Assignment 2: Network Models

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1 Introduction

This assignment uses critical path analysis to outline best-case, worst-case, and expected times to complete a development project. The development project consists of eight general tasks, with one general task comprising of either software development sub-tasks. Assumptions were made to estimate completion times, per-hour costs, and persons responsible.

2 Problem Setup

Estimations for time to completion for each task is the first step in setting up the problem. A table has been provided of tasks, completion times, and persons responsible in the "References" section (Figure 5). The front-end developer, back-end developer, and data engineer are mainly involved in developing the prototype. The project manager is involved in non-technical tasks. The data scientist is involved throughout the process. A directed graph was also generated showing the flow of tasks (Figure 1).

There are also areas of uncertainty regarding project components and time estimates. The first task, describe product (A), is likely an exploratory and creative part. But if the problem is well-understood, it could be done relatively quickly.There could be some time for revisions and clarifications.

If the market is well-known and strategies are clear, developing marketing strategy (B) could be straight forward. Normally there is some research and strategy sessions involved. The duration could be extended if extensive market research is needed. This could be done in parallel with A.

Designing the brochure (C) depends on how quickly the product descriptions is finalized since it is a predecessor. With a ready template, the design could be swift. It could take longer if content creation is needed.

For product prototype development (D) and subtasks (D1-D8), each subtask often involves a significant amount of technical work which could vary in time based on complexity, integration, issues, and testing. Requirement analysis (D1) requires A to be completed beforehand. Since the client requires selected software for the project, some of the requirements are already known. But others, like which major cloud platform to host on, would require some research

to decide which fits the client's needs best. Next, software design (D2) and system design (D3) need the requirements analysis to be completed beforehand. These subtasks can be done in parallel as even though they are separate, they are related. The more complex the requirements, the more time is needed on software and system design. Next, coding (D4) has a large range of potential time scenarios. Unknown problems and issues can arise, increasing the time allotment. Writing documentation (D5) and unit testing (D6) can be done in parallel after coding is complete. These tasks can be quick but can also take long if there are issues with the prototype. System testing (D6) comes next, which can also range depending on how well the previous code works. Last is package deliverables (D8), which is a simpler task depending on the complexity of the prototype.

Surveying the potential market (E) requires tasks B and C to be completed. While it could theoretically be done in conjunction with D, resources may be needed to develop the prototype first. Time duration can extend if extensive market research is needed.

Developing a pricing plan (F) requires all of D and E to be complete. Developing an implementation plan (G) requires A and all of D to be complete. These can be done in parallel.

Last task is to write the client proposal (H). This requires steps F and G to be complete. Depending on the complexity of the project, this step could require extended time.

3 Model Specification

A linear program was developed to aid in the project plan. To simplify, the assumption was made that all contributors to the project charge the same hourly rate. Therefore, total minimum time solution will the same as total cost solution. The decision variables would be the start times for each task, denoted as X where i is the task identifier. d is a fixed variable denoting the duration of task i which is a known constant for each task. The constraints would specify that certain tasks must be completed prior to others.The complete linear programming model is provided in the "References" section.

4 Solution

This sections describes the project plan under expected, best case, and worst case scenarios. Gantt charts are included in the "References" section.

Under expected time, the project is estimated to be completed in 138 hours (Figure 2). The project starts with tasks A and B. After A is completed, tasks C and D1 are started. After B is completed, task E is started. After task D1 is completed, tasks D2 through D8 are completed. Tasks D2 and D3 are done in parallel as well as tasks D5 and D6. Tasks F and G are worked in parallel after D8 is complete. Task H is last to be completed.

Under the best case scenario, the project is estimated to be completed in 56 hours (Figure 3). The critical path is the same as the expected scenario. The one difference is that D2 and D3 are completed at the same time.

Under the worst case scenario, the project is estimated to be completed in 276 hours (Figure 4). The critical path is similar to the previous paths. However, in this critical path, task D4 is started only after task D3 is completed; in the best case critical path, tasks D2 and D3 are completed at the same time.

5 Overview

The project is expected to be completed in 138 hours with a range of 56 to 276 hours. Assuming labor costs of $75/hour, the expected cost would be $10,350 with a range of $7,728 to $38,088. This range depends on how quickly work can be completed, any potential issues in building the prototype, and if any extensive research is needed. This also ignores software licensing and cloud hosting.

Delving into the specifics of the project timeline, the prototype is slated for release in just over 17 days of actual work, based on an eight-hour workday. This timeline is meticulously designed to encompass all critical phases of the development process, including the initial design phase, system integration, the main development phase focused on building functional and backend capabilities, and the initial round of testing to ensure operational integrity. This comprehensive approach ensures that each component of the recommendation system is well-integrated and functioning as intended before the prototype goes live.

Moreover, the introduction of additional contractors could significantly expedite the prototype development phase. By increasing manpower, particularly in critical areas such as backend development and data engineering, tasks that typically would be executed sequentially could instead proceed in parallel, potentially reducing the overall timeline by weeks. This strategic deployment of additional resources would not only shorten the development cycle but also provide greater flexibility in managing project timelines and mitigating any delays that might arise from unforeseen complications, thereby ensuring a faster route to market readiness.

6 References

Linear Program:

$$minimize \quad Z = X_A + d_A + X_B + d_B + X_C + d_C + X_D1+$$

$$\mathrm{d}_D1 + X_D2 + d_D2 + X_D3 + d_D3 + X_D4 + d_D4 + X_D5 + d_D5 + X_D6+$$
$$\mathrm{d}_D6 + X_D7 + d_D7 + X_D8 + d_D8 + X_E + d_E + X_F + d_F + X_G + d_G+$$
$$\mathrm{X}_H + d_H$$

subject to

$$
\begin{aligned}
&\mathrm{X}_C \geq X_a + d_a \\
&\mathrm{X}_D1 \geq X_a + d_a \\
&\mathrm{X}_D2 \geq X_D1 + d_D1 \\
&\mathrm{X}_D3 \geq X_D1 + d_D1 \\
&\mathrm{X}_D4 \geq X_D2 + d_D2 \\
&\mathrm{X}_D4 \geq X_D3 + d_D3 \\
&\mathrm{X}_D5 \geq X_D4 + d_D4 \\
&\mathrm{X}_D6 \geq X_D4 + d_D4 \\
&\mathrm{X}_D7 \geq X_D6 + d_D6 \\
&\mathrm{X}_D8 \geq X_D5 + d_D5 \\
&\mathrm{X}_D8 \geq X_D7 + d_D7 \\
&\mathrm{X}_E \geq X_B + d_B \\
&\mathrm{X}_E \geq X_C + d_C \\
&\mathrm{X}_F \geq X_D8 + d_D8 \\
&\mathrm{X}_F \geq X_E + d_E \\
&\mathrm{X}_G \geq X_A + d_A \\
&\mathrm{X}_G \geq X_D8 + d_D8 \\
&\mathrm{X}_H \geq X_F + d_F \\
&\mathrm{X}_H \geq X_G + d_G \\
&\mathrm{X}_A \geq 0 \\
&\mathrm{X}_A \geq 0 \\
&\mathrm{X}_B \geq 0 \\
&\mathrm{X}_C \geq 0 \\
&\mathrm{X}_D1 \geq 0 \\
&\mathrm{X}_D2 \geq 0 \\
&\mathrm{X}_D3 \geq 0 \\
&\mathrm{X}_D4 \geq 0 \\
&\mathrm{X}_D5 \geq 0 \\
&\mathrm{X}_D6 \geq 0 \\
&\mathrm{X}_D7 \geq 0 \\
&\mathrm{X}_D8 \geq 0 \\
&\mathrm{X}_E \geq 0 \\
&\mathrm{X}_F \geq 0 \\
&\mathrm{X}_G \geq 0 \\
&\mathrm{X}_H \geq 0
\end{aligned}
\tag{1}
$$

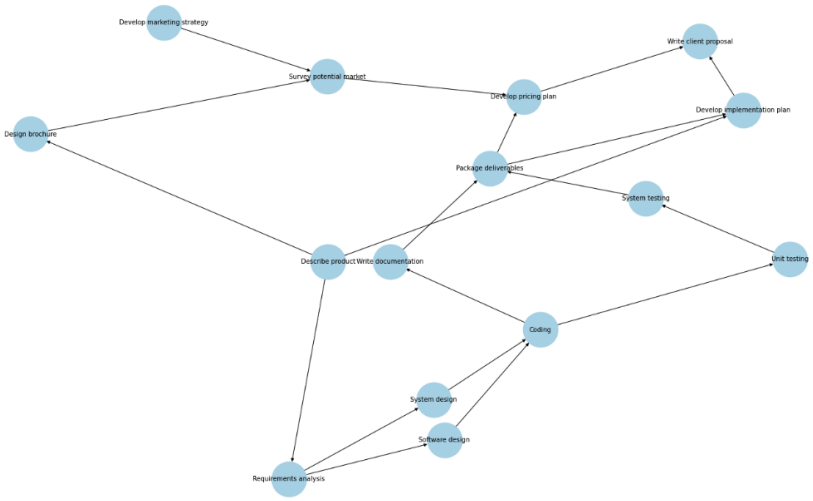

Figure 1: Directed Graph of Tasks

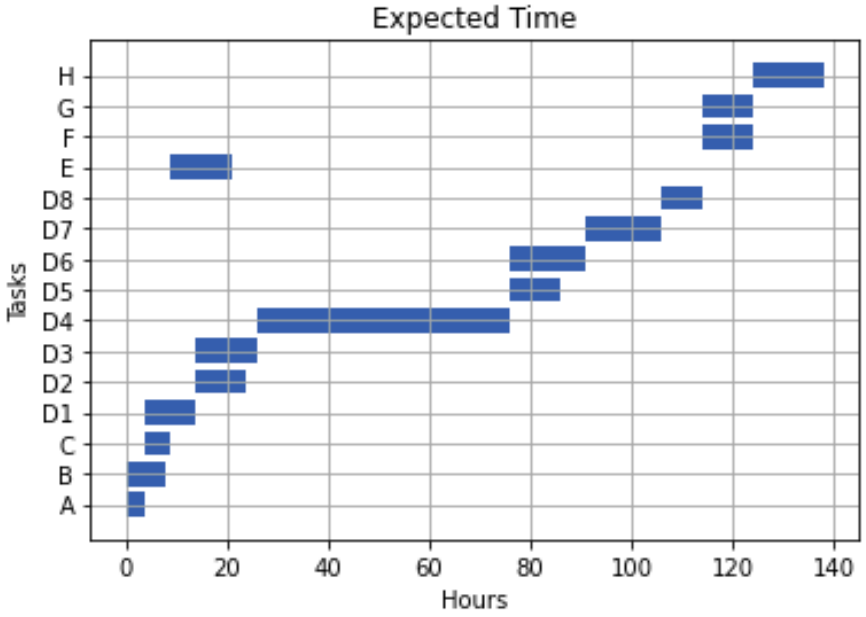

Figure 2: Gantt Chart for Expected Scenario

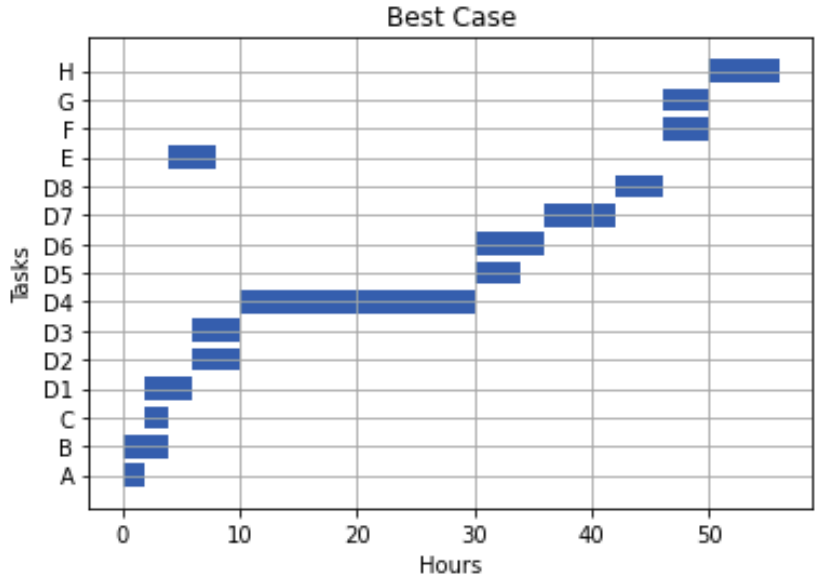

Figure 3: Gantt Chart for Best Case Scenario

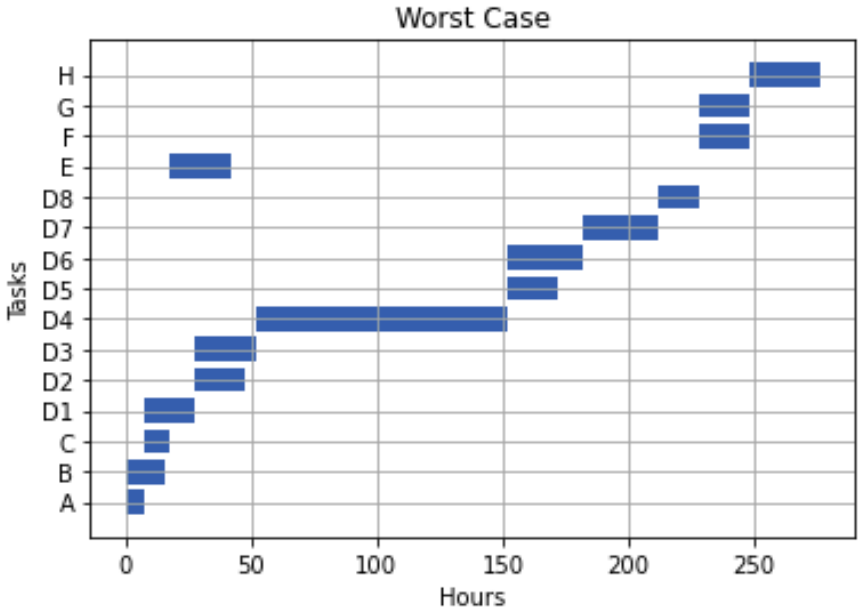

Figure 4: Gantt Chart for Worst Case Scenario

taskID	task	predecessorTaskIDs	bestCaseHours	expectedHours	worstCaseHours	projectManager	frontendDeveloper	backendDeveloper	dataScientist	dataEngineer
A	Describe product		2	4	8				x	
B	Develop marketing strategy		4	8	16	x				
C	Design brochure	A	2	5	10	x				
D	Develop product prototype									
D1	Requirements analysis	A	4	10	20				x	
D2	Software design	D1	4	10	20		x	x	x	x
D3	System design	D1	4	12	24		x	x	x	x
D4	Coding	D2, D3	20	50	100		x	x	x	x
D5	Write documentation	D4	4	10	20		x	x	x	x
D6	Unit testing	D4	6	15	30		x	x	x	x
D7	System testing	D6	6	15	30		x	x	x	x
D8	Package deliverables	D5, D7	4	8	16		x	x	x	x
E	Survey potential market	B, C	4	12	24		x			
F	Develop pricing plan	D8, E	4	10	20	x				
G	Develop implementation plan	A, D8	4	10	20	x			x	
H	Write client proposal	F, G	6	14	28	x			x	

Figure 5: Excel Spreadsheet