Assignment 2: Network Models

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Part 1: Introduction and Problem Setup

Given a list of 16 tasks to be completed in a specific order, first the tasks were assigned to various project members. A task could have 1 or more project members assigned to it. Then hours to complete the task were assigned that included all human hours. For example, if a task would take 2 people, 8 hours each to complete a task, then the total expected hours would be 16 hours.

The expected hours for each task were filled out with respect to the number of people involved in the task, our expected scenario hours were complete. Then rough estimates for best case scenario and worst-case scenario were calculated using ideal hours +/- 15%. Both a table showing calculated hours for tasks for all 3 scenarios and a graph representing the order of tasks s can be found below in the Appendix in figures 1 and 2 respectively.

Many variables can influence these time calculations such as a project manager being new to the project could cause a longer time to complete tasks A. Describe product and B. Develop marketing strategy. A less or more experienced back end or front-end engineer could cause the time for tasks related to the code and prototyping to fluctuate as well as cost per hour of the individual.

Part 2: Model Specification

For this network problem, the critical or shortest path is the problem to solve for. A minimization linear programming model using Pulp in python is ideal for this scenario. Assumptions of the project include that all contractors working on the project make the same

rate, which means that the shortest path doubles as the minimum cost solution. According to ZipRecruiter, the product manager has the highest average hourly rate for a contractor at $76.64 per hour. Software engineers have an hourly rate of $71. Data scientists $59, and data engineers $79.34. For purposes of this problem, an assumption is being made that the front-end developer and back- end developers have the same hourly average rate. This will differ from scenario to scenario as sometimes this can be the same developer, known as a full-stack developer, or can indeed be two different people with various skills which can cause a fluctuation in pay and time it takes to complete tasks.

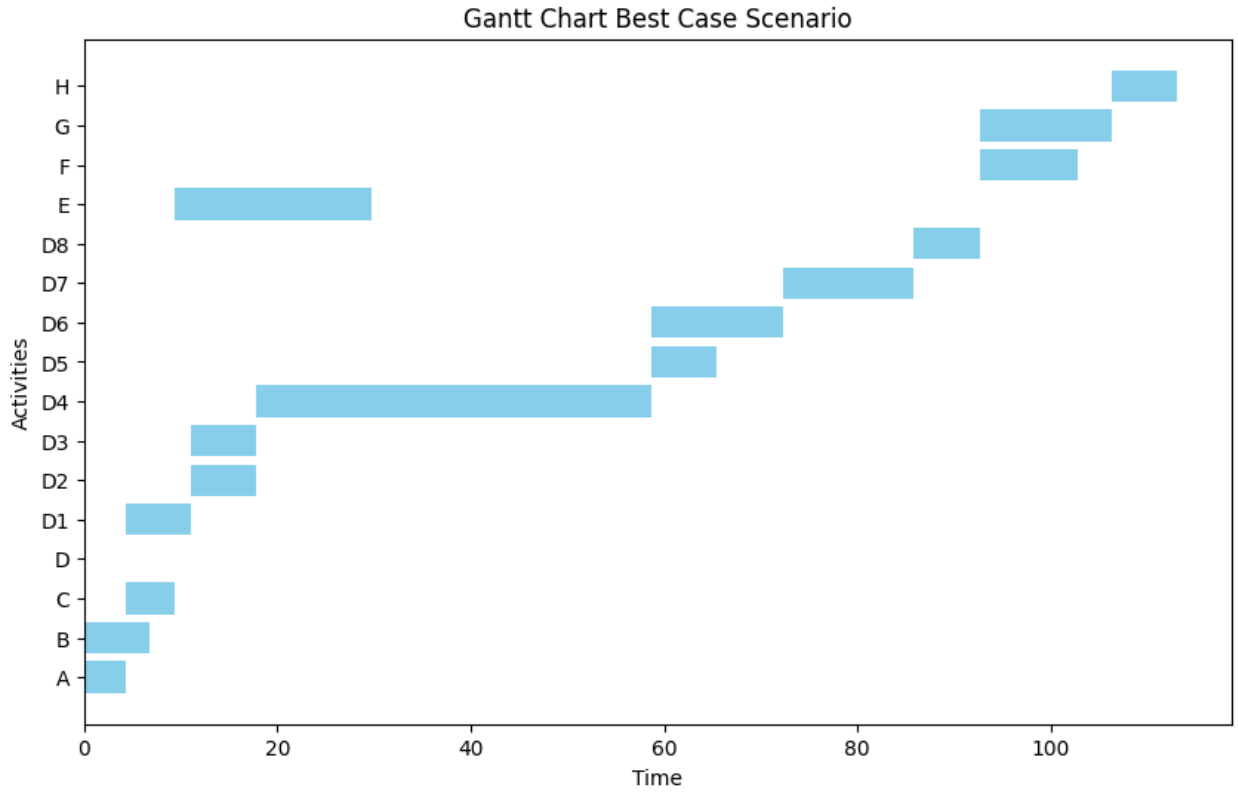
Part 3: Solution

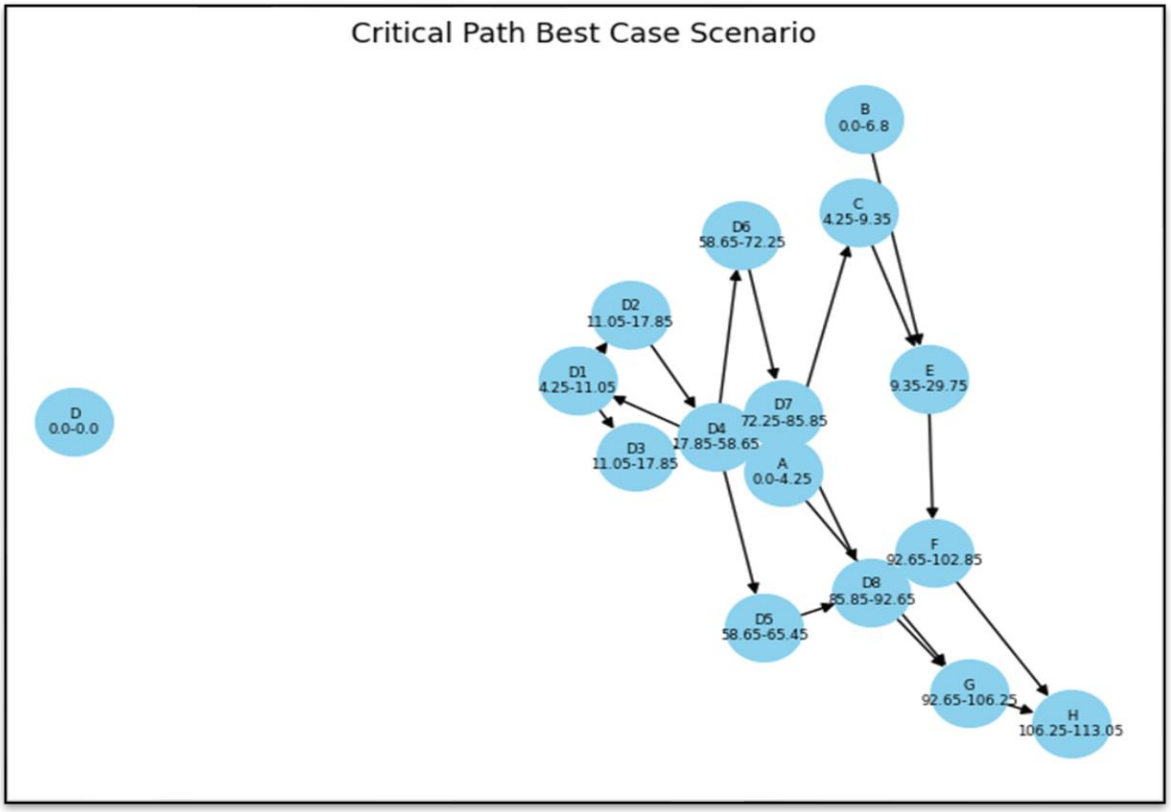
The problem was solved three times: best-case, expected, and worst-case. Best-case and worst-case were +/- 15% hours of the expected/ideal case. Each solution maintained the desired order of tasks. The best case had the shortest time to complete the project at 113.05 hours, expected second at 133 hours, and worst case coming in the longest at 152.95 hours. Gantt and critical path visuals for each scenario can be found below. Beginning and end times for each task for each scenario can be found in the appendix in figure 3.

This solution is rather straightforward – the longer the tasks take, the more expensive the project is proportionately. However, if the contractors each made different rates, if the specific contractor took longer or shorter for each task or one task took an extremely long time unexpectedly, all these elements would affect the final time it took to complete the project. Things like bug fixes and unit testing fall into these categories that can quickly expand beyond the allotted time depending on the technology used and experience of the contractors.

3.1 Best-Case Results:

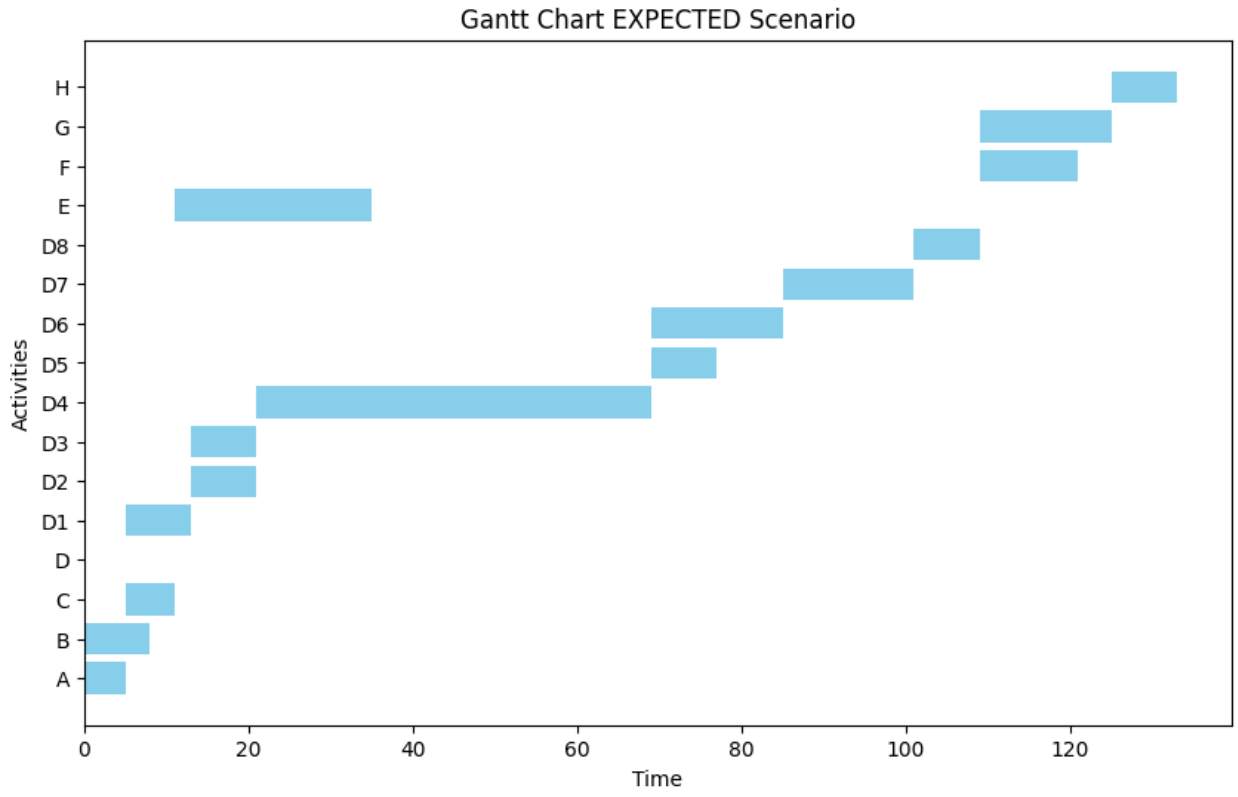
The best-case time scenario for each task resulted in a total duration of 113.05 hours. With an estimated hourly cost of $76.64, the cost of executing the project would be $8,664.15.

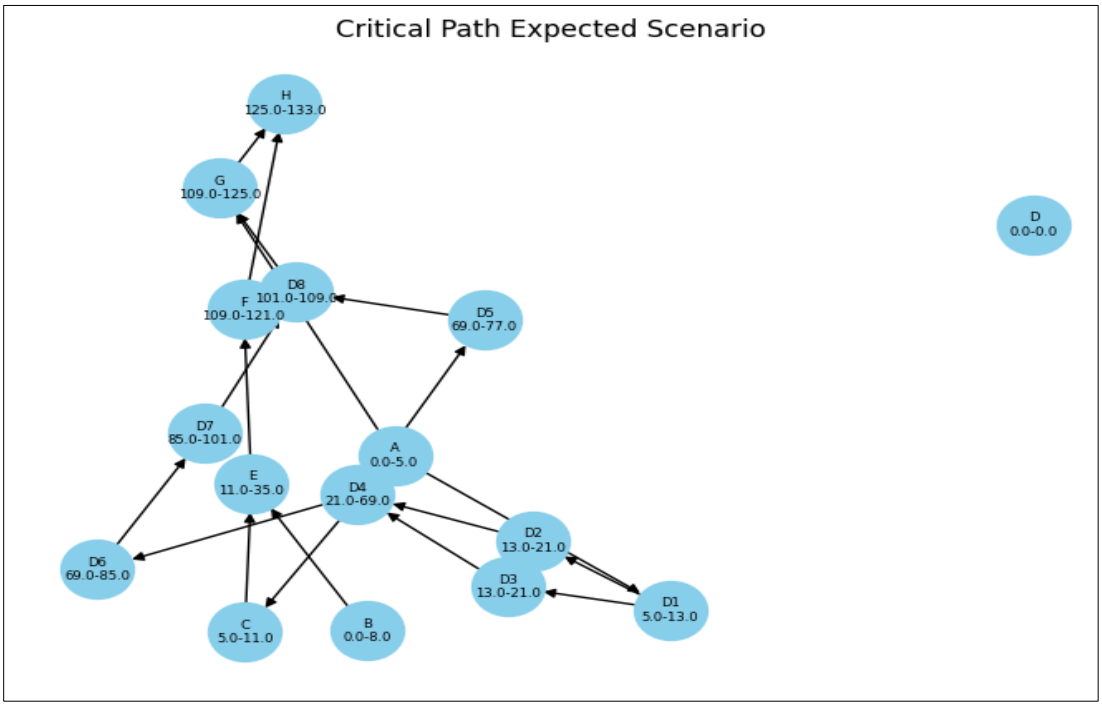




3.2 Expected Case Results:

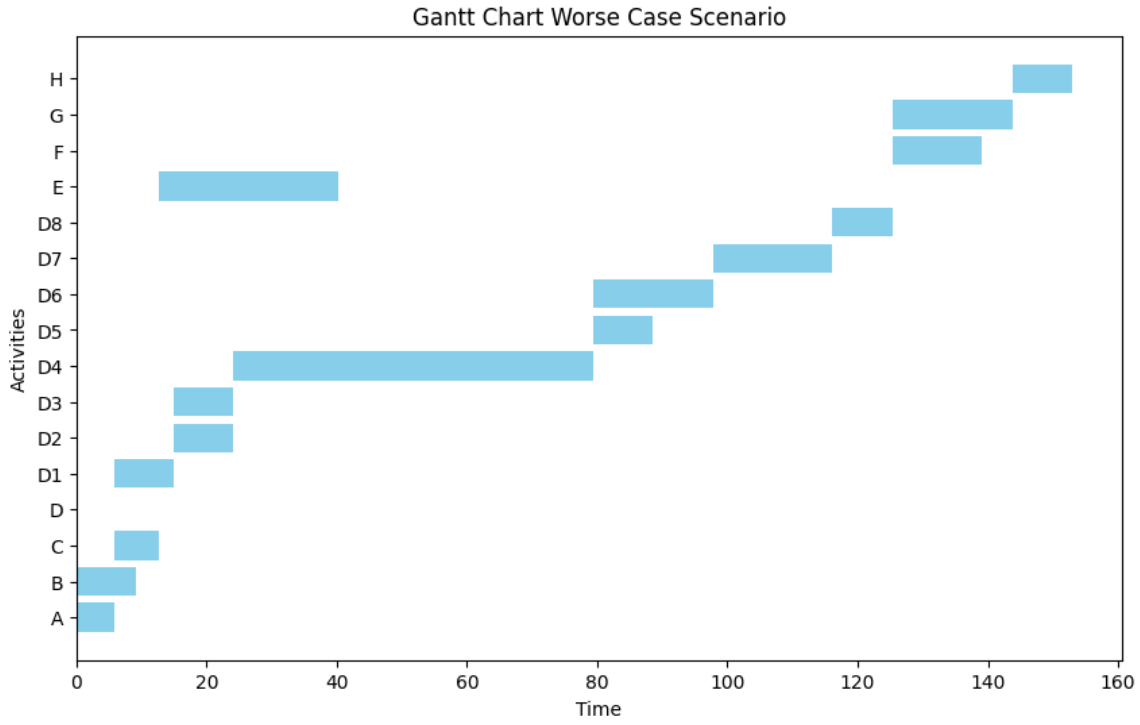
The expected case time scenario for each task resulted in a total duration of 133 hours. With an estimated hourly cost of $76.64, the cost of executing the project would be $10,193.12.

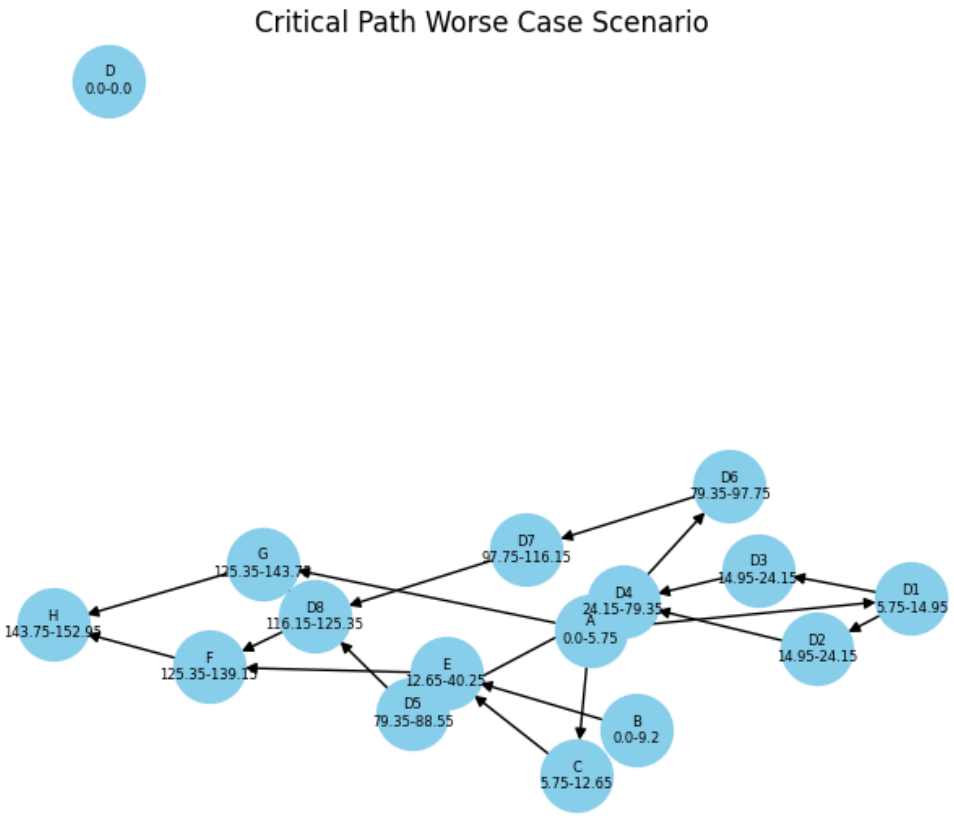

Gantt Chart EXPECTED Scenario
Activities
H
G
F
E
D8
D7
D6
D5
D4
D3
D2
D1
D
C
B
A
0
20
40
60
80
100
120
Time


Critical Path Expected Scenario
H
125.0-133.0
G
109.0-125.0
D
0.0-0.0
D8
101.0-109.0
F
109.0-121.0
D5
69.0-77.0
D7
85.0-101.0
A
0.0-5.0
E
11.0-35.0
D4
21.0-69.0
D2
13.0-21.0
D6
69.0-85.0
D3
13.0-21.0
D1
5.0-13.0
C
5.0-11.0
B
0.0-8.0

3.3 Worst-Case Results:

The worst-case time scenario for each task resulted in a total duration of 152.95 hours. With an estimated hourly cost of $76.64, the cost of executing the project would be $11,723.6175.





Part 4: Overview

This project consists of 16 individual bodies of work that will require a minimum of 5 specialties: project manager, front end and back-end developer, data scientist, and data engineer. If we are successful in finding a full stack engineer for front end and back end, we would only need 4 people to complete this project. However, full-stack engineers tend to be more expensive so it will depend on timeline and budget.

At 5 employees, the project completion will take 153 hours or roughly 4 weeks from start to finish. The prototype is scheduled to be delivered at 125 hours, or roughly the 3rd week of the project. The total cost of the project will be $15,240.70 (worst case cost * 30% profit margin).

The project can be delivered sooner but will cost more as more people would need to be hired in direct relation to the short deadline.

Appendix

Figure 1 Excel detailing hours per task for each scenario:

taskID	task	predecessorTaskIDs	bestCaseHours	expectedHours	worstCaseHours	projectManager	frontendDeveloper	backendDeveloper	dataScientist	dataEngineer
A	Describe product		4.25	5	5.75	x				
B	Develop marketing strategy		6.8	8	9.2	x				
C	Design brochure	A	5.1	6	6.9	x				
D	Develop product prototype		0							
D1	Requirements analysis	A	6.8	8	9.2	x			x	x
D2	Software design	D1	6.8	8	9.2	x	x			
D3	System design	D1	6.8	8	9.2			x		
D4	Coding	D2, D3	40.8	48	55.2		x	x		
D5	Write documentation	D4	6.8	8	9.2	x	x	x		
D6	Unit testing	D4	13.6	16	18.4		x	x		
D7	System testing	D6	13.6	16	18.4		x	x		
D8	Package deliverables	D5, D7	6.8	8	9.2	x				
E	Survey potential market	B, C	20.4	24	27.6				x	x
F	Develop pricing plan	D8, E	10.2	12	13.8				x	x
G	Develop implementation plan	A, D8	13.6	16	18.4	x				
H	Write client proposal	F, G	6.8	8	9.2	x				

Figure 2 Diagram detailing order of tasks:

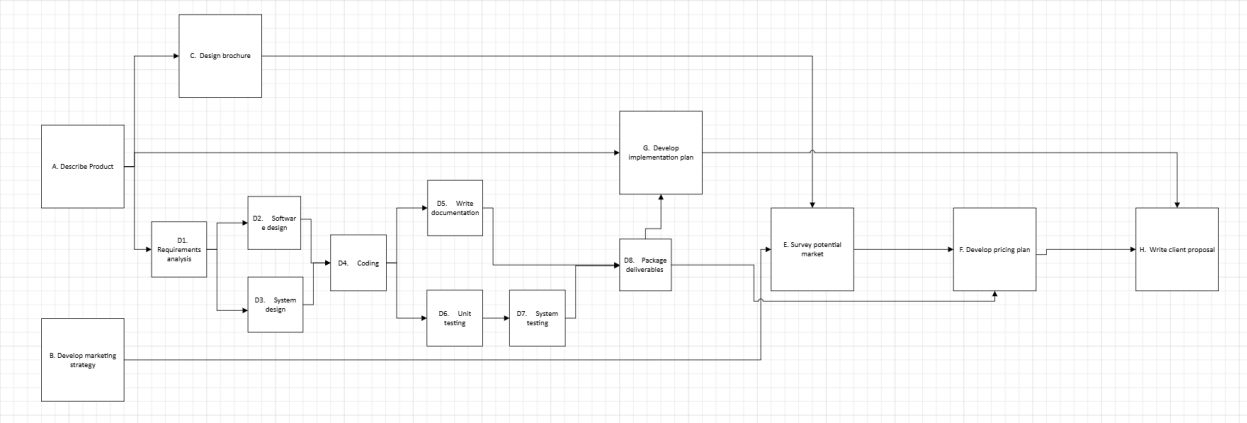


Figure 3 Beginning and end times for each stage of project for each scenario:

Variable	Value_Best	Value_Expected	Value_Worst
end_A	4.25	5	5.75
end_B	6.8	8	9.2
end_C	9.35	11	12.65

end_D	0	0	0
end_D1	11.05	13	14.95
end_D2	17.85	21	24.15
end_D3	17.85	21	24.15
end_D4	58.65	69	79.35
end_D5	65.45	77	88.55
end_D6	72.25	85	97.75
end_D7	85.85	101	116.15
end_D8	92.65	109	125.35
end_E	29.75	35	40.25
end_F	102.85	121	139.15
end_G	106.25	125	143.75
end_H	113.05	133	152.95
start_A	0	0	0
start_B	0	0	0
start_C	4.25	5	5.75
start_D	0	0	0
start_D1	4.25	5	5.75
start_D2	11.05	13	14.95
start_D3	11.05	13	14.95
start_D4	17.85	21	24.15
start_D5	58.65	69	79.35
start_D6	58.65	69	79.35
start_D7	72.25	85	97.75
start_D8	85.85	101	116.15
start_E	9.35	11	12.65
start_F	92.65	109	125.35
start_G	92.65	109	125.35
start_H	106.25	125	143.75

References

ZipRecruiter. “Contractor Data Engineer Salary” 10/19/2024. https://www.ziprecruiter.com/Salaries/Independent-Contractor-Data-Engineer-Salary#:~:text=As%20of%20Sep%2022%2C%202024%2C%20the%20average%20annual,This%20is%20the%20equivalent%20of%20%243%2C173%2Fweek%20or%20%2413%2C751%2Fmonth.

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ZipRecruiter. “Contractor Product Manager Salary” 10/19/2024. https://www.ziprecruiter.com/Salaries/Product-Manager-Contract-Salary#:~:text=As%20of%20Sep%2022%2C%202024%2C%20the%20average%20annual,This%20is%20the%20equivalent%20of%20%243%2C065%2Fweek%20or%20%2413%2C283%2Fmonth.

ZipRecruiter. “Contractor Software Engineer Salary” 10/19/2024. https://www.ziprecruiter.com/Salaries/Contractor-Software-Engineer-Salary#:~:text=As%20of%20Jul%2030%2C%202024%2C%20the%20average%20annual,This%20is%20the%20equivalent%20of%20%242%2C837%2Fweek%20or%20%2412%2C293%2Fmonth.