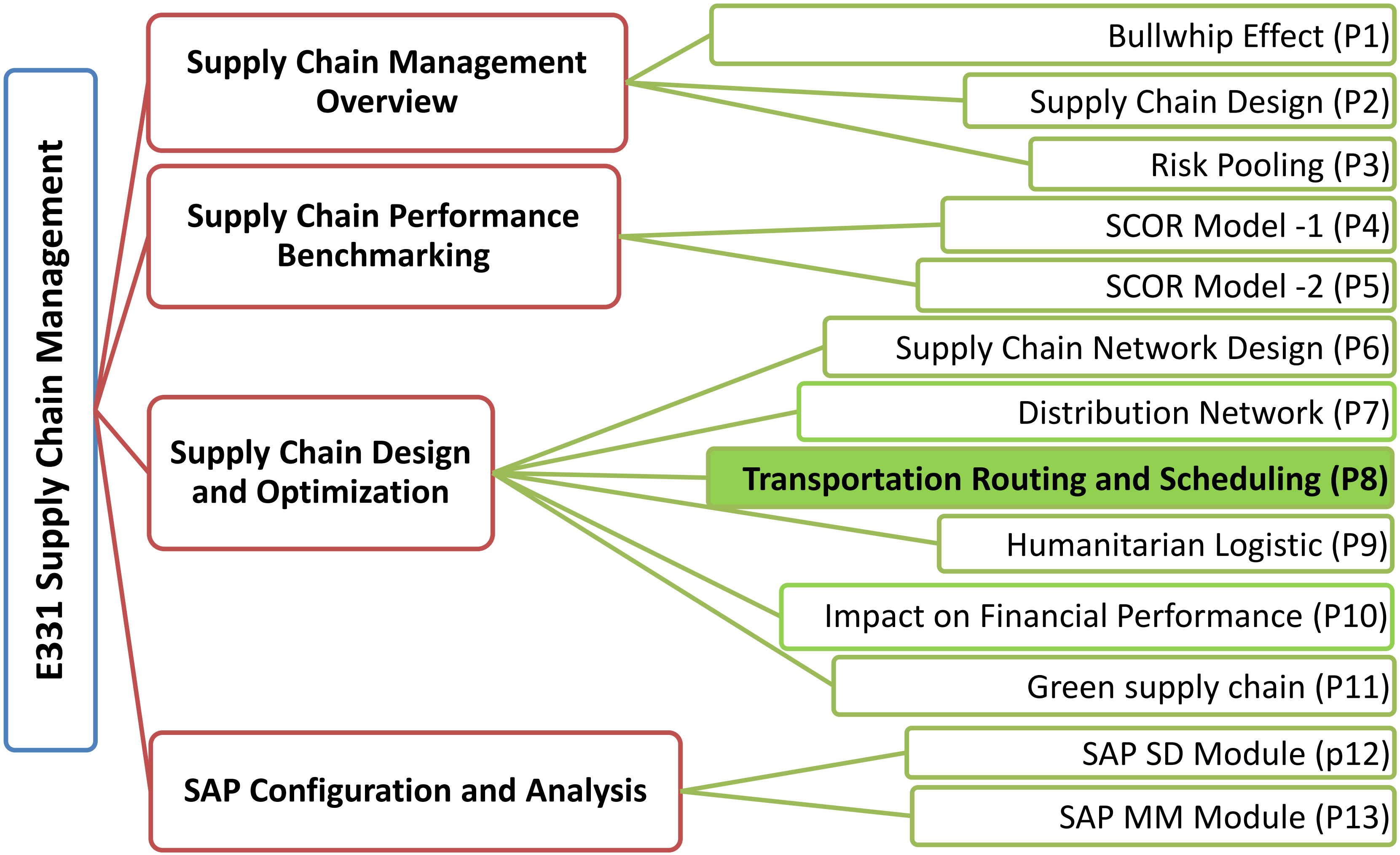
P08
Freshly Delivered

E331 – Supply Chain Management

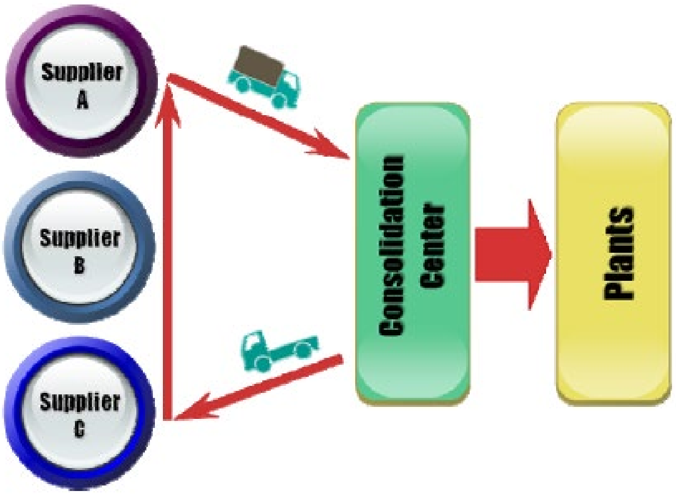
Diploma in Supply Chain Management

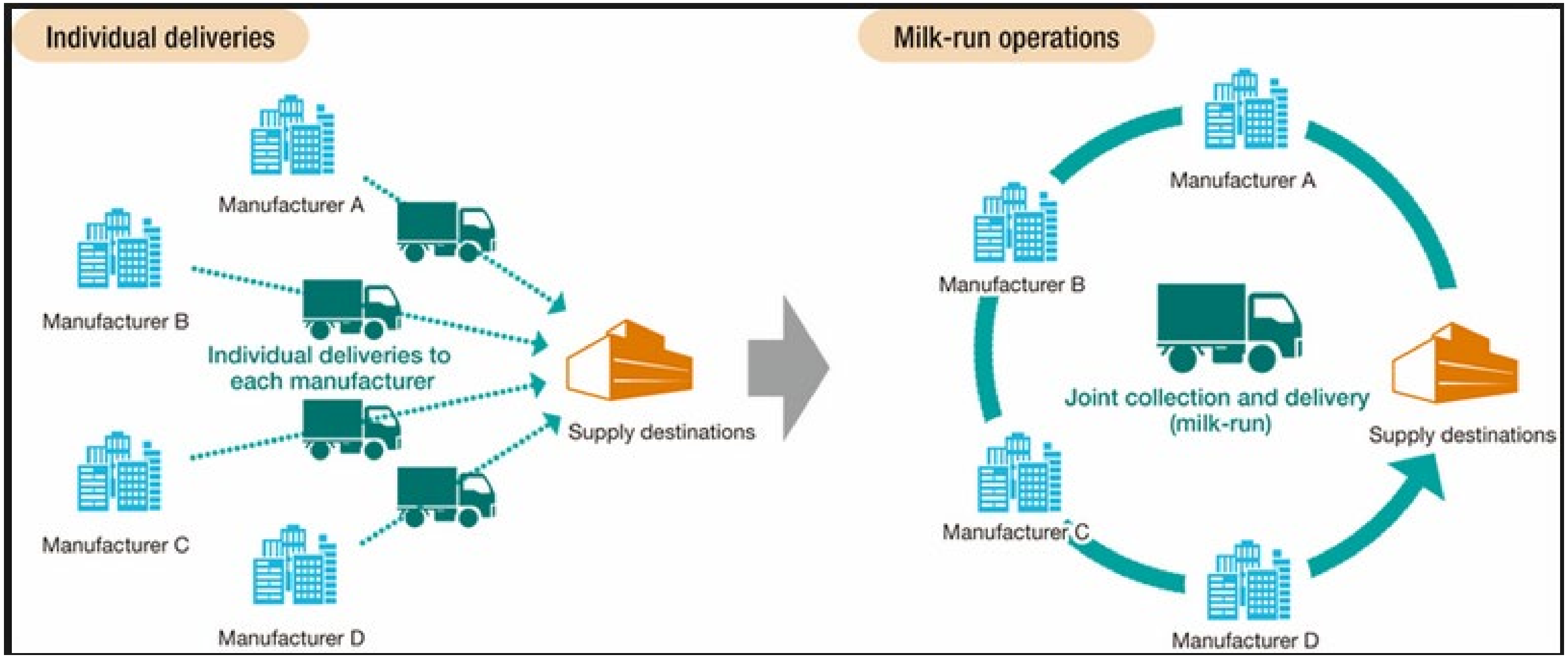
E331 Module Overview



Today's Problem

- Multiple trucks
- Capacity Constraints
- Many route possibilities
- Even more complicated if suppliers are considered at the same time (supply chain)



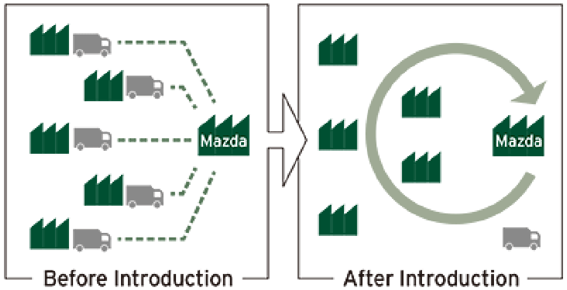


Milk Run in Transportation

- A milk run is a route in which a transport vehicle either delivers product from a single pickup point to multiple delivery points or from multiple pickup points to a single delivery point.

- A milk run combines multiple pickups or deliveries into one multi-stop shipment. It can be a very effective way to increase return on your supply chain investment

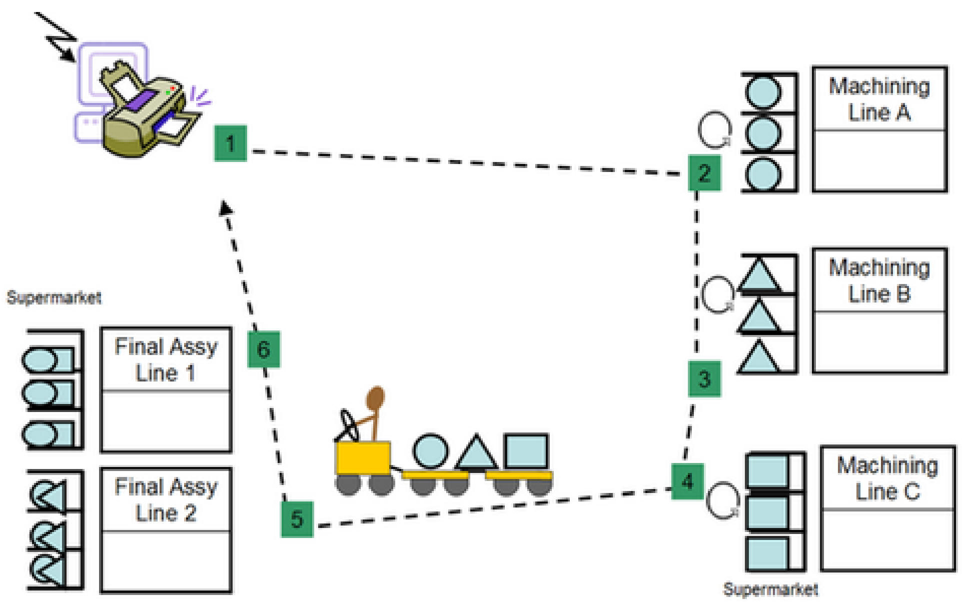
- Benefits include:



  - To save trucking costs
  - To save the travelling distance or time
  - To reduce the number of trucks being used
  - To ensure FTL and avoid LTL (Less Truck Load)
  - To reduce the fuel consumption
  - To eliminate environmental impacts by reducing carbon emission

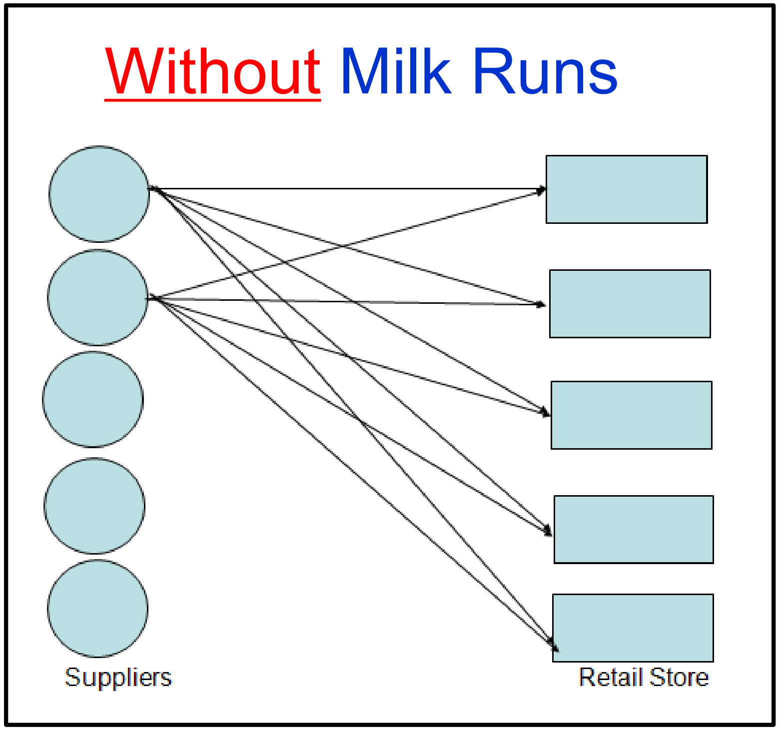
Milk Run in Production

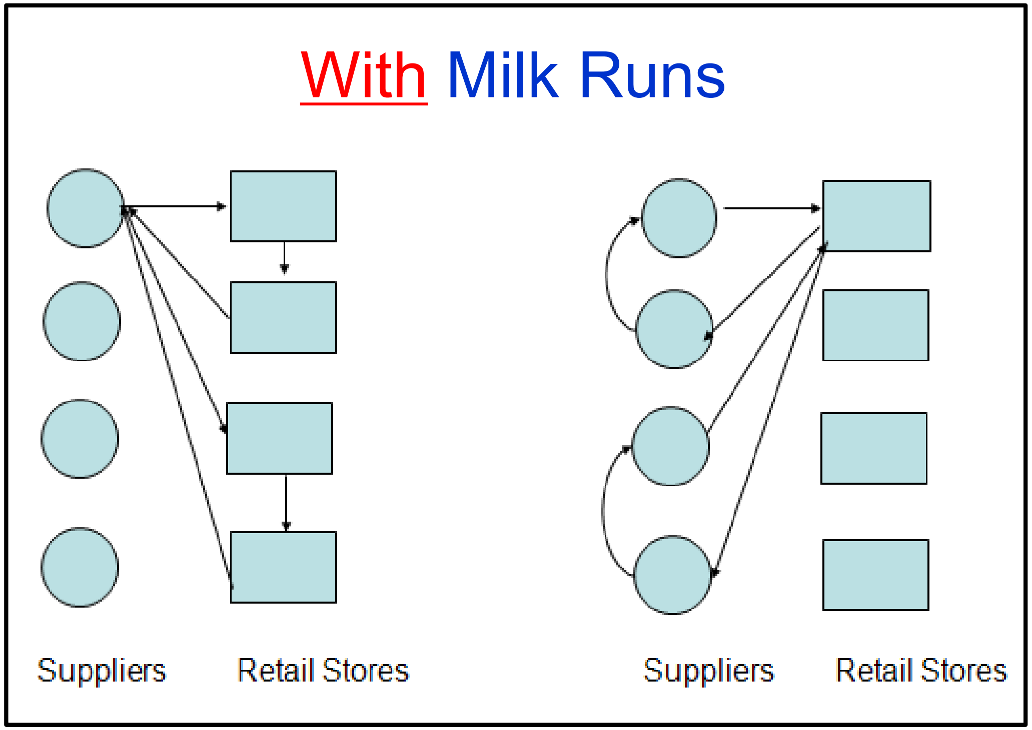
- A milk run is a classic example for a Kanban system, which is used in industrial manufacturing as a signal to act.
- A milk run can contain multiple stations where product is needed for point of storage use. In case the on-hand inventory is insufficient until the next run, that inventory can be increased by special orders.
- Increasing the frequency of the runs would reduce the inventory on hand and the replenishing inventory. In a perfect environment, a milk run can provide just enough inventory until the next milk run, with no or very little buffer at each station.



Direct Shipment Network

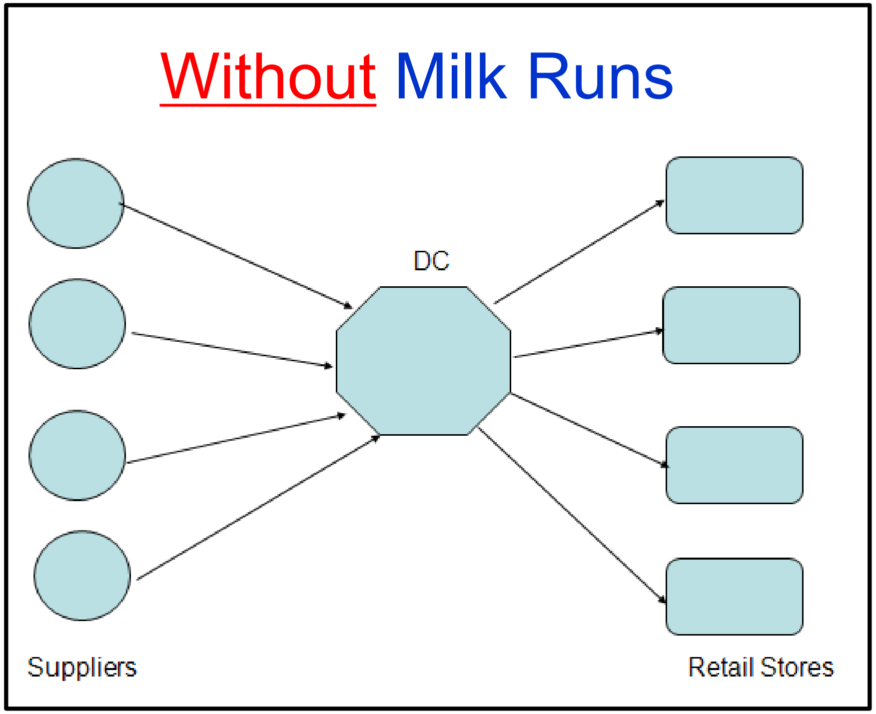
- We can consider the Direct Shipment Network in 2 ways:
  - without milk runs
  - with milk runs

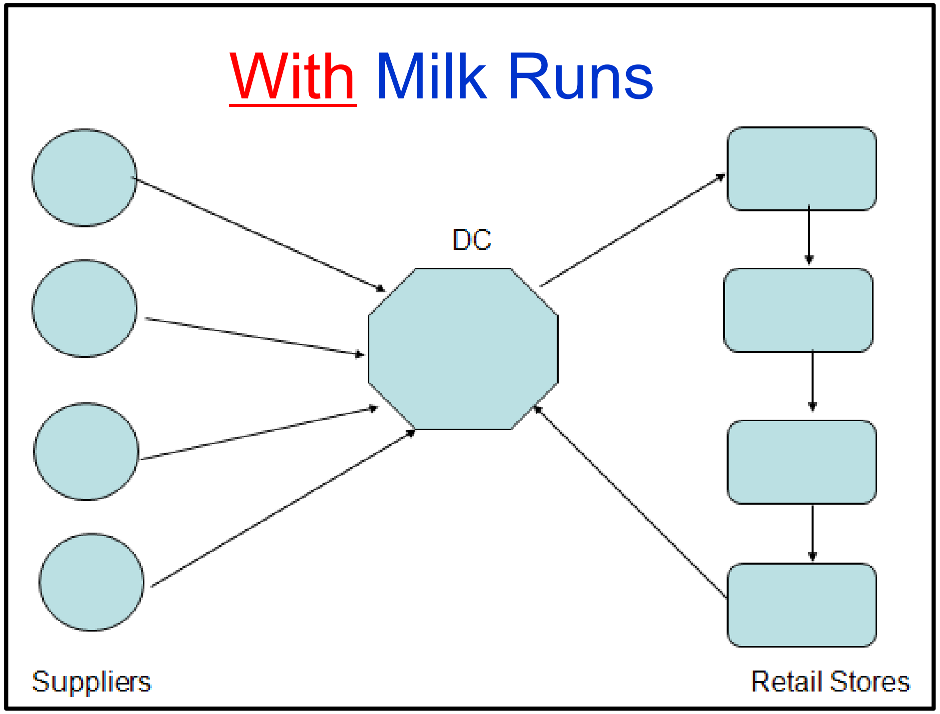




Shipments Via Central DC

- We can consider this method in 2 ways:
  - without milk runs
  - with milk runs





Routing and Scheduling Decisions

- The most important operational decision about transportation in a supply chain is the routing of deliveries.
- Typical objectives when routing and scheduling transport vehicles are a combination of minimizing costs by:
  - *decreasing the number of vehicles needed*
  - *decreasing the total distance travelled by vehicles*
  - *decreasing the total travel time of the vehicles*
  - *eliminating service failures such as a delay in shipments*
- Jordan has to consider that the goal is to route and schedule vehicles such that the costs incurred to meet the delivery promises are kept as low as possible.
- Jordan must decide *which truck to deliver to which customers* and the *route that each truck will take when making the deliveries.*
- Jordan must also ensure that *no truck is overloaded.*

The Savings Matrix Method

- This method is simple to implement and can be used to assign customers to vehicles even when the delivery time windows or other constraints exist.
- The major steps involve:

  Step 1: Identify the distance matrix (given today)

  Step 2: Identify the distance savings matrix

  Step 3: Assign customers to vehicles or routes

  Step 4: Sequence customers within routes

- Step 1-3 are used to assign customers to vehicles
- Step 4 is used to route each vehicle to further minimize the total distance travelled

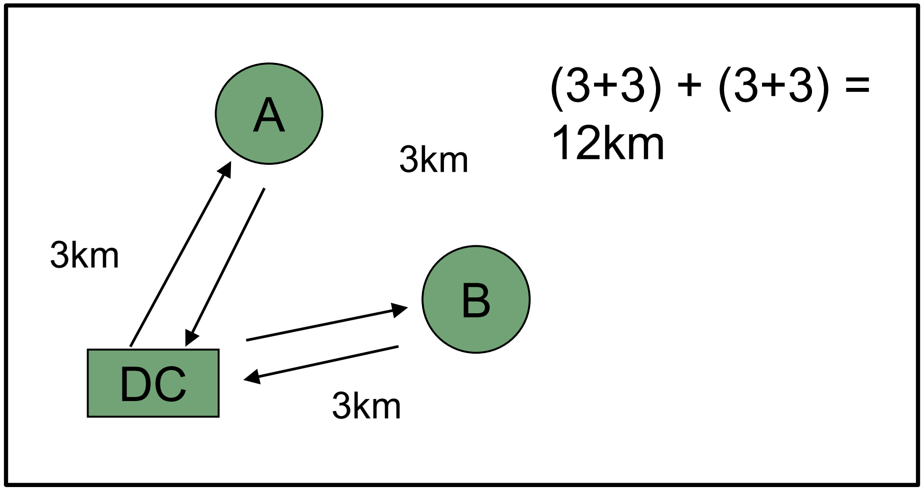
Step 1: Identify the Distance Matrix

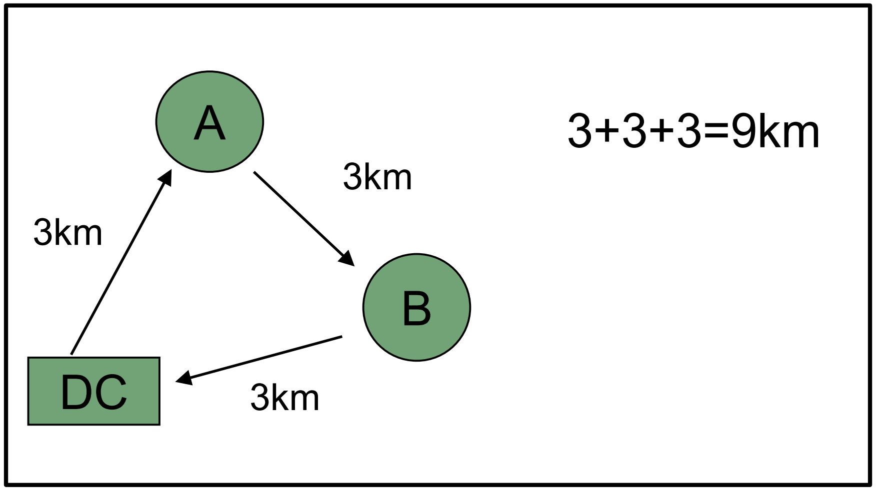
- If the transportation costs/ travelling time between a pair of locations are known, then we can use the transportation costs / time directly in place of the distances.

	SF	Store 1	Store 2	Store 3	Store 4	Store 5	Store 6	Store 7	Store 8	Store 9	Store 10	Store 11	Store 12	Store 13
SF	0													
Store 1	5.6	0												
Store 2	6.8	3.2	0											
Store 3	5.6	4.4	2.0	0										
Store 4	10.5	8.1	5.6	4.4	0									
Store 5	11.7	10.5	8.1	6.8	3.2	0								
Store 6	15.3	15.3	12.9	11.7	6.8	4.4	0							
Store 7	17.7	16.5	14.1	12.9	8.1	5.6	2.2	0						
Store 8	21.4	22.6	20.2	18.9	11.7	10.5	6.8	4.4	0					
Store 9	28.6	28.6	26.2	25.0	17.7	16.5	11.7	10.5	4.4	0				
Store 10	26.2	25.0	22.6	21.4	16.5	15.3	10.5	6.8	3.2	3.2	0			
Store 11	23.8	20.2	17.7	16.5	12.9	12.9	10.5	6.8	6.8	8.1	5.3	0		
Store 12	15.3	15.3	12.9	11.7	10.5	11.7	11.7	9.3	10.5	11.7	9.3	4.4	0	
Store 13	18.9	14.1	11.7	10.5	14.1	14.1	15.3	11.7	11.7	14.1	12.9	8.1	3.2	0
Store 14	17.7	16.5	14.1	12.9	14.1	15.3	16.5	12.9	14.1	15.3	15.3	10.5	3.2	3.1

Step 2: Identify the Distance Savings Matrix

- How do we calculate the distance savings?
- Let's consider a simple example:





- Generally,

  $S(\mathrm{A,B}) = Dist(\mathrm{DC, A}) + Dist(\mathrm{DC, B}) - Dist(\mathrm{A,B})$

- For this example, distance savings = 12 – 9 = 3km

Step 2: Identify the Distance Savings Matrix

	Store 1	Store 2	Store 3	Store 4	Store 5	Store 6	Store 7	Store 8	Store 9	Store 10	Store 11	Store 12	Store 13	Store 14
Store 1	0													
Store 2	9.2	0												
Store 3	6.8	10.4	0											
Store 4	8.0	11.7	11.7	0										
Store 5	6.8	10.4	10.5	19.0	0									
Store 6	5.6	9.2	9.2	19.0	22.6	0								
Store 7	6.8	10.4	10.4	20.1	23.8	30.8	0							
Store 8	4.4	8.0	8.1	20.2	22.6	29.9	34.7	0						
Store 9	5.6	9.2	9.2	21.4	23.8	32.2	35.8	45.6	0					
Store 10	6.8	10.4	10.4	20.2	22.6	31.0	37.1	44.4	51.6	0				
Store 11	9.2	12.9	12.9	21.4	22.6	28.6	34.7	38.4	44.3	44.7	0			
Store 12	5.6	9.2	9.2	15.3	15.3	18.9	23.7	26.2	32.2	32.2	34.7	0		
Store 13	10.4	14.0	14.0	15.3	16.5	18.9	24.9	28.6	33.4	32.2	34.6	31.0	0	
Store 14	6.8	10.4	10.4	14.1	14.1	16.5	22.5	25.0	31.0	28.6	31.0	29.8	33.5	0

- 51.6 is the saving in travelling distance if store 9 and 10 are grouped in a single milk run

Step 3: Assign Stores to Vehicles/Routes

Highest saving: 51.6 (Route 9-10) (**start the 1st route**)

Vehicle load: 35 + 61 = 96 < 200, OK

Next highest saving: 45.6 (Route 8-9)

Vehicle load: 96 + 30 = 126 < 200, OK **(first route: 8-9-10)**

Next highest saving: 44.7 (Route 10-11)

Vehicle load: 126 + 50= 176 < 200, OK **(first route: 8-9-10-11)**

Cancel store 8,9,10 and 11 as no order size is < 200-176 = 24 and no other stores can be added into the current route

	Store 1	Store 2	Store 3	Store 4	Store 5	Store 6	Store 7	Store 8	Store 9	Store 10	Store 11	Store 12	Store 13	Store 14
Store 1	0													
Store 2	9.2	0												
Store 3	6.8	10.4	0											
Store 4	8.0	11.7	11.7	0										
Store 5	6.8	10.4	10.5	19.0	0									
Store 6	5.6	9.2	9.2	19.0	22.6	0								
Store 7	6.8	10.4	10.4	20.1	23.8	30.8	0							
~~Store 8~~	~~4.4~~	~~8.0~~	~~8.1~~	~~20.2~~	~~22.6~~	~~29.9~~	~~34.7~~	~~0~~						
~~Store 9~~	~~5.6~~	~~9.2~~	~~9.2~~	~~21.4~~	~~23.8~~	~~32.2~~	~~35.8~~	~~45.6~~	~~0~~					
~~Store 10~~	~~6.8~~	~~10.4~~	~~10.4~~	~~20.2~~	~~22.6~~	~~31.0~~	~~37.1~~	~~44.4~~	~~51.6~~	~~0~~				
~~Store 11~~	~~9.2~~	~~12.9~~	~~12.9~~	~~21.4~~	~~22.6~~	~~28.6~~	~~34.7~~	~~38.4~~	~~44.3~~	~~44.7~~	~~0~~			
Store 12	5.6	9.2	9.2	15.3	15.3	18.9	23.7	26.2	32.2	32.2	34.7	0		
Store 13	10.4	14.0	14.0	15.3	16.5	18.9	24.9	28.6	33.4	32.2	34.6	31.0	0	
Store 14	6.8	10.4	10.4	14.1	14.1	16.5	22.5	25.0	31.0	28.6	31.0	29.8	33.5	0

Step 3: Assign Stores to Vehicles/Routes

- Next highest saving: 33.5 (Route 13-14) (**start the 2nd route**)
  - Truck load = 48 + 61 = 109 < 200, OK

- Next highest saving: 31 (Route 12-13) (**12-13-14 tentatively**)
  - Truck load = 109 + 57 = 166 < 200, OK

- Next highest saving: 30.8 (Route 6-7)
  - Truck load = 166 + 80 + 36 = 282 > 200, not OK

- Cancel store 12,13 and 14 as no order size is < 200-166 = 34 and no other stores can be added into the current route

Step 3: Assign Stores to Vehicles/Routes

Next highest saving: 30.8 (Route 6-7) (**start the 3rd route**)

Truck load = 80 + 36 = 116 < 200, OK

Next highest saving: 23.8 (Route 5-7)

Truck load = 116 + 40 = 156 < 200, OK **(3rd route : 5-6-7)**

Leftover capacity = 200 – 156 = 44, only store 2 can be tagged along to deliver.

The 3rd route will include 2, 5, 6 and 7, then cancel the stores

	Store 1	Store 2	Store 3	Store 4	Store 5	Store 6	Store 7	Store 8	Store 9	Store 10	Store 11	Store 12	Store 13	Store 14
Store 1	0													
Store 2	9.2	0												
Store 3	6.8	10.4	0											
Store 4	8.0	11.7	11.7	0										
Store 5	6.8	10.4	10.5	19.0	0									
Store 6	5.6	9.2	9.2	19.0	22.6	0								
Store 7	6.8	10.4	10.4	20.1	23.8	30.8	0							
Store 8	4.4	8.0	8.1	20.2	22.6	29.9	34.7	0						
Store 9	5.6	9.2	9.2	21.4	23.8	32.2	35.8	45.6	0					
Store 10	6.8	10.4	10.4	20.2	22.6	31.0	37.1	44.4	51.6	0				
Store 11	9.2	12.9	12.9	21.4	22.6	28.6	34.7	38.4	44.3	44.7	0			
Store 12	5.6	9.2	9.2	15.3	15.3	18.9	23.7	26.2	32.2	32.2	34.7	0		
Store 13	10.4	14.0	14.0	15.3	16.5	18.9	24.9	28.6	33.4	32.2	34.6	31.0	0	
Store 14	6.8	10.4	10.4	14.1	14.1	16.5	22.5	25.0	31.0	28.6	31.0	29.8	33.5	0

Step 3: Assign Customers to Vehicles/Routes

- The last route will be 1, 3 and 4
  - Check capacity, 51+61+72 =184 < 200, OK **(4th route : 1-3-4)**

	Store 1	Store 2	Store 3	Store 4	Store 5	Store 6	Store 7	Store 8	Store 9	Store 10	Store 11	Store 12	Store 13	Store 14
Store 1	0													
~~Store 2~~	9.2	0												
Store 3	6.8	10.4	0											
Store 4	8.0	11.7	11.7	0										
~~Store 5~~	6.8	10.4	10.5	19.0	0									
~~Store 6~~	5.6	9.2	9.2	19.0	22.6	0								
~~Store 7~~	6.8	10.4	10.4	20.1	23.3	30.8	0							
~~Store 8~~	4.4	8.0	8.1	20.2	22.6	29.9	34.7	0						
~~Store 9~~	5.6	9.2	9.2	21.4	23.3	32.2	35.8	45.6	0					
~~Store 10~~	6.8	10.4	10.4	20.2	22.6	31.0	37.1	44.4	51.6	0				
~~Store 11~~	9.2	12.9	12.9	21.4	22.6	28.6	34.7	38.4	44.3	44.7	0			
~~Store 12~~	5.6	9.2	9.2	15.3	15.3	18.9	23.7	26.2	32.2	32.2	34.7	0		
~~Store 13~~	10.4	14.0	14.0	15.3	16.5	18.9	24.9	28.6	33.4	32.2	34.6	31.0	0	
~~Store 14~~	6.8	10.4	10.4	14.1	14.1	16.5	22.5	25.0	31.0	28.6	31.0	29.8	33.5	0

- We get the 4 route-truck assignments as:
  - Truck 1 is assigned to stores (8-9-10-11)
  - Truck 2 is assigned to stores (12-13-14)
  - Truck 3 is assigned to stores (5-6-7-2)
  - Truck 4 is assigned to store (1-3-4)

Step 4: Sequence Customers Within Routes

- The 14 stores are now grouped into 4 groups, with each group being assigned to a specific vehicle.
- The next step is to identify the sequence in which each vehicle will visit the companies.
- There are many types of route sequencing techniques available.

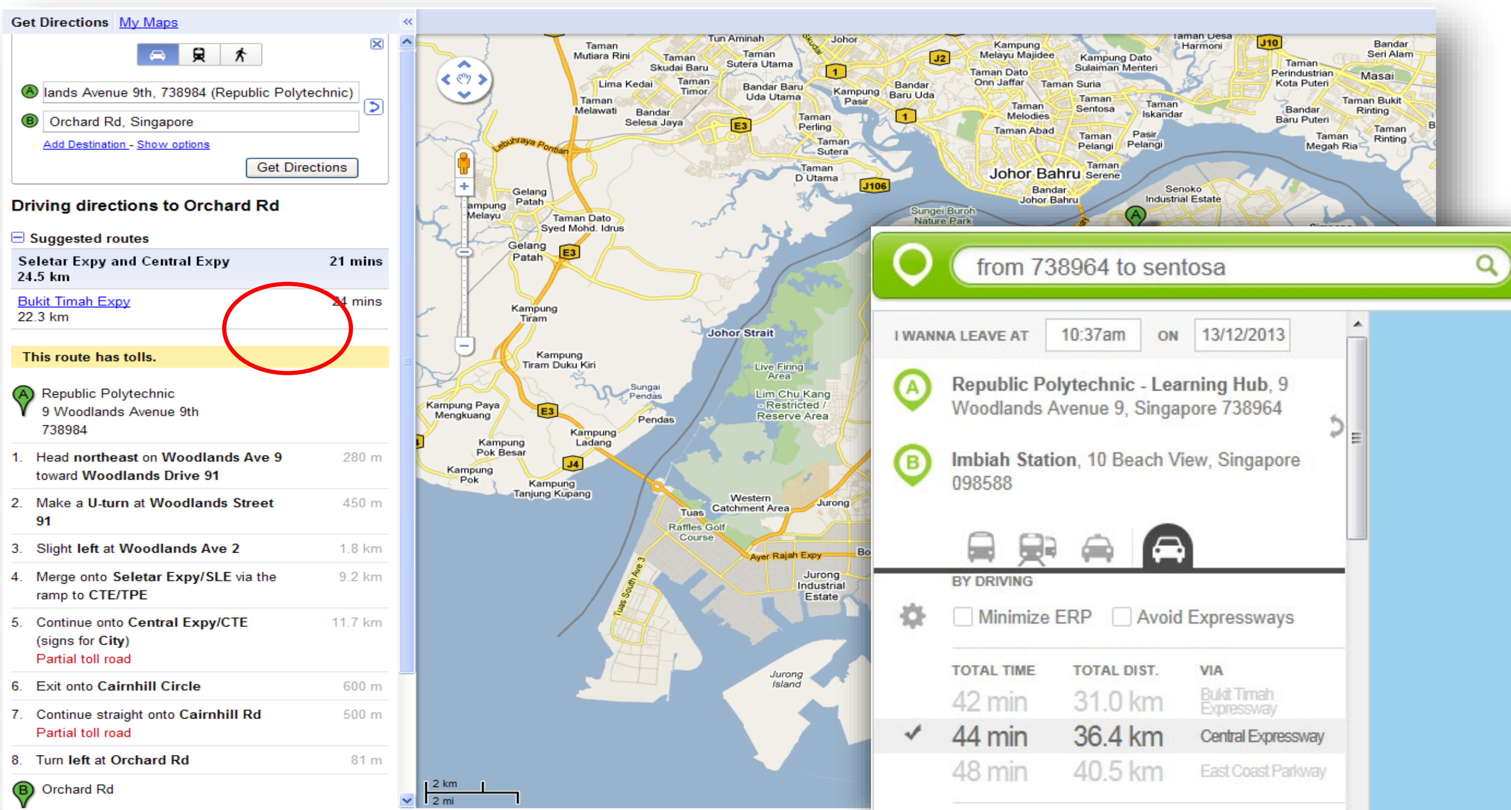
Nearest Neighbor:

- Starting from the farm, this procedure adds the **closest** store to extend the trip.
- At each step, the trip is built by adding the store **closest to the point last visited** by the vehicle until all the stores have been visited

Nearest Neighbor	Resulting Trip	Trip Length
(8-10-9-11)	SF→8→10→9→11→SF	59.7
(12-13-14)	SF→12→13→14→SF	39.3
(2-5-6-7)	SF→2→5→6→7→SF	39.2
(1-3-4)	SF→1→3→4→SF	24.9

Traveling Time or Distance?

- Traveling time maybe a better measurement especially when there is an agreed timeframe with customers. In this case, the distance matrix will be replaced by a time matrix, before applying step 2 to 4.
- So how do we get the traveling time within Singapore?



Learning Outcome

- Describe the concept of milk run and its benefits

- Describe the factors considered when deciding the appropriate routing and scheduling for a given transportation network

- Apply the Savings Matrix Method for a given scenario:
    - Step 1: Identify the Distance Matrix
    - Step 2: Identify the Distance Savings matrix
    - Step 3: Assign customers to vehicles or routes
    - Step 4: Sequence customers within routes

- Apply the Route Sequencing Procedures on a route:
    - Nearest Neighbour