Role-Based Collaboration for Smart Grocery Optimization Using Group Role Assignment

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Abstract- This project aims to develop a smart grocery shopping assistant that recommends the most cost-effective stores to visit based on a user's grocery list, location, and time constraints. The application will apply concepts from Role-Based Collaboration (RBC) and Group Role Assignment (GRA. Roles would be the items from the user's grocery list and agents would be stores within proximity. Using flyer data (from platforms like Flipp), the system will model the assignment problem as a GRA problem to find optimal agent-role combinations. The evaluation will use total price, computation time, and assignment quality as core metrics.

I. Problem statement/Objectives

Traditional grocery shopping requires users to manually compare store flyers, prices, and travel distances. This is how my mom and many others attempt to budget or save money while doing groceries. This process becomes especially inefficient when time is limited, or when trying to maximize savings. The goal of this project is to automate and optimize the store-selection process using GRA principles, where each store is treated as an agent with roles (i.e., item availability and prices), and the shopping list defines the set of roles to be assigned.

The goal of this project is quite simple. To give users the most savings possible given the amount of stores they would like to frequent, as some shoppers go to 2-3 grocery stores to get good deals.

II. Methodology

The core methodology involves modeling the grocery shopping problem as a Group Role Assignment (GRA) scenario within a Role-Based Collaboration (RBC) framework. In this setup, grocery stores act as agents, grocery list items are treated as roles. User input—including their grocery list, location, amount of grocery stores and available time will be used to define the system. The assignment of roles to agents will be optimized using either Python-based tools, like PuLP or Java based, like Google OR-Tools, to handle the underlying assignment algorithms. Natural Language Processing techniques may be used to match user-entered items with flyer descriptions. The optimization will consider total cost, travel distance, and time constraints, ultimately producing an assignment that identifies the best store or combination of stores to fulfill the user's needs. The final application will be accessible through a simple web interface developed using technologies like Flask, SpringBoot or React.

III. Libraries/APIs

- PuLP, for GRA and GMRA algorithm - https://coin-or.github.io/pulp/
- NumPy, for computing – https://numpy.org/
- Pandas, for data analysis - https://pandas.pydata.org/
- spaCy, for NLP – https://spacy.io/
- pdfplumber, for PDF extracting data – https://pypi.org/project/pdfplumber/
- OpenCV, for extracting image data – https://opencv.org/
- Google Maps API, for travel time and GPS – https://developers.google.com/maps

IV. Expected Contributions

For this project, the expected contribution is to define a complex system of grocery stores, items, locations and flyers. With this formal definition of the system, the optimizing task through GRA can be proved with real-world logic. In addition, another contribution is providing an application to users a method of saving on groceries, which grows in importance, as inflation continues.

V. Desired Timeline

The timeline can be approximated as follows:

Week 1-2	Research and proof-of-concept
Week 3-4	Prototyping with Flyer APIs and GRA
Week 5-6	Beginning implementation of UI
Week 7-8	Continuation of implementation of UI
Week 9-10	Continuation of implementation of UI (2)
Week 11-12	Implementing prototype into backend of application
Week 13-14	Debug, fix issues, improve design
Week 15-16	Debug, fix issues, improve design (2)

VI. Feasibility

In terms of difficulty, it is quite high for this project. As the application includes web-scraping for flyers, navigational requirements for GPS tracking and most likely Natural Language Processing, there are a lot of components that will need to be researched and be my first time working with them. Although the application is relatively simple in concept, the prototyping phase may be quite long and arduous. Web scrapping is not evident as aggregate platforms like Flipp do not allow it. This application would have to work directly with the websites of bigger chains (Walmart, NoFrills, Independent, etc.)

This project can work if users upload flyers themselves. As .pdf, .png or .jpg.

VII. Datasets Required

The data will be taken from either local imports (images of newspapers) or large chains (Walmart, independent and Sobeys) which offer APIs and post weekly flyers online.

VIII. Similar\Related Research

While no directly related research exists on multi-store grocery optimization for price savings, existing research often focuses on in-store path optimization—guiding a customer through the most efficient route within a single grocery store based on their list. These studies utilize store layouts and pathfinding algorithms to minimize time spent shopping. Though conceptually similar in optimizing the grocery shopping experience, such research primarily targets time efficiency, not financial savings. The proposed project builds on this ideology but shifts the focus toward cross-store optimization, aiming to reduce total cost while limiting the number of stores visited—thus balancing convenience with affordability.