## 1. Methods

This problem involves a client that seeks to use large volumes of Yelp data to inform a software product for restaurant owners. To model this project, we assume a development team is assembled that includes the following roles with an 8-hour workday: Project Manager, Frontend Developer, Backend Developer, Data Scientist, and Data Engineer. To simplify the problem, each role is priced at $50 per hour.

Each task is defined along with any pre-requisites to represent the phases of software development, including setting requirements, establishing robust testing, and of course, writing the code (Appendix 1). These dependencies ensured that the logical sequence of development activities was maintained throughout the project timeline.

The tasks also have requirements with the number of hours to be contributed by each role, defined based on the nature and complexity of each task, and using a gut estimate based on what each role would contribute during the course of the project.

Once this is defined, a network graph can be created to visualize the project's dependencies, and its critical path. The grouping of P1, P2, P3 indicate tasks that can be completed in parallel. If a task along the critical path is delayed, that creates a higher impact on the project than the others. The optimization model places a higher degree of emphasis on these tasks as well.

Figure 1: Network Graph for Yelp Project
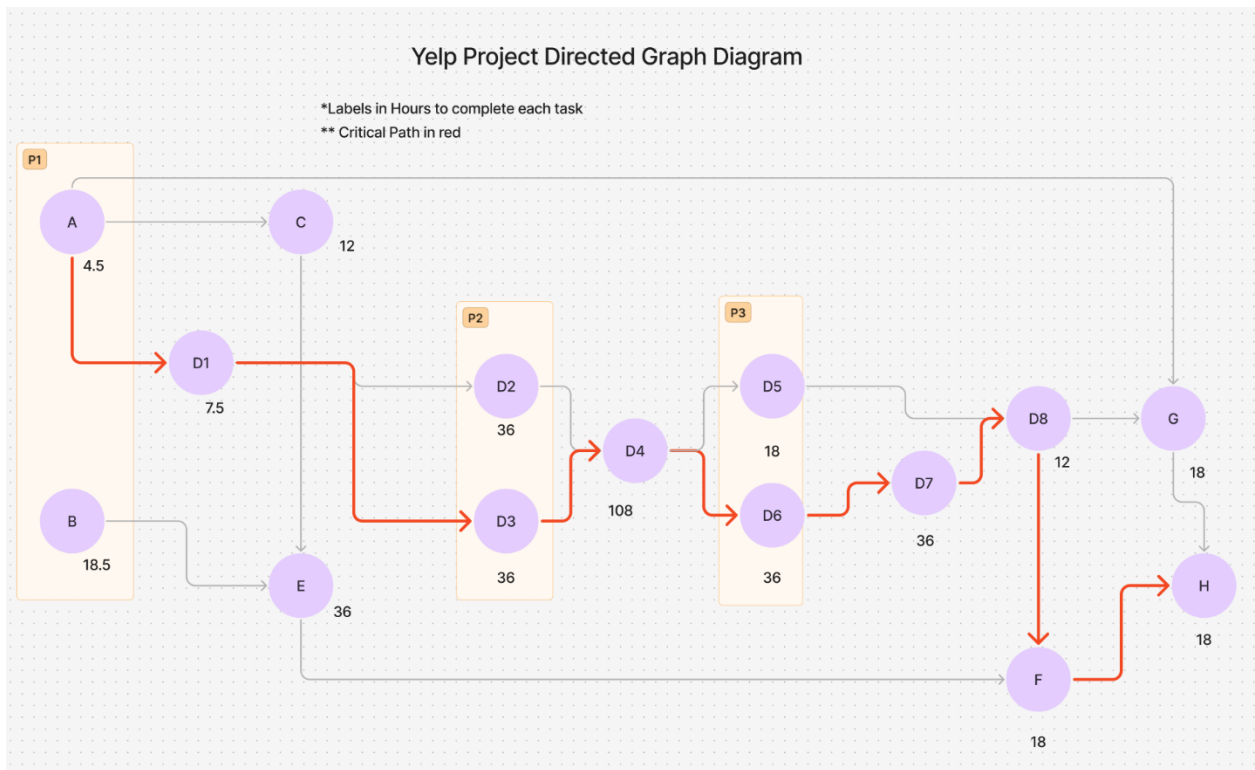
The model was implemented using the PuLP library in Python. Decision variables represent the start time of each task and the allocation of work hours for each role on each task for each day of the project. The constraints were expressed as linear inequalities and equalities, forming a system of equations that the solver would optimize. For the sake of simplicity, each role is assumed to have the same hourly rate, meaning that the shortest path to completion is equal to the lowest cost option.

2. Results

The project is estimated to be completed in about 38 days, with a total of 775 work hours collectively allotted, carrying a cost of $38,725. This baseline scenario represents the most likely outcome based on current estimates. The best-case scenario presents a more optimistic outlook,

with the project being completed in only 29 days, whereas the worst-case scenario extends the timeline to 48 days (Appendix 2). The difference in cost is about $20,000 between the two extreme scenarios.

To calculate the best and worst-case scenarios, the hours for each task, and the amount of time spent per role respectively decreased or increased by 25% across the board (Appendix 3). Time could be reduced through increased efficiency or the absence of unforeseen challenges in building the proposed solution, while time could increase due to resource constraints or complications during development.

Each scenario took the optimal path to project completion, simultaneously starting tasks A, B on day 1, and beginning tasks C and G shortly thereafter. The worst-case scenario is particularly noticeable in longer tasks such as D4, which increases from 13.5 days in the expected scenario to 17 days in the worst case.

The roughly 20-day difference between the best and worst-case scenarios shows how managing the impact of risk factors throughout the project can be the key to success. This analysis can inform contingency planning, resource allocation decisions, and client communications, ultimately increasing the likelihood of project success.

As far as what to charge for this project, the lowest possible option should be around $50,000 to account for some profit under the worst-case scenario. Restaurant owners typically deal with tight margins and may be unwilling to sign on to a significant upcharge. The final price would come down to a clear demonstration of ROI for the client, I would initially propose a price of $65,000, assuming that number would be negotiated down.

Appendix

Appendix 1: Task and Role Definitions

Task	Description	Prereqs	Expected Hours	Project Manager	Frontend	Backend	DS	DE
A	Describe product		4.5	X			X	
B	Develop marketing strategy		18	X				
C	Design brochure	A	12		X			
D1	Requirements analysis	A	7.5	X	X	X	X	
D2	Software design	D1	36		X	X		
D3	System design	D1	36			X		X
D4	Coding	D2, D3	108		X	X	X	X
D5	Write documentation	D4	18		X	X	X	X
D6	Unit testing	D4	36		X	X	X	X
D7	System testing	D6	36		X	X	X	X
D8	Package deliverables	D5, D7	12		X	X		
E	Survey potential market	B, C	36	X			X	
F	Develop pricing plan	D8, E	18	X			X	
G	Develop implementation plan	A, D8	18	X	X	X		
H	Write Client Proposal	F,G	18	X				

Appendix 2: Scenario Project Duration and Cost

Scenario	Duration (days)	Cost ($)	Total Project Hours
Expected	37.625	38725.00	774.5
Worst Case	27.0625	48406.25	968.125
Best Case	28.3125	29043.75	580.875

Appendix 3: Scenario Task Duration from Schedule Optimization (days)

Task	Description	Expected Duration	Best Case Duration	Worst Case Duration
A	Describe product	0.5625	0.4219	0.7031
B	Develop marketing strategy	2.3125	1.7344	2.8906
C	Design brochure	1.5	1.125	1.875
D1	Requirements analysis	0.9375	0.7031	1.1719
D2	Software design	4.5	3.375	5.625
D3	System design	4.5	3.375	5.625
D4	Coding	13.5	10.125	16.875
D5	Write documentation	2.25	1.6875	2.8125
D6	Unit testing	4.5	3.375	5.625
D7	System testing	4.5	3.375	5.625
D8	Package deliverables	4.5	3.375	5.625
E	Survey potential market	4.5	3.375	5.625
F	Develop pricing plan	2.25	1.6875	2.8125
G	Develop implementation plan	2.25	1.6875	2.8125
H	Write Client Proposal	2.25	1.6875	2.8125