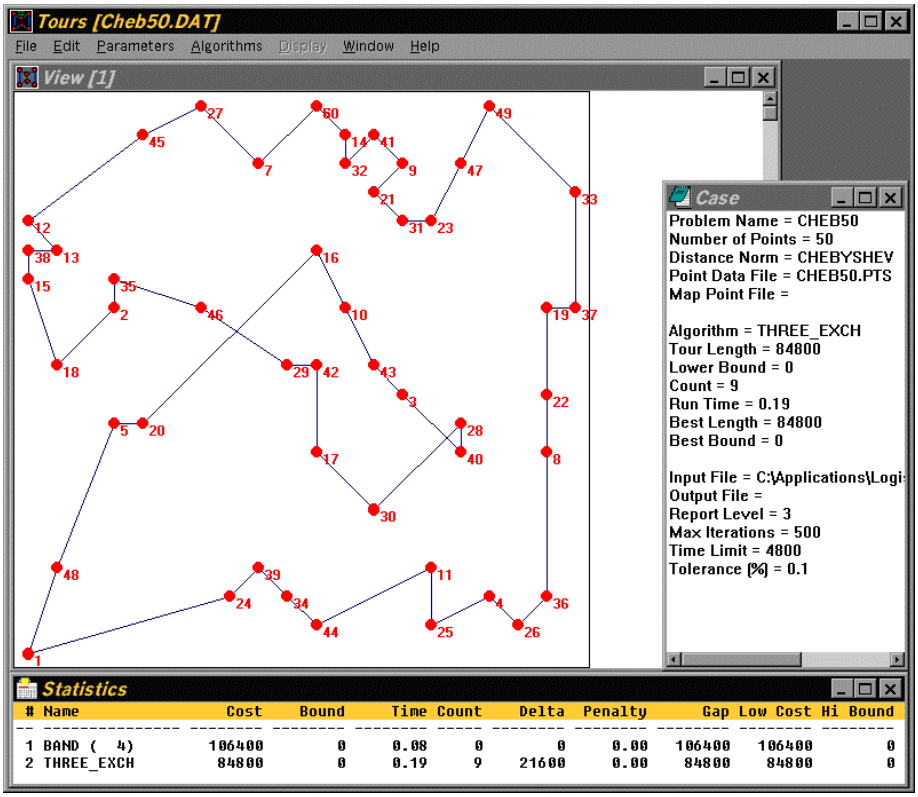

Figure 21.27. TOURS Local Improvement 3 Opt Tour Illustration

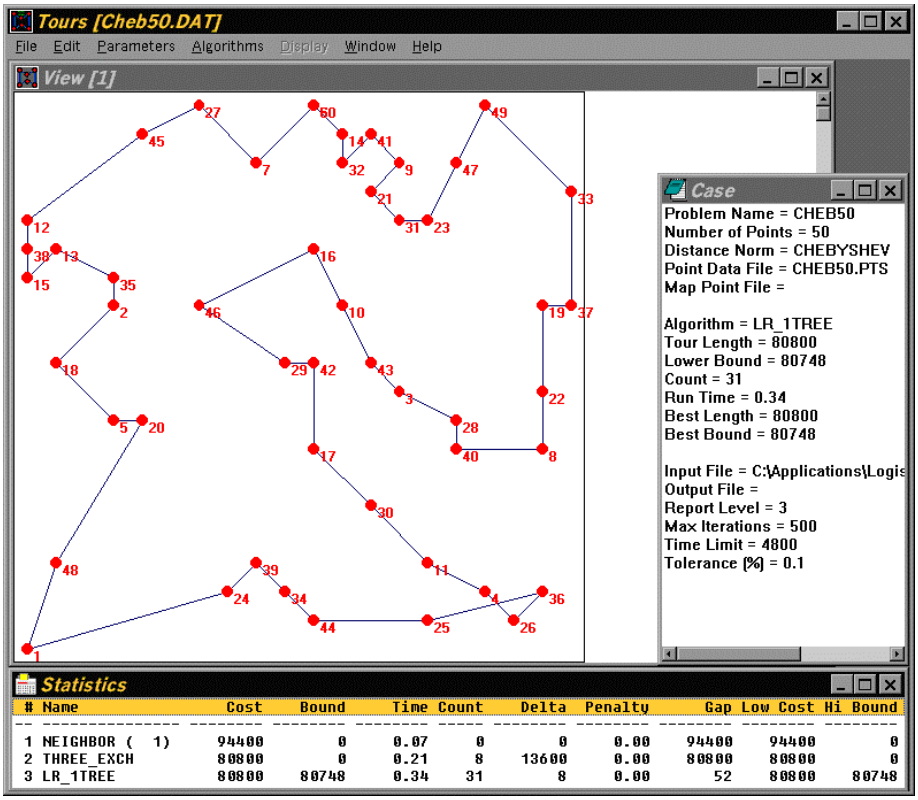

Figure 21.28. TOURS Lower Bound Tour Illustration

Tour Type Comparison

Higher Density = Harder Problem

Squarer Rack = Harder Problem

2 Strip has 13 % longer travel time.

Person-Aboard Conclusions

Improvement Step is Required

Band Heuristic Preferred (Easy, Fast, Good)

Number of Bands

- 0 < 2 Bands < 25 Items
- 25 < 4 Bands < 75 Items
- 75 < 6 Bands

Item Limits Divided by b when $b \neq 1$

This page left intentionally blank.