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Homework Assignment 2: Network Models---Project Management

1.0 Problem Setup

We broke the development of the consumer-focused recommendation system into two parts: an eight-stage prototype development process and an eight-stage recommendation system development process. We first came up with the estimation of expected completion hours for each of the development tasks. The estimated hours consist of both production and review time. Once we derived the expected hours, we then applied a factor of 90% and 110% for the best-case hours and worst-case hours, respectively, to get a sense of the range of potential development times. Based on the development process, we believe a combination of senior software engineer and marketing experiences will be sufficient to deliver the final output. We found the annual salary range of $194,284 to $213,868 for a senior software engineer on Glassdoor, so we used $200,000 as the annual salary for the hourly rate calculation. With the assumption of 2,000 working hours a year, the hourly rate for this project would be $100 ($200,000/2,000=$100).

Once we had the estimated hours for each of the development processes, we put together the project diagram based on the task dependencies given. We made an important assumption that, among our group members, we all have the required skill sets to complete each of the development processes independently and that each of the development processes can only be worked on by one person at a time. How we assign the various responsibilities among ourselves is critical to minimizing the completion time.

The Excel table detailing tasks, completion time, and personnel assignments is included in Appendix A. A directed graph diagram summarizing the stages in developing the recommendation system and product prototype is included in Appendix B.

2.0 Model Specification

The group elected to solve this problem using linear programming. The objective is to minimize the completion time of the project, and the decision variables are the starting time for each of the development processes. Based on our expected hours for each of the development processes and the task dependencies given, we derived the associated constraints. Additionally, linear programming creates an additional revenue opportunity in the form of a sensitivity analysis at the client's request. The Python code detailing the problem setup is included in the Github repository.

3.0 Programming

Starting with the expected hours from the table in Appendix A, the group utilized the Python PuLP library to optimize the two linear programming models, one for the product prototype and the second for the recommendation system. The code optimized the prototype critical path (D1-D8) and captured the optimal decision variable values in a list. The second model optimized the recommendation system critical path (A-H), and utilized list indexing in the constraints to incorporate the optimal value from the prototype model. We repeated this two-model process for the estimated worst-case hours and best-case hours. We utilized PuLP's GNU Linear Programming Kit (GLPK) package to perform sensitivity analysis, allowing for the exploration of possible changes to the optimal solution and constraints for the six individual models. The Python code, Python output, and sensitivity analyses are included in the Github repository.

4.0 Solution

The cost analysis for the expected, best-case, and worst-case time estimates assumes all project team members charge the same hourly rate of $100 ($200,000 annual salary / 2,000 hours =$100/hour). The objective of the linear programming model is to minimize the project completion time, though total costs are considered.

The expected hours optimal solution resulted in 336 hours for prototype development, 408 hours for the completion of the recommendation system, and a total project labor cost of $63,200. The best-case optimal solution resulted in 302.4 hours for prototype development, 367.2 hours to develop the recommendation system, and a total labor cost of $56,880. The worst-case optimal solution resulted in 369.6 hours for prototype development, 448.8 hours to develop the recommendation system, and a total labor cost of $69,520. The three model solutions resulted in ranges of 67.2 hours for prototype development and 81.6 hours for recommendation system development.

The critical path to developing the product prototype is requirements analysis, software design, coding, unit testing, system testing, and package deliverables. The critical path for the recommendation system is describing the product, developing the product prototype, developing an implementation plan, and writing the client proposal. The general path is listed below and more path details and node hourly values are included in the Python code output in the Github repository.

- Prototype: d0 - d1 - d2 - d4 - d6 - d7 - d8
- Recommendation System: t0 - t1 - t4 - t7 - t8 - t9

The changes in hourly projections did not affect the prototype and recommendation system critical paths as the paths remained constant between all three models. Gantt charts illustrating

timelines for the best-case, expected, and worst-case project timelines are included in Appendix C.

5.0 Overview

The total expected cost for developing the recommendation system is $69,520. This is a combination of a total development time of 695.2 hours at an hourly rate of $100. Assuming a January start date, the product is projected to be delivered no later than the last week of March. You are one of our most strategic clients, and we would like to ensure that we meet your business needs.

If you are looking for an earlier delivery date, we could partner with a third-party contractor to speed up the prototype delivery by splitting up the operations with the longest lead time. This third-party contractor would help us to design the software, code, test the unit and system, and deliver packages. With the involvement of a third party, we can substantially shorten the product delivery time to 7 weeks. Assuming a January start date, we would be able to deliver the product by no later than the last week of February. The third-party contractor charges an hourly rate of $200. Therefore, with the shortened delivery timeline, the total expected cost will be $87,120. An Excel table detailing the project completion hours and costs with the involvement of a third-party contractor is included in Appendix A.

Appendix A

Excel Tables

Task Details, Completion Hours, Assigned Associate Table - Original Team

taskID	task	predecessorTaskIDs	best case hours	expected hours	worst case hours	best case cost	expected cost	worst case cost	assigned associate
A	Describe product		7.20	8	8.80	720	800	880	Anhua Cheng
B	Develop marketing strategy		36.00	40	44.00	3,600	4,000	4,400	Rebecca Bailey Scoville
C	Design brochure	A	36.00	40	44.00	3,600	4,000	4,400	Rebecca Bailey Scoville
D	Develop product prototype (min completion time)		302.40	336	369.60	30,240	33,600	36,960	
D1	Requirements analysis	A	14.40	16	17.60	1,440	1,600	1,760	Anhua Cheng
D2	Software design	D1	108.00	120	132.00	10,800	12,000	13,200	Griffin Arnone
D3	System design	D1	36.00	40	44.00	3,600	4,000	4,400	Anhua Cheng
D4	Coding	D2, D3	72.00	80	88.00	7,200	8,000	8,800	Griffin Arnone
D5	Write documentation	D4	36.00	40	44.00	3,600	4,000	4,400	Griffin Arnone
D6	Unit testing	D4	36.00	40	44.00	3,600	4,000	4,400	Anhua Cheng
D7	System testing	D6	36.00	40	44.00	3,600	4,000	4,400	Anhua Cheng
D8	Package deliverables	D5, D7	36.00	40	44.00	3,600	4,000	4,400	Anhua Cheng
E	Survey potential market	B, C	36.00	40	44.00	3,600	4,000	4,400	Rebecca Bailey Scoville
F	Develop pricing plan	D8, E	21.60	24	26.40	2,160	2,400	2,640	Rebecca Bailey Scoville
G	Develop implementation plan	A, D8	21.60	24	26.40	2,160	2,400	2,640	Anhua Cheng
H	Write client proposal	F, G	36	40	44	3,600	4,000	4,400	Rebecca Bailey Scoville
	Subtotal		568.80	632.00	695.20	56,880.00	63,200.00	69,520.00	

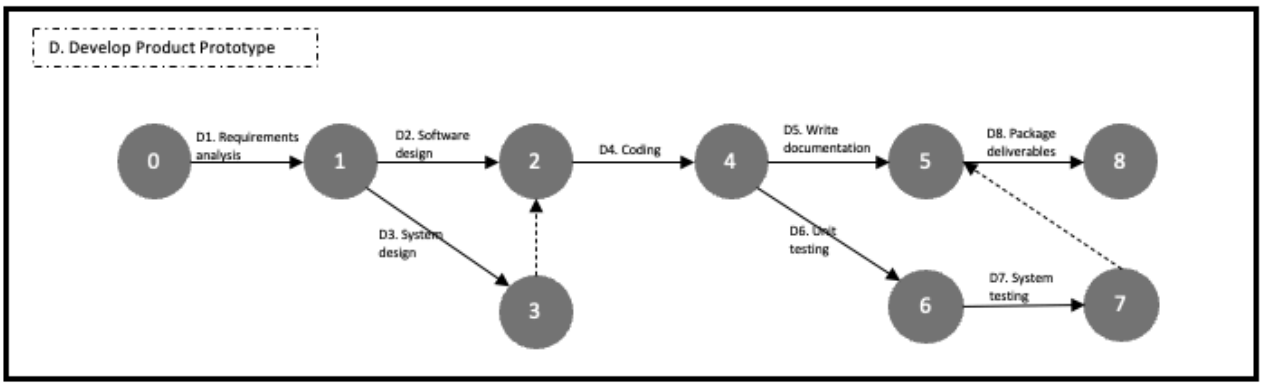
Task Details, Completion Hours, Assigned Associate Table - With Independent Contractor

taskID	task	predecessorTaskIDs	worst case hours with independent contractor	worst case cost with independent contractor	assigned associate
A	Describe product		8.80	880	Anhua Cheng
B	Develop marketing strategy		44.00	4,400	Rebecca Bailey Scoville
C	Design brochure	A	44.00	4,400	Rebecca Bailey Scoville
D	Develop product prototype (min completion time)		193.60	19,360	
D1	Requirements analysis	A	17.60	1,760	Anhua Cheng
D2	Software design	D1	66.00	19,800	Griffin Arnone + Contractor
D3	System design	D1	44.00	4,400	Anhua Cheng
D4	Coding	D2, D3	44.00	13,200	Griffin Arnone + Contractor
D5	Write documentation	D4	44.00	4,400	Griffin Arnone
D6	Unit testing	D4	22.00	6,600	Anhua Cheng + Contractor
D7	System testing	D6	22.00	6,600	Anhua Cheng + Contractor
D8	Package deliverables	D5, D7	22.00	6,600	Anhua Cheng + Contractor
E	Survey potential market	B, C	44.00	4,400	Rebecca Bailey Scoville
F	Develop pricing plan	D8, E	26.40	2,640	Rebecca Bailey Scoville
G	Develop implementation plan	A, D8	26.40	2,640	Anhua Cheng
H	Write client proposal	F, G	44.00	4,400	Rebecca Bailey Scoville
	Subtotal			87,120.00	

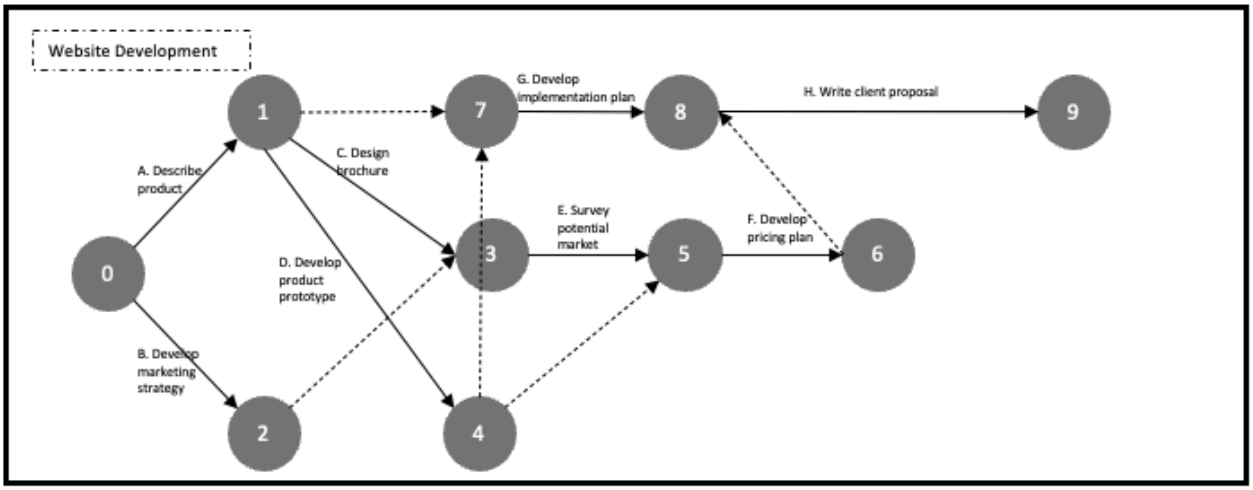
Appendix B

Graph Diagrams

Prototype Development Path - D1-D8



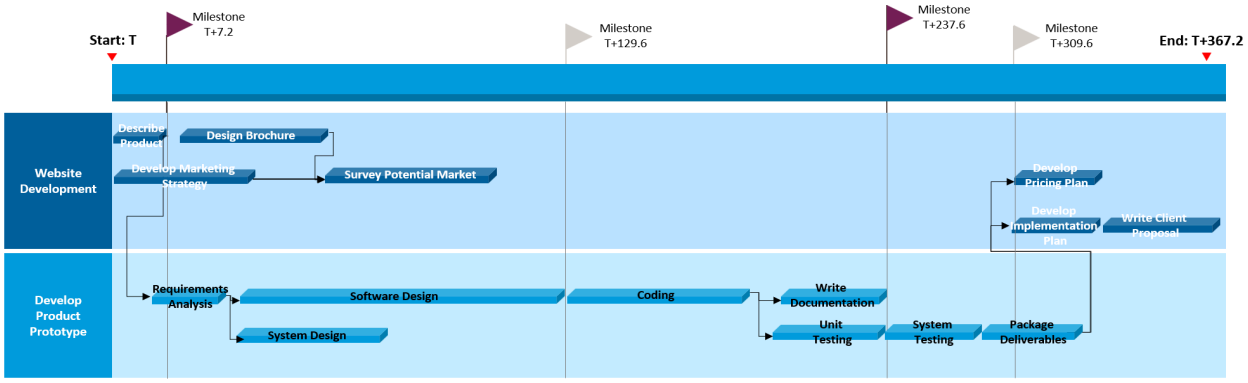
Recommendation System Development Path - A-H



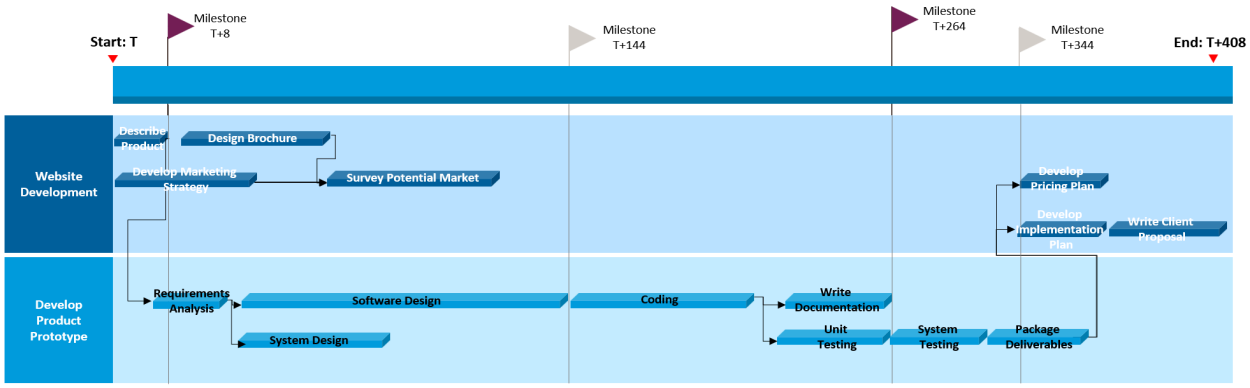
Appendix C

Gantt Charts

Project Timeline – Best Hours



Project Timeline – Expected Hours



Project Timeline – Worst Hours