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MSDS460 Decision Analytics

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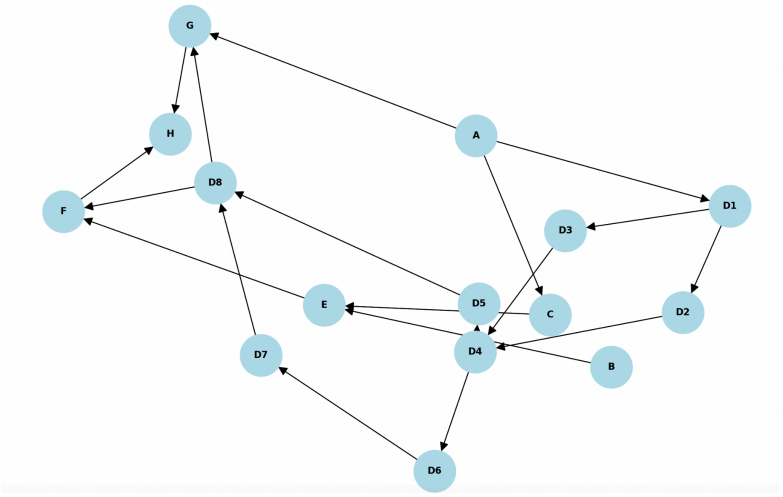
Assignment 2: Project Management

1. Problem Setup

After reviewing the tasks and subtasks for this recommender system development project, I filled in the provided spreadsheet with my worst-case, expected, and best-case hourly estimates for each task based on my knowledge of myself and my team's abilities. The updated spreadsheet with hourly estimates is shown below.

taskID	task	predecessorTaskIDs	bestCaseHours	expectedHours	worstCaseHours	projectManager	frontendDeveloper	backendDeveloper	dataScientist	dataEngineer
A	Describe product		3	4	6	4				
B	Develop marketing strategy		6	8	12	8				
C	Design brochure	A	5	7	10	7				
D1	Requirements analysis	A	6	8	12	4			4	
D2	Software design	D1	12	16	20		8	8		
D3	System design	D1	12	16	20			8		8
D4	Coding	D2, D3	18	24	30		8	8	4	4
D5	Write documentation	D4	6	8	10	6	1	1		
D6	Unit testing	D4	8	12	16		3	3	3	3
D7	System testing	D6	8	12	16	4	2	2	2	2
D8	Package deliverables	D5, D7	6	8	10	8				
E	Survey potential market	B, C	5	7	10	2			5	
F	Develop pricing plan	D8, E	5	7	10	2			5	
G	Develop implementation plan	A, D8	5	8	10	2	2	2		2
H	Write client proposal	F, G	10	15	20	15				

Based on the dependencies detailed in the spreadsheet, I used the NetworkX library in Python to develop a directed graph diagram visualizing the project in terms of task dependencies.



2. Model Specification

To find the optimal schedule on which to execute the project plan outlined above, I set up a linear programming model as follows.

2.1 Decision Variables

I let the variable t_i represent the start time of task i for tasks A-H. Then, I let e_i represent the end time for task i by adding the duration in hours for task i to the start time - I tweaked this variable to reflect the three different end time estimates for the worst-case, expected, and best-case scenarios.

2.2 Constraints

I set up the time dependency constraints as follows: if task t_i must be completed before task t_j, then we have the constraint:

$t_j \geq e_i$

This ensures that task t_j can only start after task t_i is finished.

I also ensured that no task could have a negative start time (as this would not make logical sense) by adding the constraint:

$t_i \geq 0$

2.3 Objective Function

For this simplified scenario where all contributors to the project are assigned the same hourly rate, minimizing total time for the project will lead to the same solution as minimizing total cost. I chose to write my objective function in terms of minimizing the total time for the project. I set variable T equal to the total duration of the project in hours, and wrote the objective function to minimize T as follows:

$T \geq e_i$

3. Programming

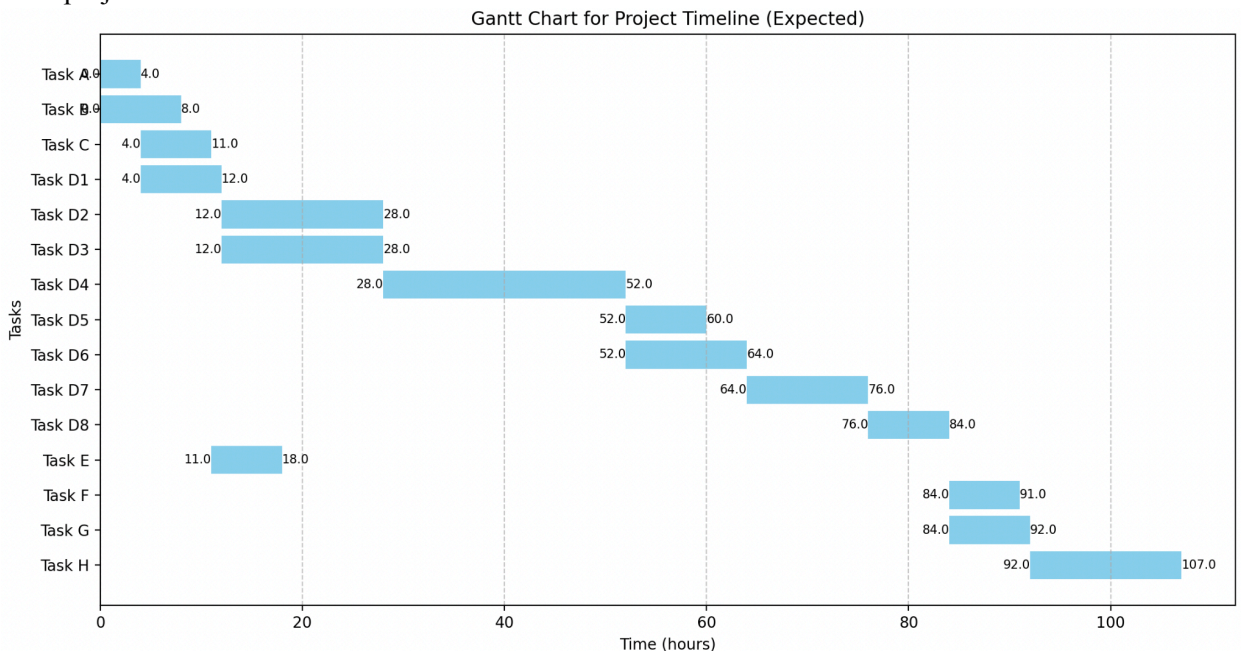
I implemented the linear programming model as outlined above using Python PuLP. I ran the program three separate times to find the optimal solutions using the worst-case, expected, and best-case hourly estimates for each task. My program code and plain text output for each of these three scenarios can be found in the GitHub repository for this assignment.

4. Solution

To determine the critical path for the worst-case, best-case, and expected timelines, I ran the linear programming model three separate times using the different hourly estimates for each of the three scenarios. Below are the results, representing the critical path for each scenario. I also created Gantt charts for each critical path in python (shown below).

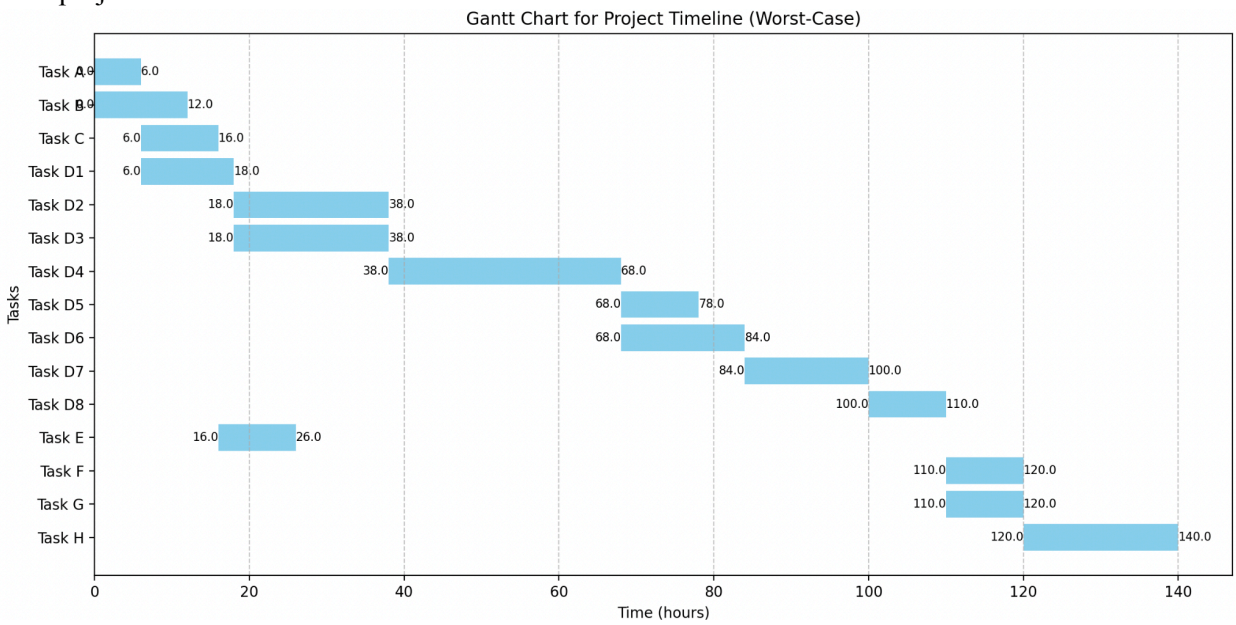
4.1 Expected Timeline

Task A starts at: 0.0 hours, ends at: 4.0 hours
Task B starts at: 0.0 hours, ends at: 8.0 hours
Task C starts at: 4.0 hours, ends at: 11.0 hours
Task D1 starts at: 4.0 hours, ends at: 12.0 hours
Task D2 starts at: 12.0 hours, ends at: 28.0 hours
Task D3 starts at: 12.0 hours, ends at: 28.0 hours
Task D4 starts at: 28.0 hours, ends at: 52.0 hours
Task D5 starts at: 52.0 hours, ends at: 60.0 hours
Task D6 starts at: 52.0 hours, ends at: 64.0 hours
Task D7 starts at: 64.0 hours, ends at: 76.0 hours
Task D8 starts at: 76.0 hours, ends at: 84.0 hours
Task E starts at: 11.0 hours, ends at: 18.0 hours
Task F starts at: 84.0 hours, ends at: 91.0 hours
Task G starts at: 84.0 hours, ends at: 92.0 hours
Task H starts at: 92.0 hours, ends at: 107.0 hours
Total project duration: 107.0 hours



4.2 Worst-Case Timeline

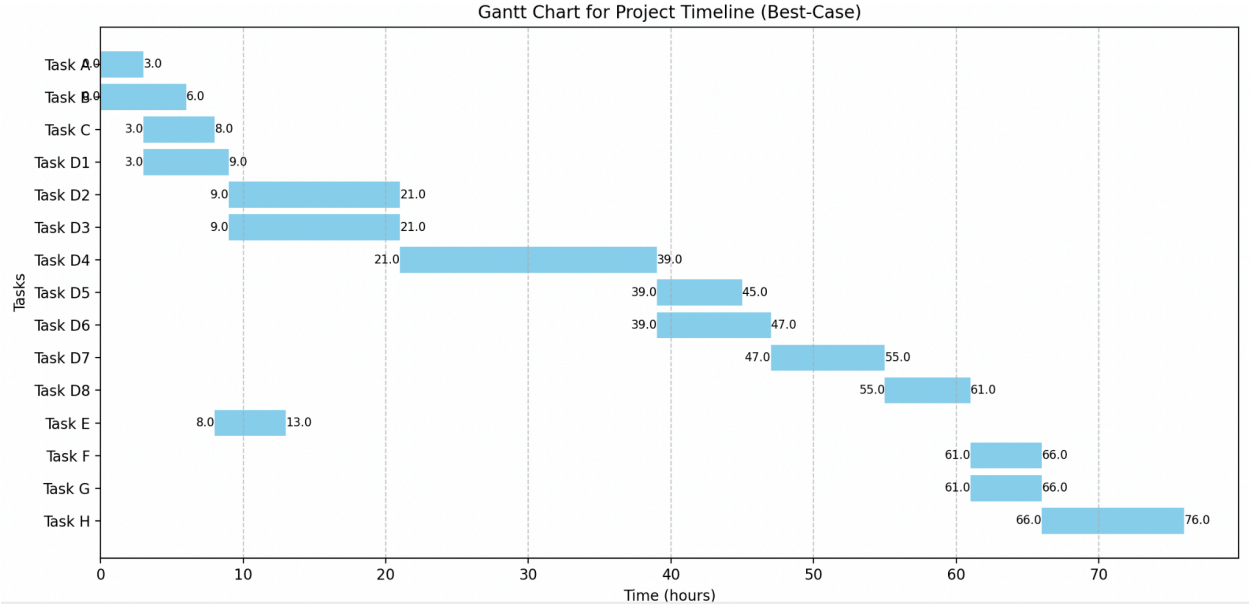
Task A starts at: 0.0 hours, ends at: 6.0 hours
Task B starts at: 0.0 hours, ends at: 12.0 hours
Task C starts at: 6.0 hours, ends at: 16.0 hours
Task D1 starts at: 6.0 hours, ends at: 18.0 hours
Task D2 starts at: 18.0 hours, ends at: 38.0 hours
Task D3 starts at: 18.0 hours, ends at: 38.0 hours
Task D4 starts at: 38.0 hours, ends at: 68.0 hours
Task D5 starts at: 68.0 hours, ends at: 78.0 hours
Task D6 starts at: 68.0 hours, ends at: 84.0 hours
Task D7 starts at: 84.0 hours, ends at: 100.0 hours
Task D8 starts at: 100.0 hours, ends at: 110.0 hours
Task E starts at: 16.0 hours, ends at: 26.0 hours
Task F starts at: 110.0 hours, ends at: 120.0 hours
Task G starts at: 110.0 hours, ends at: 120.0 hours
Task H starts at: 120.0 hours, ends at: 140.0 hours
Total project duration: 140.0 hours



4.3 Best-Case Timeline

Task A starts at: 0.0 hours, ends at: 3.0 hours
Task B starts at: 0.0 hours, ends at: 6.0 hours
Task C starts at: 3.0 hours, ends at: 8.0 hours
Task D1 starts at: 3.0 hours, ends at: 9.0 hours
Task D2 starts at: 9.0 hours, ends at: 21.0 hours
Task D3 starts at: 9.0 hours, ends at: 21.0 hours
Task D4 starts at: 21.0 hours, ends at: 39.0 hours
Task D5 starts at: 39.0 hours, ends at: 45.0 hours
Task D6 starts at: 39.0 hours, ends at: 47.0 hours
Task D7 starts at: 47.0 hours, ends at: 55.0 hours
Task D8 starts at: 55.0 hours, ends at: 61.0 hours

Task E starts at: 8.0 hours, ends at: 13.0 hours
Task F starts at: 61.0 hours, ends at: 66.0 hours
Task G starts at: 61.0 hours, ends at: 66.0 hours
Task H starts at: 66.0 hours, ends at: 76.0 hours
Total project duration: 76.0 hours



5. Overview

Based on the critical path analysis above and comparing the three different scenarios, I could confidently tell the client that this project is estimated to take between 2-4 weeks to complete. Generally when working with a client, I try to follow the principle of under-promising and over-delivering, so I would set the expectation that we would be delivering the product prototype 4 weeks from the project start date.

In terms of charging the client, based on the hourly totals from the project plan spreadsheet, the project is estimated to take between 115 and 212 hours of work total across all team members. If we can assume a flat rate of $100/hr for all team members, then I would quote the client between $11,500 and $21,200 for the project. While this is a large price range, I believe that it is important to provide a realistic range of estimates when giving the client an initial quote, because it is difficult to know the full scope of the project and any roadblocks that the development team may encounter along the way. As the team works through the phases of the project, I would be able to provide the client with narrower and narrower ranges of time and price estimates as the project gets closer and closer to completion.

If additional independent contractors were added to the mix, it is possible that we would be able to deliver the product on an even shorter timeline due to contractors being able to team up with my team members to complete individual tasks more efficiently.