

# Roommates: A commercial & social driven web-based platform dedicated to finding roommates

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## ABSTRACT

The following document introduces the "Roommates" platform developed as part of the Yearly Project in Computer Science course at the Technion, Israeli Institute of Technology.

In the last years, home life for young people has dramatically changed. The rate of young people who live with roommates grows constantly.

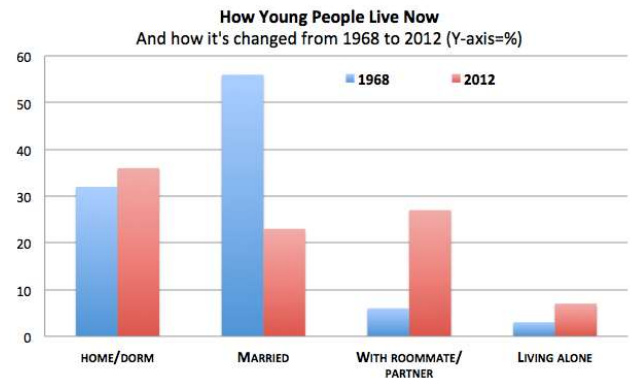
However, according to a survey conducted by Boise State ScholarWorks among students<sup>[31]</sup> – about 25% reported roommate problems – why? Finding a roommate isn't an easy task. It consists of two tough sub tasks – finding a person and finding a property. "Roommates" platform goal is to create a simple system that will ease the lives of landlords and tenants and make this complicated task a fast and enjoyable experience. The system will be able to match the searchers to the most suitable apartments and roommates for them according to criteria that characterize them, such as occupations, hobbies, lifespan, and interests. As a result, they are more likely to have made the right choice and find the right place for them.

In the article we will demonstrate and prove that we can find a match according to our definition of match and that a match that corresponds with our definition has a chance to hold water in real life i.e. the definition meets the market needs.

We managed to build a system that does not exist anywhere today. Although there are different solutions that try to help people to find roommates, none of them provide the perfect suite which covers both – the social and the commercial aspects of the problem as will be explained in the article.

## I. INTRODUCTION

Most people at some time of their life, usually during their university or college years, have searched for a lovely roommates apartment. In the last half-century, home life for young people has undergone a dramatic shift – more and more young people live with roommates.



(Figure 1.1) How young people live now <sup>[30]</sup>

There are many considerations and concerns involved in this process. How far is the location from the educational institution, how is the landlord, how are the roommates, how is the standard of living in the area, and many more. It happens all the time that people find out that they made the wrong decision because they didn't have enough information. This situation might be a nightmare for both the landlord and the inhabitants. An example I came across is from a friend of mine who told me this story:

*"I lived with two very nice roommates. Everything was great until one of them decided to leave and we found another guy that will replace him. When we first met him, he told us that he is allergic to radiation which is outputted from electronic devices. When we asked him to explain to us what he meant, he said that devices divulge frequency in the shape of waves, and when it reaches him he is controlled by instructions that he cannot resist"*

Well, that may sound like an entertaining story, but it wasn't very entertaining for my friend and the other roommate that had to be on the watch. Even during sleep, they had to take precautions such as locking their bedroom door so that the other roommates that was under the control of electronic devices would not enter their room.

There are a bunch of ways that exists today which are used for finding real estate online. The two major players in the Israeli market today are "Yad 2"<sup>[1]</sup> and "Facebook"<sup>[2]</sup>. Yad 2 is a web platform which is used as a huge board for advertising various products, such as: cars, apartments for rent, apartments for sell, electronic

products and so on. Yad 2 describes itself as "*the biggest advertisement board in Israel*" and its popularity proves its claim. The second's popularity is known worldwide. Due to its popularity people tend to advertise products, among other apartments, on their private profile and in dedicated existing groups. Lately Facebook also added a new feature called "Facebook Marketplace"<sup>[6]</sup> which allows its users to discover, buy and sell items with other users around their area. Other popular companies out there are "WinWin"<sup>[3]</sup>, "Homeless"<sup>[4]</sup> and "Madlan"<sup>[5]</sup> with a core concept similar to this of Yad 2's.

Even though there are all these alternatives, it doesn't mean they solve the "finding a good roommates" problem. Yad 2 is proud of its size, but its greatest strength is also its biggest weakness. It was designed to support variety of products, which means it does not focus on a specific point of interest. That's a good concept, but is limiting the resources and finesse of apartment advertisement specifically. Private people started advertising apartments for rent in Facebook just because of its popularity, but Facebook is by no mean a platform designed for this kind of stuff. The most important thing all those platforms lack regarding the problem we are trying to solve is a convenient flow for finding the most suitable roommates. None of them provide any mechanism for categorizing candidates by different criteria which will guide the users for closing the best deal (note that the word "best" in this context is individual). This is the main goal "Roommates" is trying to solve!

This article will describe in detail throughout of it what Roommates exactly is. It will dive deeply on the problems it solves, how it solves them and what mechanisms and technology it uses to achieve the goal. Also, it will continue to compare Roommates with the other alternatives.

## II. RELATED WORK

The task of finding the best roommate is consist of two sub-tasks. The first one - finding the right property and the second one is finding the right people. We can divide the existing alternatives into 3 groups:

- a. Group A – platforms aim to solve only one problem out of the two.
- b. Group B – platforms focus on answering one of the problems but also provide the user information and services which may help him with the other task.
- c. Group C – platforms aim to solve both problems.

In this section we are going to review and cover three popular alternatives to the "Roommate" platform, each one belongs to a different group of the above.

**Facebook** - Facebook is an American online social media and social networking service with more than 2 billion monthly active users as of June 2017<sup>[22]</sup>. Facebook is a great example of a service belongs to group B. In the last years, Facebook is undoubtedly the most popular platform for finding a roommate. In a Niche survey of more than 800 users, 31 percent reported Facebook being the top way to reach out to a new roommate, while 28 percent admitted they already knew their roomie before starting school<sup>[23]</sup>. Furthermore, according to a survey conducted at Vanderbilt University School of Medicine – 18% of the roommates at the school met on Facebook - the top ranked online platform<sup>[24]</sup> (Figure 2.1).

What makes Facebook the preferable option? social media is all about interpersonal interaction, so it is obvious that you can use social sites to find and meet roommates. The popularity and the nature of Facebook i.e. being a social network provides the users a great opportunity to find the right person to live with. With a single post on Facebook you can reach a lot of people (your friends, friends of friends and even all Facebook members!) notifying them that you are looking for flat partners. In addition, there are dedicated groups for seeking roommates. But it doesn't end there. Not too long ago, the only way to get know with your candidate roommate was a brief interview with him. Facebook allows you to meet the person before the physical meeting. Once you find a potential roommate you can gather a lot of information about him from the profile page: his favorite food, hobbies and music, his origin, his views, etc. Moreover, Facebook provides its users the entire suite of social related services like a live chat with the other person.

However, although Facebook provide the landlords the option to publish apartment ads, the ability of the platform to find the relevant flat for the users based on their preferences is very limited. There are 3 main reasons causing Facebook to miss the perfect match:

- a. Although Facebook offers a special advertisement post, its template is generic and consist of price, location, description and pictures. Furthermore and as a direct consequence, Facebook doesn't let the user to perform smart searches and filter the ads based on his needs e.g. the user can't search for apartments with AC.
- b. Facebook is a distributed environment. The member who searches an apartment must join several groups in the platform. It should be

emphasized that to join a group you have to find it and be approved by the admin of the group, so things get complicated. The landlord faced the same problem – he has to publish his apartment i.e. an identical ad in all relevant groups and to track them all afterwards.

**Classified advertisements websites** (e.g. Yad2 and Craigslist<sup>[25]</sup>) – the classified advertisements websites might be considered as "old-fashion" platforms but they are still relevant today and they are considered as popular platforms belonging to group A. The line of business of those websites is not limited to apartment ads, but we are going to focus on this aspect. The relevance of those websites stems from the fact that they meet the need of getting the right property which is one of the two sub-tasks.

The focus of those websites is put on the property side means they serve as a centralized collection of available apartments and provide the user the ability to search and filter big data based on his needs and preferences. The problems we listed as the blockers of Facebook from solving the property issue are the key features of the classified advertisements websites – centralization and smart searches. A user who seek for a room can surf to one of those websites, fill in his needs and preferences: location, required facilities, budget, etc. and within seconds he will be offered with a list of relevant properties based on his search parameters. It also makes the life of the landlord much easier – a single ad is exposed to all visitors of the site.

However, the social part doesn't exist at all. An apartment might be classified as a "roommates apartment" but there are no social services provided by the websites so the task of finding the roommates doesn't get an answer. As said, the problems we listed as the blockers of Facebook from solving the property issue are the key features of the classified advertisements websites but vice versa – the key features of Facebook are just not a part of such websites.

We should now explore some of the group C category.

**Roomster.com** <sup>[26]</sup> – Founded in September of 2003 and based in New York City. Roomster offers people to post & search for accommodations around the world with other likeminded individuals. The Roomster

platform requires an active Facebook account which is used as the login identification, no registration is required. In this way, Roomster covers the social aspect of the mission. The website distinguishes between two use cases – looking for a place and looking for people.

The website provides you a platform to find a room in apartment. Once you filled a form with the following parameters: location, move date and budget you are displayed with a list of available properties that meet your parameters. The list can be filtered by price, age, radius, household sex and whether pets are allowed.

Furthermore, the website also covers some social features that can help you and the owner/already living roommates decide whether you should live together. A short profile paragraph is enclosed in any ad listed on the site. In addition, you can browse to the public Facebook profile of the person published the ad. The website also offers messaging feature between the seeker and the person who published the ad via an internal messaging system or via the Facebook Messenger.

However, the site ability to find you the right property and right people is limited. The fact that the site doesn't let you perform smart filtering makes it almost impossible to find the relevant apartment. The current filter supports the following: price, age, radius, household sex and whether pets are allowed. It doesn't support filtering by other important properties like: apartment facilities (AC, elevator, balcony, parking etc.), floor, etc. Furthermore, the platform doesn't perform basic matching based on the nature of the people since it doesn't hold the data and passes the buck to the users.

Websites belongs to the group C operates mostly in the USA & Canada and still aren't considered as popular platforms. There is not even one representative in the survey conducted at Vanderbilt University School of Medicine<sup>[24]</sup>.

### III. DESIGN AND IMPLEMENTATION

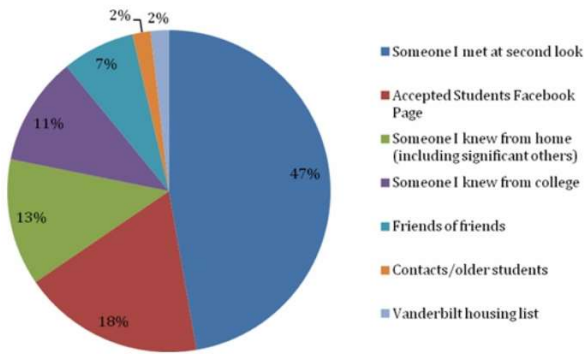
We wanted to build a platform that would enable people looking for a roommates apartment or for partners to have a convenient and reliable way to fulfill their mission. The role of the platform is to lead the users hand-in-hand in the pathway, which will eventually end in "closing a deal." There were two options that were at stake in terms of platform type. The first option was to build a website and the second option was to build an application for mobile. Of course, there is no great significance to choosing between them if our goal was only research. Nevertheless, there is great advantage of an internet site compared to a mobile application which lies in the fact that it can run properly on any device that supports network traffic in general, and in computers and cell phones in particular. However, it should be emphasized that the UI should be designed such it would fit any screen size i.e. it should be responsive, so that it will also work properly on mobile.

#### Back-End

There is a large number of technologies that perform all the "dirty work" of the server side behind the scenes, allowing the programmer to concentrate only on the core logic relevant to his application. This is the reason why our initial research was finding that kind of technology. One of the first options we encountered was using a framework called Spring<sup>[7]</sup>. Spring is a framework implementation for Java<sup>[33]</sup> programming language. It looked like a framework that was old and wrought, but on the contrast outdated and overwhelming. That is why we finally chose the Node.js<sup>[8]</sup> platform, which allows server-side scripting in JavaScript<sup>[9]</sup> (a language originally intended to run on client-side browsers). Node.js is very popular today, and there are no shortage of directories and third-party libraries that make it even better.

Every reputable service today contains a data structure for keeping its data. It was obvious that we would need one, at least to keep user and apartment abstraction. The first option was to use a relational data structure such as SQL<sup>[10]</sup>. Another option was to use MongoDB<sup>[11]</sup>, which is a document data structure that stores the information in JSON format. Both options are good, allowing easy implementation of the application we planned to build. The most prominent advantage of MongoDB over SQL is that most Node.js tutorials on the web mention, among other things, the use of MongoDB as their data structure. In fact, this was the decisive reason why we think MongoDB is a better choice.

A traditional Website works as follows: The client first sends an HTTP request to the server, when the request is encoded in the URL sent to the server. If this is a valid request, the server runs a code on its side that is relevant to that request. Finally, the server sends back to the same



(Figure 2.1) Answer given in the Vanderbilt University School of Medicine survey to the question – how did you find your roommates?

Furthermore, as Figure 2.2 and Figure 2.3 show, it seems that type C websites don't provide the user the added value they claim to.

#### Customer Review Rating: ?



(Figure 2.2) Customer review rating for Roomster.com. Taken from Better Business Bureau<sup>[32]</sup>.

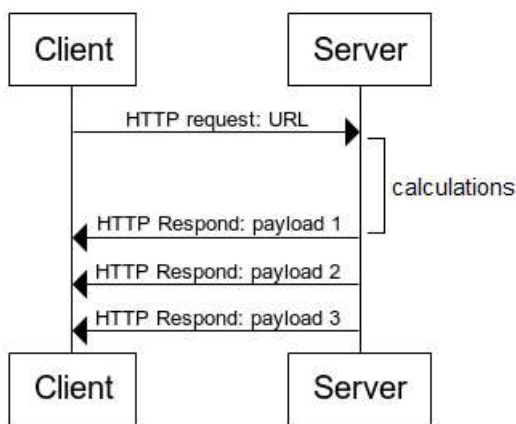
#### Customer Review Rating: ?



(Figure 2.3) Customer review rating for RoomieMatch.com. Taken from Better Business Bureau<sup>[32]</sup>.



client an answer, in the networking jargon it is called a response. The result is presented to the user in the browser through which he browses (Figure 3.1). To handle the requests, a mechanism must be used to enable the definition of valid requests and the execution of an appropriate code, which at the end of it a response is sent back to the client. One of the most popular mechanisms which exists for Node.js is called Express.js<sub>[12]</sub>. This framework allows to do everything described above in an easy and readable way. For example, if we want a customer to be able to obtain information for a particular roommate apartment in which he or she is interested, it is required to simply define a server-side "route" that says: "When a request is made with the URL X, execute the code Y." On the response, there is no need to configure the HTTP messages ourselves, Express.js does this for us. All we should worry about is putting in the content of the response.



(Figure 3.1) Typical client-server HTTP communication

There are various of ways to define the API of a service. In our project we used RESTful API for managing the requests. REST<sub>[13]</sub> is short for *Representational State Transfer* and its main idea is to define the resource which is being manipulated or modified as part of the request itself. Let's assume we have a user in the database with an ID of "12345". Then, if a client wants to get the information of this user he will send to the server a GET request with the URL: "domain.com/users/12345". We can divide this request into 3 parts. The first one is the domain of the server; this string address is a mapping between a string to an IP address. This translation is under the responsibility of the DNS server, from our perspective it is transparent. The second part describes the entity whose information we want to receive. The third and final part of this example indicates that the information requested is that of the user with the ID "123456" and not of all existing users in the system.

We identified 2 main entities: users and apartments. Users are divided into two types - the first type is an unregistered user, called a visitor. A visitor can search and view apartment ads and view profiles of registered users. But it does not enjoy personalized presentation of apartments and other users on the site. That is, the system does not categorize and filter apartments and potential roommates that are most suitable to the searcher. The expectation is that visitors will sign up to the site in order to exploit the full potential of the system. The site provides a standard registration mechanism that includes email verification. A registered user is the second type of user. The user's details are stored in the database and the password is kept hashed using Node.js' bcrypt<sub>[14]</sub> library, so that the password file is protected from theft attack. These users will be able to use all the interesting features of the site, which we will expand on immediately. The other entity is an apartment, or rather an apartment ad. Ads of apartments are advertised by registered users and contain important details about the apartment. An apartment ad should contain at least the following details: advertiser, location, price, image, number of roommates living in the apartment, number of roommates required and existing services in the apartment (e.g. elevator, safe room etc.). It is an option to expand the object even more. For example, we chose to allow to add a short general description, the apartment floor number, the total floors of the building, the square meter area, other users' comments to the ad and to allow a user to express interest on the property. Searching for apartments is done by a HTTP GET request where the information that characterize the apartments to be searched for are attached as query parameters to the URL of the request. Many kinds of query parameters can be invented, but above all of them stands the one that defines the area in which the apartments should be searched. For every Apartment we maintain its geolocation coordinates. Geolocation is a vector of 2 elements named latitude and longitude. Of course, the user is not required to provide these coordinates on his own, they are calculated by the server from the string address he provided when he published the ad. In order to calculate the coordinates, we use Google Maps API<sub>[15]</sub>. All that the server has to do is to perform a query that contains an iteration on the existing apartment ads in the database and by doing so, create a list of all the apartments whose distance from the geolocation supplied is not greater than a certain distance. The distance calculation between two geolocation points is performed using the following formula:

$$a = \sin^2\left(\frac{\Delta\varphi}{2}\right) + \cos(\varphi_1) \cdot \cos(\varphi_2) \cdot \sin^2\left(\frac{\Delta\lambda}{2}\right)$$

$$c = 2 \operatorname{atan2}\left(\sqrt{a}, \sqrt{1-a}\right)$$

$$d = R \cdot c$$

where  $\varphi$  is latitude,  $\lambda$  is longitude,  $R$  is earth radius ( $R = 6371km$ ). If  $d$  is less than or equal to the maximum allowed distance, then the apartment is added to the results list.

Authorized users can have the ability to control their profile information which includes the user's first and last name, age, free language description, lifestyle and skills. They are also provided with services to update their account information (currently only a password reset can be performed) and to view a list of their published apartment ads and the apartments they expressed interest on. The personal information that a user enters on his personal profile is important in order to optimize the search results presented to him. The site will display to the user apartment ads that are sorted in a way that the apartments that are most suitable for him will be shown first. Each skill and lifestyle property has a predefined weight (integer). After the server fetches all the relevant apartments at the user's request, it runs a matching algorithm. this algorithm compares the searcher's properties to the properties of the other roommates currently living in the apartment. The roommates living in the apartment are part of the information that is saved in each apartment record. First, a counter is set to zero and for each common property, the counter is incremented by the property's weight. If the same apartment has several roommates, we may run the algorithm several times on each roommate and take the average of the overall sum. The same is done when a user asks to see the list of other users who have expressed interest in a specific apartment. This list is displayed sorted so it gives the user an idea to whom should he make a contact with. This mechanism is special since no platform out there supplies such behavior. This is because none of them emphasized the aspect of roommates matching.

The password reset mechanism consists of several steps. Each step is important, because it influences the system's overall security. In the first step, a registered user sends a POST request to the server indicating that he wants to reset his password. Following this request, the server sends an e-mail message to the user that contains a unique link to the password reset page. The link is unique because it contains a special token specifically created for that user. Only the authenticated user has access to the same page, from security considerations. Through the same link the user can send a PATCH request containing, as part of its message body, the new password. The unique token by the following process: the server encrypts the user's ID and e-mail address with a unique key created on-the-fly for the user. The secret key is created by taking a number of properties from the user's personal information, concatenating them to a private key known only to the server. After that, an encryption takes place using the *JSON Web Token (JWT)*<sup>[16]</sup> library. Because the key is derived from the server's secret key, only the server can

recreate the key. Now, how the verification takes place is pretty obvious. The user must be logged in to perform the password reset, so the server can verify that the user has sent the message containing the new password by restoring the key from the user personal information. If the key generated is the correct key, that is, it decrypts the token successfully, the password is updated successfully; Otherwise the message might have been sent by a potential attacker. It should also be noted that the token has an expiration time.

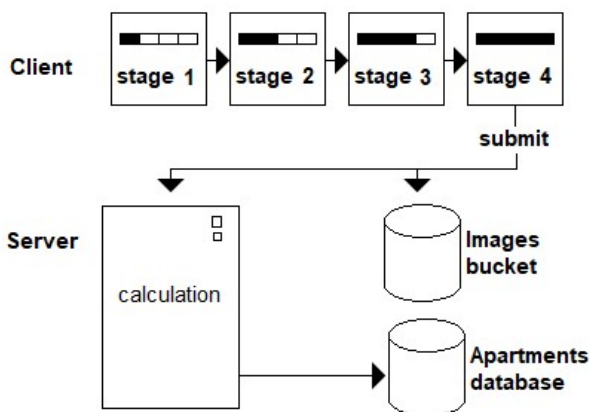
## Front-End

We had several framework alternatives we were investigating also on the side of the front-end. The dilemma was between Angular<sup>[17]</sup>, a framework developed by Google, React<sup>[18]</sup>, a framework developed by Facebook and Vue.js<sup>[19]</sup>, a framework developed by the talented developer Evan You. We initially thought of using Angular because it organizes the UI code in a structured way. Nevertheless, it has a big drawback - it is quite complicated and takes quite a while to adapt to it, a time we did not have. We finally decided to use Vue.js because it provided order and organization like Angular on the one hand, and on the other hand, easy and rapid development, as React provides. Vue.js also has broad network support that includes many tutorials. Reactive Web Design is implemented using "Bootstrap Vue"<sup>[34]</sup> and "Vuetify.js"<sup>[35]</sup>, which are both very popular frameworks.

The site is a *Single Page Application (SPA)*<sup>[19]</sup> with each item composed of a Vue-Component. For example, the main header is a component, the footer is another component, and everything between them are components. Routing between pages in the site does not involve the server. We did that with the help of a great Vue.js addon called "vue-router"<sup>[20]</sup>. For every page the user navigated to, the Vue instance re-renders the page, while everything is performed on the client side. For global state management we use another Vue addon called "Vuex". Vuex<sup>[21]</sup> is like a store that allows secure access by all the vue-components. It is very useful for storing the logged in user data, or the last search results and saves repetition of the same requests to the server.

When a user enters the site, he is presented with a large search form through which he can search for roommates apartments, similar to the Google search line. Once searching, the results are shown as a list below one another, where each result showing a summary of the details of the apartment. Clicking on one of the ads leads to a page detailing the apartment and its advertiser. In addition, a list of people interested in the apartment appears on this page and is sorted individually, the most suitable interested users will appear first. Each registered user will have a button through which he can also express interest in the apartment. A section of comments on the apartment appears at the bottom of the page. People are allowed to add comments as they wish

to ads. We've added the comment section to allow people to ask questions and add a social aspect to the platform, as on Facebook but lacking from others such as Yad 2. Through the main menu at the top of the page, one can connect if not already connected, and once connected he can access the "Add New Apartment" page. From there he can also access his "Control Panel" whose functionality has been described in the Back-End section. The process of adding the apartment is simple, and includes 4 steps, each step is indicated to the user by a progress bar that fills up. The first stage includes defining essential characteristics of the apartment and uploading pictures. The second step includes additional information that the user can provide, but is not necessary. In the third stage, the user defines the services included, such as "elevator", and constraints, such as "no smoking". The last stage presents the user with all the details he filled up in the previous stages so that he can review them before the advertisement is published. At each step, the user can return to each of the previous steps. All this is done on the client's side and does not involve the server. Only when the user finally clicks submit, the information is sent to the server that in turn handles the request. Thus, the information is only saved at the end of the process. This is good in case the user cancels the posting procedure in the middle. All information provided, except the images, is stored in the database on the same server that stores the apartment records. The images are encoded into base64 format and uploaded to a separate storage bucket (the procedure is shown in Figure 2). Once published, any surfer will be able to see the ad.



(Figure 3.2) Uploading a new apartment flow

#### IV. EVALUATION

To prove our solution and to demonstrate the potential of the platform, we have to show that we meet the need i.e. that both tasks – finding the relevant

property and finding the right people are resolved by "Roommates".

Unfortunately, there is no proven method to proof that both issues get a solution since matching (of properties and/or people) is subjective. However, we are going to build a proof system which theoretically proves that we can find a match according to our definition of match and that a match that corresponds with our definition has a chance to hold water in real life i.e. the definition meets the market needs. Moreover, we have to show that "Roommates" algorithm follows its definition.

We are going to distinguish between the two types of matching – matching a property and matching a person. For each type we should show that the definition we chose is relevant and prove that our platform follows the definition.

People Matching – the root question we need find an answer to is: "what are the circumstances that make individuals form bounds?". The answer of this question will serve as the base for the matching algorithm. According to a research done by scientists from the University of Southampton, Royal Holloway, University of London, and the Institute of Zoology at London Zoo (which was published in the Journal of the Royal Society Interface), we choose our friends mainly because we have shared interests. The researchers concluded that people go from clique to clique as their interests change, usually forming a tight knit of friends.

One of the researchers, Dr. Sebastian Funk, from the Institute of Zoology, said:

*"We changed the model so that individuals tended to form links with similar others and we saw the cliques start to form."*<sup>[27]</sup>.

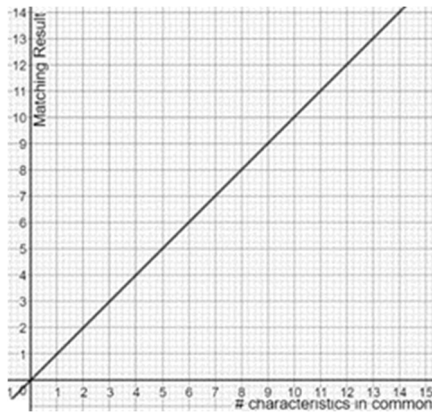
The conclusion of the research is the cornerstone, underlying concept of our algorithm i.e. we used this research to build our person matching prediction algorithm - the algorithm ranks the match with a better possibility score as there are more things in common between the people.

"Roommates" matching algorithm calculates the result of  $M(P_a, P_b)$  where  $P_a$  and  $P_b$  be two different persons. Let  $[C_1, C_2, \dots, C_n]$  be a set of pre-defined characteristics of a person e.g. interested in music, interested in politics, etc. In addition, there is another set of  $[W_1, W_2, \dots, W_n]$  where  $W_i$  is the weight of  $C_i$  in the matching calculation. By default,  $\forall 1 \leq i \leq n, W_i = 1$ .

Let  $[I_{a_1}, I_{a_2}, \dots, I_{a_n}]$  and  $[I_{b_1}, I_{b_2}, \dots, I_{b_n}]$  be a set indices where any indicator,  $I_i$ , may be set to 0 or 1 (depends whether the person owns characteristic  $C_i$ ).

Then,  $M(P_a, P_b) = \sum_{i=1}^n ((I_{a_i} + I_{b_i}) \cdot W_i)$  i.e.  $M(P_a, P_b)$  is a sum of all  $W_i$  where both persons own

characteristic  $C_i$ . For  $\forall 1 \leq i \leq n, W_i = 1$ , we get a linear function as shown in figure 4.1.



(Figure 4.1) matching result as function of number of in common characteristics.

It means that the result of the calculation is higher as much as there are more characteristics in common, so the Roommates algorithm follows the results of the research.

*Example:* Let the characteristics set be: [interested in sports, interested in music, interested in politics, quiet person, vegan]. The weight of each characteristic is the same and equals 1.

Consider we have 3 persons: Alice, Bob and Mate and we look for 2 partners match. Assume that Alice is interested in sports and vegan, Bob is interested in sports, music and politics and Mate is interested in sports, music and considers himself as a quiet person.

The set of indices is built to be:

Person/indices	$I_{sport}$	$I_{music}$	$I_{politics}$	$I_{quiet}$	$I_{vegan}$
Alice	1	0	0	0	1
Bob	1	1	1	0	0
Mate	1	1	0	1	0

The algorithm calculates the following matrix:

Person/Person	Alice	Bob	Mate
Alice	X	1	1
Bob	1	X	1

Mate	1	2	X

The algorithm looks for 2 partners match (the assumption) so it returns the partnership Bob – Mate as the best match. We can see that Bob and Mate indeed have the greatest number of characteristics in common hence the algorithm suggests them as the match (in accordance with the research that people with shared interests tend to form links).

An important result we should pay attention to is the symmetric matrix. At this point, it should be emphasized that relationship between two people is a symmetric connection because it depends on both sides. We have to show that "Roommates" algorithm can't behave abnormally and contradict this axiom:

$$M(P_a, P_b) = \sum_{i=1}^n ((I_{a_i} + I_{b_i}) \cdot W_i) = 2 \cdot \sum_{i=1}^n (I_{a_i} \cdot W_i) = M(P_b, P_a)$$

Furthermore, it is important to emphasize that the "Roommates" algorithm serves as the first filtering.

The second filtering is done by the user using the social suite provided by "Roommates". "Roommates" provides its users additional tools and services to check their match. The main two services are:

- The platform will allow its members to communicate via an internal messaging system.
- The platform exposes the profile of its members, so you can get know with the hobbies and the biography of another user.

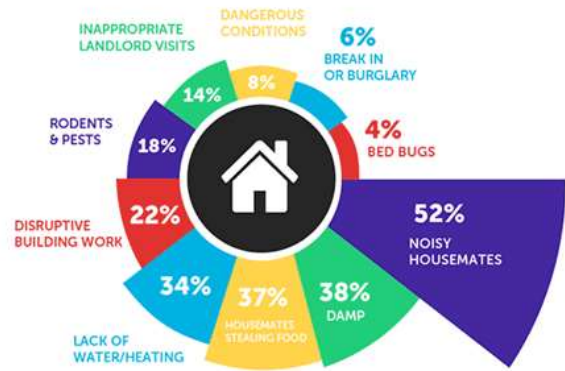
Property Matching – what are the factors of apartment people searching for? In an article published on moving.com<sub>[28]</sub> Marian White, the author, listed 10 considerations to keep in mind while apartment hunting: price, quality, landlord, roommates, neighbors, neighborhood, lease, pet policy, utility costs and the amenities.

"Roommates" property matching engine takes these factors into consideration while filtering and sorting relevance results to the user query hence, it follows the market needs.

- Price – the user can limit the range of ads prices. "Roommates" won't suggest the user results which are out of his budget.
- Quality – the user is able to filter the ads based on his needs i.e. he can select the features and facilities he wants. "Roommates" won't suggest the user results which don't have the requested features.



- c. Landlord – the "Roommates" platform will support ranking and reviews. Each member of the platform will be able to rank and write a review about other users. The reviews might help you to get know with the landlord and his history.
- d. Roommates – See previous issue, "People Matching".
- e. Lease –"Roommates" will suggest the roommates to sign on a contract created by the platform itself - a standard lease with no surprises.
- f. Pet policy – the user is able to filter the results according to their pet policy. "Roommates" won't suggest the user results which don't follow the selected policy.
- g. Utility costs, amenities, neighbors and neighborhood – "Roommates" will provide data about the area of the property gathered from official databases. Furthermore, the platform offers the user to ask questions in the comment section of each ad. The comments can be read and answered by any member of the service.



(Figure 4.2) Top 10 problems for renters.

## V. CONCLUSIONS

We managed to build a system that does not exist anywhere today. On the one hand it provides advertising services to individuals similar to Yad 2, and on the other hand emphasizes the social aspect similar to Facebook. And even more, it successfully connects people with similar traits, leading to better prospects for finding suitable roommates. We combined existing tools with code we wrote ourselves, to achieve the initials goals.

Of course, it is always possible to improve and expand the project. We are planning on adding a few more special mechanisms:

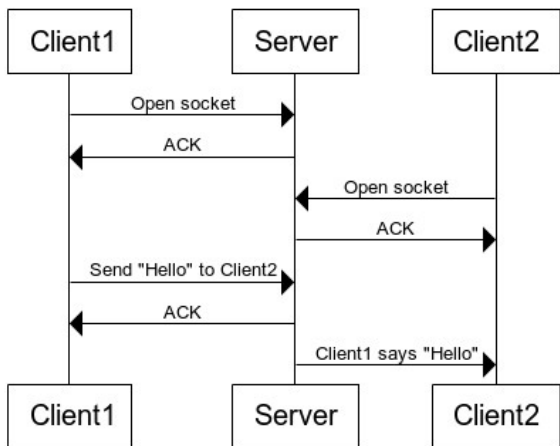
- a. As mentioned in the beginning of the article, we want the platform to guide the user in "closing a deal". For that, one of our next steps is to create a mechanism that automatically constructs recommended matching groups for an ad publisher. That is, the publisher will be offered with several groups of people of size of the number of roommates required for the apartment. These people will be picked from the apartment's expressed-interest list. The total group matching score, which will be available to the publisher, will be calculated in the same way the expressed-interest list is sorted, mentioned in section III, but will have to take into account the weighted score among all of the group's members. The publisher will also be capable of modifying the groups by himself. "Closing the deal" will then be simple by "Signing the group". As a result, the apartment status will be changed to "Deal closed", which will then be shown to everyone, as part of the apartment's ad information.
- b. We have also mentioned the importance of integrating social aspects into the platform. This lead us to the decision of adding the option of live private messaging between users. Thus users will be able to manage all related activities within the same frame without the need to use outside resources.

The fact that "Roommates" platform follows and takes into account all "must" considerations proves that it meets the market needs.

Another way to prove and demonstrate that the platform meets the market needs is by examining whether "Roommates" platform can assist with the biggest problems for renters. According to a survey conducted by the National Student Accommodation [29] which polled 2,246 students in the UK between 1st – 14th February 2018, discovered that the severe problems are related to the nature of the roommates and the landlord. 52% of the students reported that they have "noisy housemates", 37% reported that their partners stealing food and 14% complained about their landlords' visits. The rest of the problems have the same origin - the property itself – damp, lack of water, building work, rodents and pets, bugs and dangerous conditions (see figure 4.2).

With a better person & property matching and matching of expectations (by reading reviews and communicating with the landlord and other roommates) prior to the lease, the statistics can be improved – this is exactly what "Roommates" aims to do.

One of the libraries we are planning to use in order to implement it is called "Socket.io"<sup>[36]</sup>. This library provides a simple way to opening TCP sockets with users as soon as they first communicate with the server, so that the server is able to initiate sending of segments to them. Thus, when a user on one side sends another user a message, this message first arrives at the server, and then the server can forward the message to the user on the other side.



(Figure 5.1) High level representation of socket communication.

- c. In addition, to induce a feeling of liveness and activity we want to add notifications system which will inform the user upon internal system events related to him. Such events can be, for example, publication of new comments or new expression of interests on the user's post.
- d. Another great feature we are planning on adding is "Location Reviews" – Next to every apartment advertisement there will also be a relevant review which will be presented based on the apartment's location. An interested person will then be able to get a general impression of the region.

There are few points that we think need more work, such as improving the design of the UI to make it more user-friendly. In addition, the project was built so that it is very easy to convert from a website to a mobile application. There is no need to change the back-end at all because it provides an API which does not depend on the application running on the client-side. So shifting everything into a mobile application is an option too. We encourage anyone who wishes, to take what we have created and enhance it.

## REFERENCES

[1] <http://www.yad2.co.il>  
 [2] <http://www.facebook.com>

[3] <https://www.winwin.co.il>  
 [4] <https://www.winwin.co.il>  
 [5] <https://www.madlan.co.il/>  
 [6] <https://www.facebook.com/marketplace>  
 [7] <https://projects.spring.io/spring-framework>  
 [8] <https://nodejs.org>  
 [9] <https://www.javascript.com>  
 [10] <https://he.wikipedia.org/wiki/SQL>  
 [11] <https://www.mongodb.com>  
 [12] <https://expressjs.com>  
 [13] <https://he.wikipedia.org/wiki/REST>  
 [14] <https://www.npmjs.com/package/bcrypt>  
 [15] <https://developers.google.com/maps>  
 [16] <https://jwt.io/>  
 [17] <https://angular.io>  
 [18] <https://reactjs.org>  
 [19] <https://vuejs.org>  
 [19] [https://en.wikipedia.org/wiki/Single-page\\_application](https://en.wikipedia.org/wiki/Single-page_application)  
 [20] <https://router.vuejs.org>  
 [21] <https://vuex.vuejs.org>  
 [22] <https://en.wikipedia.org/wiki/Facebook>  
 [23] <https://ink.niche.com/roommate-dilemma-random-roommates-vs-living-friends>  
 [24] <https://medschool.vanderbilt.edu/paddle/housing/>  
 [25] <https://www.craigslist.org>  
 [26] <https://www.roomster.com>  
 [27] <https://www.telegraph.co.uk/news/science/science-news/8171136/Shared-interests-key-to-friendship.html>  
 [28] <https://www.moving.com/tips/10-important-things-to-consider-when-renting/>  
 [29] <https://www.savesthestudent.org/accommodation/national-student-accommodation-survey-2018.html>  
 [30] <https://www.theatlantic.com/business/archive/2013/09/how-roommates-replaced-spouses-in-the-20th-century/279210/>

[31] <https://stevebrownaps.com/blog/research-shows-25-students-experience-college-roommate-problems/>

[32] <https://www.bbb.org>

[33] <https://www.java.com>

[34] <https://bootstrap-vue.js.org>

[35] <https://vuetifyjs.com>

[36] <https://socket.io/docs/server-api/>