ISY5001 INTELLIGENT REASONING SYSTEMS
Group Project Report

Credit Card Recommendation System

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1.0 EXECUTIVE SUMMARY

A vibrant city located in the heart of Asia, Singapore offers global investors unparalleled access to global markets. Strategically located to serve Asia Pacific, one of the world's fastest-growing regions, Singapore's well-established business infrastructure, global connectivity and trade linkages enable investors to access the approximately 4 billion strong Asian market within a radius of 7 hours' flight time.
In Singapore, one of the first things people do after getting their first job is to apply for a credit card. It makes perfect sense that paying with a credit card allows them to enjoy many benefits that using cash wouldn't provide. With the advancement of technology, the people nowadays could even embed the credit card with their phone with the various mobile payment introduced such as Apple Pay, Samsung Pay, Google Pay and etc.

In the past, carrying credit cards were considered one of the elusive "5Cs" (Cash, Car, Credit card, Condominium and Country club membership) that people in Singapore worked hard to attain. Today, owning a credit card is not only the norm, but the financially-savvy option.

However, picking a credit card can be a very frustrating process and most of the people have went through a hard time in finding the best credit card. By trying to optimize the reward from credit card, they might have fallen into the pitfall of applying excessive credit card, resulting in burdened themselves with unnecessary late payment charge or principal annual fee. Overall, no single credit card is better than all others in all categories, but by asking the right questions, each person can find the card that best fit his spending habit and credit situation.

Our team, comprising of 5 members from different nationalities, looking forward to achieve financial freedom in one day. As the first step towards the financial freedom, we have developed a credit card recommendation system, with the aim to help all the first time credit card applicants in optimizing the credit card selection and better their financial management.

2.0 PROBLEM DESCRIPTION

In today's context, credit card plays inevitable role in our daily purchases. With a card in hand, we can simply skip the trouble of counting notes, not to mention forsaking the burdensome coins that line our pockets. In addition, credit card acts as an additional protection for our purchases as our losses can be reimbursed by the credit card company when something unexpected happens to our purchases, denying us from receiving the expected item. Also, by using credit card, we are able to establish a good credit rating, which will help us in getting a loan from banks more easily in the future, provided that balances are being paid on time every month. Credit cards also provide us with additional benefits such as cashback and rewards for our purchases.

With the aforementioned benefits, it is not surprising that many people own multiple credit cards. According to the statistics provided by Monetary Authority of Singapore (MAS), a credit card holder owns an average of 6 credit cards (Cheng, 2015).

However, when we consider the consequences of having multiple credit cards, such as potentially racking up greater amount of debt due to mismanagement of spending and repayment (Forbes, 2016), having a single card may be a better option as it will be much more manageable. Having multiple cards also entails that the monthly expenditure is spread over many cards, and ultimately may end up reducing the amount of rebates card holders earn since he or she is spending less per card (Cheng, 2015). According to our survey results, one of the most important factor why most people apply for a credit card is because of the cashback provided by credit card companies (See Appendix C2). By spreading their expenditure over multiple cards, credit card holders may not hit the minimum spending requirement for each of their card, resulting in lower cashback rate as compared to combining all their expenditure into a single card, which defeats the purpose of why the credit cards were obtained in the first place. After considering why people apply for credit cards and their usage patterns, we hope to close the information gap for first-time credit card applicants, guide them to apply for a credit card that suits their needs, and enable them to maximize the cashback that they can get by using a single credit card.

2.1 PROJECT OBJECTIVE

We want to help first time credit card applicants select the ideal credit card, catering to their needs, minimizing redundancy, and maximizing benefits.

3.0 KNOWLEDGE MODELING

Knowledge modeling can be classified into three different stages (Schreiber, et al., 2001), which are,
(i) Knowledge identification
(ii) Knowledge specification
(iii) Knowledge refinement

Each stage of the is being developed based on the knowledge gained from lesson and are further explained in the section below.

3.1 KNOWLEDGE IDENTIFICATION

The first step in building the knowledge based system is to gather all related and necessary information. This is done mostly via web research and survey. In this problem, there are 2 main objects that we need to focus on: user (human) and credit cards itself.
For user/human we will tend to focus on the behaviour that is related to how credit card will be used, for example the spending amount, and the category spent on. And for credit card we will need to know the specifications, rules, and benefits each credit card offers. Knowledge on user habit is acquired by conducting survey while credit card information can be easily gathered through website.

3.2 KNOWLEDGE SPECIFICATION

A two-pronged approach was taken to acquire knowledge and discover insights, and then to formalize a model for problem solving.

3.2.1 KNOWLEDGE ACQUISITION

As stated previously, the acquisition methods are done by both interview elicitation and manual extraction from documented source. For interview we are choosing the users from credit card holders since we want to know the relation between credit card and the holder behaviour. See the table below for more explanation on how we can gain all necessary raw knowledge:

Source	Insight gained	Technique
Credit card holders Survey	Users behaviour on : - Their income, overall spending and their basic	Interview elicitation through survey form. The user interviewed is a credit card holder to get valuable

	profile. - Their habit in using credit card: how much spend, type of spending, user interest, etc.	information.
Credit card website	Each of credit card: - Benefits and its rule - Prerequisite / requirements	Manual extraction from the credit card documents available

Table 3.2.1.1 Knowledge Source and Acquisition techniques

Based on our survey results shown in Appendix C, three of the most common biggest expenditure by credit card holders are on dining, bills and transport (See Appendix C1).

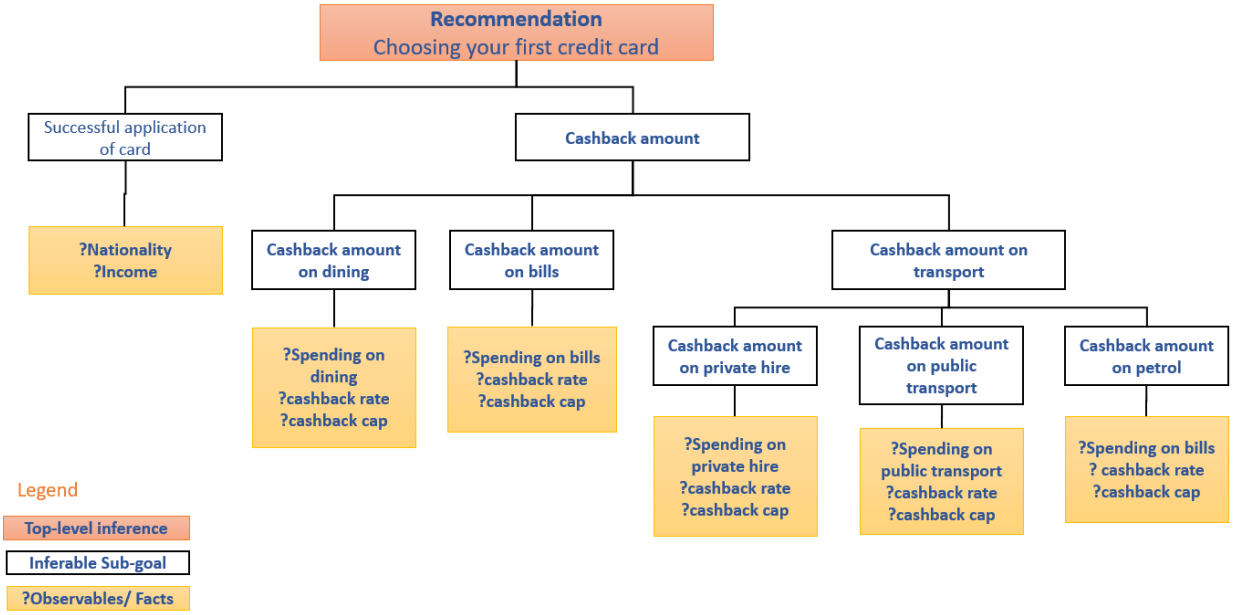

Figure 3.2.1.2 Dependency Inference Diagram

The techniques adopted for knowledge acquisition have been described in Table 3.2.1.1 and the corresponding results are presented using a dependency diagram as shown in Figure 3.2.1.2.

The dependency diagram arranges the factors affecting credit card applicant's choice of bank in a hierarchical tree structure. The decision of the proposed system is illustrated by the top most level node, which in this case, the recommended credit card to the user. This decision is broken down into layers of inferable sub-goals or sub- factors before arriving at a list of "observables". These "observables" are derived from our credit card usage survey results and they represent the main factors that influence the decision of users when selecting the preferred credit card. Table 3.2.1.3 illustrates an example using the dependency diagram in Figure 3.2.1.2.

S/N	Category	Information
1	Observable	A young working adult who travels to work on a daily basis via Grab.
2	Sub-level goal	The young adult described in [1] would likely be interested in a credit card that can provide cashback on his private hire expenditure.
3	Sub-level goal	Cashback for spending on transportation described in [2] are one of the three categories of cashback which have been identified. Other categories include: (i) cashback amount on public transport and (ii) cashback amount on petrol.
4	Goal/top level inference	The amenities described in [3] are also one of the three main categories affecting credit card applicant's eventual choice of credit card. Other categories include (i) cashback amount on dining and (ii) cashback amount on bills.

Table 3.2.1.3: Example to illustrate a branch of the dependency diagram

3.3 KNOWLEDGE MODEL AND REFINEMENT

For a start, we created a prototype that takes three main user input values of dining expenditure, bill expenditure and transport expenditure for our rules calculation. After testing the prototype with a small group of users, we received feedback that some of the input fields were rather generic and confusing. One example was the transport expenditure. As the costs between different transportation mode in Singapore vary to a large extent, it was difficult for users to determine which transportation cost they should provide if they used multiple transportation modes for their daily travel. After considering feedback as well as how different credit cards provided different cashback rate for different transportation mode, we further refined our rules to split transportation expenditure into three different categories, as shown in Figure 3.2.1.2.

Figure 3.3.1 explains the process of knowledge refinement through (i) model validation & verification with the feedback from users and (ii) model reinforcement. The former is conducted by collecting survey result from the small group of users. The collected results are then validated with the respective user who can provide feedback on the area of improvement. In the future for improvement, the acquired tacit knowledge could be built into the system to provide a more precise credit card recommendation.

An example of the iteration is the enhanced prototype with refined rules on transportation expenditure due to the variety of transportation mode in Singapore.

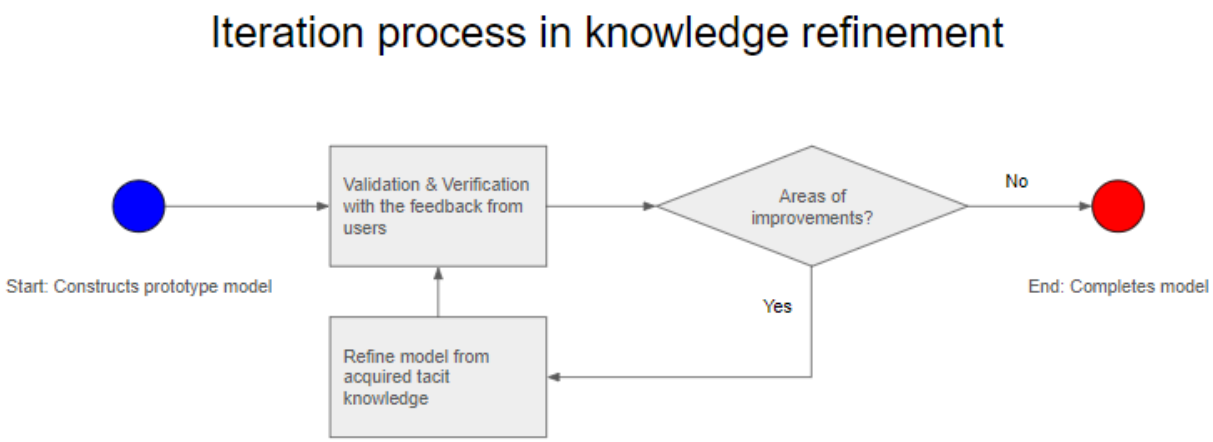

Figure 3.3.1 Iteration process in knowledge refinement

4.0 Solution

4.1 SYSTEM ARCHITECTURE

The system can be divided into 2 parts, frontend and backend.
The frontend is a web based application for user to interact with backend. We use Vue.js javascript framework to easily create and deploy interactive ui. Frontend job is mainly to ask the required questions to the user, relay the answer to backend, and display the result, which is the recommendation that has been analyzed by backend. On the other hand, we use durable_rules (https://github.com/jruizgit/rules) as our rule engine. It is a python based framework, for the simplicity in definition of rulesets, and with the core engine implemented in C, for ultra fast evaluation of the rules as well as multi language support. The knowledge model and rules that we have gained are then imparted into our rule engine so that the backend can give recommendation based on what user has input. After the computation and evaluation, backend system will send the best credit card and its recommended to the user along with its metadata. As the url for each of credit card is also available, user will just have to click on the image of credit card to check more details on the source page.

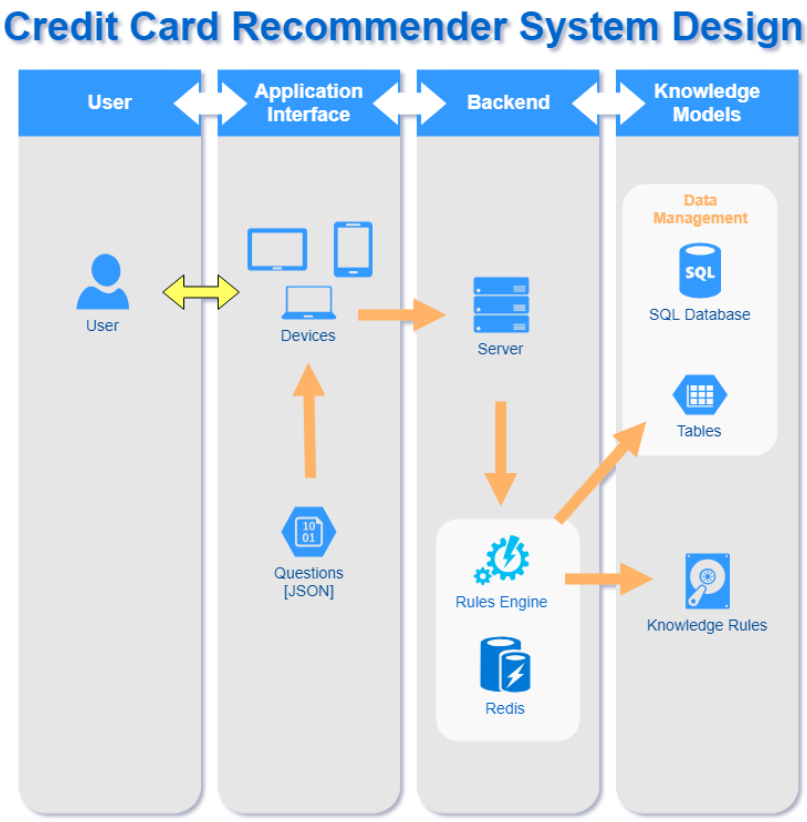

Figure 4.1. Overall System Design Diagram

4.2 PROJECT SCOPE

The scope of our system is limited in suggesting the best credit card for the user by assessing user habit and demand in spending the money. Hence the result that we achieve is solely affected by the survey we have conducted and how we interpret the data.

From our survey results, we have observed that cashback component in a credit is the most important factor and in the usage of a credit (See Appendix C2). Therefore, with this knowledge, we have decided to develop our system to recommend credit cards to user based on cashback. Our system will recommend credit card to user based on spending habits of the user in each category that we have identified to be important area of spending in general, which are dining, transport and bills payment. Cashback amount is maximized with the recommended credit card that the system has evaluated to be ideal.

4.3 ASSUMPTIONS

Assumptions that we made when we building our system include:

1. User is neutral (No preferences on any banks or credit card). We assume everyone has no issue with any particular bank, hence the recommendation can be created without any biased on the user preference and biasedness.
2. The user input is accurate (no consideration of user inaccuracy in giving information). We will always assume that what the user has input is accurate and true, as it would be difficult to validate the truthfulness of the input.
3. The list of credit cards that we have in our knowledge database are up to date based on the system is created, hence some of details might be inaccurate or outdated at the point of usage of the system..
4. List of credit cards we have is not complete. The list of credit card we have in our database is based on the most popular or best credit cards among many more credit cards existing in the market.

4.4 SYSTEM'S FEATURES

Despite of the limitations mentioned in the previous sections, we were able to implement some key features as illustrated in this section.

4.4.1 System Reusability & Scalability

Firstly our frontend and backend are decoupled by REST Application Programming Interface (API). This mean that our frontend can be used with any other backend easily and vice versa. For example if we deploy several different rules engine on many backend server, frontend just need to change the API to get result from different engines. On the other hand our backend can be used by many other frontends too as long as the api contract is satisfied.
Additionally our questionnaire form can be easily modified and expanded as necessary. This is because the question is not hardcoded into the HTML, but instead it is loaded from JSON file. Hence any modification to the questions in the future can be done by only change in the JSON file.

4.4.2 Ease of usage

As the system is a web based application, it can be easily accessed by any electronic device nowadays as long as the device has web browser and internet connection. Furthermore, our recommender system also attach the url for each of credit card. This is very convenient as the user can directly go into the details of the card without the needs of doing the search again.

4.4.3 Rules engine

Our backend service that is based on rules engine is the backbone of our system. With the rules engine our system can easily analyze all the data received and arrive at the conclusion to search for the best credit card of the user. This is the primary feature of our system.

4.5 LIMITATIONS

The knowledge model that are used to build the system has been simplified This is mainly happen because of the complexity of the problem that we would like to tackle. The result of knowledge acquisition is insufficient to give all the insights needed to solve the problem. Hence the system tend to focus to solve on one small part of the area. However going forward we can expand our system to cover more cases from different perspectives.

5.0 CONCLUSION & REFERENCES

The group discussion session was fruitful and rewarding as we have learnt much from each other. Even though every one of us has personal commitment on our work, we still committed a substantial portion of our rest time and weekend to deliver the project. The time spent on this group project was not wasted, the joy of witnessing the completion of final product was unforgettable and we are glad that we have successfully achieved our objective of recommending the best credit card to the users.

5.1 IMPROVEMENTS

If we were given a longer duration to work on this project, we would have worked upon the following points of improvement:

5.1.1 Interviewing a Domain Expert

We considered interviewing a banking professional who specializes in credit card application to assist in providing knowledge. However, we were not able to schedule an interview appointment with her within our project timeline due to her hectic schedule. By interviewing a domain expert, we would be able to cross verify our factors for consideration when designing the credit card recommendation system.

5.1.2 Add in a certainty factor determiner in the algorithm

Even though most of our surveyed respondent responded that they got their first credit card within the age of 21-30 (See Appendix C4), and that the approximately half of our survey respondents are from our age group of 21-30 (See Appendix C3), we felt that by gathering more responses from our age group, our data on spending expenditure might be more accurate since our target audience are first time credit card applicants. Also, as the respondents from older age groups tend to have different spending requirements due to additional financial and family commitments, the data collected from the older age group might have impacted the accuracy of our results. By adding a certainty factor based on age group to our algorithm, we could have improved its accuracy.

5.1.3 Expanding our knowledge base

Our knowledge base was built through manual means of data collection by referencing individual banking websites. As such, we collected a rather limited number of types of credit card data within the project timeframe. If we had a longer project timeframe, we could collect more data and expand our knowledge base to include a larger variety of credit card types.

6.0 BIBLIOGRAPHY

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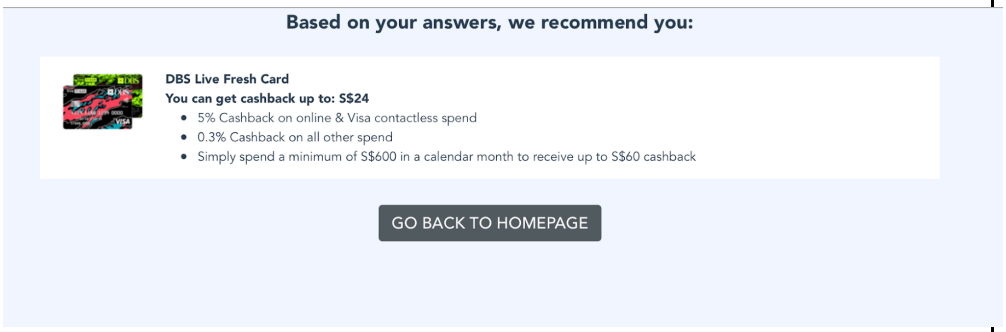
Appendix

APPENDIX A: SAMPLE INPUT & SYSTEM OUTPUT

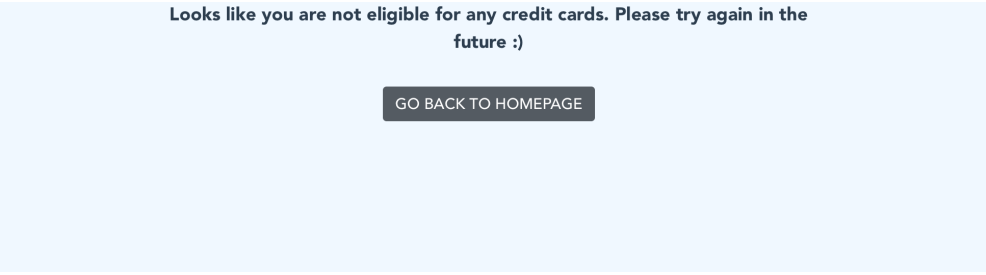
A.1 Scenario 1

<table>
<tr><td>Characteristic of user</td><td colspan="3">25 years old Singaporean who is employed in Finance industry. He is current staying with his parents, both of which are still working in the management level. He eats out most of the time as both parents are still working.</td></tr>
<tr><td>Questions:</td><td colspan="3">What is your age? : 25
What is your nationality? : Singaporean/PR
How much is your annual income? : $60,000
How much is your average monthly spending? : $600
[Breakdown] How much do you spend on dining? (Please answer in % of monthly spending you have) : 60
[Breakdown] How much do you spend on public transport? (Please answer in % of monthly spending you have) : 20
[Breakdown] How much do you spend on petrol ? (Please answer in % of monthly spending you have) : 0
[Breakdown] How much do you spend on taxi/private hire ? (Please answer in % of monthly spending you have) : 20

[Breakdown] How much do you spend on house bills ? (Please answer in % of monthly spending you have) : 0</td></tr>
<tr><td>System output:</td><td colspan="3"> 
</td></tr>
<tr><td rowspan="2">Analysis of system output</td><td>Features</td><td>Output</td><td>Explanation of system’s output</td></tr>
<tr><td>Recommended Credit Card</td><td>DBS Live Fresh Card</td><td>Based on the user’s inputs, the system has recommended DBS Live Fresh Card as the cashback rebates of this card matches the user’s spending patterns the most amongst all the cards in the</td></tr>
</table>

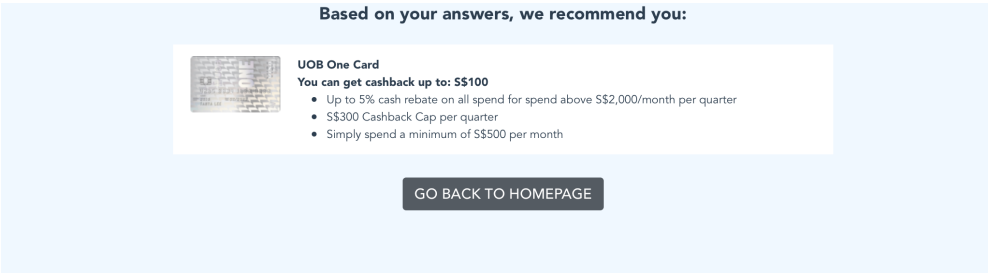
			database, and it allows the user to get the most cashback amount as compared to the other cards.
	Cashback amount	S$24	This is the monthly cashback amount the user can get if he were to pay all his expenses via the recommended credit card.

A.2 Scenario 2

Characteristic of user	20 years old foreigner who is studying in National University of Singapore. She stays in the school hostel and most of her lunches are provided by hostel during weekdays. Her parents are staying overseas and they send her some money for her daily expenses on a monthly basis.		
Questions:	What is your age? : 20 What is your nationality? : Foreigner How much is your annual income? : $0 How much is your average monthly spending? : $300 [Breakdown] How much do you spend on dining? (Please answer in % of monthly spending you have) : 80 [Breakdown] How much do you spend on public transport? (Please answer in % of monthly spending you have) : 20 [Breakdown] How much do you spend on petrol ? (Please answer in % of monthly spending you have) : 0 [Breakdown] How much do you spend on taxi/private hire ? (Please answer in % of monthly spending you have) : 0 [Breakdown] How much do you spend on house bills ? (Please answer in % of monthly spending you have) : 0		
System output:			
Analysis of	Features	Output	Explanation of system's output

system output	Recommended Credit Card	NA	Based on the user's inputs, the system did not recommend any credit card as the user did not qualify for any card's minimum requirements in the database.

A.3 Scenario 3

Characteristic of user	50 years old Singaporean who is working as a Vice President in a local bank. He is the sole breadwinner of his family. His family consists of his spouse as well as 2 kids, who are studying in local secondary schools.		
Questions:	What is your age? : 50 What is your nationality? : Singaporean/PR How much is your annual income? : $120,000 How much is your average monthly spending? : $3,000 [Breakdown] How much do you spend on dining? (Please answer in % of monthly spending you have) : 30 [Breakdown] How much do you spend on public transport? (Please answer in % of monthly spending you have) : 0 [Breakdown] How much do you spend on petrol ? (Please answer in % of monthly spending you have) : 30 [Breakdown] How much do you spend on taxi/private hire ? (Please answer in % of monthly spending you have) : 0 [Breakdown] How much do you spend on house bills ? (Please answer in % of monthly spending you have) : 40		
System output:			
Analysis of system output	Features	Output	Explanation of system's output
	Recommended Credit Card	UOB One Card	Based on the user's inputs, the system has recommended UOB One Card as the cashback rebates of this card matches the

			user's spending patterns the most amongst all the cards in the database, and it allows the user to get the most cashback amount as compared to the other cards.
	Cashback amount	S$100	This is the monthly cashback amount the user can get if he were to pay all his expenses via the recommended credit card.

APPENDIX B: USERS MANUAL

SYSTEM OVERVIEW

Our Credit Card Recommendation System is a webapp generally targeted at young working adults looking to apply his or her first credit card. The website will require the applicant to key his or her personal information into the form, calculate which is the best credit card that will maximize cashback for the applicant and return the details of that credit card to user interface.

USER INTERFACE

Our user interface runs on Vue.js. Once our rule engine returns the resulting credit card match, the resulting credit card with its details coded in Vue.js, will be displayed in the web interface.

RECOMMENDED BROWSERS

Credit Card Recommendation System supports the following Web Browsers:

- Internet Explorer 11
- Google Chrome Version 72 and above
- Safari Version 12 and above

REQUIREMENTS

Please ensure you have the following installed. Otherwise, follow the respective links to install your required libraries:

- Anaconda / Python 3.6 or older
- Node.js
- Microsoft Visual C++ 14.0 (Build Tools for Visual Studio 2017)

DEPLOYMENT

```
# 1. install all front end dependencies
cd web/
npm install

# 2. install all backend dependencies
pip install requests flask flask_cors durable_rules

# 3. (Windows only) run start.bat to start all application
./start.bat
# 3. (Non windows) you need to run redis server manually, and then run the rules engine by running cc_system.py inside rules-engine folder
```

```
python cc_system.py


# 4. Try access localhost:8080/home


# Alternatively you just need to run rules engine by running python script and redis
start_server.bat
# And then access the frontend from AWS host. This static host will connect to your localhost rules engine backend
http://machine-reasoning.s3-website-ap-southeast-1.amazonaws.com/home
```

APPENDIX C: SURVEY RESULTS

Survey results csv file: https://bit.ly/2Tsy5wr

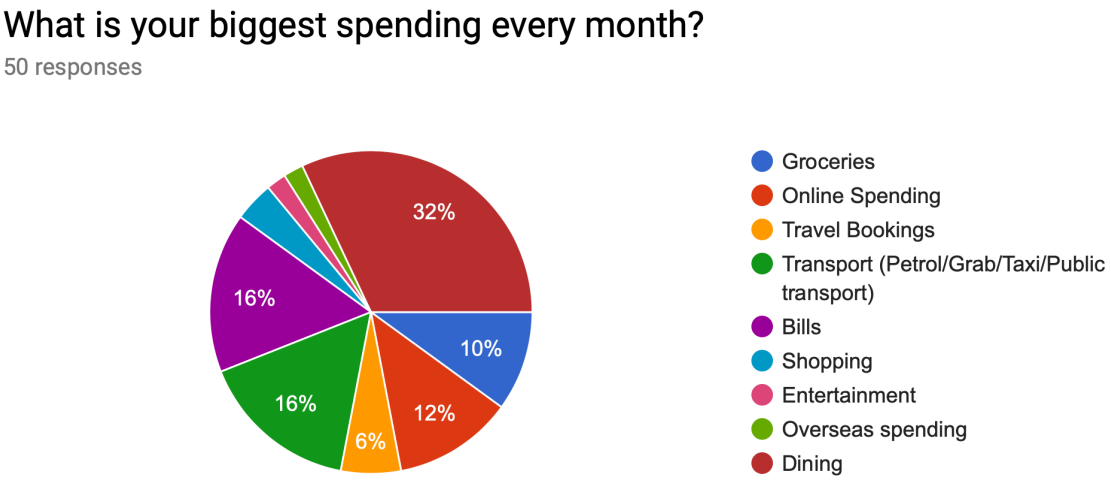


Figure C1. Largest expenditure item for each surveyed credit card holder

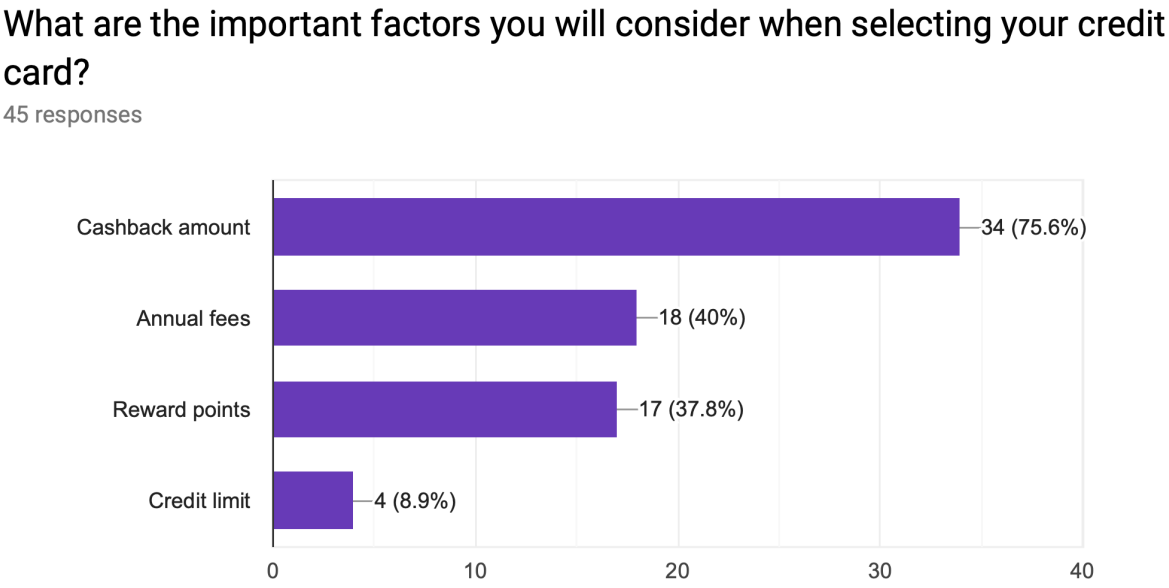


Figure C2. Factors of consideration for surveyed credit card holder

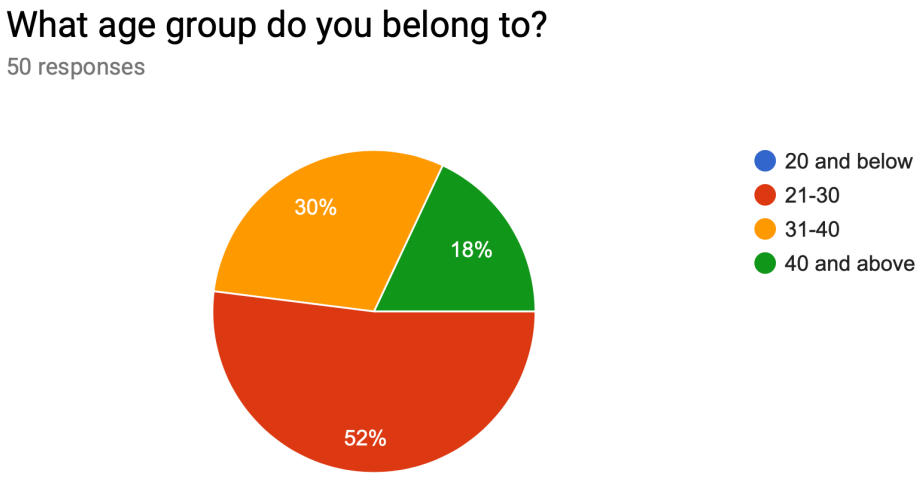


Figure C3. Age group of survey respondent

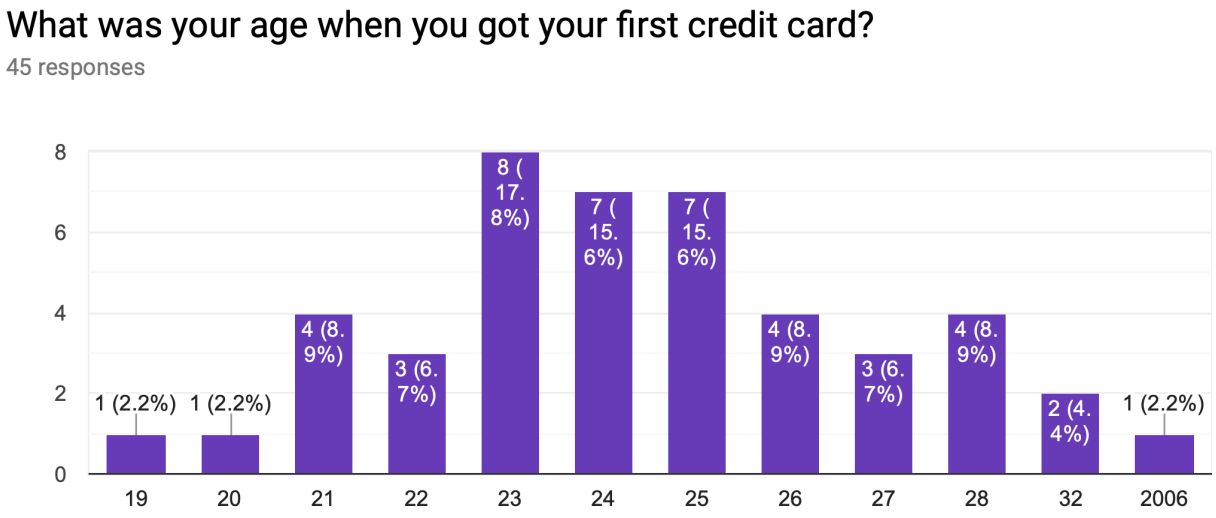


Figure C4. Age of survey respondent when obtaining his/her first credit card