UPS Optimizes Delivery Routes

Derya Erkan

Hakan Dorukhan Yeşilli

Göksu Ece Okur

Adnan Emre Selçuk

Introduction

- 1907, in Seattle, Washington
- Logistics
- Broad portfolio of services
- By 1972, had the largest IE department in the world

Introduction

- 495,000 employees globally
- Over 220 countries and territories
- On a typical day:
  - delivers 18 million packages
  - documents to 10 million customers
  - collects packages from 1.8 million customers

Small Package Operations

Two main groups:

1. **Transportation group**

   from origin cities to destination cities

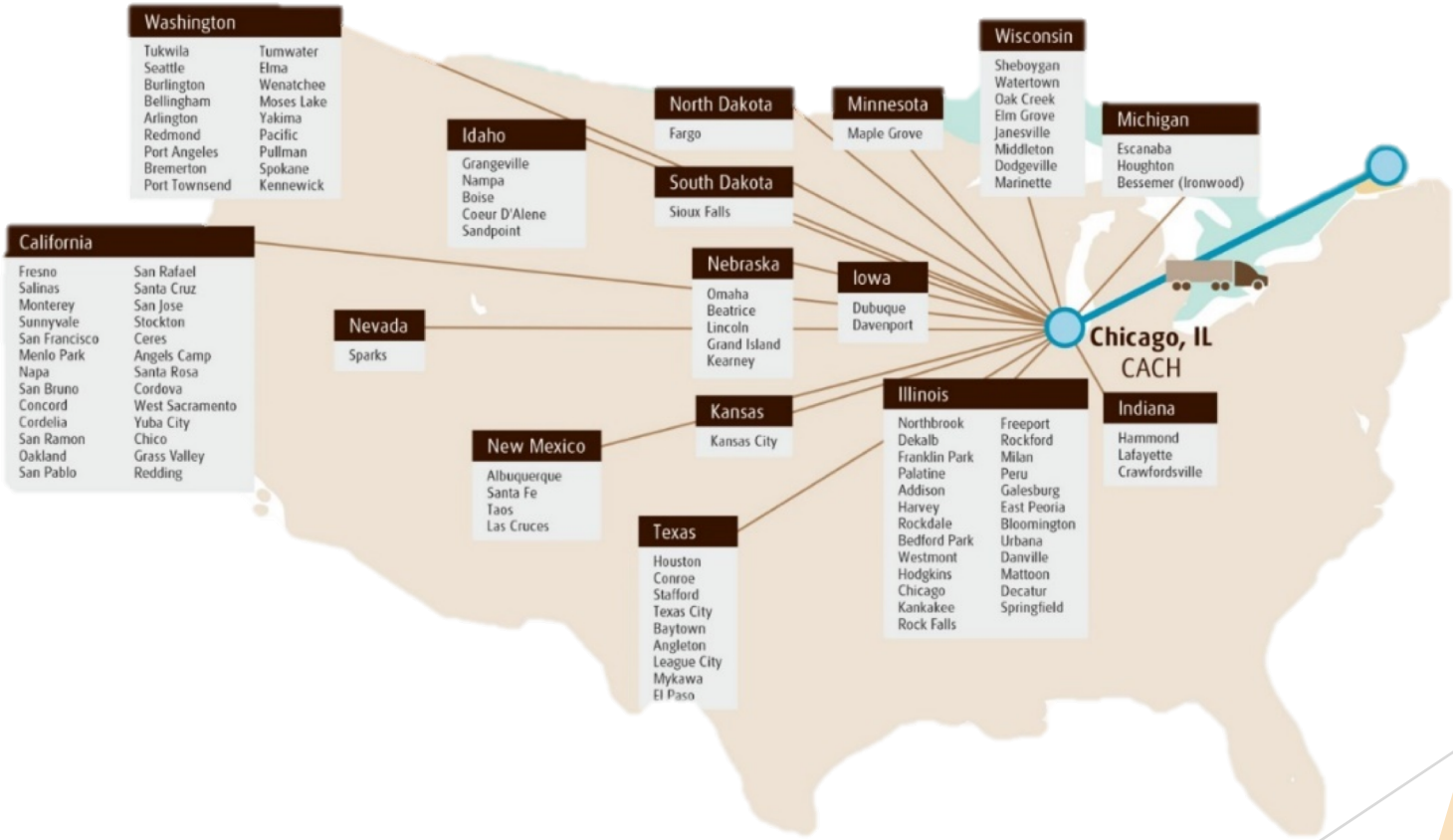
   - airline
   - ground

2. **Pickup and delivery**

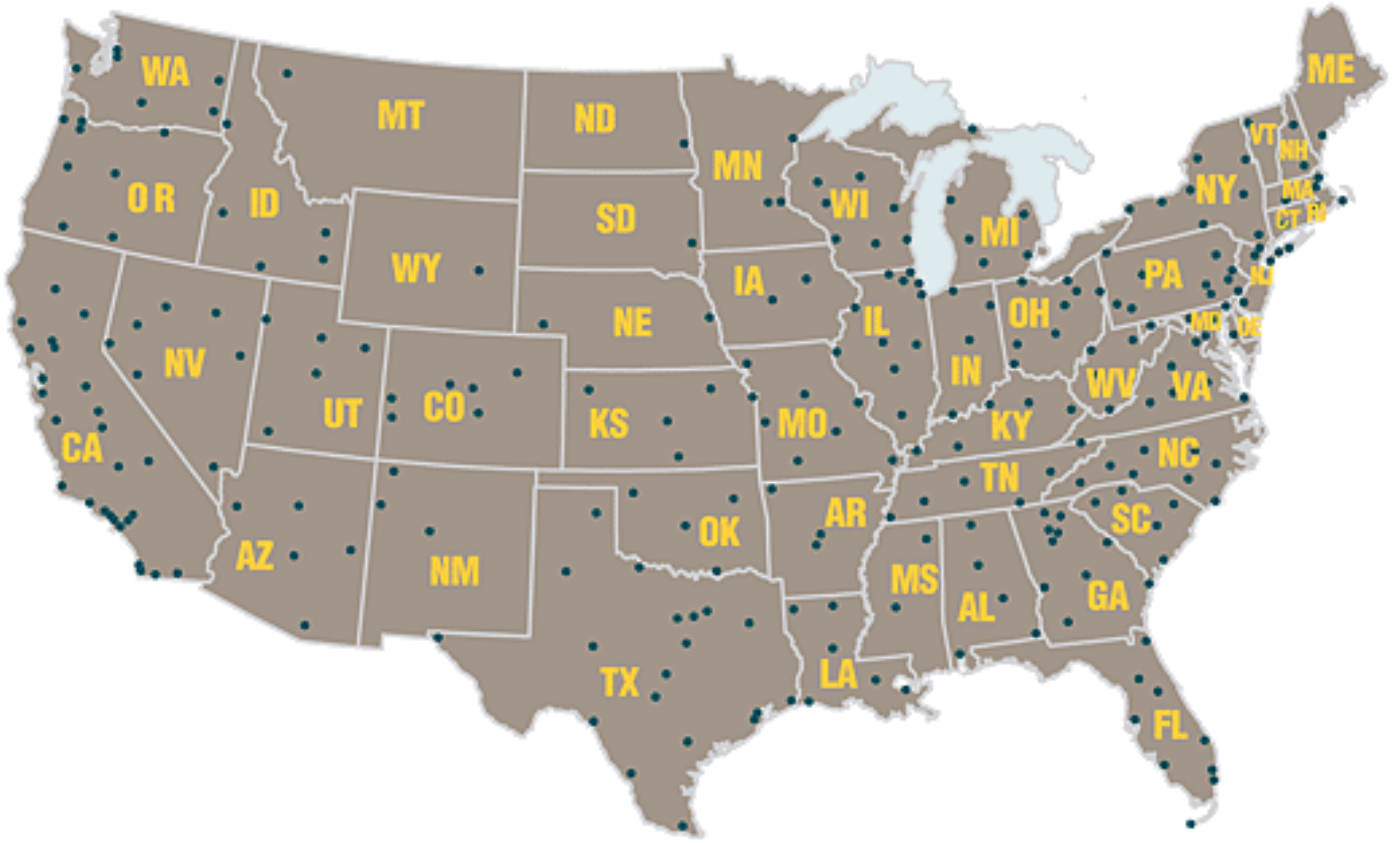
   local pickup and delivery

   - ground

Small Package Operations - Hubs

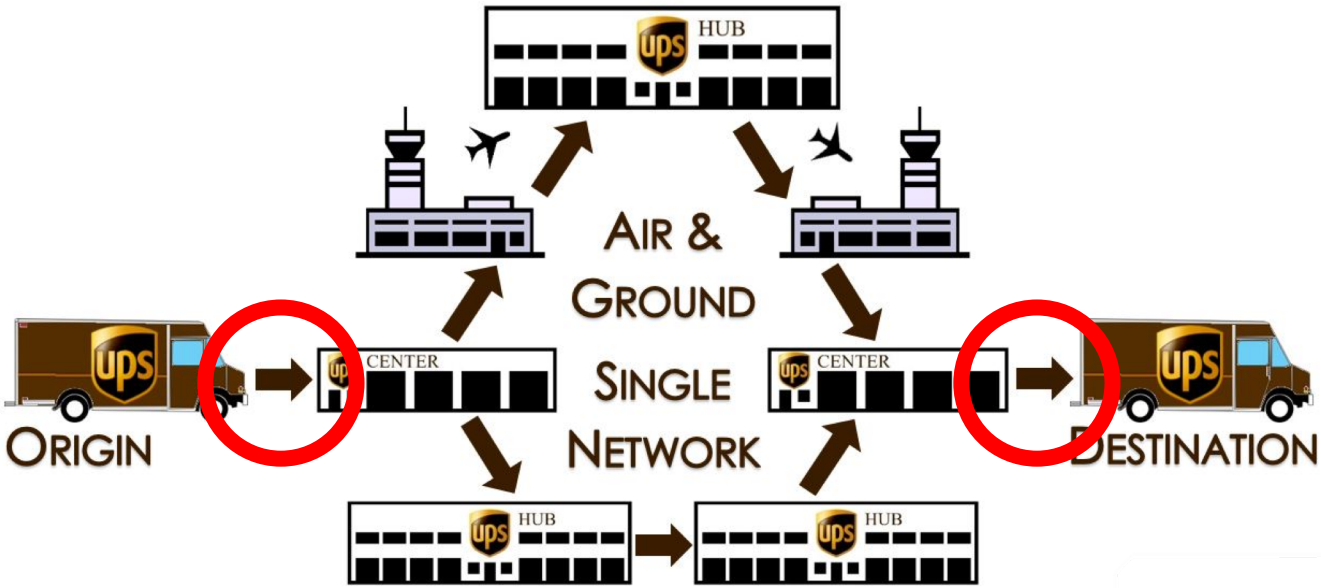


Small Package Operations - Hubs



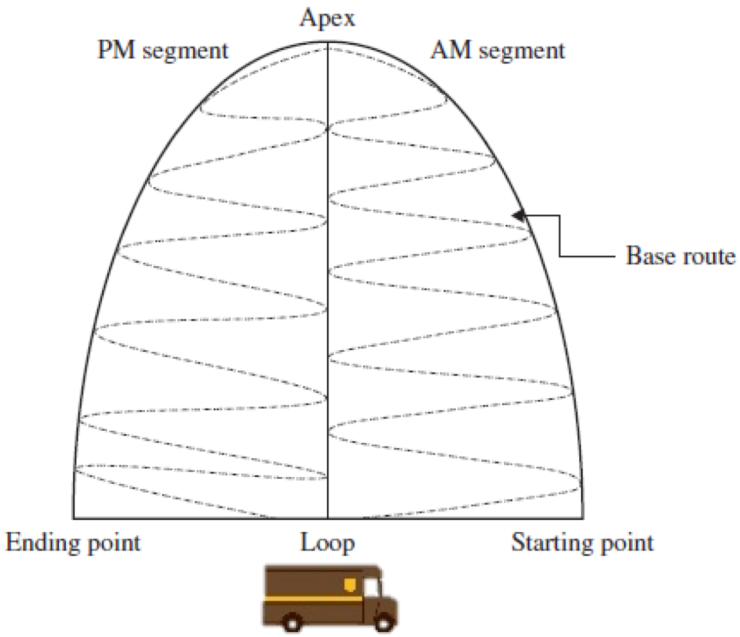
Small Package Operations - Hubs

Small Package Operations - Network



Planning Package And Delivery Operations In The 1970s

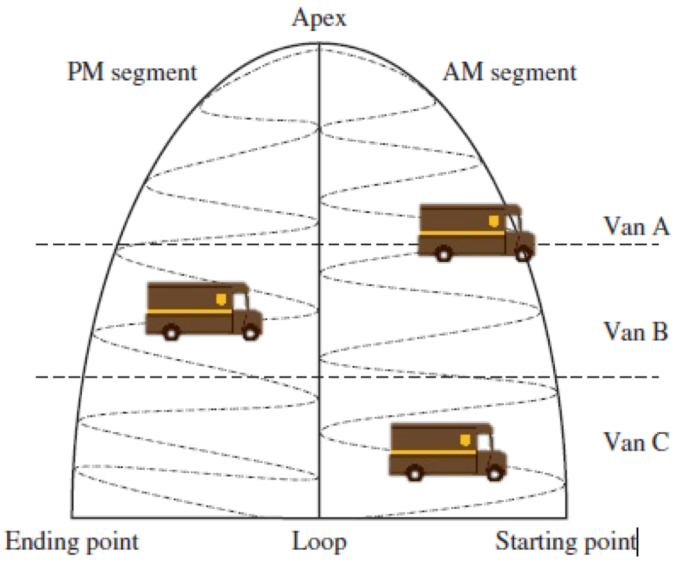
(0) Van Assignment



- Job of IE
- Objectives of the base route:
  - minimizing travel time
  - serving business customers in the early part of the day
  - avoiding traffic congestion
- Each street segment was assigned a specific position in the base route.

Planning Package And Delivery Operations In The 1970s

(0) Van Assignment



- Day-to-day planning:
  - number of vans
  - Van-to-territory assignment
- Each subarea would become a route and would be assigned to a delivery van.

Planning Package And Delivery Operations In The 1970s

- **Controlled dispatch** assisted in determining:

  (1) package-to-van assignment

  (2) package-to-shelf assignment

  (3) sequence of package delivery

- Historical information
- On paper and orally

Planning Package And Delivery Operations In The 1970s

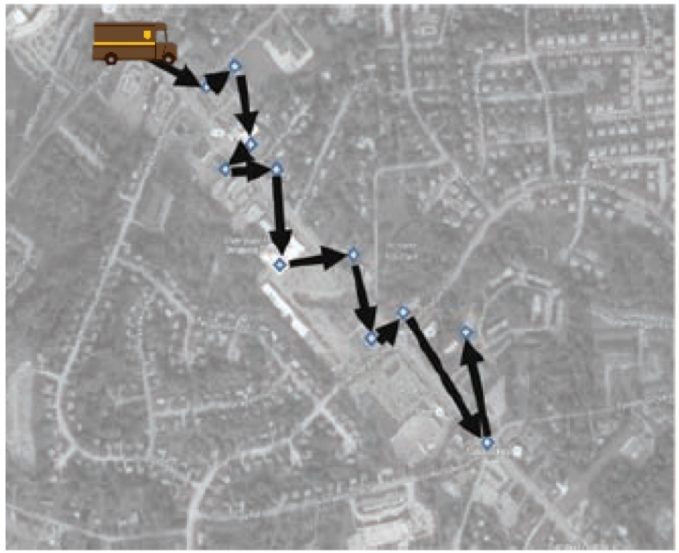
(1) Package-to-van assignment

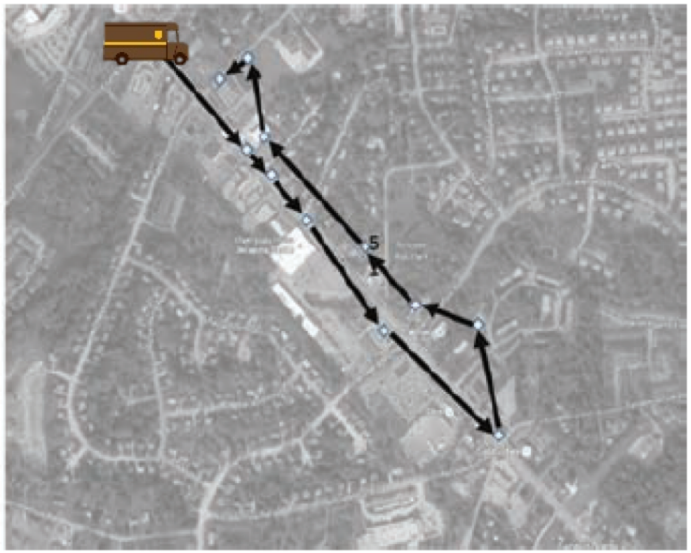
Planning Package And Delivery Operations In The 1970s

(2) Package-to-shelf assignment:

Planning Package And Delivery Operations In The 1970s

(3) Sequence of package delivery

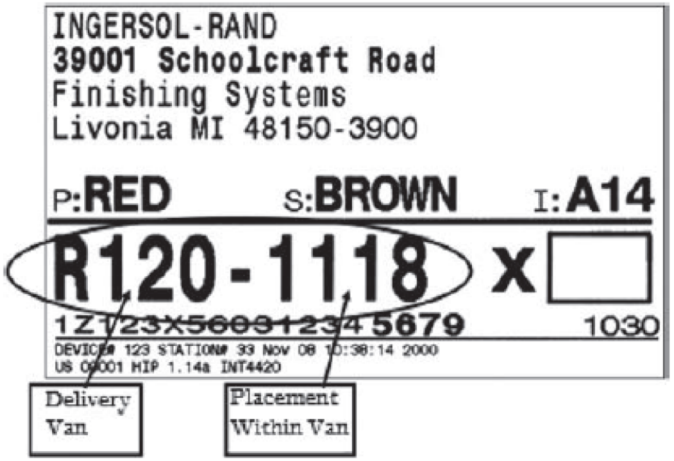




The Need For a New Planning Paradigm

- Most of the planning was done manually on paper, and the plans were often communicated orally.
- Increased volume and variability in the demand pattern.
- Introduction of multiple premium services.
- Had to compete with smaller companies.
- Managing the information about the packages became important.
- Changing demographics made hiring and keeping good preloaders difficult.
- In summary, the company’s logistics became more complex.

Computerizing The Process



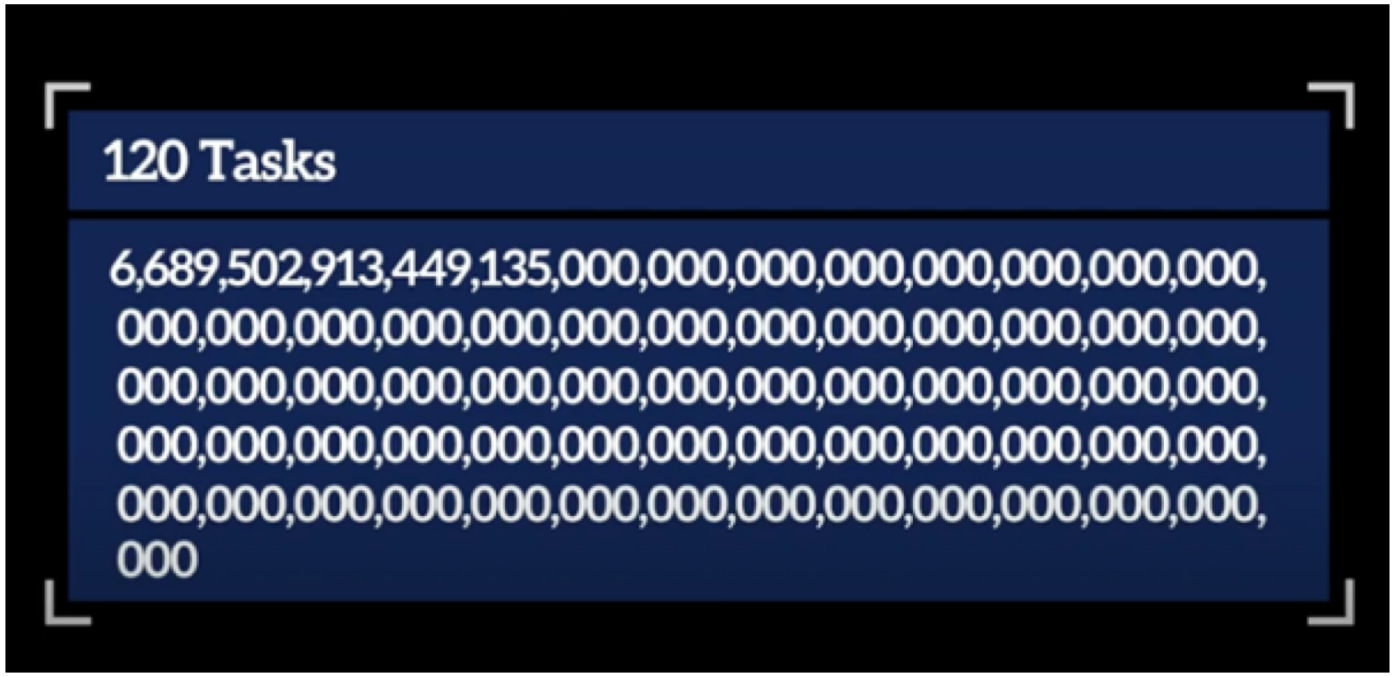
Preload Assist Label (PAL)

- Package-flow technologies (PFT)
- Computerize the planning process and simplify the job of the preloader
- Reduce annual travel by 85 mil miles
- Save 8.5 million gallons of fuel
- Reduce CO2 emissions by 85,000 tons annually

ORION


UPS ORION: The Driver Helper
S's ORION technology is revolutionizing package pickup and delivery operations. ORION combines package-level
ail and customized online map data with expansive fleet telematics and advanced algorithms to provide UPS
rs with the most efficient delivery routes. A big task considering there are more ways to deliver a route than the
f the Earth in nanoseconds. No wonder ORION has been called "the world's largest operations research project!"
ORION and check out the amazing results it delivers...
ups
implemented,
reduction of
OM
RIVEN
LLY
At full deployment, expected savings of
$300M TO $400M
PER YEAR
Expected cut of greenhouse gas emissions by about
100,000
METRIC TONS
ANNUALLY
10M
GALLONS
ANNUALLY
in projected fuel usage cuts
30,000
U.S. route optimizations per minute
16M
approximate U.S. deliveries daily
250M
address points analyzed daily
ORION
MEET ORION:

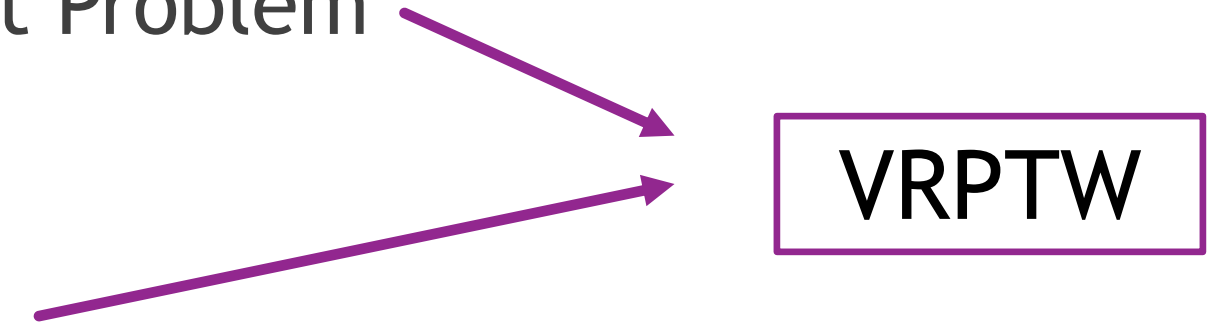
6 Tasks:	720
10 Tasks:	3,268,800
12 Tasks:	479,001,600



https://www.youtube.com/watch?v=lBS-FVsUN4Y

Two principal problems;

- Van-Assignment Problem
- Routing Problem



Objective

- low-cost route
- deliver and pick up all packages
- while meeting the time-window requirements.

Revolutionary routing system boosts driver efficiency, cost savings, customer service and the environment. [1]

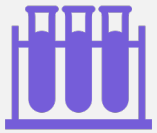
One minute of nonproductive time per day per driver would cost UPS $15 million annually.

Fast algorithm is needed.

No publicly available algorithm is applicable for UPS.

What they do?

meta-heuristic consisting of local-search algorithms



Tested for several months

But, did not work

Why they failed?

SOFTWARE

DATA

EXISTING METHODS AND METRICS

Round 2

- Correct the map data
- Computer program to build routes
- Incorporating the base route while sequencing the deliveries
- adding upper-bound and lower-bound constraints on the customer positions on the route

After 10 months of testing

- “Does it mean that all these years we have been telling our drivers to do the wrong thing and rewarding them for it?"

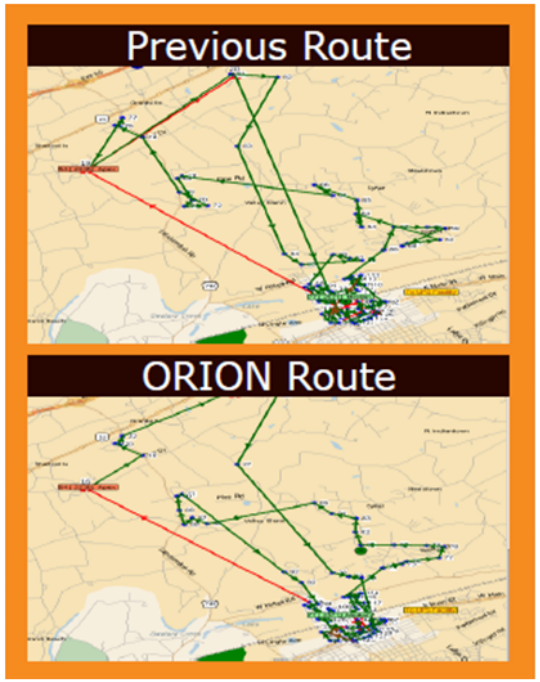
1000 pages trade secret

- The ORION algorithm is a metaheuristic that contains variants of *k*-Opt procedure, adoptive large-neighborhood search with variable-length neighborhood, Lagrangian relaxation

How ORION Reduces Cost

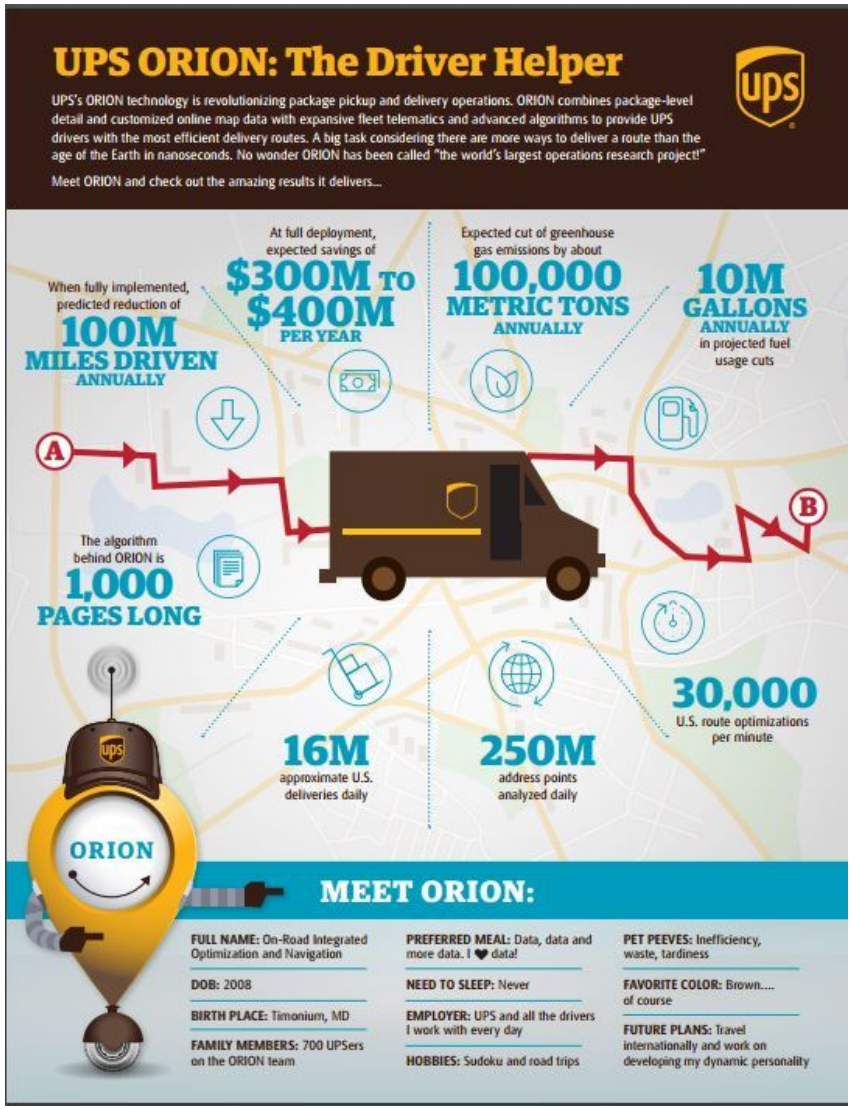
- reducing multiple visits to a customer and (or) neighborhood (if not which means multiple visits cost less)
- making small adjustments to the base route when those adjustments result in reducing the total cost
- Left turns [2]

UPS's ORION Technology

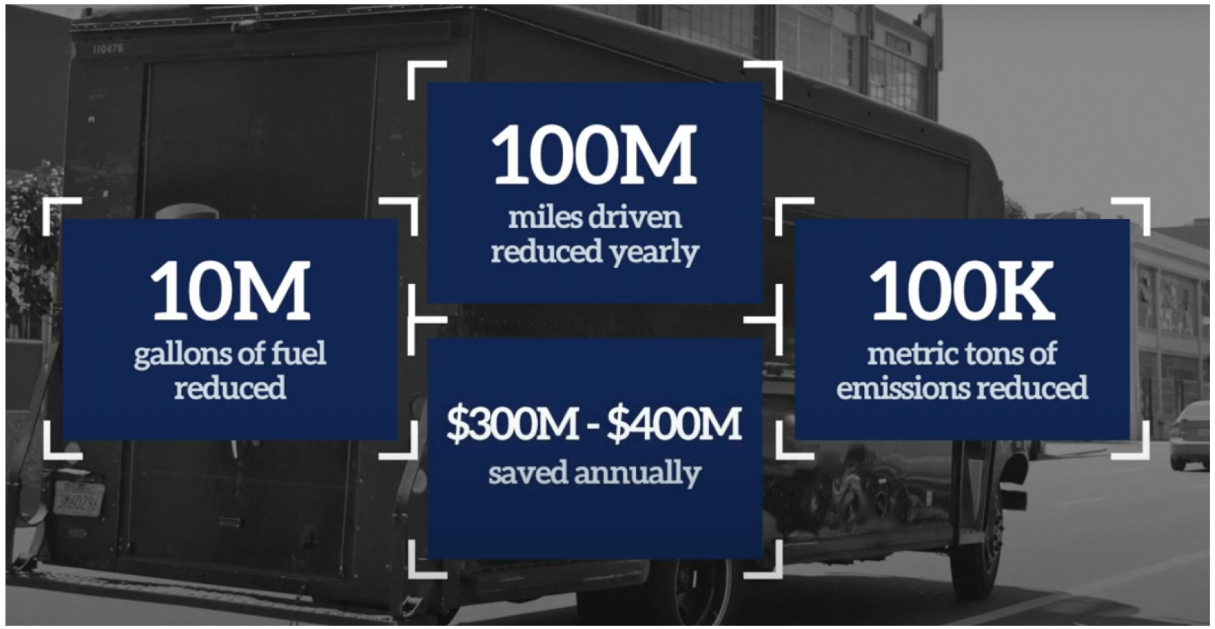


Market Realist

Source: UPS website



ORION, is arguably the world's largest operations research project [3]



BUT;
workplace surveillance [4]
Some people still do not like it
It is not good as it can be, because there are some drivers who can do better than ORION.

Let

V = Set of service locations (nodes), including customers, start locations, and end locations;
A = Set of all permissible sequencing arcs between nodes;
p = Special node added to represent the start location of the driver;
q = Special node added to represent the end location of the driver; start locations and end locations are usually the same;
n = Total number of locations that need to be visited, including the start and end locations.

Data

C_{ij} = Cost of serving customer i and traveling from i to customer j;
C^w = Unit cost of driver wait time;
C_i^{LT} = Unit penalty cost of lateness to customer i;
$C_i^{PD^-}$ = Unit penalty cost for delivering earlier than the earliest preferred route position for customer i;
$C_i^{PD^+}$ = Unit penalty cost for delivering later than the latest preferred route position for customer i;
t_{ij} = Time required to serve customer i and travel from i to customer j;
ET_i = Earliest time at which the customer i may be served;
LT_i = Latest time at which the customer i may be served;
UDO_i = Upper bound on the route position for customer i;
LDO_i = Lower bound on the route position for customer i;
M = A very large constant . . . used to enforce and (or) relax a constraint.

Decision Variables

x_{ij} = 1, if customer j is served immediately after serving customer i, = 0, otherwise;
S_i = Service start time at customer i;
D_i = Position of customer i in the route; $D_p = 1$ and $D_q = n$.
W_i = Wait time before serving customer i; because there is a lower bound on the service start time, a driver may have to wait sometimes before starting the service;
OT_i = Lateness in serving customer i;
PD_i^- = Deviation from the lower bound on the route position for customer i;
PD_i^+ = Deviation from the upper bound on the route position for customer i.

$$\text{Minimize} \quad \sum_{(i,j)\in A} C_{ij}x_{ij} + \sum_{k\in V} C^w W_k + \sum_{k\in V} C_k^{LT} OT_k + \sum_{k\in V} C_k^{PD^-} PD_k^- + \sum_{k\in V} C_k^{PD^+} PD_k^+ \qquad (1)$$

subject to

$$\sum_{j\in(V\setminus p)} C_{ij}x_{ij} = 1, \quad \forall i \in (V\setminus q); \qquad (2)$$

$$\sum_{i\in(V\setminus q)} C_{ij}x_{ij} = 1, \quad \forall j \in (V\setminus p); \qquad (3)$$

$$S_i + t_{ij} - (1 - x_{ij})M + W_j \le S_j, \quad \forall (i,j) \in A; \qquad (4)$$

$$S_j \ge ET_j, \quad \forall j \in V; \qquad (5)$$

$$S_i - OT_i \le LT_i, \quad \forall i \in V; \qquad (6)$$

$$D_i + 1 - (1 - x_{ij})M \le D_j, \quad \forall (i,j) \in A; \qquad (7)$$

$$D_p = 1, \qquad (8)$$

$$D_q = n, \qquad (9)$$

$$D_i + PD_i^- \ge LDO_i, \quad \forall i \in (V\setminus(p,q)); \qquad (10)$$

$$D_i - PD_i^+ \le UDO_i, \quad \forall i \in (V\setminus(p,q)); \qquad (11)$$

$$x_{ij} = \{0,1\}, \quad \forall (i,j) \in A;$$

$$D_i, PD_i^-, PD_i^+ \ge 0, \quad \text{and integer } \forall i \in V;$$

$$S_i, W_i, OT_i, M \ge 0, \quad \forall i \in V.$$

- In 2008 they decided to use ORION to optimize all routes for a small-package center and they developed a prototype optimization system.
- After, making necessary corrections, and training the drivers and package center management their evaluation of the results showed that ORION provided significant benefits.
- Later, they extended their test centers and added people who were non planners to the deployment team to see the success of the project.

MAP DATA

- They realized that accurate map data were essential in project's success and that the map data they had was not precise.
- They bought a map database and edited it to meet their needs.
- Today, UPS's map database can locate their customers very accurately.

Additional Gains

- ORION increased the accuracy of the local planners' estimates of the time that drivers need to serve their assigned customers.
- This knowledge has helped them to make better van assignments.
- They were also able to understand how the base route affects the ORION route.

Infrastructure

- To integrate ORION with additional legacy operational systems, they developed an infrastructure.
- The infrastructure supports 30,000 route optimizations per minute.
- When a correction to a map is made, the corrected data are available nationwide within 15 seconds of making that correction.

Additional Optimizations

- They do additional optimizations during the loading operation.
- ORION gathers information once every minute and develops optimized routes.
- The routes are always optimized and available at each moment to the local planners and drivers.
- The planners continuously monitor the work and make adjustments if necessary.

- Because of the multiple time zones in the United States, a processing capacity of 30,000 routes per minute is sufficient to meet the needs of the 55,000 drivers.
- During the peak Christmas season, they add additional processing capacity to manage the increased number of drivers.

Managing Change

1) Seperation of Research & Development:

- Why do they frequently fail? (Data Certainty)
  - Research projects are planned and executed as if most elements are known with a high degree of certainty.
- What happens if cost overruns occur for IT type projects?
  - Leads to pressure to take shortcuts
  - Leads to losing focus and acting based on goal-setting (Reference to TPS Onba's example)
- What did this accomplish?
  - Ensured the initial investment for the project, and set a guideline for actions.

Managing Change

2) Stage the implementations:

- Pre loading practice(Van assignment problem) vs Routing(TSPTW)
- You can’t change everything at once!

3) Do not churn more than necessary:

- Provide a feeling that was close to initial experience to ensure adjustability and understandability.
- Do not scare off management.

Managing Change

4)Be Creative:

- Show, not tell !
- Playing the routing game;
  - The task is to find the best route by sequencing the customers. Competition based on a total route cost.

5) Simulate:

- The ORION ride
  - Could simulate multiple customers and incorporates many UPS businesses and operations rules.
  - Again, show the effectiveness of your solutions, get support from management. (Particularly David Abney & Myron Gray) – Remember the Henry Ford scene from Ferrari v Ford

Managing Change

6)Carefully select team members:

- Pick open minded, yet questioning people to ensure that the initial situation is consistantly held as a standard.

7) If the data are not available, create the information you need:

- Inaccuracy of map data was a major problem.
- It created difficulty in cost justifying the project.
- Reduction in preparation time was reduced to six days. Again, appeal to the management.

8) Deploy early:

- Don’t wait until everything is perfect. Just do it.
- If you wait, you lose attention and thus you lose support.
- At least you get more experience.

Managing Change

9) Monitor deployment:

- Check before, during, after deployment.
- UPS work measurements(motion& time studies) are considered critical.
- If data is not maintained, wait for deployment to ensure data to be updated.
- Always validate loops & base routes. (Reference to TPS, hypothesis testing – eliminating noise)
- Wait until your baby learns to walk before setting it free in the wild
- Check results and ensure improvement before moving on.

Managing Change

10) Develop a training program

- Establishing a framework to ensure proficiency is key!
- 90 short video clips; each 4 minutes long.

11) Hide complexity from the user and allow the user to customize:

- Don’t be like ERPnext, be like apple’s settings.

(Hard to understand, customizable UI vs Very easy to understand, 80% customizable UI)

- Planner can select time buffers to achieve the desired level of safety.
- The buffer modifies the algorithm that builds a route considering the safety buffer.
- Users get a smooth experience; where they can use the software yet, not feel intimidated

Managing Change

12) Provide field support:

- Collect data, analyze the problems provide support.
- Collect questions and give feedback to the user.
- Benefits are a more integrated data structure and reduced user anxiety.

Impact Value and Significance

FINANCIAL IMPACT TO UPS

NONFINANCIAL AND INDIRECT IMPACT TO UPS

IMPACT ON THE OR PROFESSION

Managing Change

1)Financial Impact

- At full deployment, ORION reduces 100 million miles driven annually with driver cost-avoidance and fuel savings of between $300million to $400million annually.

2) Nonfinancial and indirect benefits to UPS

- ORION has made drivers' job safer by relieving drivers of the complexitiy of determining how to make their deliveries.
- CO2 emissions will be reduced by 100,000 metric tons annually, and the yearly fuel consumption will decrease by 10 million gallons.
- ORION ensures that UPS drivers are the highest paid in the industry.
- ORION enables additional services such as being able to choose the time window deliveries are made.
- ORION provides the infastructrue to price new services.

Managing Change

3) Impact on the OR profession and other organizations:

- ORION attracted a lot of media attention to show how OR can be used to increase an organization's profitability.
- Balancing optimality and consistency has sparked research interest in academic researchers.
- ORION was responsible for UPS sponsorship of the UPS George D. Smith Prize to encourage admins of academic programs to be effective and innovative in training future OR practitioners.

Examples from Turkey?

- Unilever
- Migros Hemen
- Aras Kargo & Yurtici Kargo
- Yandex: Routing Optimization

References

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