Project Description

Introduction

"Any business is centered around creating and delivering something of value that other people want or need at a price they are willing to pay in a way that satisfies their expectations so that the business brings enough profit to make it worthwhile for the business owners to continue operation." — From "The Personal MBA".

The value being offered by a business falls under one of *twelve standard forms values*. Popular forms in large and small businesses are: product (e.g. groceries, chairs, perfumes), service (barbers, doctors, therapists, taxis), and shared resource (e.g. gyms, museums, amusement parks.).

Building a business involves a lot of aspects including (but not limited to) finances, marketing, sales, operations, human resources, general management and more. A lot of businesses nowadays utilize creating a *technology* to give them a competitive edge over other businesses. For some technologies, optimization problems lie at the heart of them.

In this project, you will be given a customer problem and a business idea is proposed to solve this problem. The business owner will take care of the whole business (validating the idea, market research, sales, etc) and is asking you to develop the core of the technology.

Milestones

Each milestone represents an important stage in the project. It helps you transform an ambiguous idea into a working product.

M1. Business Problem

In this stage, you will start with the project abstract that briefly describes the customer problem and the solution idea. As any typical idea at the beginning, there is a lot of ambiguity and details need to be extracted. You are required to connect to the business owner of the project, ask questions to get all the details you want.

Deliverables

A document describing a clear problem statement in English. The document should cover the following elements:

- Problem: the customer need or challenge to be addressed
- Objective: the proposed solution (service or product) to solve the problem
- Inputs & Outputs: the data that must be provided as input for the solution and the output that is produced by the solution
- Features: special structures about the problem, relationships, limitations, restrictions that is affecting the solution
- Key metrics: that define the success criteria of the project

Pro Tips

- When you communicate with your business owner, prepare a set of questions. Asking the right questions is the key to define the problem well and set clear expectations
- Keep your document organized and well-formatted with subsections, bullet points and tables as much as you can to minimize any back and forth before you start implementing solutions
- Try to be as detailed as possible on required data fields to validate with your business owner the availability of the data and set expectations on output

M2. Research Problem

After approving the document from your business owner and aligning on expectations, it's time to do some research to collect information about related work and efforts done on that problem or similar ones. Research helps you not to waste time re-inventing the wheel. You might figure out from the research that:

- This problem has already been solved before and there is a software that does the job. Your business owner can purchase a license or use it directly if it is for free.
- The problem has already been solved before, but there is no available software. You will have to translate the algorithm into a working code.
- The problem has not been solved before, but there are similar problems whose solutions can be used with some adaptations.
- The problem has not been solved and there are no similar problems.

The problem given to you falls either under category one or two. In this stage, you are required to search for papers, find the research problem that is most relevant to yours and summarize research efforts done on that front.

Deliverables

Literature review document that highlights:

- Problem analysis and definition in literature and possibly a taxonomy or classification of different variants
- Different modeling approaches that have been previously used in the mathematical formulation of the problem
- Different solutions that have been previously tried to solve the problem
- Discussion on which models and solutions might be the best for your problem
- References

Pro Tips

- Try to use the common notation and terms as used in the scientific community. For example, if your problem is around using land cruisers, most probably it's commonly referred to as "vehicles" in literature. This makes it easier for generalization and discussions outside the project (e.g. getting consultancy from an academic professor on the solutions of a problem will be easier if you used a familiar language)

M3. Modeling

Now that you have already understood the problem well both from business perspective and from in literature, it's time to start implementation. In this stage, you will write a mathematical program that describes the business problem you delivered in M1. The mathematical program brings ultimate clarity on how the problem is defined in terms of objective and constraints. It might be the case that you will re-iterate on the business problem document in case a misalignment popped up while reviewing the mathematical program with your business owner (yes, she knows how to read equations and inequalities).

Deliverables

Problem formulation document (in LaTeX) describing the mathematical program. The document must be super clear and easily readable top to bottom.

Pro Tips

To ensure document clarity, you can follow these guidelines:

- Start by defining your notation of all symbols
- Write the program with numbered equations
- Explain each equation using a simple English statement

M4. Prototyping

After approving the mathematical model, you can then brainstorm, innovate solutions, implement them and show results of your proof-of-concept (PoC) to your business owner. For the sake of this project, you need to implement four solutions:

- Baseline: a feasible solution with non-trivial results. This baseline might be greedy, random or any algorithm you like.
- Mixed-Integer programming solution
- Dynamic programming solution
- Metaheuristic solution

Your solution doesn't have to use only a single approach. For example, you can use MIP together with some other supporting algorithms. However, MIP should be the star of your solution.

Unfortunately, your business owner cannot share data with you at the moment, since she didn't launch yet. So, in order to unblock yourself, you are required to create your own artificial datasets or look for public datasets similar to your problem.

Deliverables

A presentation containing the following elements:

- Business problem summary
- Visual example of input and output
- Research problem summary
- Mathematical formulation
- Brief description of each solution
- Results summary: a table showing values of objective function on the four solutions across all datasets
- Detailed results: a table per dataset showing key metrics on the four solutions

Pro Tips

- Create the datasets in a way that demonstrates the trade-offs of each solution. For example, the baseline shouldn't be the only best on any dataset while other solutions should be better than all others on certain datasets (depending on dataset size or scenario).

M5. Productization

You didn't build the product yet. You communicated results on a prototype to evaluate if the results meet the acceptance criteria or you need to re-iterate and come up with better solutions. If results met the acceptance criteria, then you can now ship your solution as a packaged code or service.
In this stage, you will wrap your solution into a working software with a web app. The web app must support the following functionalities:

- Create new problem instance (or reset button)
- View existing input records in tabular format
- Add an input record through input fields
- Bulk-upload input records using CSV format
- Configure models parameters
- Run button by selecting one of the four solvers
- View run results (values of all key metrics)
- View output records in any format you like
- View input and output on the map

Deliverables

- Github repo link. The code should work by just cloning the repo and following the exact instructions in the README.md file (copying and pasting cli commands). It should open a webapp on the localhost
- Demo video with voice-over that runs an example (or more) experimenting all webapp features

Pro Tips

- Dockerize your code to avoid any environment-related issues on submission.
- Use fast webapp frameworks such as streamlit or dash to speed up the development process.

Timeline & Grading

Due dates represent the latest hard deadline. However, you are advised to make early submissions or take feedback as soon as you can.

Milestone	M1	M2	M3	M4	M5	Total
Delivery Due	June 10th	June 10th	June 10th	June 24th	July 1st	–
Points	5	10	30	40	15	100

Projects Abstracts

Project 1: McBalland's

Business Owner: Michael Ball

Abstract: I want to open a American-cuisine restaurant franchise in Cairo. I will do some research to list down units for sale that I can buy for restaurants and kitchens. The main challenge will be which units to buy to serve as many customers as possible while keeping operating costs at minimum.

Project 2: Talab

Business Owner: Jose D. Carver

Abstract: Food lovers might be loving a lot of restaurants but craving certain dishes on one day. It is a satisfying feeling to imagine a dish in your head and have it delivered at your doorstep without worrying about which restaurant to bring it from. I am creating an app where people can select their favorite restaurants and at order time, they only select a dish and we take care of making the order and delivering it.

Project 3: Shipit

Business Owner: Kelley Edwards

Abstract: Small businesses are struggling with international shipping. Making small shipments is either costly or some carriers might reject to do it. I am creating a business to collect shipments from small businesses and deal with inexpensive carriers on their behalf. Carriers have fixed regular trips between facilities across the globe and they differ in price. My challenge after collecting the shipments is how to distribute them across carriers I am working with.

Project 4: Erqab

Business Owner: Raul Miller

Abstract: As summer is approaching, people travel between Cairo and Sahel a lot possibly every weekend. Driving drains a lot of energy specially on hot days. I want to create a business to connect people together. Travelers are willing to pay up till certain amount of money and willing to take at least a certain amount of money in case they will be the ones to drive. The most challenging part about this business is deciding who should ride with who.

Project 5: now8

Business Owner: Marsha Palmer

Abstract: A lot of people waste their time waiting in bank queues. I want to create a mobile app where every customer sends a request one day ahead and the app will decide which customer goes to which branch at which time of the day. That will make the service instantaneous and no one will wait in the bank anymore.