UNIVERSITY OF Southampton

BUILDING HOUSE-GURU.CO.UK: AN OPEN DATA APPLICATION

GROUP REPORT

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A REPORT

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1. Abstract:

House-Guru is a professionally developed web application which informs potential homeowners of local house prices, crime statistics, amenities and other points of interest. There are available datasets which have information about different features, including hospital data, crime records, school data etc. This information allowed the users to choose their location according to the features they want and based on that it provides an effective medium for users looking to buy, rent quality properties.

Keywords: Information Extraction; Features;Properties;Open data

2. Table of Contents:

3. Background:

On average a million homes change hands every year, with the market gaining momentum over the last 4 years, but still not having recovered to pre-recession levels [5]. The recovery can be attributed to a number of factors affecting the market, the most obvious being the historically base-rate of interest set by the Bank of England which has helped to make mortgages more affordable with low fixed and tracker-Mortgage interest rates [6]. Another factor is the help to buy scheme created by the government, whilst some economist argue that it is causing more harm than good to the market [9], its aims were to help improve the affordability of homes to first-time buyers [7][8].

As with any sector of a modern economy, the opportunities for digital services to supplement the sector are key to a business' success, as is most prominently shown in the retail sector with businesses such as Asos outperforming traditional high street rivals [10]. As such the first company to develop a successful disruptive technology for their market will dominate it for years to come. The UK housing market has not invested too deeply into these technologies and has rather opted for a simple digitising of their traditional approach, with online house listing and images of the properties they are offering.

4. Objective:

The idea of the project is to create a web application for house hunters. The application uses information collected from several datasets that include crime data, school zone etc and make available the zone that they prefer investing on the property. This application guides the users to select their location with their own interests. The vital characteristics of the application allows the person to choose areas based on their feature selection. The user will be receiving information related to their interaction patterns. In the future, the system will regulate the desire of the users based on the exploration of their interaction during use. This way the application is able to rate what part would suit user's wish.

5. Research Methods:

The initial idea for the project came from Edmund, as he was looking into buying houses after university and found that whilst a wide array of open data existed about the UK, but that outside certain small area projects, such as maps.soton, it was not widely consolidated into a single usable place. So the decision was made to make such a consolidated map of as much useful open data about a geographical area as possible with a view to helping potential house buyers.

The next step was to decide what information potential customers would be interested in viewing on a map. We did this through interviews with a random sample of friends and colleagues, this was chosen due to the relatively small amount of time it would take to perform and prepare, as well as for the fact that since most of them would be graduating soon or have recently graduated are in a position where they too will soon be or have been searching for housing, making them fit

a potential customer profile. From these interviews three key services were viewed to be most important, those were crime statistics, food retail outlets and schools.

A small literature review was carried out as part of the research part of this project, which was focused on the areas of usability and user experience design. Since the project's core component was a user-centered map displaying geographical data the issue of Human Computer Interaction (HCI), particularly usability, was a key consideration. Usability can be defined as "ensuring that interactive products are easy to learn, effective to use and enjoyable from the user's perspective"[17]. This seems simple enough but it is common for web applications to create common usability problems, as suggested by Brinck, Gergle and Wood[18]: Human perception problems, where data is displayed in a manner such that it suits how the at a is stored rather than how a user would want to use it; Navigation design issues, where the site structure is not designed in a way logical to the user. Both of which would need to be kept in mind whilst developing the application. A final usability issue to be considered would be that of loading times, as page loading times leave a lasting impression on the user of the website, as if a user is using a fast website, they will be getting to their information faster and be rewarded for their efforts more quickly, conversely if a user is kept waiting for a prolonged period of time they will simply get annoyed at the website and may look for competitors to that website to take their business to. Despite there being much research into this field there is not a clear dataset on precisely how this effects sites in the long term, however there exists a well regarded study, funded by Google and Bing[19] which suggest that user satisfaction drops significantly if the website takes longer than 2 seconds to load[19], so we should aim for our web application to take less than two seconds to load.

6. Datasets/Licensing:

A large number of open datasets were used in the creation of this product. These datasets have been retrieved from a number of reputable sources, with the most common being from the UK government's open data service, data.gov.uk. The datasets include schools location and ratings from the department for education, to crime statistics from the Home Office, to a list of prepared food retails from the Food Standards Agency (FSA). The data from data.gov.uk is available under the Open Government Licence for public sector information, which allows for the data to be copied, published, distributed, transmitted, adapted, commercially and non-commercially exploited so long as the source of the data is acknowledged.

Some open data APIs are also used, such as the Zoopla API which is used to find property listings and associated information, as well as to use Zoopla's heat map of UK house prices, which is an initiative way to display house price trends across geographical areas.

Dataset	Source	Licence
Open Street Maps	http://openstreetmap.org	CC BY-SA 2.0 [14]
UK PostCodes	https://www.freemaptools.com/download-uk-postcode-lat-lng.htm	Contains OS data © Crown copyright and database right (2018)[12] Open Government Licence v3.0 [13]
UK Crime	https://data.police.uk/data/	Open Government Licence v3.0 [13]
English Schools	https://www.gov.uk/government/publications/schools-in-england	Open Government Licence v3.0 [13]
UK NHS Pharmacies	https://data.gov.uk/dataset/e373eb6a-fffd-48e5-b306-71eb17f97af2/pharmacies	Open Government Licence v3.0 [13]
FSA hygiene ratings	http://ratings.food.gov.uk/open-data/en-GB	Open Government Licence v3.0 [13]
UK House Prices	https://www.zoopla.co.uk/heatmaps/	CC BY 2.0 UK [15]
Paid Prices For property transactions	https://data.gov.uk/dataset/4c9b7641-cf73-4fd9-869a-4bfeed6d440e/hm-land-registry-price-paid-data	Open Government Licence v3.0 [13]

Table 1: Data Sources used and Licences of the datasets

7. Design And Prototype

7.1.Technical Design

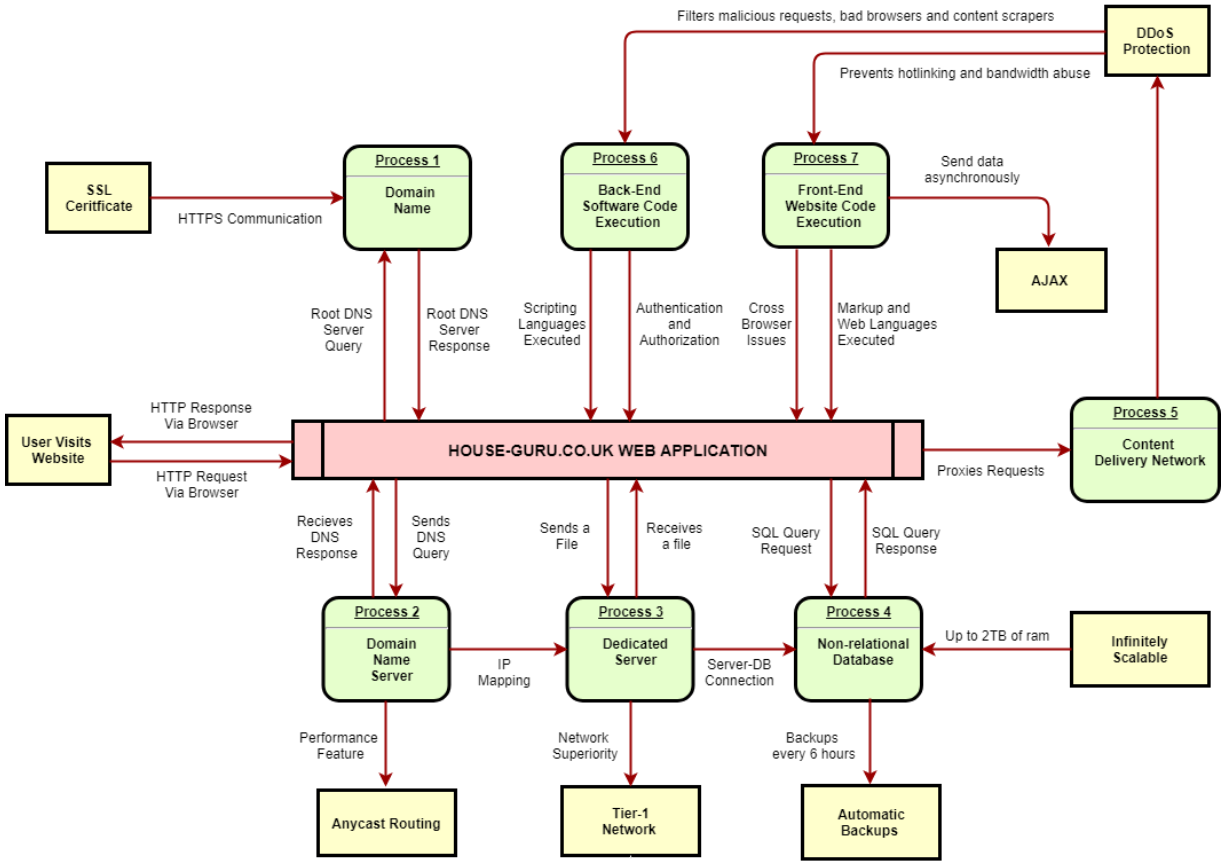
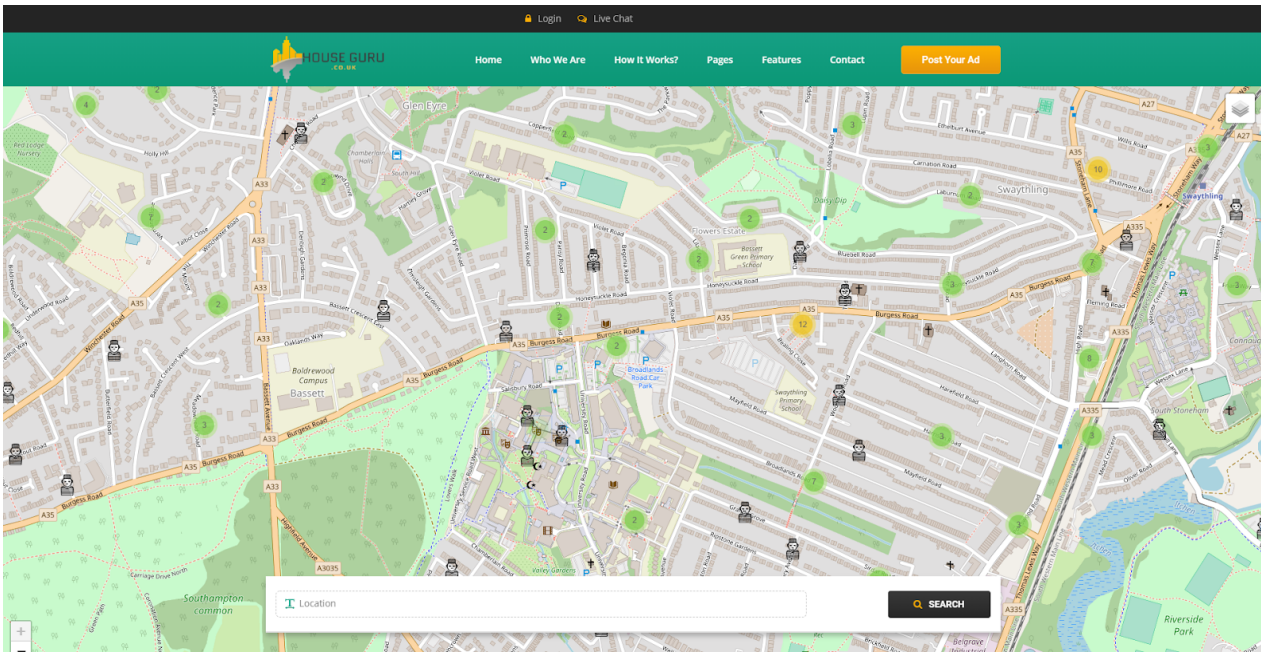


Figure 1 [11[2]] - Technical Design and Prototype

Our application consists of a simple client server architecture, with most of the processing occurring on the client side of the application. The application will be globally accessible, with a domain name for ease of access to potential users as well as using HTTPS for all communication to increase customer security during application use. Cloudflare will be used as a Content Delivery Network (CDN) which we will use to allow for lower access times across the world. We will also make use of Cloudflare's DDoS protection to reduce server load and to improve site uptime.

[2] Image Adapted from previous drawing.

7.2.UI Design



The application User Interface was designed around the idea of giving the user access to the information they want as quickly as possible, and as such the map was place in the middle of the landing page for the website. Since user customisation was a key aim of the project, the box in the top right of the screen allows for users to add or remove informational layers from the map rapidly and with great ease.

8. Architecture and key components:

Our website application has two main framework patterns:

- Layered architecture
- Client-server architecture

Layered Architecture

Our layered architectures is composed of three logical layers: presentation tier, application tier and data tier in which each has a specific job.

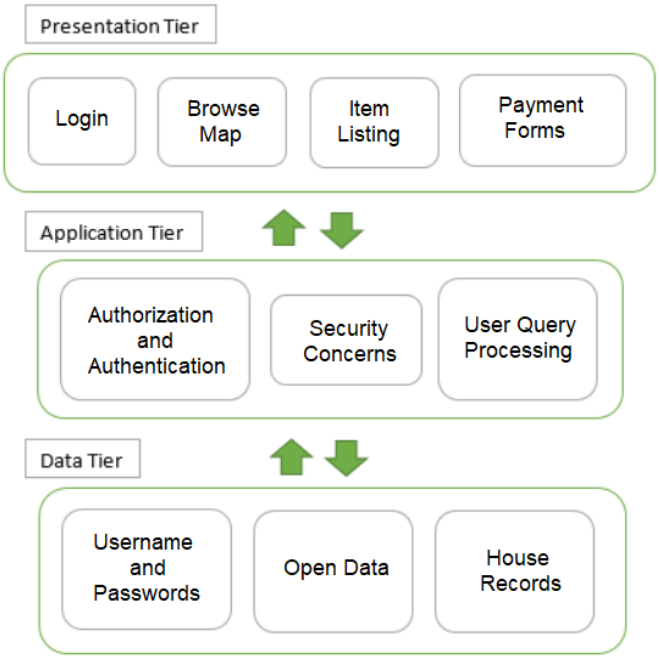


Figure 2 - Layered Architecture

Presentation Tier

The first layer is related to the user interface. It related to the appearance of our website where our users can perform very simple transactions. Front-end and languages (HTML, CSS. Javascript). In this layer, we also ensure our website is responsive on different browsers on desktop on mobile. This is accessible by a web browsers.

Application Tier

The second layer is related to the system functions where our dedicated backpend cloud instance performs its job. Various system functions already described in this report take place. This tier is in-between the presentation layer and the data layer.

Data Tier

The third layer is related to our data and is the base core of our system. It is where we store all of the information related to our map aad users. After the user sends requests from the presentation layer to the application layer, data from this tier is retrieves.

Server-Client Architecture

We adopted the network architecture ‘server-client’ where each entity on our network is either the client or the server, it can’t be both. The client cannot see the resources of the server but can only perform requests and the response will be provided from the server.

9. Implementation and Technology choice:

There are many technologies and libraries used in our web application, we summarize and justify their use below.

SSL Encryption

We're using a Secure Socket Layer (SSL) certificate to increase the security on our website. This would increase the encryption between the website and the user.

Libraries

We used a set of useful libraries for multiple web technologies to help build our web application, the libraries used are:

- jQuery: jQuery is open-source and free-to-use javascript library, accessible on many platforms, provides a handy set of functionalities and is executed on the client side.
- Bootstrap: Bootstrap is an open-source and free library developed by Twitter and simplies the front-end design of website. It contains premade CSS designs and templates such: forms, buttons, etc…
- Font Awesome: Font Awesome is a font toolkit that provides many premade icons and logos that are free to use on any web application.
- Leaflet JS: A free open source platform for creating simple, lightweight responsive maps with a web browser, with a wider array of free third party content available to extend the library functionality.

Cloud Platform Technologies

We use server instances that support scalability. Those technologies are provided as a service by companies such as AWS and DigitalOcean.

Content Delivery Networks

All of static assets such as JS, CSS and HTML are cached by Cloudflare's CDN. This technology allows the file to be placed in around 100 data centers so when requested by the user, the file is retrieved from the closest datacenter.

10. Hosting and Collaboration:

We summarize how we host our application below:

Hosting

A cloud and scalable virtual machine running NodeJS 6.12.3 on 16.04 from DigitalOcean was used to host the source code of our website application and make it accessible on the World Wide Web. The reason why we chose a virtual server instead of pre-rented is that the we get to easily upgrade the resources of the instance such as storage, memory or computing power.

Database

A virtual machine running MongoDB 3.3.10 on Ubuntu 16.04 was used as well.

Reverse Proxy

All of the requests on our server are handled, filtered and processed by Cloudflare reverse proxy before reaching our server. This is done to prevent DDoS (Distributed Denial of Service Attacks).

Domain Name Server

We use a DNS server whose job is to link our domain name house-guru.co.uk to the public IP address of our server. This is what allows people to memorize domain names instead of IP addresses.

11. Results and Achievements:

The result of this project is an application, which can be used to facilitate the process of buying or renting or selling a property by providing users with different layers of information. In the process of application, development documentations were produced and a business canvas was created. Different datasets were collected and aggregated to fuel the application and the collection procedure we learned principles of managing open data and how to use them to create an innovative solution to an already existing problem.

12. Business Case:

12.1. Customer Segment

Our application can be used by people who are interested in renting, buying, selling or letting a property or startups or companies, looking for office area. Also Information available on our website can be used by investors, who invest in real estate.

12.2. Channel

The website is the main channel to deliver content and subscribe. Google Adsense, and Adwords, and social medias can be used along our website to promote our products and advertise our services. Also email marketing is a very common mean of advertisement utilised my many companies.

12.3. Customer relationship

We use automated customer service support and provide other resources such as FAQs to users, the reason is to reduce costs as much as possible. Since, this application is not a critical application having a human operated customer support desk is not necessary.

12.4. Business Plan

12.4.1. Revenue streams

Our main revenue comes from advertising by estate agents based on a click through model. Subscription fees can also be collected from estate agents. The main service, which is displaying a map with different layers of data is free for everyone to use. Also users can see property postings by estate agents for free. They can see agent's contact information, to do so they have to click on a button, which we use to count click through in order to calculate fee for agents.

12.4.2. Values proposed

The main values proposed by HouseGuru is illustration of several layers of open data to user in one place, so that users be able to evaluate the properties they are interested in. Agents postings are also displayed on our website and can be displayed based on their locations to the user, who is searching a specific area.

12.5. Key Business Activities

This section describes key activities necessary to make this business functional.

Related to product: Providing integrated and aggregated information to users is one of the most important activities of our application along with accepting and advertising postings from estate agents.

Related to Customer: Key business activities, which are concerned with our customers is giving them more information, so they become able to make better decisions when selecting a property and connect them to estate agents.

Related to Infrastructure: It is also important to mention activities required for the IT infrastructure we use. Main activity in this section is developing the software platform and its

maintenance and maintenance of data feeds used to fuel our application. Maintenance of data feeds can be decomposed to updating data feeds, adding and aggregating new data feeds.

12.6. Key Business Resources

Every business uses resources, which are important for its function. In our application key resources can be grouped in several categories.

Physical resources such as IT infrastructure, which is our website and database, and Data, which is in fact aggregated open data sets we use and users' information, which can be used for further analysis.

Trademark and our brand is capable of being a key resource, as we progress and build reputation.

Our human resources such as team members is a vital resource for our company. If key team members leave, it is highly likely to damage the functionality of this business.

12.7. Key Partners

Real estate agents are key partners of this business. They are involved in key activities such as advertising property postings, as the postings are provided by real estate agents. The other group involved is potential investors, who might be willing to cooperate in some key activities or provide key resources.

12.8. Financial Analysis

The market analysis conducted in this section shows similar applications in Real Estate business and the market size in this area is considered to be big enough for a new startup to enter.

Information given in Table 2 is about top five active website in Real Estate business. It can be seen that the most popular website, rightmove.co.uk had more than 60 million visitors during past 6 months, which implies that people are interested in using online applications to look for properties. From this observation we can conclude that there are enough users using similar online applications and the market has the potential.

Name	Date Founded	Average Views Past 6 Months (million people)	Employees
rightmove.co.uk	2007	64.38	200-500
zoopla.co.uk	2007	29.45	-
primelocation.com	2007	5.4	50-200
openrent.co.uk	2011	2.25	-
propertypal.com	2007	1.65	-

Table 2: Top 5 similar businesses in Real Estate business.

12.8.1. Operating Costs

There are different costs associated with each resource or activity involved in a business. These costs can be classified as either fixed or variable costs.

Fixed costs associated with this business can be IT infrastructure costs, which can go up to £4000 yearly for decomposition see table 2. Beside costs of marketing, tax, and employees salaries, it is likely to have expenses associated with office area if one is required.

Variable costs are costs, which vary through time. In this case, advertisement campaigns on google adwords and IT infrastructure costs, which are based on website's traffic, are foreseen variable costs for this business.

Element	Unit	Cost
Domain Name Registration	1	£10/year
Cloud Server Instance	1	£150/month
SSL Dedicated Certificate	1	£160/year
Cloudflare's Reverse Proxy	1	£150/year
Cloud Nonrelational Database	1	£75/month

Table 3: Element Pricing

12.9.Risk Analysis

There are several risks to the monetisation of the business idea, the first and most important is how able the market is to support the new business. In the case of this product the market is closely tied to the UK house market which whilst suffering from overheating in London, causing a fall in prices and sales [1], across the country it is faring better, further buoyed by removal of the stamp duty for first time buyers reducing the barriers to entry for people to this market thus increasing the size of the market [2] and therefore our potential user base.

The risk of having other companies moving into our business space is high, especially since the the key component of the product is the open data on which it is based, which by definition "Open data is data that's available to everyone to access, use and share" [3] which means there are no barriers to entry to our market from our key asset. This means that our product needs to either integrate proprietary data to generate a unique selling point (USP) for our product, or to gain market dominance and retain this dominance, the later of which will most likely need frequent updates to our product.

A risk to any company especially start-ups is securing insufficient funding to remain afloat, leading to insolvency. To help minimise the risk of this costs should be kept to a minimum with a portion of the company always looking for new funding opportunities, the former can be achieved by reducing fixed costs through not having an office, and instead relying on telecommuting and working from home, which would allow for the companies cash reserves to stretch considerably further. The later would require specialist knowledge of the marketplace and the funding options available to the company, such as venture capital, government fund and angel investors. Looking specifically at angel investors they will be looking for the following in a company: a sound idea; a prototype exists; management team in place; strategic relationship exists; sales plan exists[4]. Of these things our company offers 4 of the 5 developments such an investor would be looking for which puts our company in a strong place to compete from.

These risks to the business, along with development risks are outlined in the risk assessment below, based on the risk matrix:

Severity	5	Extreme	5	10	15	20	25
	4	Major	4	8	12	16	20
	3	Serious	3	6	9	12	15
	2	Minor	2	4	6	8	10
	1	Negligible	1	2	3	4	5
			Very unlikely	Unlikely	Moderate	Likely	Very Likely
			1	2	3	4	5
			Likelihood				

No.	Hazard	Harm and how it could arise	Inherent Risk			Control Measures/ risk mitigation	Residual Risk		
			Likelihood	Severity	Risk		Likelihood	Severity	Risk
1	Data Loss	Loss of the backing data would render the application useless, this could arise from cyber attacks by malicious agents, hard-drive corruption or user error.	3	2	6	Outsourcing security to make sure that our services are as resilient to cyber attacks as possible. Multiple, regular cloud backups of our product to minimise disruption in the event of data loss.	3	1	3
2	Change of Licence on newer version of existing open data source	The information of our map cannot be updated to the newest version of the dataset without breaching copyright or incurring monetary expenses	2	3	6	Keep updated on the licensing agreements of all data sources we are using. Keep copies of old data sources, such that they can continue to be used under the licence they were published even if new data is under a different licence	2	2	4
3	Unable to secure vital funding	The company could run out of money and be unable to continue operating, leading to loss of jobs, Intellectual property and other company assets.	4	5	20	Create a clear budgetary plan showing how long existing fund will last given the company's current revenue and expenditure streams. Have redundancy plans in place, for how to save costs to prolong how long the company can survive on existing funding, such plans may include staff redundancies.	4	3	12
4	Legal dispute over use of data	Potential costly litigation against the company by data owner.	1	3	3	Have a company lawyer available for potential legal disputes Have a clear province of all data used and the agreements under which it is being used.	1	3	3
5	Data being used is out of data, or otherwise incorrect	Incorrect data use could drive our customers towards our competition	2	2	4	Constantly keep searching for new data sources, and other ways to continually iterate on the application design.	2	1	2
6	Loss of talent	A key team member could leave, leading to issues with the counting function of the company	3	3	9	Regular checks in with all staff to check if they are happy with their job and if they are planning to leave, so as to either tempt them back or find a replacement for them in a timeframe such as to minimise the negative effects	2	2	4
7	Failure to stick to development timetable	New feature may be delivered late, or missing from releases leading to loss of consumer and investor confidence in the business leading to business failure	3	4	12	Adopt a rigid development strategy, such as agile scrum combined with regular meetings with staff to find development issues and to rectify them early, before they threaten the business. If the deadlines are still being missed despite the initial control measures being implemented, consider hiring more employees, increasing work hours or replacing underperforming members of staff.	2	3	6
8	Deviation from budget	Loss of confidence with investors, bankruptcy	3	3	9	Regular evaluation of budget and company expenses and revenue trends, to adjust the budget in a more managed manner.	2	2	4
9	Theft of company data	Loss of intellectual property, loss of customer data, fines from the ICO of upto £17.6million	3	3	9	Enforcing strong data protection policies and minimising the volume of personal data kept. Outsourcing some security elements to external security experts, if such expertise is not currently available within the company.	2	2	4
10	Failure to complete prototype for investors in time	The lack of a prototype would be a major hurdle to securing funding, so not having one could cause us to miss out on funding	2	4	8	Not progress with the business until such a time as a prototype exists.	1	4	4
11	Denial of service attack	Reduced uptime of the product leading to a loss of consumer confidence in our application leading to a decline in the user base of the application and ultimately bankruptcy.	2	3	6	Have a company lawyer available for potential legal disputes Have a clear provenance of all data used and the agreements under which it is being used.	2	2	4

13. Future Iterations and Conclusion:

As mentioned in the Risk Analysis the application will need to be continuously iterated upon to keep up customer interest as in this market customer retention will be difficult as people tend not to buy/rent new houses very regularly. There are three main areas in which we can iterate on the design: expansion, community and machine learning.

The first being to keep expanding the number of datasets we use, however this will eventually lead to the application becoming quite heavyweight which will lead to a poor user experience for users on mobile and other lightweight or old devices. This can be resolved by doing creating efficiencies on the server requests, such that a user downloads the minimum amount of data required for their use of the application, such as location restricting the data more closely to their current view of the map.

The second option is that of community, which itself has two branches. The first is that of some kind of forum, which would be community driven, where users could ask other people for their views on locations, amenities and other things about an area that is not encompassed within out map. The second branch attempts to pull that community data onto the map by crowdsourcing information about a local area for which no data exists, such as youth activities centre, scout and guide groups, local historic monuments and so on. Such additional data would add a personal touch and allow for more localised information about an area which would improve customers overall satisfaction with the application, leading to personal recommendations which are highly valuable free marketing tools [16].

The third option is the most complex but also the most interesting. Tracking users through the site and monitoring their behaviour, we can build up customer profiles via machine learning techniques to spot patterns in user activity. From this we could optimise the site for one or more customer profiles, allowing for a more personalised, speedier and generally better user experience for all of our future users.

In conclusion there are exciting ways in which this application could be expanded in the future but for now a functional prototype exists, which should be sufficient to start a business around, especially given the in depth business and funding plan for the application which should allow for us to start a small business which will grow overtime into a large company within this emerging market.

14. References:

[1] Pickford, J. (2018). Property sales in London fall 20% in four years. *Finacial Times*. [online] Available at: https://www.ft.com/content/45cd72fa-05b8-11e8-9650-9c0ad2d7c5b5 [Accessed 30 Apr. 2018].

[2] Pickford, J. (2018). Stamp duty cut helps nearly 70,000 first-time buyers. *Financial Times*. [online] Available at: https://www.ft.com/content/407b5d66-4961-11e8-8ae9-4b5ddcca99b3 [Accessed 30 Apr. 2018].

[3] Theodi.org. (2018). *What is 'open data' and why should we care? – The ODI*. [online] Available at: https://theodi.org/article/what-is-open-data-and-why-should-we-care/ [Accessed 1 May 2018].

[4] Christou, V. (2018). *Sources of Finance*.

[5] HM Revenue and Customs (2018). *UK Property Transaction Statistics*. [online] Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/700950/UK_Tables_Apr_2018__cir_.pdf [Accessed 1 May 2018].

[6] Francis, C. (2011). Five Questions About: Interest rates. *Independent*. [online] Available at: https://www.independent.co.uk/money/spend-save/five-questions-about-interest-rates-2276746.html [Accessed 1 May 2018].

[7] GOV.UK. (2014). *Affordable home ownership schemes*. [online] Available at: https://www.gov.uk/affordable-home-ownership-schemes [Accessed 1 May 2018].

[8] Jones, R. and King, M. (2011). First-time buyers face scramble for FirstBuy loans. *The Guardian*. [online] Available at: https://www.theguardian.com/money/2011/mar/26/first-time-buyer-firstbuy [Accessed 3 May 2018].

[9] Giles, C. (2013). IMF says Help to Buy risks inflating prices. *The Financial Times*. [online] Available at: https://www.ft.com/content/6f8c2d50-30f3-11e3-b478-00144feab7de [Accessed 1 May 2018].

[10] Wood, Z. (2017). Asos overtakes M&S – is this the UK high street's Tesla moment?. *The Guardian*. [online] Available at: https://www.theguardian.com/business/2017/nov/18/asos-overtakes-m-and-s-marks-spencer-uk-high-street-tesla-moment [Accessed 1 May 2018].

[11] Chalhoub G. (2016) THE NATIONAL RAMZI A. HARATY LIBRARY

[12] Ordnancesurvey.co.uk. (2018). How to acknowledge OS OpenData copyright. [online] Available at: https://www.ordnancesurvey.co.uk/business-and-government/licensing/using-creating-data-with-os-products/os-opendata.html [Accessed 7 May 2018].

[13] Nationalarchives.gov.uk. (2018). Open Government Licence. [online] Available at: http://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/ [Accessed 7 May 2018].

[14] Creativecommons.org. (2018). Creative Commons — Attribution-ShareAlike 2.0 Generic — CC BY-SA 2.0. [online] Available at: https://creativecommons.org/licenses/by-sa/2.0/ [Accessed 7 May 2018].

[15] Creativecommons.org. (2018). Creative Commons — Attribution 2.0 UK: England & Wales — CC BY 2.0 UK. [online] Available at: https://creativecommons.org/licenses/by/2.0/uk/ [Accessed 7 May 2018].

[16] Whitler, K. (2014). Why Word Of Mouth Marketing Is The Most Important Social Media. Forbes. [online] Available at: https://www.forbes.com/sites/kimberlywhitler/2014/07/17/why-word-of-mouth-marketing-is-the-most-important-social-media/#5a411b7154a8 [Accessed 7 May 2018].

[17] Rogers, Y., Sharp, H. and Preece, J. (2011) Interaction design : beyond human-computer interaction. Wiley.

[18] Brinck, T., Gergle, D. and Wood, S. D. (2002) Designing web sites that work: Usability for the web, Context. Morgan Kaufmann Publishers. doi: Doi 10.1002/Asi.10099.

[19] Schurman, E. and Brutlag, J. (2009) ‘Performance Related Changes and their User Impact’, in Velocity Web Performance and Operations Conference. O’Reily.

15. Appendix:

Appendix A: business canvas