

MSDS 460 Assignment 2: Network Models - Project Management

Problem setup: After reviewing the required software components and restaurant data sample file, our team was able to create a high-level project plan as a guide for the overall Marlborough restaurant recommendation system. Below is the updated task spreadsheet, with estimated best-case, expected, and worst-case hours for each task, along with which team members will work on each task:

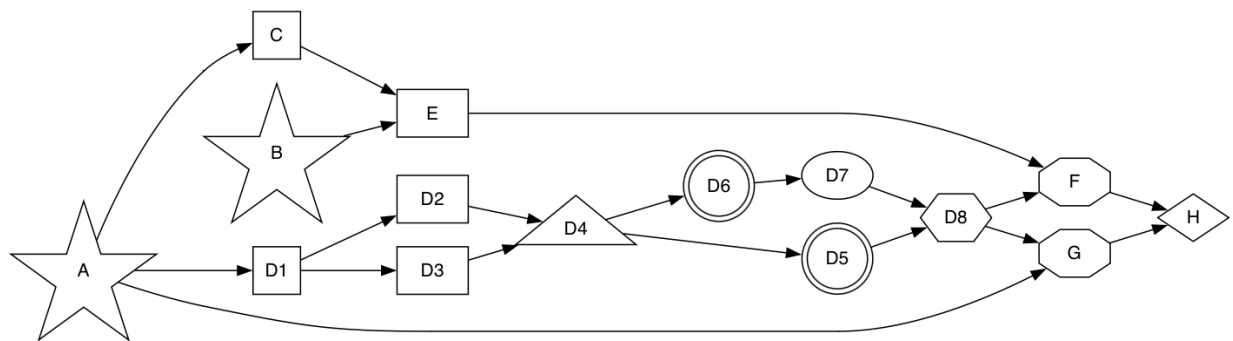
taskID	task	predecessor TaskIDs	bestCaseHours	expected Hours	worstCaseHours	projectManager	frontendDeveloper	backendDeveloper	dataScientist	dataEngineer
A	Describe product		4	8	12	X			X	
B	Develop marketing strategy		15	25	30	X	X			
C	Design brochure	A	8	15	20	X	X			
D	Develop product prototype									
D1	Requirements analysis	A	8	12	15	X			X	
D2	Software design	D1	30	45	60		X	X		
D3	System design	D1	30	45	60			X	X	X
D4	Coding	D2, D3	40	55	70		X	X	X	X
D5	Write documentation	D4	15	20	23	X	X	X		X
D6	Unit testing	D4	25	35	40		X	X		X
D7	System testing	D6	25	35	40		X	X		X
D8	Package deliverables	D5, D7	6	10	13	X			X	
E	Survey potential market	B, C	25	30	35				X	
F	Develop pricing plan	D8, E	6	8	10	X			X	
G	Develop implementation plan	A, D8	15	20	24	X			X	
H	Write client proposal	F, G	10	13	15	X				

For each task, the hours will be split amongst the team members assigned to the task, and each team member will be compensated \$60/hr, which is just above the average hourly rate for software developers according to popular US job recruitment site ZipRecruiter (ZipRecruiter, “Salary: Software Engineer”).

We are providing 3 separate time estimates to account for common uncertainties that arise in all software development projects. Many of the tasks with wide-ranging time estimates are technical in nature. Software design, system design, and coding will

require thorough planning and testing, and in the case of integrating the front-end, back-end, API, and database server together, the amount of time required can vary greatly as development progresses. Similarly, developing a marketing strategy, especially for a market that our team is adapting to on-the-fly, will likely be an iterative process.

To help visualize the task dependencies of this project, below is an activity-on-node (AON) directed graph diagram containing all tasks and their corresponding dependencies, as indicated by directional arrows:



Note that the tasks with matching node shapes (ex: both of the star-shaped nodes) can be completed concurrently.

Model specification: The objective function for the best-case hours scenario is:

Minimize z

S. T.

$$-t_0 + t_1 \geq 4$$

$$-t_0 + t_2 \geq 15$$

$$-t_1 + t_4 \geq 8$$

$$-t_1 + t_2 \geq 8$$

$$-t_4 + t_5 \geq 30$$

$$-t_4 + t_5 \geq 30$$

$$-t_5 + t_6 \geq 40$$

$$-t_6 + t_7 \geq 15$$

$$-t_6 + t_8 \geq 25$$

$$-t_7 + t_9 \geq 0$$

$$-t_8 + t_9 \geq 25$$

$$-t_9 + t_{10} \geq 6$$

$$-t_{10} + t_{11} \geq 6$$

$$-t_{10} + t_{11} \geq 15$$

$$-t_2 + t_{10} \geq 25$$

$$-t_{11} + t_{12} \geq 10$$

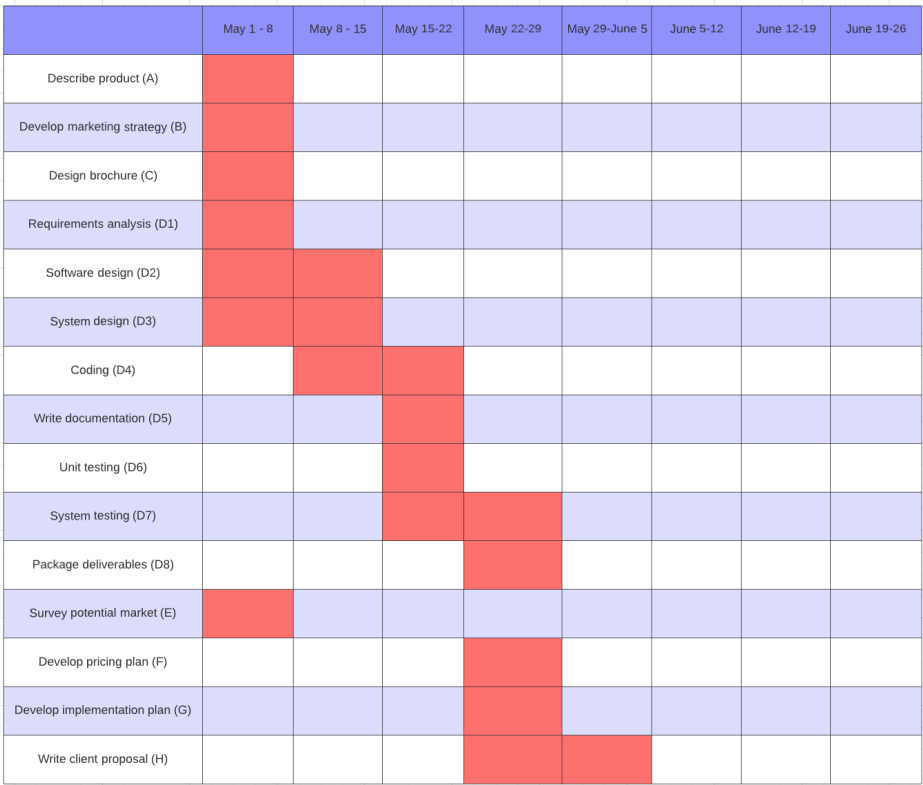
where z represents the total time in hours to complete all tasks.

Each constraint is a representation of a task's dependencies (the left-hand side of the constraint) and the estimated completion time of the task (the right-hand side of the constraint). The expected and worst-case hours scenarios will follow an identical structure, with the RHS of each constraint updated to the appropriate time estimates for each scenario.

Solution: Our team has implemented a linear program using Python's PuLP library to determine best-case, expected, and worst-case minimum-time/minimum-cost estimates for this project. These solutions take into account the various task dependencies, as well as our minimum-time/minimum-cost goal, and output the overall

time to complete the project, as well as the start and end times for each task within the project.

Best-case: Under the best-case scenario, we anticipate the project to take 163 total working hours. At a rate of \$60/hr, this comes to a projected total labor cost of \$9,780. Below is a Gantt chart that projects the rough project completion dates, assuming a standard 40-hour work week and a start date of May 1st, 2024:



Expected case: In the most likely expected hours scenario, we estimate the project will require 233 working hours, and will cost \$13,980 in labor costs. Below is the corresponding expected case Gantt chart:

	May 1 - 8	May 8 - 15	May 15-22	May 22-29	May 29-June 5	June 5-12	June 12-19	June 19-26
Describe product (A)								
Develop marketing strategy (B)								
Design brochure (C)								
Requirements analysis (D1)								
Software design (D2)								
System design (D3)								
Coding (D4)								
Write documentation (D5)								
Unit testing (D6)								
System testing (D7)								
Package deliverables (D8)								
Survey potential market (E)								
Develop pricing plan (F)								
Develop implementation plan (G)								
Write client proposal (H)								

Worst-case: The worst-case scenario estimates that the project will take 289 total working hours, with an estimated labor cost of \$17,340. Below is the corresponding worst-case Gantt chart:

	May 1 - 8	May 8 - 15	May 15-22	May 22-29	May 29-June 5	June 5-12	June 12-19	June 19-26
Describe product (A)								
Develop marketing strategy (B)								
Design brochure (C)								
Requirements analysis (D1)								
Software design (D2)								
System design (D3)								
Coding (D4)								
Write documentation (D5)								
Unit testing (D6)								
System testing (D7)								
Package deliverables (D8)								
Survey potential market (E)								
Develop pricing plan (F)								
Develop implementation plan (G)								
Write client proposal (H)								

In each of these scenarios, the critical path remains the same:

A → D1 → D2 or D3 → D4 → D6 → D7 → D8 → G → H

The tasks in this critical path cannot be delayed without delaying the entire project. Most of the tasks in the critical path are technical in nature, and they also have the widest potential variations in completion time. It stands to reason, then, that any delays in these tasks - in particular, the Develop Product Prototype (D) tasks - will delay the completion of the project.

Overview: For this project, we fully anticipate to achieve the expected hours timeline. With a tentative start date of Wednesday, May 1st, 2024, our expected project completion date is Tuesday, June 11th, on which we expect to deliver a functional prototype and a formal proposal at our expected budget of \$13,980. If a faster turnaround is required, additional contractors could be hired. Our team would target additional technical workers, as these roles are involved in nearly all critical path tasks. In an expected hours scenario, if we were to double our number of workers for technical tasks on the critical path - i.e. software design, system design, coding, unit testing, and system testing - we could halve the hours required for those tasks, and deliver the completed project in 107.5 fewer hours, on Thursday, May 23rd.

We thank you for your time and your potential partnership, and we look forward to hearing from you soon!

Bibliography

“Salary: Software Engineer (April, 2024) United States.” ZipRecruiter, March 11, 2024.
<https://www.ziprecruiter.com/Salaries/Software-Engineer-Salary>.