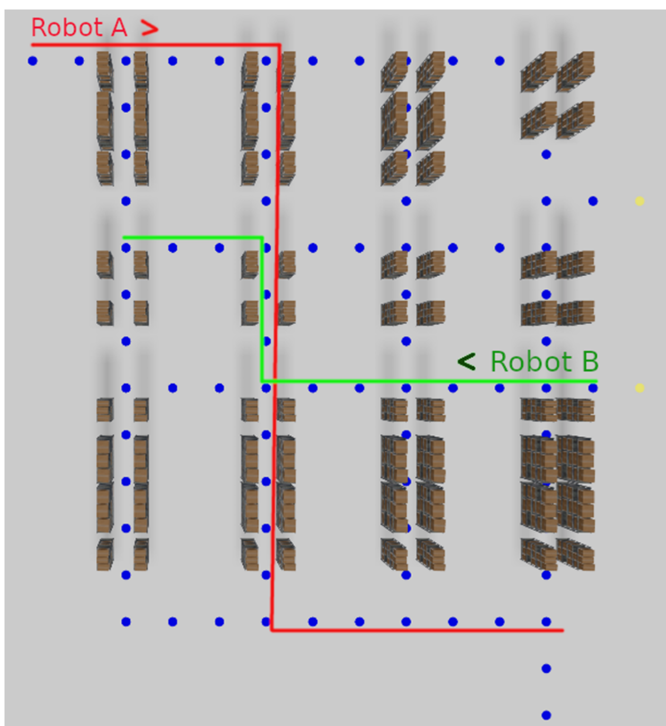
Intern Task 1

Scenario:

You are tasked with designing a conflict resolution module for a fleet management System (FMS) overseeing a group of mobile robots in a warehouse. In this system:- Mobile robots are assigned tasks like navigating to specific locations, picking items, and
delivering them.- Conflicts arise when:

- Two robots are scheduled to access the same aisle or node at the same time.
- One robot delays task completion, disrupting the schedule for other robots.

Refer to Fig.1. It is an example of a warehouse layout (top view) where two robots have to take
the shown path in respective directions. They can only move through those paths and all they can
do is to stop or slow down to resolve the conflict.



Task 1:

Propose a strategy to prioritize which robot should gain access to the common path (aisle) if the
FMS is yet to send the paths to the robots. Consider factors like task urgency, proximity, and
overall operational efficiency.

Explain your reasoning and trade-offs in detail. Suggest how your solution would adapt if the
number of robots increased significantly.

Solution:

Factors to be considered:

- Task Urgency
- Proximity
- Low Battery
- Operational Efficiency(amount of time delayed due to solving an issue here i am considering that if delayed time is more then it means more disruptions are being caused)
- Estimated time to complete the task(Prefer resolutions that can be executed quickly)

Based on the above factors we can come up with a mathematical equation which gives us a priority rating on 100.

for example if task assigned to robot A has 90 priority rating and B has 70 priority rating then A should move through the common path first and then B

Now to calculate priority rating we can consider the factors as positive and negative

Positive factors(these factors are added):

- Task urgency

Reason: If Robot A is delivering an item for immediate use (e.g., a high-priority shipping order), it might gain access to a common aisle over Robot B, which is restocking an item.

- Proximity

Reason:If Robot B is closer to the common aisle and can pass through it quickly without significantly impacting Robot A’s task, Robot B might be prioritized to avoid unnecessary idle time for both.

Negative factors(these factors are subtracted):

- Low battery

Reason: if a robot has low battery then it might block the path while it is going to the location, which in turn might impact the tasks of other robots as they might need the same path(Rare case)

- Operational Efficiency

Reason: Operational Efficiency can be a positive factor or a negative factor it can be positive if we give more rating to lesser time delay but we are now considering it as negative to balance the sides and as we are considering it as a negative factor we reversed the table ie more time delay more rating

- Estimated time to complete the task/Estimated Time to Clear (Conflict Resolution Speed)

Reason: For instance, if Robot A can cross the aisle in 5 seconds and Robot B requires 15 seconds, Robot A might be prioritized.

Positive Factors priority:

Task urgency > proximity

Negative factors priority:

Operational Efficiency >> Estimated time to complete the task > low battery(Rare case)

Priority ratings:

Task urgency(3)

proximity(2)

total positive priority rating: 5

Operational Efficiency(3)

Estimated time to complete the task/Estimated Time to Clear (Conflict Resolution Speed) (1.5)

Low battery(0.5 as it is a rare case)

total negative priority rating: 5

even in these factors we can have priority ratings within them(look at the tables below):

Task Urgency (A):

Task Urgency Level	Description	Rating (Out of 10)
Critical (High Priority)	Tasks that must be completed immediately (e.g., urgent order deliveries or time-sensitive tasks).	**10**
High	Tasks important for system operations but with slightly flexible deadlines.	**8**
Moderate	Routine tasks necessary for operations but not time-sensitive (e.g., restocking inventory).	**6**
Low	Tasks with minimal time constraints (e.g., relocating empty containers or optimizing layouts).	**4**
Very Low (Idle Tasks)	Tasks that can be postponed indefinitely without affecting operations (e.g., maintenance runs).	**2**

Proximity (B):

Proximity Level	Description	Rating (Out of 10)
Immediate (High Priority)	Robots that are directly in or very close to the conflict zone (e.g., right in the aisle).	**10**
Near (High)	Robots that are approaching the conflict zone or only one node away.	**8**
Moderate (Medium)	Robots that are within a couple of nodes but not in direct conflict.	**6**
Far (Low)	Robots that are significantly farther from the conflict zone and will not affect the area soon.	**4**
Very Far (Minimal Impact)	Robots that are far away from the conflict zone and have no immediate or foreseeable impact.	**2**

Operational Efficiency (C):

Operational Efficiency Impact Level	Estimated Delay (seconds)	Operational Efficiency Rating (10-point scale)
Very High Impact	> 30	10
High Impact	21–30	8
Moderate Impact	11–20	6
Low Impact	6–10	4
Very Low Impact	≤ 5	2

Estimated Time to Clear (Conflict Resolution Speed) (D):

Resolution Speed	Description	Rating (Out of 10)
Very Slow	Conflict resolution will take a long time (e.g., requires major rerouting or halting the robot for extended periods).	**10**
Slow	Conflict resolution will take a considerable amount of time (e.g., several minutes).	**8**
Moderate	Conflict resolution will take a moderate amount of time (e.g., 1-3 minutes).	**6**
Quick	Conflict resolution will take a short amount of time (e.g., a few seconds to a minute).	**4**
Very Quick	Conflict can be resolved almost immediately (e.g., minor adjustments or slight path changes).	**2**

Battery remaining(E):

Battery Level	Description	Rating (Out of 10)
Very Low (Critical)	Battery level is very low, requiring immediate attention (e.g., under 10%).	**10**
Low	Battery level is low but not critically low (e.g., 10% to 20%).	**8**
Moderate	Battery level is moderate, still enough for normal operation (e.g., 20% to 40%).	**6**
High	Battery level is high, indicating good capacity for extended work (e.g., 40% to 70%).	**4**
Very High	Battery level is very high, indicating no immediate concerns (e.g., 70% or more).	**2**

So our final equation can go like this:

P = (3*A rating+2*B rating)- (3*C rating + 1.5* D rating + 0.5* E rating) + 40

here P is the overall priority a task assigned to a robot is at a particular instant

Reasons and Justifications for the formula:

Max Priority a task can have is 40 (+50 and -10)

Min Priority a task can have is -40(10 and -40)

To make sure priority rating is always positive we will add +40 everytime so that rating will always be in the range of $0 \le P \le 80$

Suggest how your solution would adapt if the number of robots increased significantly?

if number of robots increased significantly i would use machine learning to analyze the priorities of various factors by testing with different cases including huge number of robots and i will get exact weights by using the ml model and will create a better mathematical formula to get better and accurate priority ratings based on the situation in which the robot is.

so by using highly accurate ml models we can handle robots movements in a much better way.