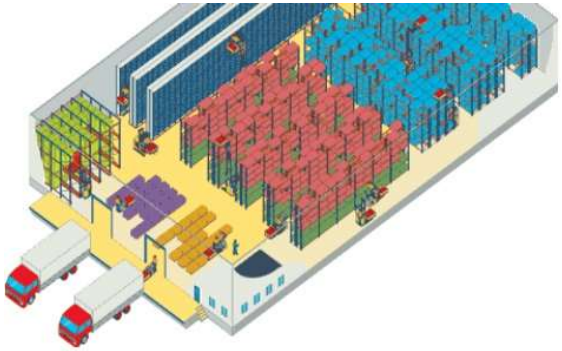
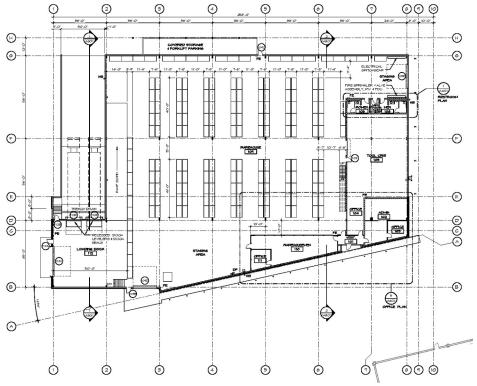
Lesson 09
Design is the key

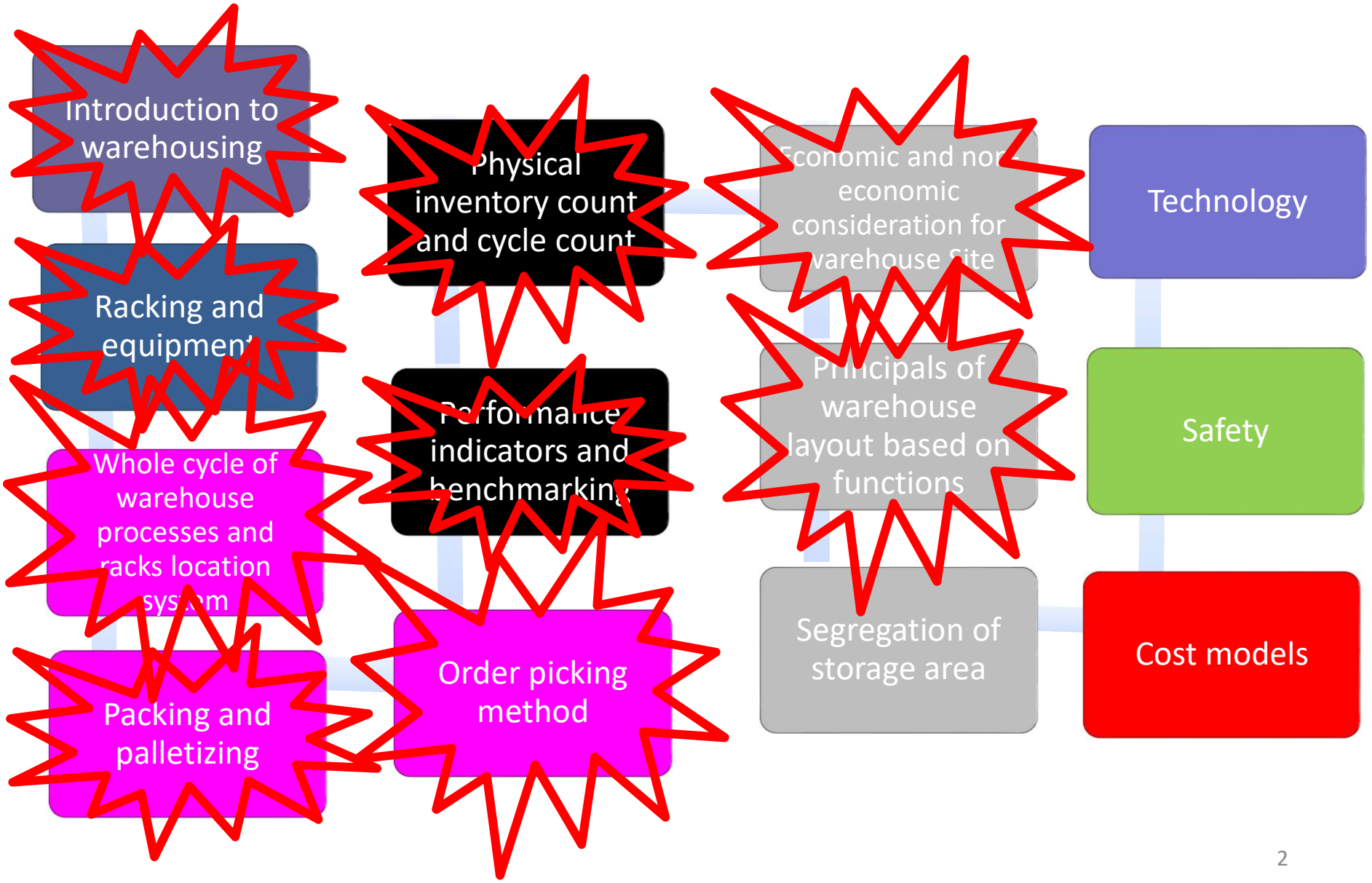




SCHOOL OF ENGINEERING

E215 – Warehousing and Storage

E215 Warehousing and Storage Topic Flow



Learning Objectives

- Explain the steps taken for the Block Layout Model approach
- Create a Relationship Diagram
- Determination of warehouse shape and product flow layout
- Develop the layout plan for the warehouse using the method based on Graph Theory

Why need to design warehouse layout?

- Good warehouse layout can:
  - ✓Provide the flexibility to adapt to change
  - ✓Allow easy access and locate materials
  - ✓Reduce the amount of travel time
  - ✓Maximize space unitization
  - ✓Meet customer service response requirement
  - ✓Meet the safety requirement

Steps for Warehouse Layout Design

Space requirements planning

- Determine the overall space requirements for all warehouse processes

Material flow planning:

- Specify a U-shape, Straight-through, or Modular overall flow design

Adjacency planning

- Locate functions with high adjacency requirement close to one another

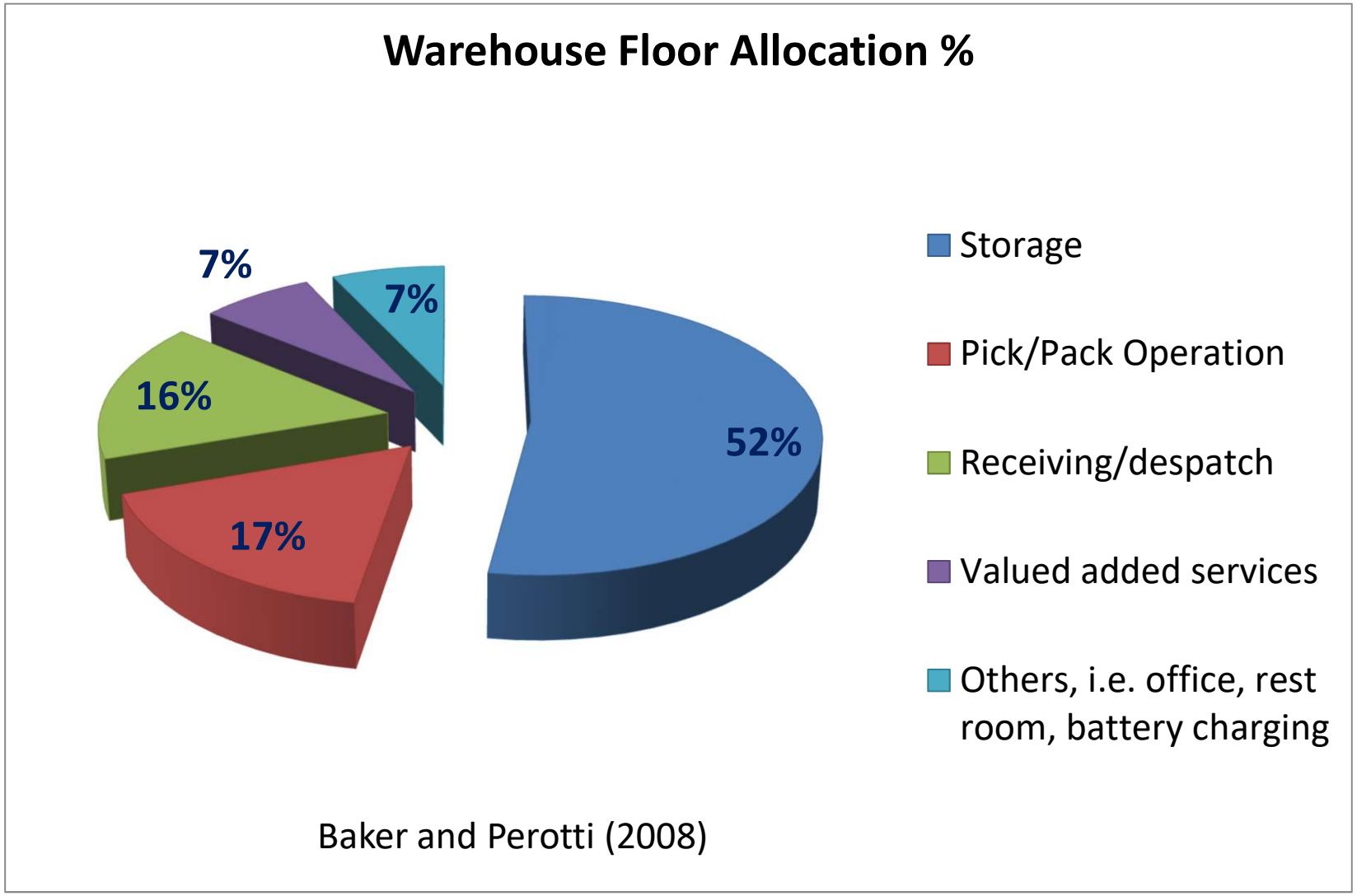
Process location

- Assign processes with high storage requirements to high-bay space, and labor intensive processes in low bay space

Expansion/contraction planning

- Document expansion and contraction strategies for each warehouse process

Warehouse Floor Area Allocation



Baker and Perotti (2008)

Warehouse Block Layout Models

- A modeling tool for generating of warehouse layouts
  - Manual or computer aided
- It does not incorporate details of types of:
  - Storage or picking system required
  - Number of racks, docks and etc
- It provides the most appropriate flow for the products
- It provides the adjacency requirements for different processes

Warehouse Block Layout Models

- The basic premise underlying the development of block layout is that the system as a whole is designed before tackling the details.
- There are some debate on which should come first:
  - The block layout or determining the storage and handling system used.
- Ideally, the best is to do both simultaneously, but it will be too complex to accomplish.

Warehouse Block Layout Models

- Therefore as a guide,
  - When designing a storage driven warehouse, usually we will look into the storage and handling systems first, as we would want to maximize the space available.
  - When designing a distribution oriented facility, we will usually design the block layout first, as we would want to maximize the throughput and product flow.

Use of Modeling Tools

- Modeling tools are used to create a block layout because:
  - There are many processes in warehouse and we need to know where these functions should be located to *maximize the throughput* and *minimize the distances travelled*.
  - Modeling tools use mathematical or geometric algorithms to create the best overall flow that reduce travel time and costs.

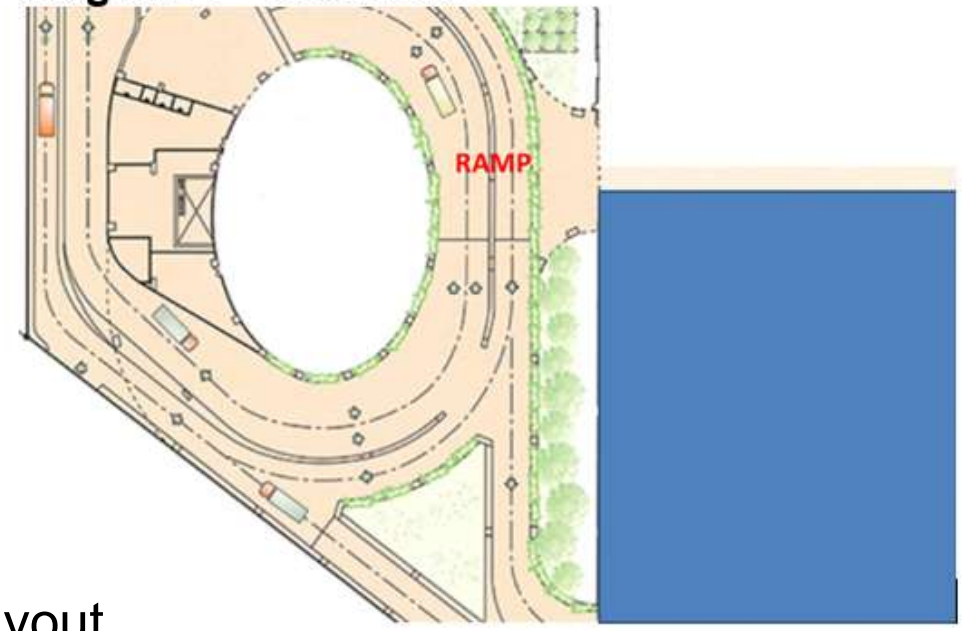
Use of Modeling Tools

- Warehouse processes to be considered:
  - Receiving
  - Receiving staging
  - Inspection
  - Repacking
  - Storage
  - Order picking
  - Sorting
  - Pricing and tagging
  - Packing and shipping
- Non-warehouse processes to be considered:
  - Empty pallet and packaging storage area
  - MHE charging area
  - Warehouse office
  - Rest room

Today's Scenario

Tristan Logistics is planning for a new warehouse to consolidate all their business. In this warehouse, all current process will be port over. These include inbound receiving, storage, picking and packing, value-added processing, sorting process before shipment, and shipment operations. The new warehouse that Tristan Logistics acquires has an area of 24,000 m^2 and is located in the first storey. Below is the floor plan.

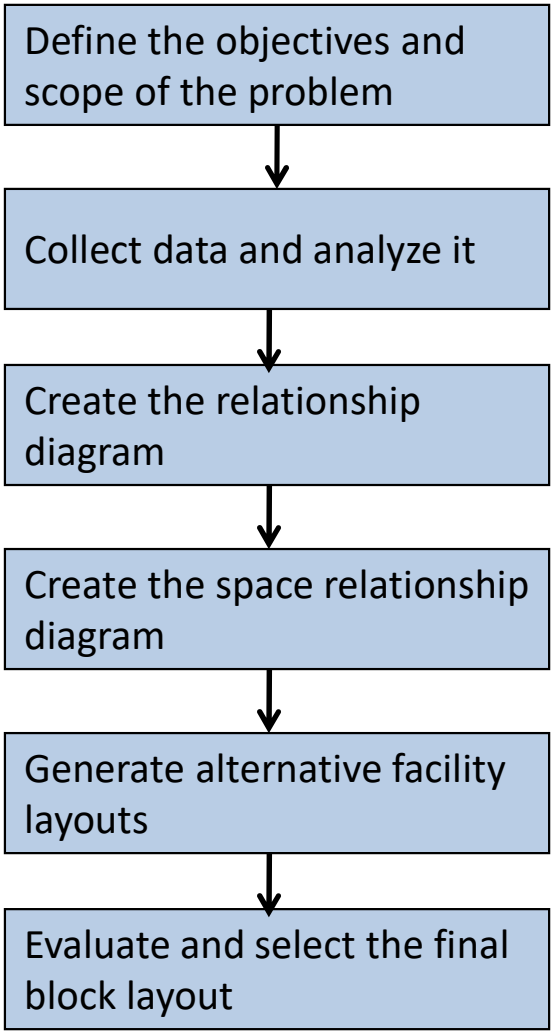
Diagram 1 – Floor Plan



Design a possible layout.

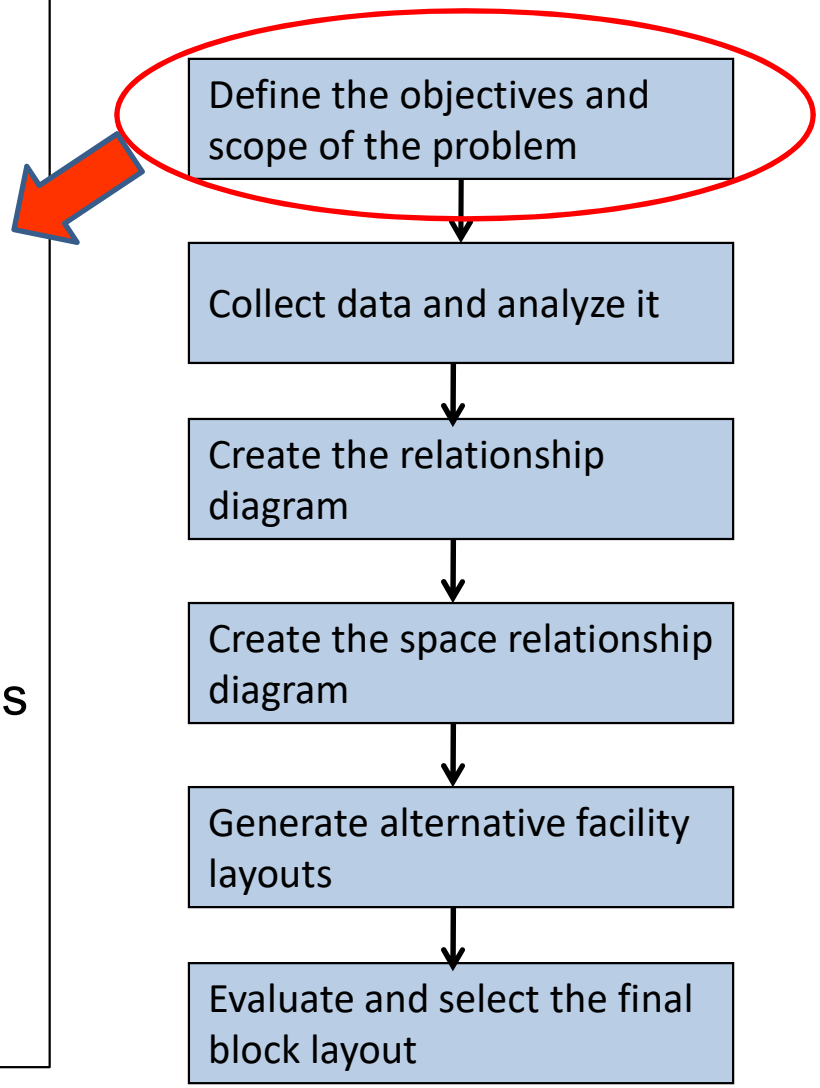
Approach - Block Layout Model

- There are manual and computerized methods for planning the layout.
- Today's scenario will cover the manual approach developed by Muther, known as Systematic Layout Planning
- There are a total of 6 steps



Approach - Block Layout Model

- Step 1:
  - When relationships between warehouse processes are expressed **quantitatively**, the objective is to minimize costs, distance and frequency of moving across departments.
  - When **qualitative** relationships are used, the objective is to maximum the adjacency score or closeness ratings, using relationship diagrams
  - Decide what is in-scope and what is out-scope.



Step 1: Provided

Before you can use the graph theory, you need to establish the activity relationship chart by establishing the Closeness table & the Reason table

Closeness table

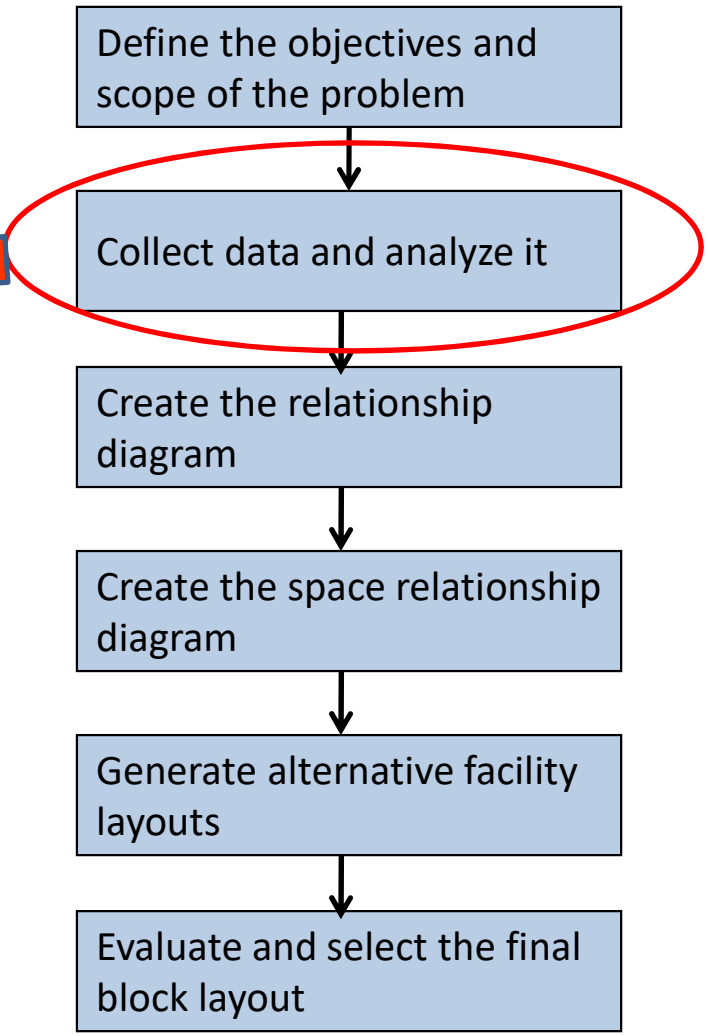
Symbol	Closeness	Weight
A	Absolutely Necessary	4
E	Extremely important	3
I	Important	2
O	Ordinary closeness OK	1
U	Un-important	0

Reason table

Symbol	Reasons for importance	Weight
S	Supervision/share labour	3
F	Finish goods to replenish pick line	1
M	Material Flow	6
W	Work flow	5
C	Material control	2

Approach - Block Layout Model

- Step 2:
  - List the warehouse processes that are within the scope of the project
  - Estimate the space required for each process
  - Establish relationships between the processes. (Relationships are defined by the flow of materials, supervisory issues, environmental considerations, control issues and process requirements.)



Step 2: Provided

Information provided by the warehouse team :

	Processes	Space required (m^2)
1	Receiving & Staging	4,200
2	Storage	12,700
3	Sorting and packing (Outbound)	2,000
4	Shipment staging	3,100
5	Value added process	2,000

Step 2: Provided

Information gathered for process closeness:

- Receiving and storage must be next to each other.
- Storage and Picking & sorting must be next to each other.
- It is extremely important that picking & sorting and shipment are next to each other
- It is important that storage is beside value-added process
- Ordinary closeness is sufficient between storage and shipment
- Ordinary closeness is sufficient between picking & sorting and value-added process
- Ordinary closeness is sufficient between shipment and value-added process
- It is unimportant for all non-mentioned process to be close together

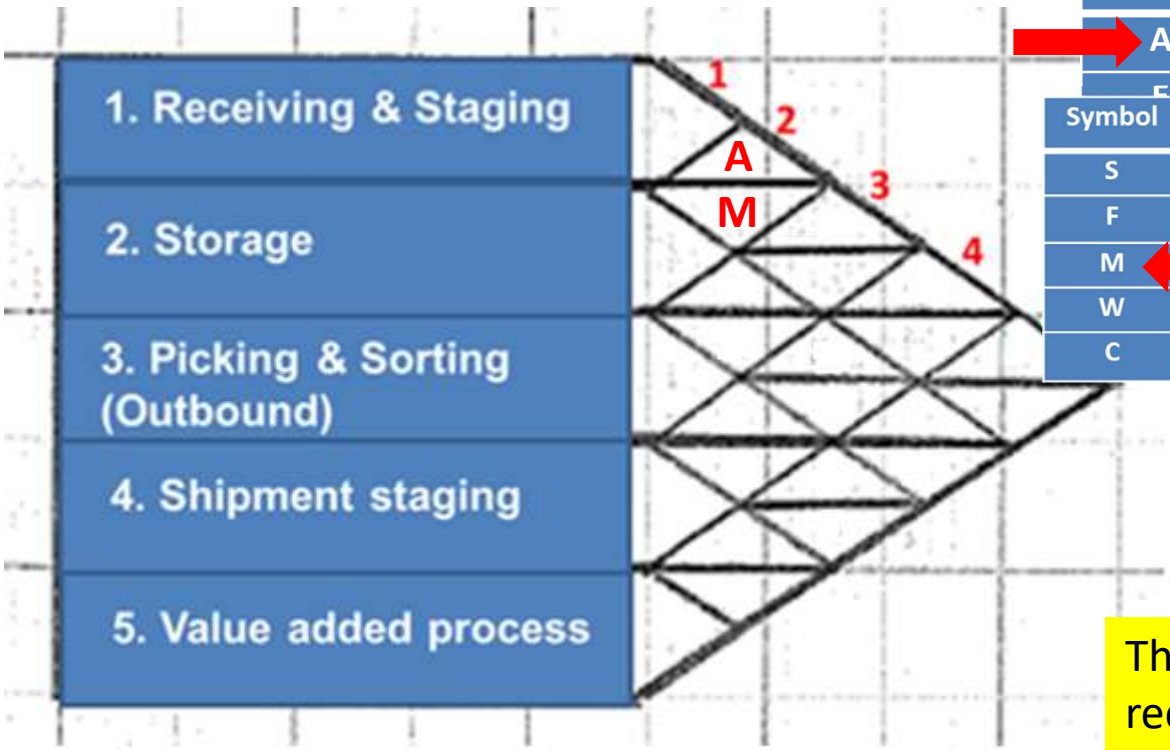
Step 2: Provided

Information for the importance of the relationships between the processes:

- There is material flow between receiving and storage
- There is material flow between picking & sorting, and shipment
- There is material flow between storage and shipment
- There is workflow between storage and picking & sorting
- There is shared labour between picking & sorting and value-added process
- There is shared labour between shipment staging and value-added process
- There is material control between storage and value-added process

Step 2: Do-it-yourself 1

Prepare the table below. In each of the diamonds, input the symbol for closeness on top and the symbol for importance below. An example has been done for you.



Symbol	Closeness	Weight
A	Absolutely Necessary	4
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Symbol	Reasons for importance	Weight
S	Supervision/share labour	3
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M	Material Flow	6
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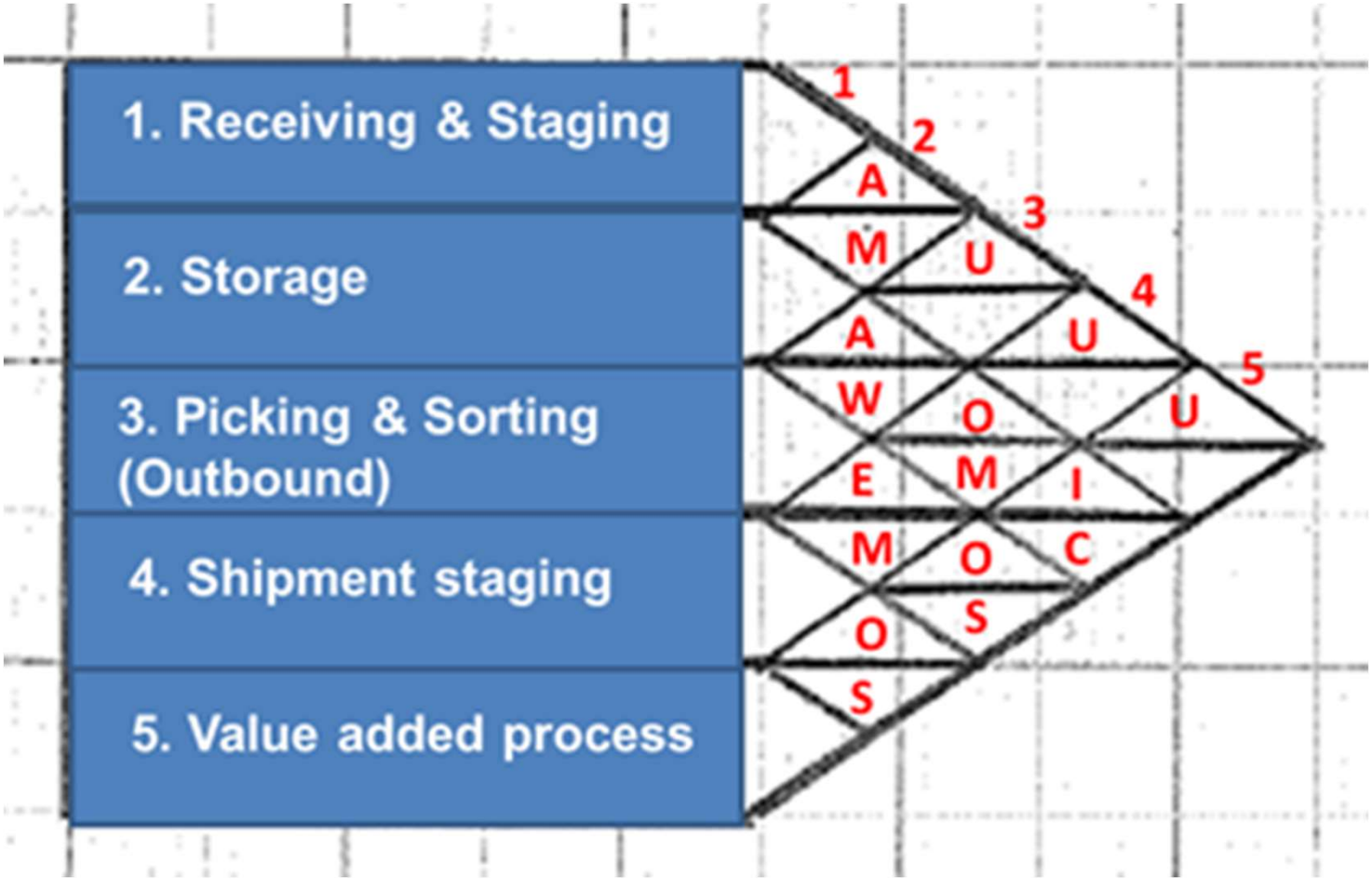
Receiving and storage must be next to each other.

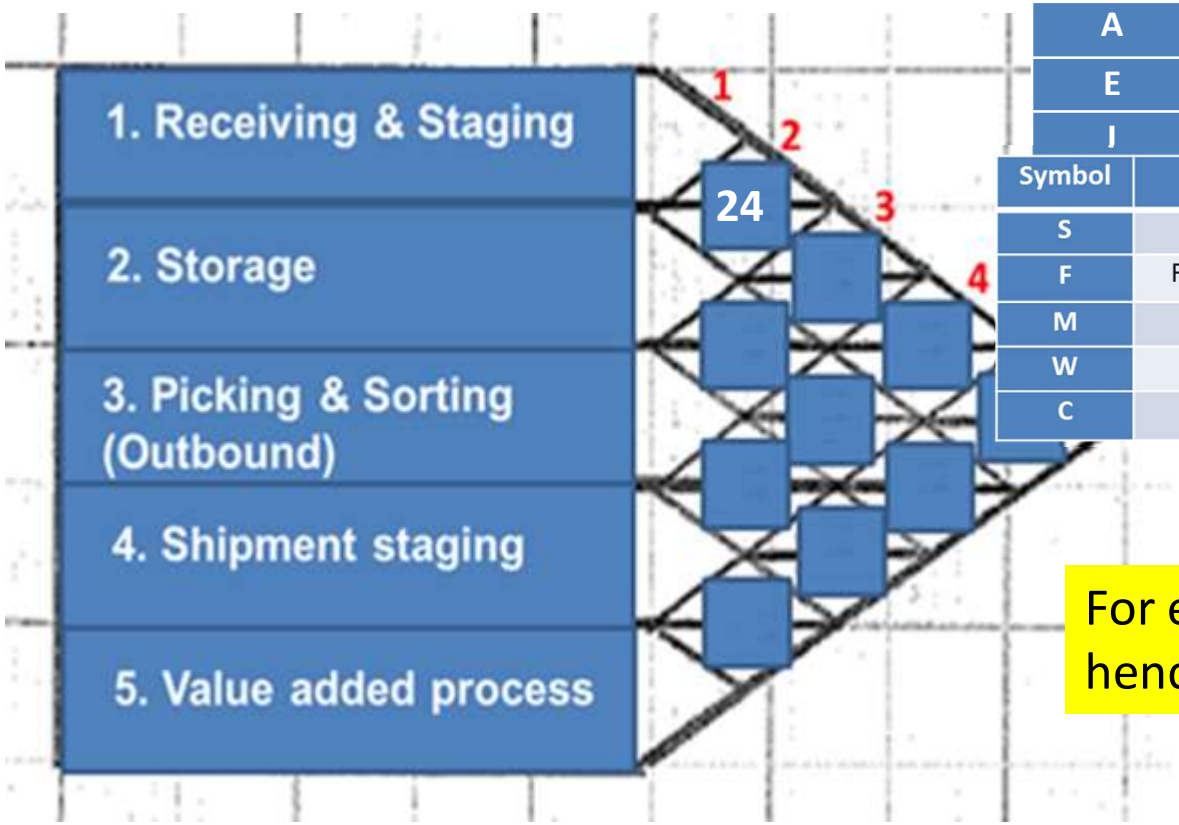
There is material flow between receiving and storage

Step 2: Answer 1



Step 2: Do it yourself 2

Compute the value in the blue boxes by multiplying the weight together.



Symbol	Closeness	Weight
A	Absolutely Necessary	4
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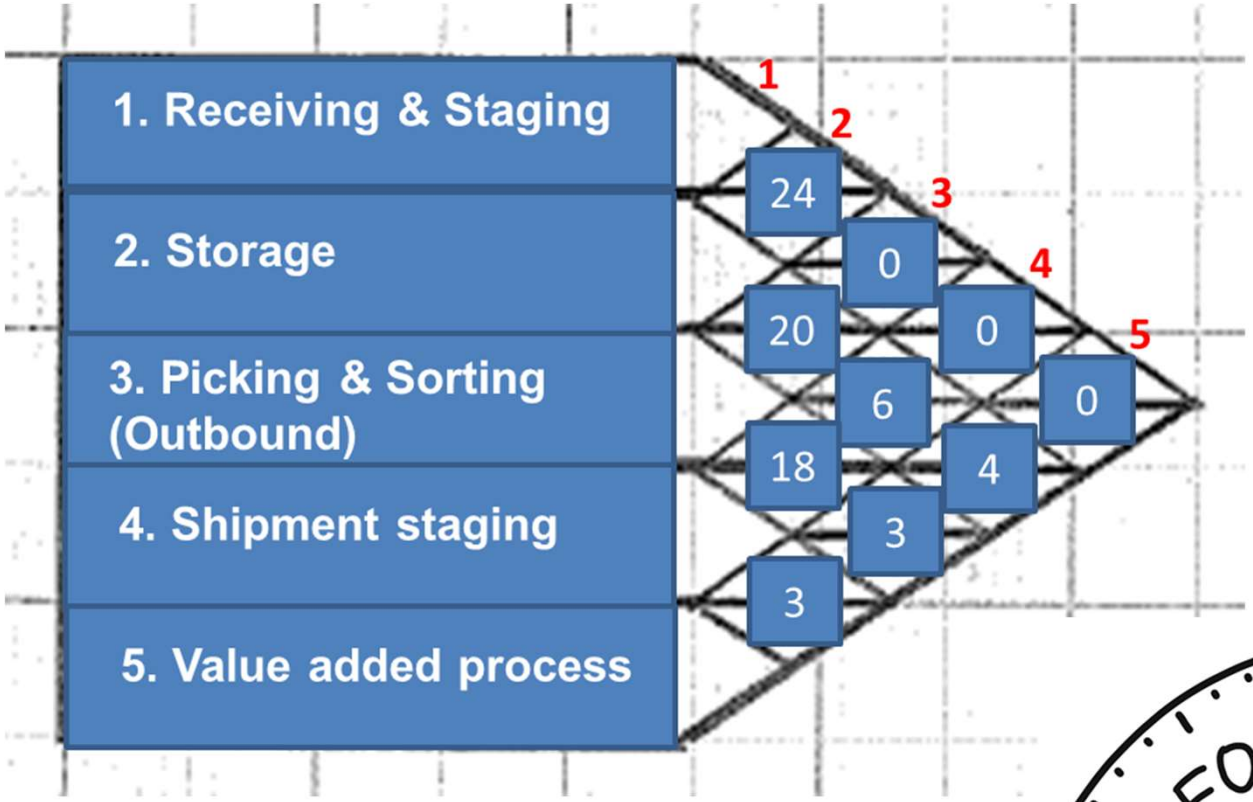
Symbol	Reasons for importance	Weight
S	Supervision/share labour	3
F	Finish goods to replenish pick line	1
M	Material Flow	6
W	Work flow	5
C	Material control	2

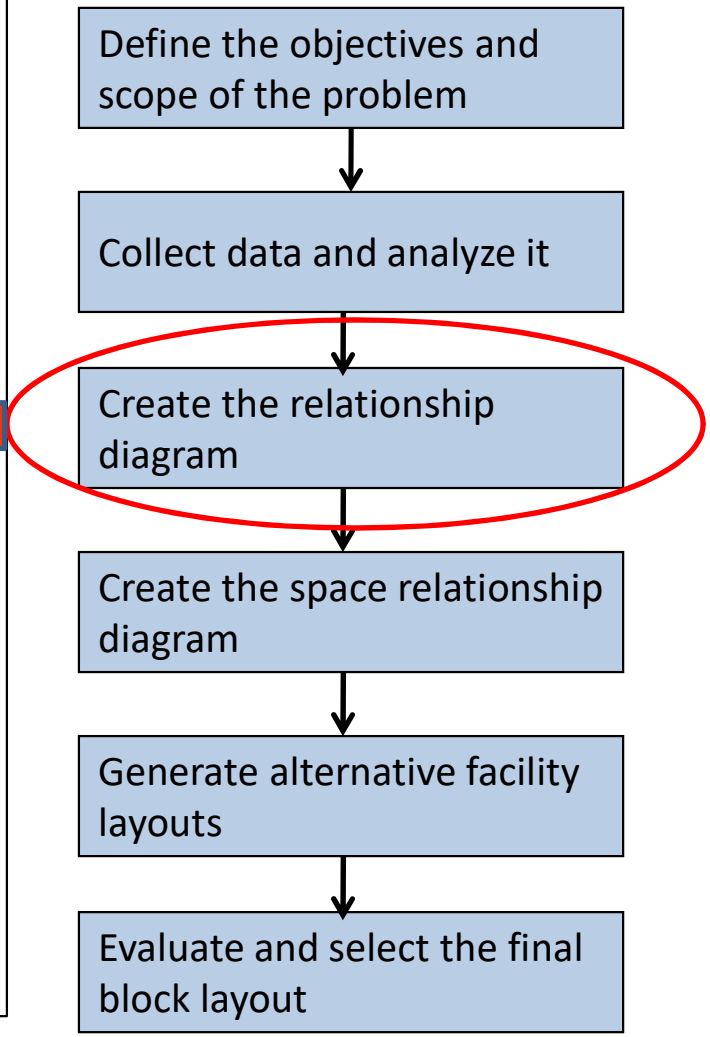
For example: A = 4, M = 6, hence A x M = 4 x 6 = 24

Step 2: Answer 2



Approach - Block Layout Model

- Step 3:
  - Using the data collected in step 2 to determine the relationship and closeness between each process.
  - There are several methods, but we will be focusing on the graph theory method.
  - Graph theory method optimizes solution using a network of weighted arcs that represent adjacency ratings. This network will then show relative spatial proximity of each process.



Supplementary Note

- Graph Theory
  - Provides optimum solution using a network of weighted arcs that represent adjacency rating.
  - This network will then reflect the relative spatial proximity of each process.
  - Used as a guide to lay out the facility using actual space requirements.

Step 3: Do-it-yourself 3

Select the pair of processes with the highest weightage between then and input the processes names into the top row. Put the other 3 processes in the first column as shown below. Fill in the value and compute the total bin the table below

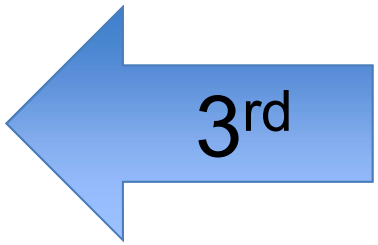
	1	2	Total
3			
4			
5			

Step 3: Answer 3

	1	2	Total
3	0	20	20
4	0	6	6
5	0	4	4

Step 3: Do-it-yourself 4

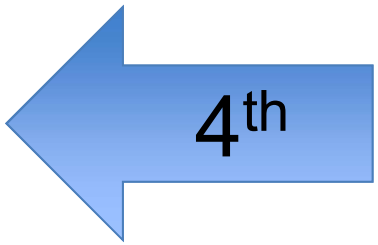
	1	2	Total
3	0	20	20
4	0	6	6
5	0	4	4



Select the highest total of the 3 processes. The selected process will be the next highest process. Repeat step 3.

Step 3: Answer 4

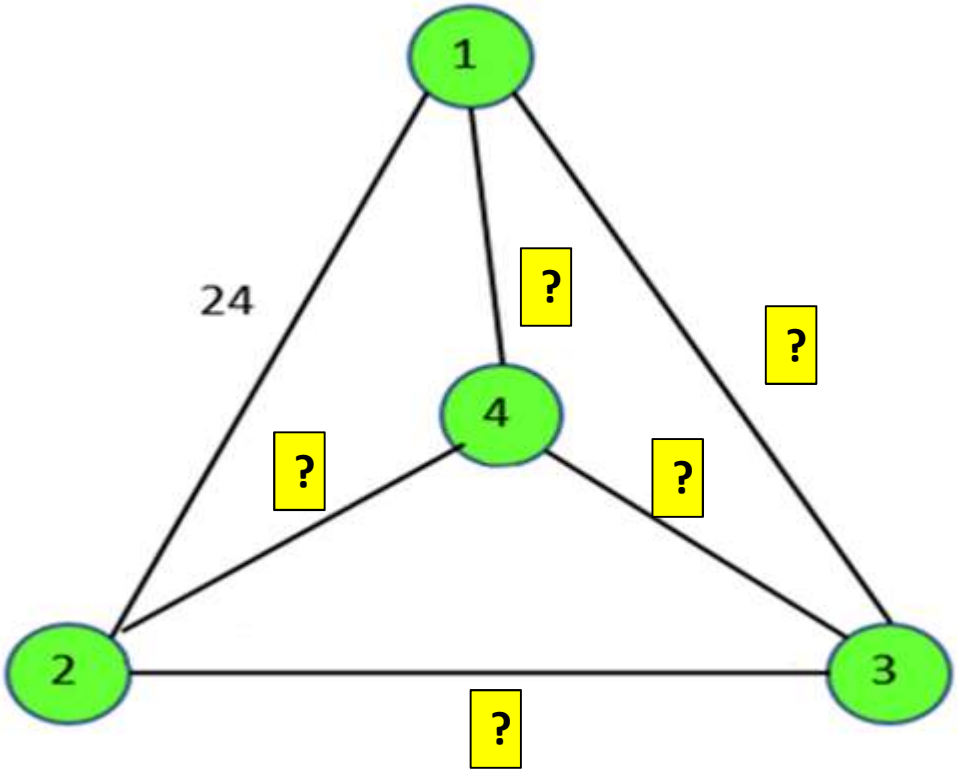
	1	2	3	Total
4	0	6	18	24
5	0	4	3	7



Now we have the ranking of the processes. It is 1,2,3,4,5

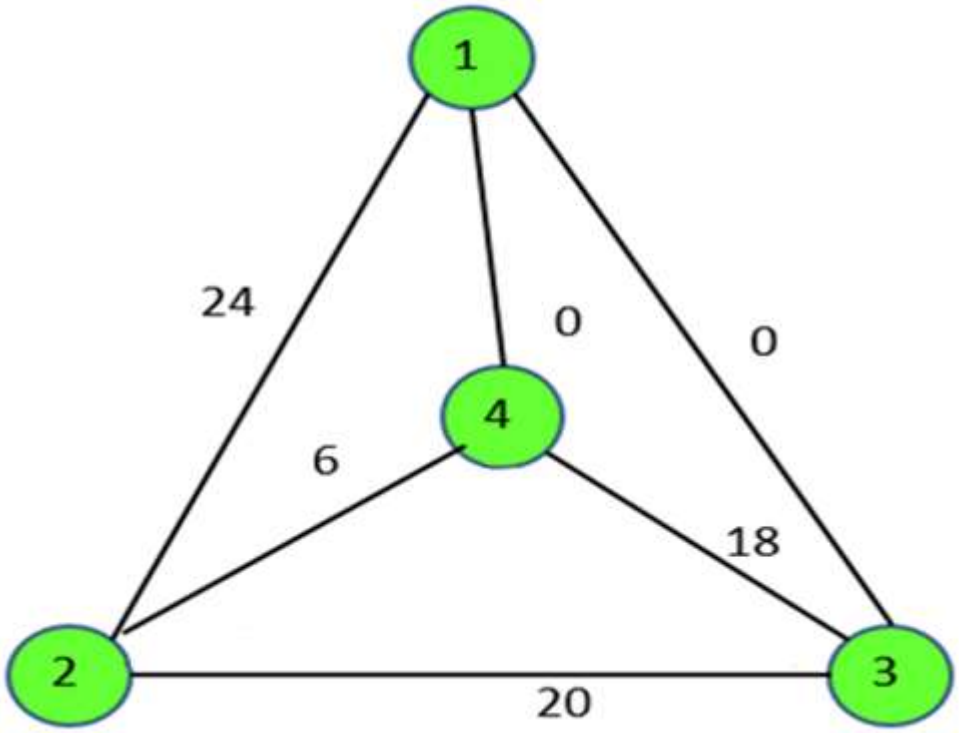
Next, we form a simple triangle with the three highest rank, and the 4th process in the middle.

Step 3: Do-it-yourself 5



The respective arc value is then entered into the triangle. One value “24” has been entered. Try and fill in the rest.

Step 3: Answer 5



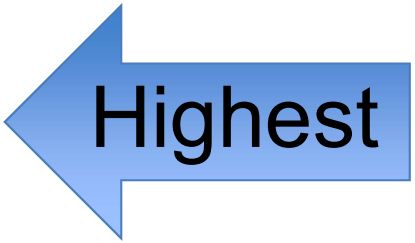
Step 3: Do-it-yourself 6

There are 4 triangles. We have to insert process 5 into the triangle with the highest total. To do that, we use this table. 1 example has been done.

Triangle	Arc 1	Arc 2	Arc 3	Total
1-2-4	‘1-5’ = 0			
1-3-4				
2-3-4				
1-2-3				

Step 3: Answer 6

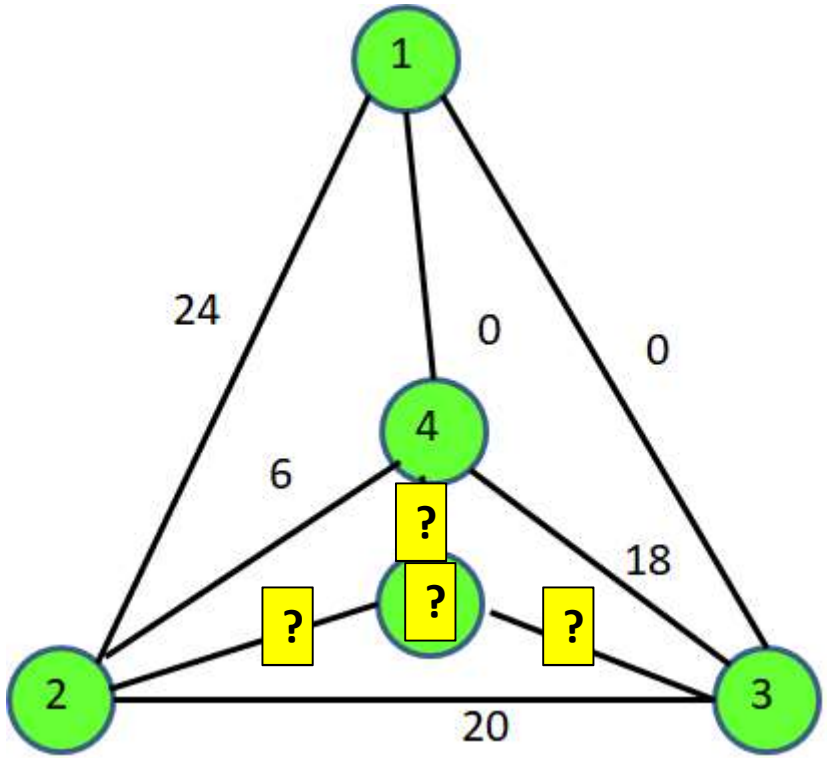
Triangle	Arc 1	Arc 2	Arc 3	Total
1-2-4	‘1-5’ = 0	‘2-5’ = 4	‘4-5’ = 3	0+3+4 =7
1-3-4	‘1-5’ = 0	‘3-5’ = 3	‘4-5’ = 3	0+3+3 = 6
2-3-4	‘2-5’ = 4	‘3-5’ = 3	‘4-5’ = 3	4+3+3 = 10
1-2-3	‘1-5’ = 0	‘2-5’ = 4	‘3-5’ = 3	0+4+3 = 7



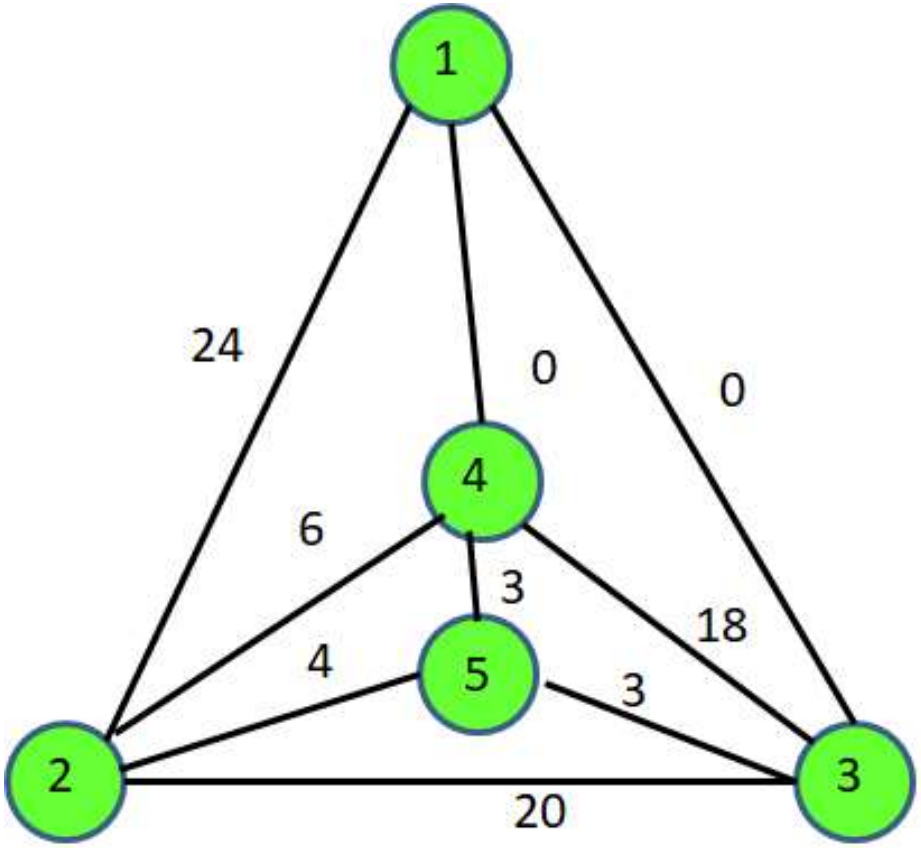
Process 5 will be inserted in triangle 2-3-4.

Step 3: Do-it-yourself 7

Again, fill in the value in the triangle.

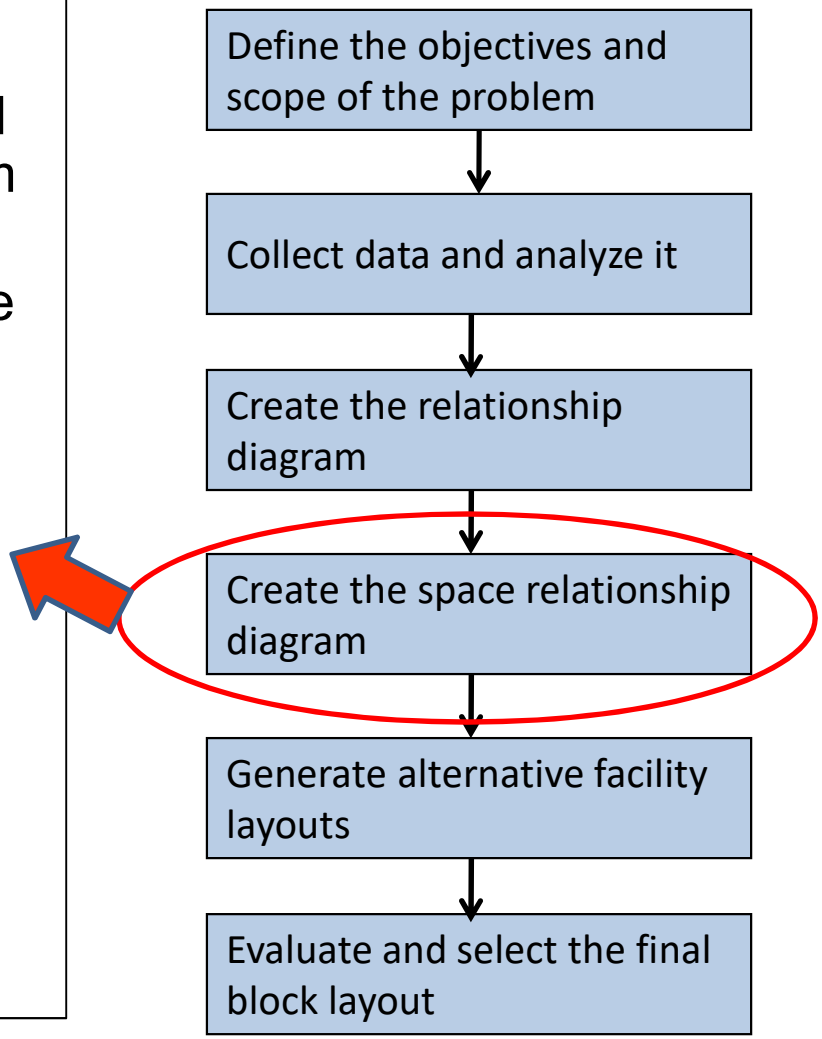


Step 3: Answer 7



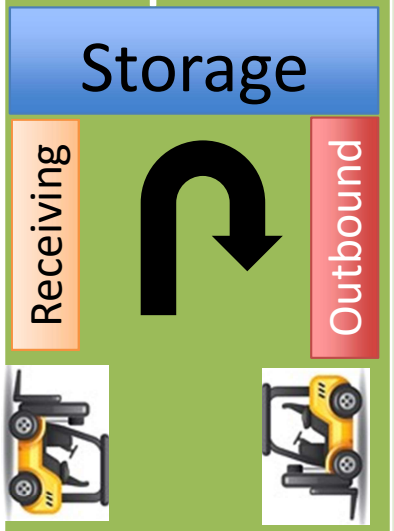
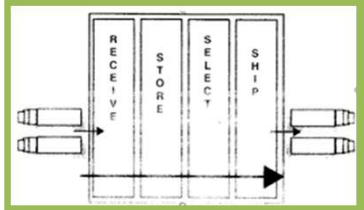
Approach - Block Layout Model

- Step 4:
  - The space requirements of each function are integrated into the relationship diagram
  - Note: at this step, it's also good that you can **verify** the space requirements.

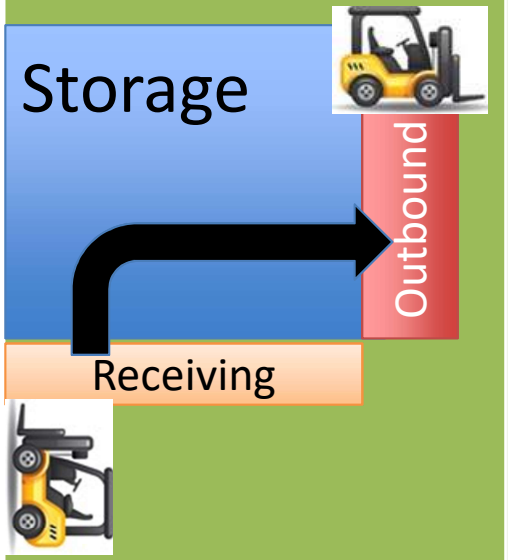


Warehouse shape and product flow

- Possible designs for general product flow

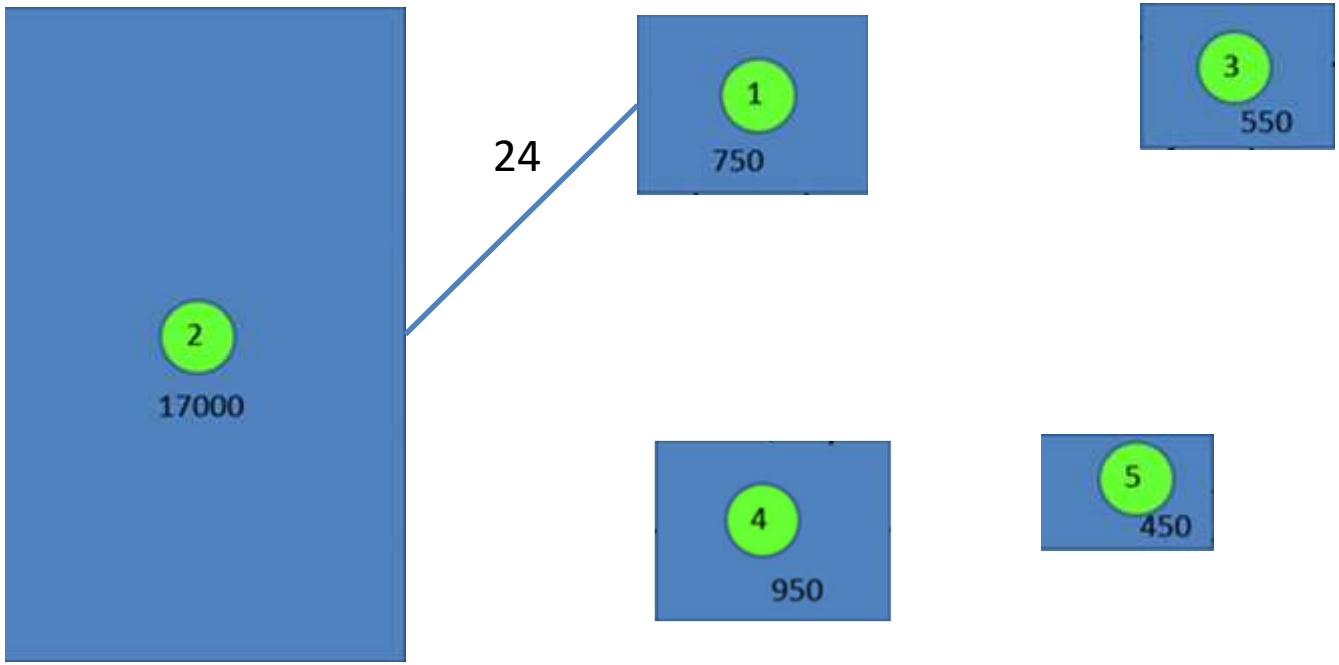
Flow Pattern	Pros	cons
U-shaped flow 	• Excellent utilization of dock resource • Facilitating cross-docking operation • Excellent lift truck utilization • Enables expansion opportunities • Yields excellent security	
Straight-thru flow 	• Efficient for pure cross-docking • Efficient for peak receiving and shipping times coincide	• Difficult to take advantage of ABC storage and dual command trips

Warehouse shape and product flow

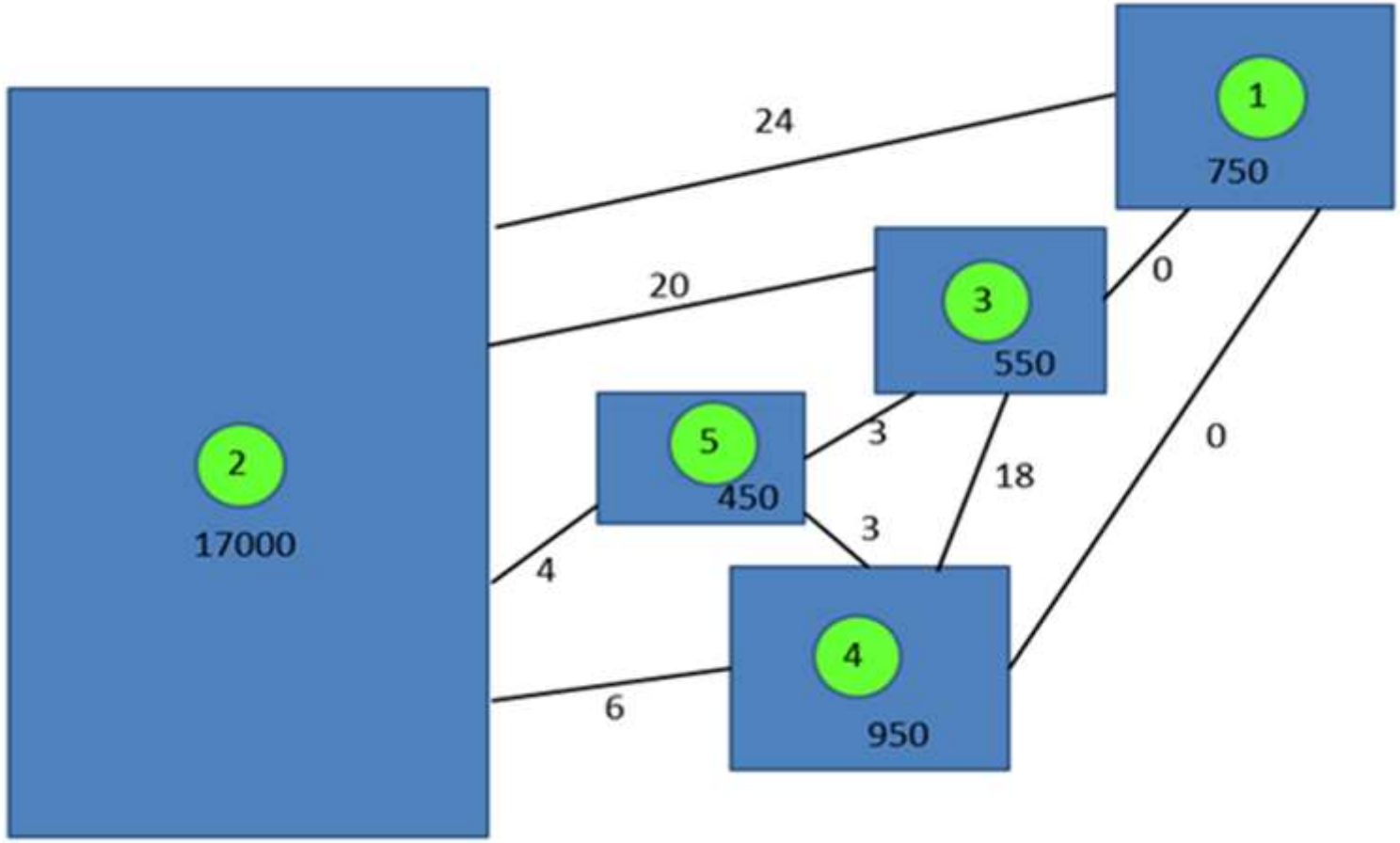
Flow Pattern	Pros	cons
Modular-spine	• Suitable for large-scale operations	Modular-spine
L-shaped flow 	• Reduces the disadvantages of Straight-thru flow, but maintained some of its advantages	

Step 4: Do-it-yourself 8

Below are the blocks for each processes according to their respective area, sketch as close as possible. Join the process with lines similar to a do-it-yourself 7. An example is done.

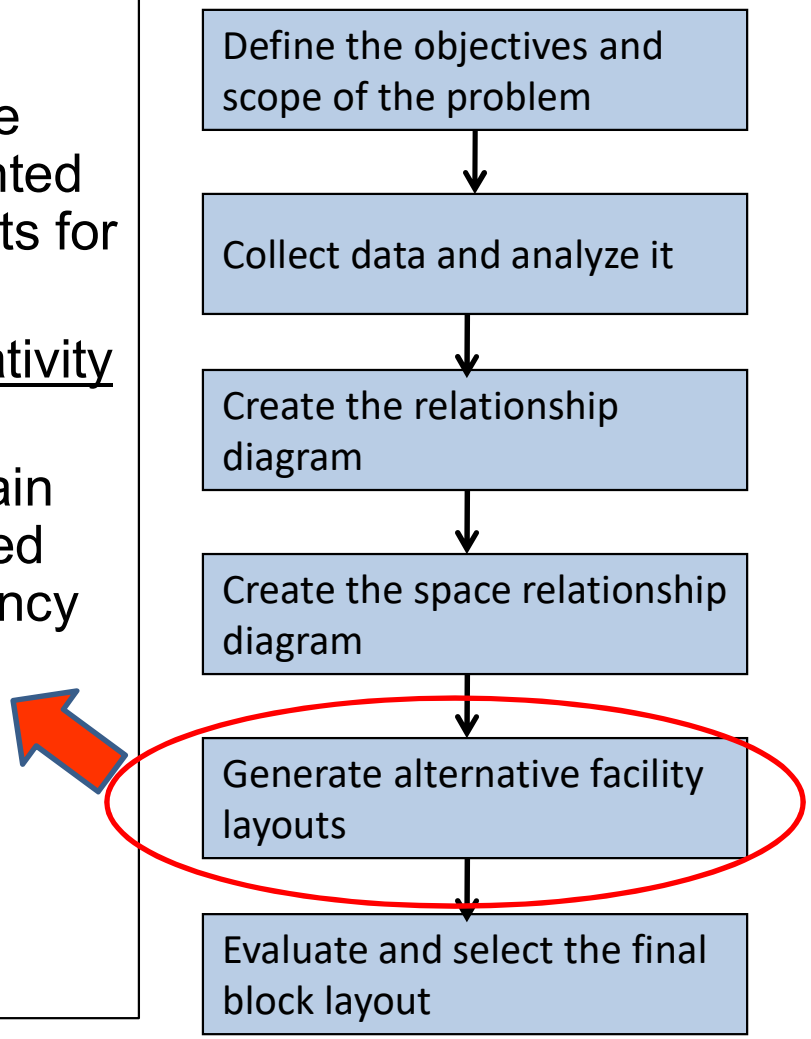


Step 4: Answer 8



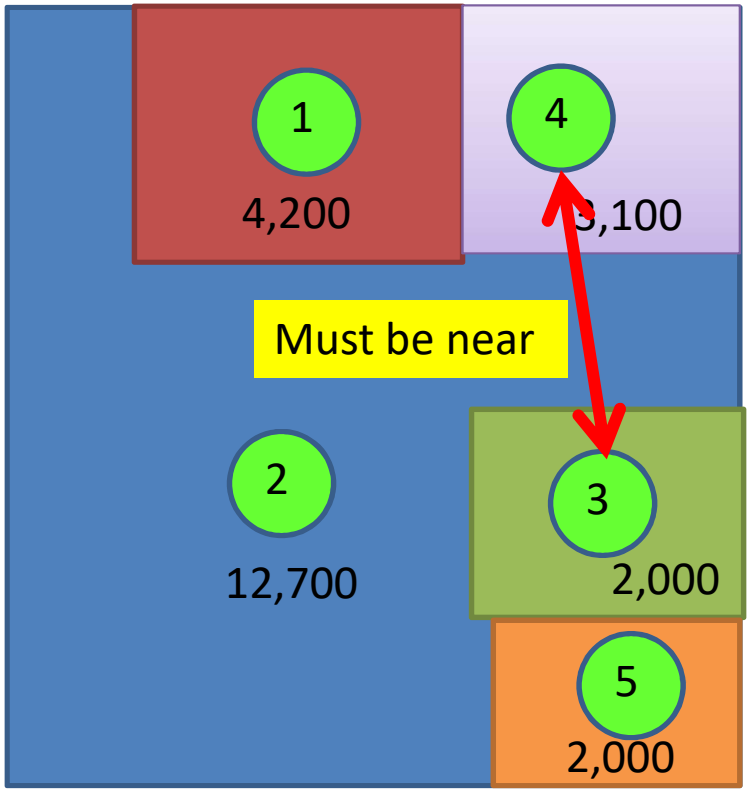
Approach - Block Layout Model

- Step 5:
  - Based on the relationship established in step 3 and the space requirements highlighted in step 4, create other layouts for comparisons.
  - This will required some creativity of the designer.
  - Changing the shape of certain areas but keeping its required size might impact the efficiency of the warehouse.



Step 5: Do-it-yourself 9

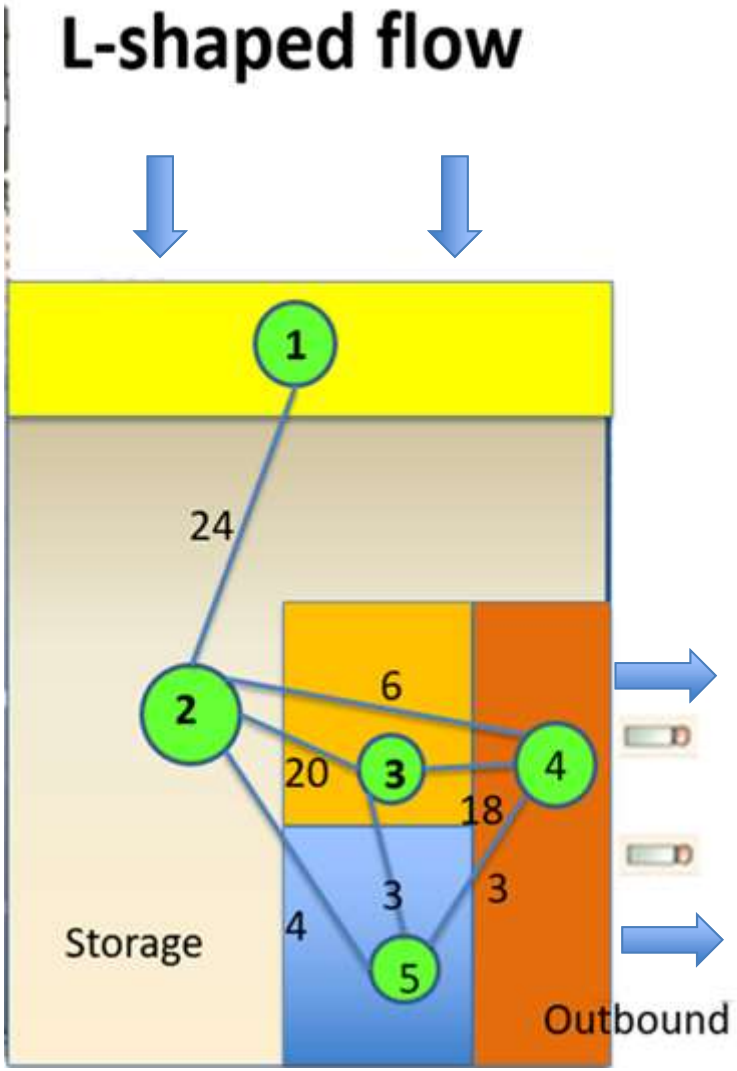
Try to piece the layout together like a jigsaw puzzle. The layout of each process can also be configure to other shape. One example is below:



We need to check that the processes with high Arc value are placed beside each other!

In the left example, processes 3 & 4 should be besides each other, as the Arc value is 18!

Step 5: Answer 9

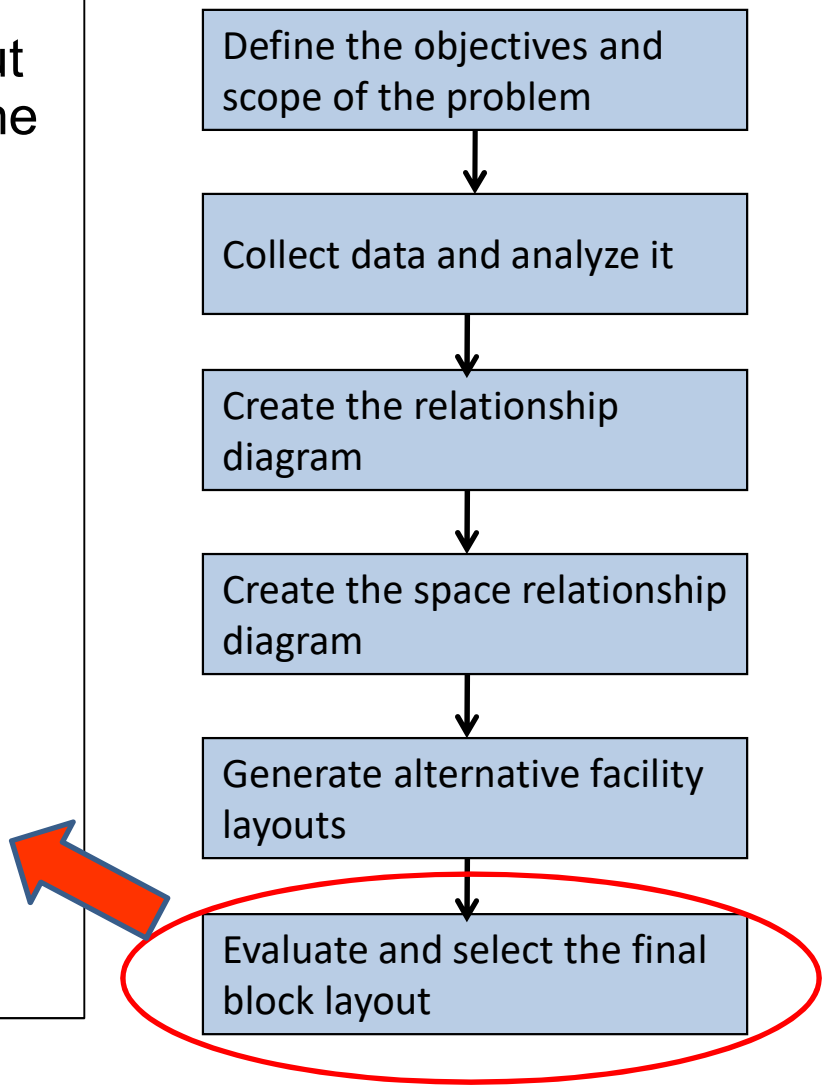


We can clearly see that process with high Arc value are placed next to each other.

Furthermore, the inbound and outbound have access to the road

Approach - Block Layout Model

- Step 6:
  - With all the alternative layout done, evaluate and select the best layout.



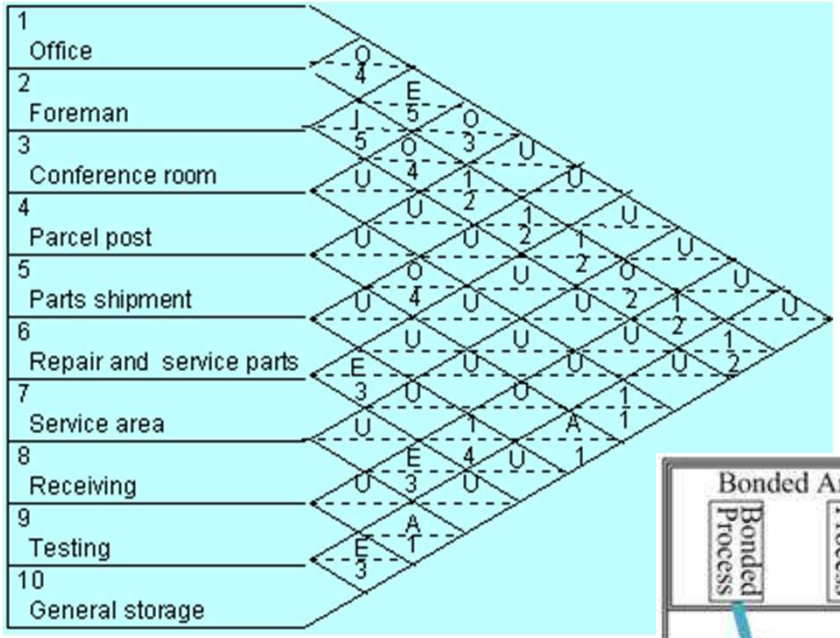
Step 6

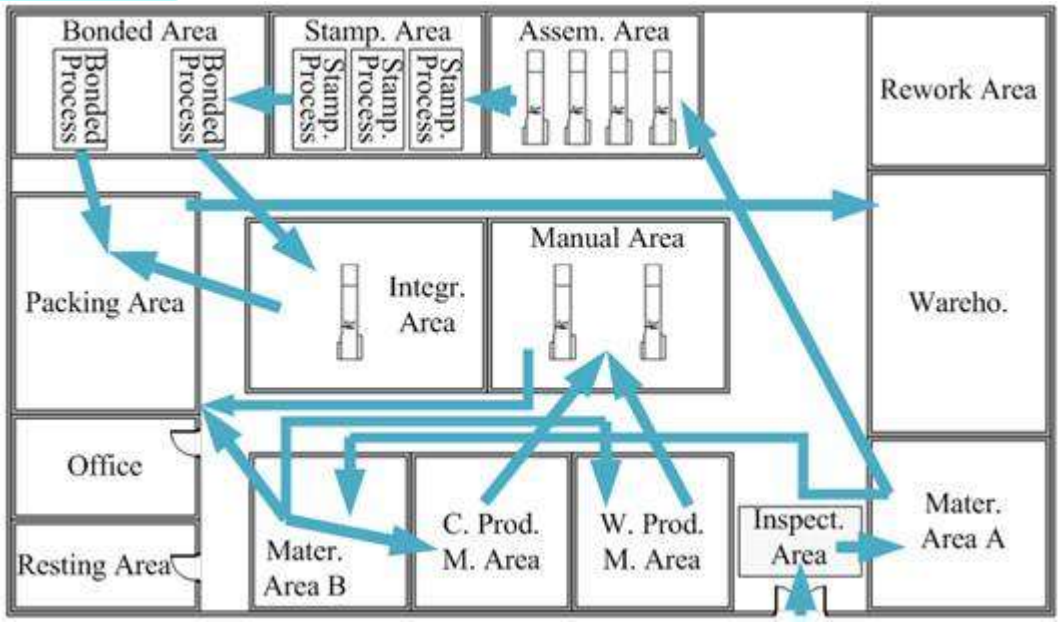
- A few more layouts should be generated and if the actual floor plan is available, it should be made reference to when designing the block layout.

- Inbound and outbound directions, warehouse openings and constraints in the warehouse must be taken into consideration when designing the block layout.

- Evaluate the alternative layouts and select the final layout.

Layout can also be complicated!





Learning Outcome

- Explain the steps taken for the Block Layout Model approach
- Create a Relationship Diagram
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- Develop the layout plan for the warehouse using the method based on Graph Theory