Chatbot Proposal: A Personal Assistant for Zillow

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1. Introduction and Purpose

1a. Goals to be Achieved

The main objective of this chatbot is to replace the current search filter system of Zillow. The filters in place now are not that useful, for example if you search for houses with two car garages, the results will still show houses with one or no garage. They are also very general filters and it is obvious that they struggle to successfully show more specified requirements. Using a chatbot instead could assist with the suggestions shown on this website and optimally be used to sell more houses.

Aside from the home search process, this bot could also accomplish other tasks such as providing contact information for real estate agents and giving some basic financial information about the properties. Zillow already provides tax history and price history information about most of the properties listed on the site, so the bot could make this information easier for the user to access and understand. It would also suggest talking to a realtor about these financial decisions, and be able to pull information from the website about what realtor is working the sale for that particular property. Having one chatbot that provides all these services would greatly improve the user experience, because it makes the process much more simplified compared to searching for all of the information on their own.

For the design goals on this project, I believe that the most effective method of creating this chatbot would be a mixture of rule based responses and AI capabilities. The start of most conversations could follow a decision tree, until the bot reaches a node where it is certain what the user wants to accomplish during the conversation. From there, the AI portion will need to take over once the user starts asking for

suggestions about houses or other in depth queries. Separate models will be used for the different situations, for example a model for house search, models for financial advice or scheduling open house tour appointments, etc. The AI would need to handle more complex queries from the user, whereas the rule based model would handle the opening conversation and determining the user's intent.

1b. Target Users

The target audience for this chatbot is the current users of Zillow, and to possibly attract new users to their site. Out of all house search websites Zillow is already among the most popular, but if the chatbot got good reviews from users, it could attract even more buyers since they hear about how simple the search process is. The bot would be designed for the average user to be able to easily understand the interface and navigate interactions with the bot. The information provided by the chatbot would be presented in a clear and concise way, and any conversations that the bot cannot handle could be passed to a real estate agent to help with the buying process. Anyone who comes to the Zillow website should be able to successfully talk to this chatbot or to the representatives, and feel that they have had a helpful experience using these new features of the site.

Obviously people that are serious about purchasing a home are the main target audience for this chatbot since they would be the ones to make Zillow a profit after purchasing, but even users who are just browsing with the bot can provide useful insights and feedback. Not to mention the publicity the bot will receive by word of mouth from different users, even if they aren't actually purchasing anything. It will allow new

potential buyers to learn more about the simplified search process using Zillow's chatbot and make them more likely to come to the site if they are looking to purchase a new property in the future.

1c. Use Cases

This bot could have a variety of uses depending on what the user is looking for when they come to Zillow's website. The main use of this site is to search for potential homes depending on user requirements, and many people likely just use the website to browse their options. The bot will mostly focus on the requirements users are looking for in a home, and provide good suggestions for them based on their ideas. There are also sections on Zillow's website for scheduling a visit to an open house tour or finding the contact information for a real estate agent in the area. The bot could assist users with this process as well, and could make scheduling appointments easier which would lead to realtors getting more new clients. Some other important features on Zillow include the financial side of things, for example estimating the monthly rent or monthly payment plan for a home and viewing the tax history/selling history of homes. The users of this chatbot may have various questions about finances, and some of them are able to be answered through Zillow's site. For example they provide "Zestimates" (Zillow's estimate) on home prices, and can easily state if there were any deductions in tax prices in recent years. But, for any serious financial advice, the bot will not be responsible for giving those suggestions. The default case will be that the bot suggests the contact information of a professional real estate agent or financial advisor instead.

2. Sample Dialogue

2a. Home Search

The most likely starting point for conversations with this bot would be searching for a home in the Zillow property database. After the bot greets the user and determines they want to search for a home, it will say something to prompt the user for requirements. It will start with the most general search filters and then have the user specify more later on. The bot may say “What area are you looking to purchase in, and what is your price range?” The user could respond with “I would like to find a one family home in Nassau County, and can afford up to $800,000.” The bot will take note of this and say “That sounds good, now what are the most important features you are looking for in a home?” It is crucial to start with the most desired features because the AI will prioritize that in the search. The user will list some of these requests, and then the bot will move on to ask “What other features would you like to see in the home?”

After getting the general information from the user, the bot will begin to suggest some properties and give the user links to view the photos/video tour of the home. The bot may say “Please take a look at these options and let me know what you think!” If the user replies, for example, “The second house has most of the features I am looking for, but I would prefer if the location was closer to a train station.” The bot will do one of two things: first it will look for similar houses which are closer to train stations and show those results, or if none exist, it will say “I can’t seem to find any homes meeting your requirements… Would you like to expand the search locations or remove some of the required features?” These statements will prompt the user to give some new

suggestions that the bot can use to look for more sufficient results, and the conversation may loop multiple times until the user is satisfied with the bot's output.

2b. Interest in Open House

After a user decides on a home they like, the next step in the conversation would be prompting the user to tour the property. The bot would say something like "You would like to tour the home? That's great! There are a few slots open next week, which days are you available?" The user may say "I am off from work on Wednesday and Friday next week." The bot will search the availability listed and then respond, for example, "The realtor is available on Wednesday at 3pm or Friday at 1pm. Would you like to schedule an appointment at either of these times?" The user responds "Friday at 1pm sounds good." The bot will schedule the appointment through Zillow's website and then confirm with the user, saying "Your appointment has been made with realtor John Doe, who you can contact at johndoe@gmail.com if you have any questions or concerns."

Providing contact information for the real estate agent is a useful default method of communication, for example if the user was having a hard time finding an appointment time that works for them. If the user is going back and forth with the bot for a while trying to find a time that works, the bot may say something along the lines of "It seems that you have a busy schedule. Maybe you would like to contact the realtor directly to set up a time which works best for you both?" If the user replies "Yes I would like the contact information of a realtor", the bot can provide the information listed from Zillow depending on the area the property is located. If the user says they do not want

to contact the realtor, the bot may suggest “When you have more available time in your schedule, feel free to come back and try to schedule another appointment!”

2c. Financial/Tax Information

The user could already have a house in mind and want more detailed financial information about it. Zillow provides tax and price history for every home, so the bot could easily provide this information. The user may say “I am interested in 123 Main Street, what are the taxes in that county like?” or “For 123 Main Street, how much would be a good monthly payment?” For the tax history, the bot will likely respond by showing some recent tax year information and asking “Is there anything specific you would like to know about the tax history?” The user may ask about tax deductions or school vs general taxes, etc. and the AI model for taxes would provide a response. For monthly payments or suggested offer prices (anything about financial advice) the bot will say “I can take a look for you, but I always suggest speaking to a professional before making any offers/purchases.” The AI model for finances could give a few suggestions about price after this, but the main goal is to suggest that the user speaks to a professional.

2d. Sample End Points

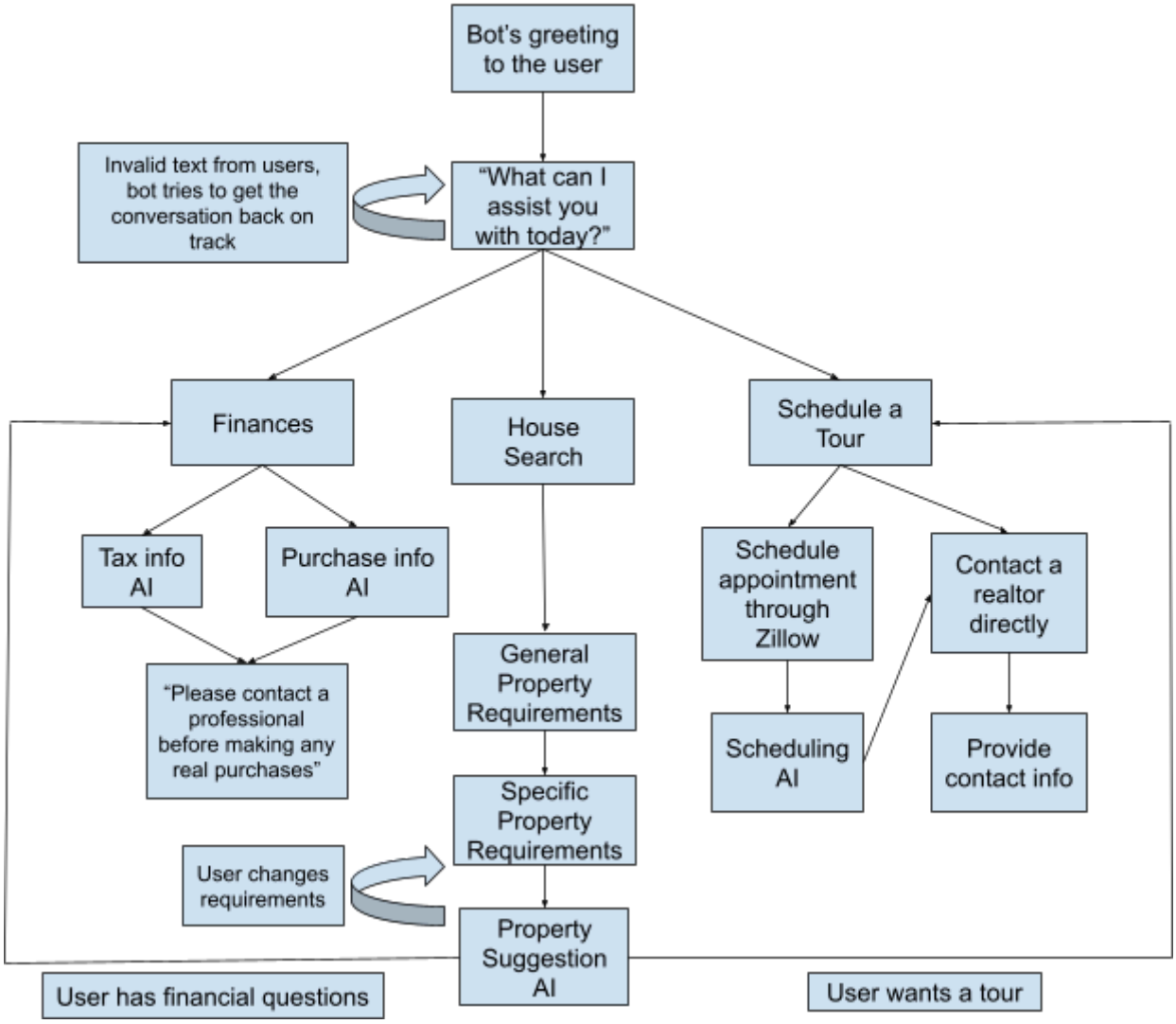
There will come some situations where the bot can no longer respond to the user’s messages. If a user is sending messages that make no sense or are clearly not related to the services of Zillow, the bot will have some default messages to try to get the conversation back on track. For example it may say things like “I’m not quite sure how to assist you, do you have any questions about buying properties?” or “My purpose

is to help users in the home buying process. Do you have any questions related to Zillow?" If the user is clearly fooling around and not using the chatbot in a serious way, the bot will eventually disconnect from the chat. But, there may also be situations where the user is just confused and doesn't know how to proceed with the chat. In that scenario the bot will focus more on redirecting the user to give some useful information in their messages. For example, it may state its functionality such as "I can assist you with searching for houses, scheduling open house tours, financial questions, etc. Do you need any help with those subjects?"

There will eventually be a natural end to the conversation as well. The user may be fulfilled with their experience and have no further questions, or they disappear from the conversation and the chat times out. If the bot detects that the user is satisfied with their search it will begin to ask questions like "Is there anything else I can help you with today?" or "Would you like me to assist you with anything else?" If the user has not responded for 10 minutes, the bot may ask "Are you still there?" After 20 or more minutes, the bot will eventually make a closing statement such as "It has been a pleasure helping you today! Feel free to return to the chat if you have further questions." I believe having multiple ways to phrase these statements make the bot feel more life-like and could give the users a more compelling experience. A nice closing statement would also make the customer more likely to return in the future, where contextual recall could help pick up the conversation where it left off.

3. Diagrams and Design

3a. Decision Tree

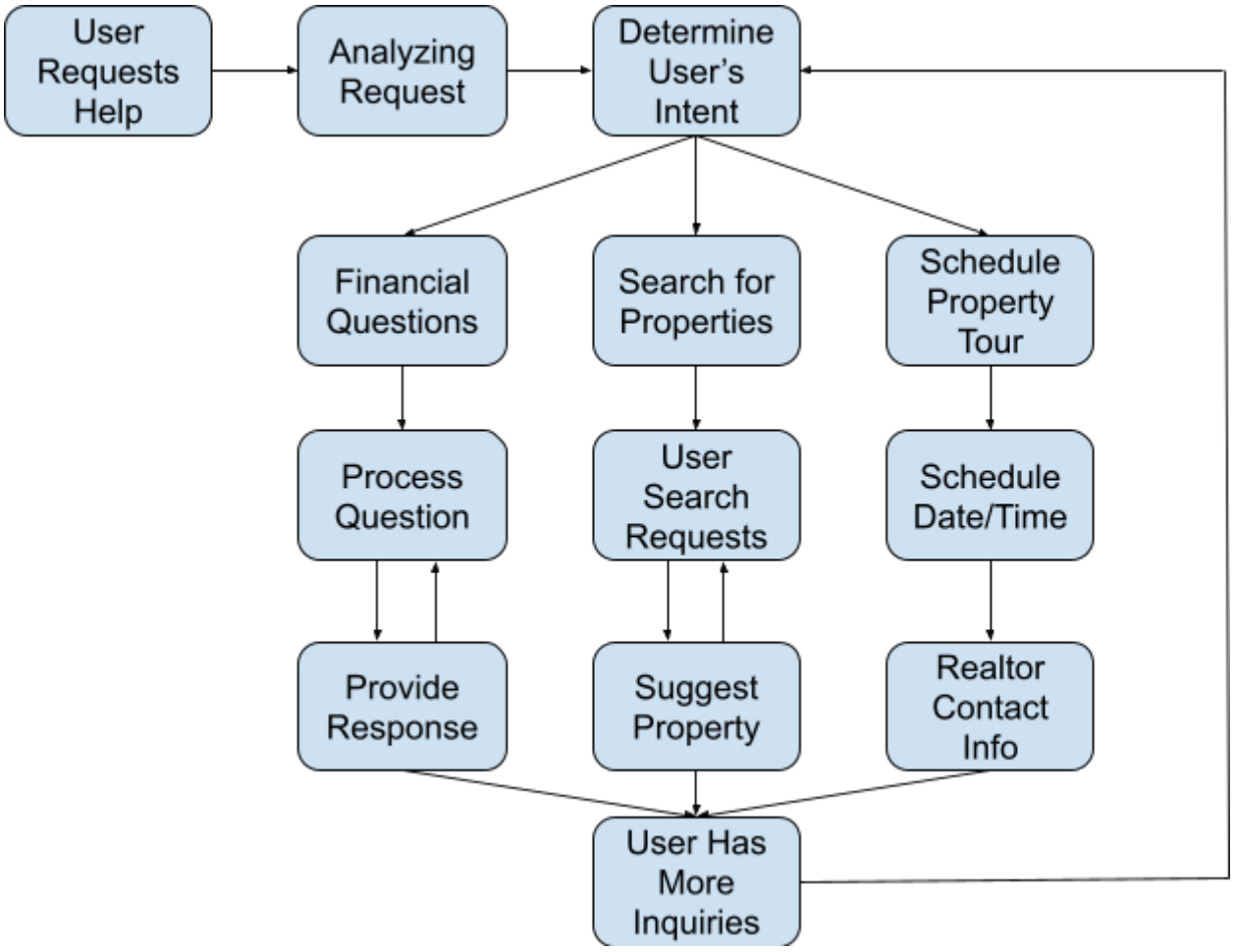


The above decision tree shows my ideas for how the functionality of the chatbot would work, and where the deterministic nature of the bot would be passed off to AI to handle more specific requests. The house search feature could eventually lead back to one of the other branches in this tree after the user shows interest in a specific property

and asks for further information. If they want to tour the home that would be handled by the scheduling branch/AI model, and if they have any financial concerns that would be passed to the finances AI models.

In order to increase containment in this system, the chatbot will never directly connect a user to customer support or to a real estate agent. It will instead provide contact information for these representatives and suggest that the user contacts them instead of the bot. This feature is especially important for any financial advice given to the user, because it would help avoid legal trouble if the bot was to give incorrect information. After any conversations related to finances, the bot will always suggest to the customer that they contact a professional realtor or financial advisor before proceeding with any real estate transaction. Mostly any path in this decision tree ends up with the bot providing contact information for some realtor, which could greatly help with liability in any legal discourse that comes from the use of this chatbot. It would also help with error handling, for example an instance where the scheduling AI cannot find a sufficient time slot for a customer to make an appointment. The bot would instead provide them the real estate agent's contact information and they could try to schedule an appointment on their own when it is convenient.

3b. Wait-State Diagram



Shown above is a simple wait-state diagram for this chatbot, which is meant to represent the possible states that the system would be in depending on the user's intents. Many more states could be added, and there is no error handling shown in this diagram for the sake of simplicity, but the overall concepts are shown to better understand the flow of functionality for this bot. The chatbot will need to take requests from the user, understand what they are asking for, and then pass them to the proper AI models that handle the more specific queries. The main states of this bot all involve processing/analyzing the user's chat messages and then providing a proper response to

their question. There are also scenarios where the conversation may lead to other states, for example if someone searching for a house begins to ask financial questions instead. Then the chatbot would move back into the state of determining the user's intent, and when it realizes they are talking about finances, it will move to the AI model for financial questions. This is why all the pathways will eventually lead back to the state for determining intent, and at the end of the conversation the user's intent would be to end the conversation so the bot can also respond to that accordingly.

3c. Intents and Entities

The intents for this project would represent what the user aims to do during the conversation with the chatbot. There are two main groups of users who may have different intents: people who are just browsing, and people who are seriously interested in purchasing a new property. The users who are just browsing would probably be less likely to inquire about the financial details of a property, aside from just looking at the price. Their intents would be to give the bot requests for what properties they would like to see, and look through the results that the bot provides. If they end up finding a property they are really interested in they may begin to ask for further details, such as open house dates or financial data, but those features would mainly be used by people who came to the bot with the intent to purchase a property. For those users, they would intend on finding properties that best suit their needs and then scheduling a tour/contacting a realtor about making an offer. They would use the bot with the intent of speeding up the buying process, whereas someone who is just browsing through the site would use it to help with their searches.

The entities in this project are referring to variables within these intents. The most obvious entities for property searching would be the features of the home that users are interested in, for example the location, price range, requirements they look for in a home, etc. There are various financial entities outside of the price range, such as tax history, selling history, proposed offer amount, monthly payment recommendations, etc. An important entity that will always be mentioned when the bot talks to the user about finances is the realtors available to help answer more detailed questions. Their contact information will also be given to users any time they request it during a conversation, or when it seems appropriate for the given intent like when they are looking to schedule an open house appointment.

3d. Error Handling

There can be various errors that occur throughout a conversation with a chatbot, whether it be a user error or the bot not understanding a query. There must be end points in the decision tree and error handling that occurs when these situations happen, and many will be implemented into this chatbot. One way to monitor these errors is creating a summary report at the end of each chat conversation, where the developers would be able to collect data that may help improve future conversations with the bot. If the same error occurs in a future chat and that error is detected, the developers would have implemented a method to prevent it or at least help the bot recover from the incident. Some examples of this were presented in section 2d. Sample End Points, which shows dialogue that the bot may use to get the conversation back on track. But other issues may require further intervention than just the chatbot dialogue.

One complex issue when it comes to large language models is multi-language processing. There are a few solutions which allow the chatbot to speak and understand multiple languages, but each solution has its pros and cons. For this chatbot, a simple solution would be for the bot to only function in English. If it detects another language is being spoken, the chatbot could try to find a real estate agent that is fluent in that language and then give the user their contact information. In the future the bot's functionality may be expanded to handle multiple languages which would make the site more inclusive for customers, but for the start of this project it would be best to focus on only the core functionality. Once everything is tested and working to the team's expectations, they could begin to focus on adding additional features such as the multi language processing.

The chatbot should also be able to detect vulgar language or inappropriate comments from the user and give them some default messages to stop those actions. If the harassment continues, the bot will know to stop engaging with that user and disconnect from the chat. The data from the chat could be stored along with the user identification information, and if the user repeatedly tries to misuse the bot, they may be banned from using the chatbot feature moving forward. At first, the chatbot will attempt to redirect the user to get the conversation back on track, but if they are continuously misusing the bot there is no point in continuing the chat. It should be pretty obvious when a user is just confused vs purposefully mistreating the chatbot, and different error handling will occur depending on the situation.

4. Business Scope

4a. Platforms and Technology

The technologies used in this project will determine the success or failure of the chatbot, and also could affect the overall cost of the project. Since this bot will use a combination of rule based and AI capabilities, we would need to utilize coding languages with good machine learning libraries. A popular combination used for chatbots is Python on the backend, and a mixture of Javascript, HTML and CSS for the frontend. The Zillow software engineering team already implements Javascript for their website, so this will allow for easy integration of the chatbot code. Zillow also uses certain open source libraries for creating and maintaining their code which could be useful for this project. One example of this is C Tabular Data Stream (cTDS), which is a Python database API that helps with communication to Microsoft SQL Server. cTDS will assist the backend of the chatbot code when it needs to pull information from Zillow's databases, which is crucial in the property searching process. Another important machine learning library is called Luminaire, and it is used for hands-off data quality and anomaly detection. This library would be very useful for monitoring the performance of the chatbot over time and being able to get alerts if there are any abnormal behavior anomalies in the chatbot's conversations with users.

Zillow currently utilizes GitLab to manage their source code; including version control, continuous integration/delivery, collaboration and code reviews. Kubernetes can be used alongside GitLab to create an efficient development and deployment environment for this project. Zillow also uses Amazon as their cloud hosting and data center provider, so it would make sense to use Amazon Elastic Kubernetes Service

(EKS) as the K8 provider for the project. This will allow for easily configuring any other AWS services necessary for this chatbot, or to combine with what they are already using. Kubernetes will be useful for the deployment strategies of this chatbot, but it is also a good tool for assisting with the API integration necessary for utilizing Zillow's databases and services. Overall, GitLab could be used to manage the source code and automate the continuous integration/delivery pipelines, and Kubernetes would be used to manage, deploy, and scale the containerized application in an efficient manner.

4b. Justification of Technological Choices

Since most of the libraries necessary for the chatbot are open source, that is a great way to save on costs for the project. Zillow utilizes much of this software already as well, so there is no additional cost or time needed to train any employees who may be monitoring the effectiveness of the chatbot after its completion. The choice of coding languages seems appropriate for a project of this scale, and they would work well to accomplish the tasks at hand. For example, many modern web applications (including Zillow's current website) use Javascript for the front end development. It also gives easy access to services like Node or React js that can be helpful with integrating some of the back end code to the front end. Python has many libraries that would be useful for the back end and AI capabilities of this chatbot, which come at no additional cost to the project. The monitoring technologies that Zillow's programming team already use are compatible with Python, therefore they could use tools like cTDS and Luminaire to assist with the chatbot. Some of their programmers have added to the open source libraries for those technologies, so if the chatbot development team needed any

assistance they should be able to easily give the team guidance. I believe that it is important to collaborate with Zillow's existing software development team during this project because the more tools that are shared between projects, the more money we could save and the easier the application of these tools can be. On that same note, sticking with Amazon as the cloud provider and K8 provider would allow Zillow to try and get better deals on their prices while purchasing the services in a bundle. Amazon may charge additional fees for Kubernetes depending on any extra storage or AWS services needed for the project, but if Zillow already owns some of those services it could reduce the overall cost. Zillow may be open to investing in the costs for this project since the purpose of the chatbot is to make their users have an easier experience using their website and purchasing homes through their site. The increase in use of the website and profits from selling the properties would probably be enough incentive for them to invest in the costs for creating and maintaining the bot.

4c. Development Processes

This chatbot could be developed with a small team of programmers, for instance a team of 6 members where one person is the manager and the other 5 are the core programmers on the project. The team at Zillow could supervise the project to ensure that the bot is meeting the requirements for their website, and to give suggestions based on what they have seen their customers like/dislike in the past. The developers would begin by creating the rule based aspects of this chatbot since it is easier to test and modify if necessary, and because this portion of the bot will handle the start of the conversations. Once that is all working properly and to Zillow's expectations, the team

would begin to implement some of the machine learning/AI techniques that will be handling more complex conversations. Hydrating the AI models is an important step which will be detailed more in the next section, and then the development team would need to test the chatbot to make sure there was no bias introduced into the models and to check if the bot is answering questions appropriately. The testing process will be detailed in later sections as well, but it will consist of testing and then going back to make modifications based on the feedback the team receives from testing software themselves or from users who are testing the chatbot for us.

4d. Training the Bot

In order to train the AI portions of this chatbot, Zillow's property database could provide some very useful information. There is a "facts and features" section for each properly available, and that is where the information for suggestions would come from. By hydrating the model with this information, the chatbot would be able to understand the key words in user's requests for features in a home and be able to pull the proper links for houses. Similar data for tax information, price history, realtor contact information, etc. is all stored in Zillow's current website and could be used to hydrate the chatbot models with current information related to user searches. There may be various ways that users phrase the same request, so the natural language processing of these models must be trained to understand it and still give the proper responses. This could be accomplished by implementing human-in-the-loop training, which involves having a developer or customer representative intervene in the conversation if there is a query the chatbot cannot understand. This will not only give important feedback that

developers would need to improve the bot's NLP training in the future, but it will also allow the customers to have a more seamless experience. It is also very important for this chatbot to be continuously hydrated with new information since Zillow's property database is constantly being updated when new properties are listed. They may partner with new real estate agents and need to update their contact information, or have new sales information about homes that could help with suggested prices on similar properties. This information would need to be updated very often to ensure that the suggestions from the chatbot are the most current and accurate information.

4e. Testing Phases

The initial alpha and beta testing of this chatbot could be done by developers, friends, family, or any real person just interacting with the bot to see how the flow of conversation feels. Since the target audience of the chatbot is any person interested in using Zillow's website, it would be great to test with a variety of users who have different backgrounds/technological capabilities. We will begin by testing the decision tree portion of the chatbot to see how the start of conversations feel to real users, and check if there are any areas that we need to add additional states or end points. The bot will need to correctly identify the intents of the user and bring the conversation to the proper AI model to handle more specific requests. Any suggestions from the testers will be taken into consideration to ensure that the conversations with this chatbot feel as realistic as possible, and that they actually feel like the bot is assisting them in the proper ways. The AI models will be tested by having the users ask specific questions or make specific search requests, and then checking that the bot is providing useful

suggestions/search results. If not, the models probably need to be hydrated or grounded in a different way and the development team will adjust accordingly. Along with this, the team must ensure that there is no bias in the AI responses and that everything is following the bot's guidelines.

After the initial testing is complete and the chatbot is ready for deployment, we will continue to test its real interactions with users on the site. One main method that will be used is A/B testing, which involves giving different groups of users different versions of the chatbot to see which version performs better. The feedback collected from the users in different groups will allow the developers to see if their new changes are effective or not. If most people like the original version of the bot better, that would indicate that the new changes are not making things more efficient or user friendly and those changes should be reverted. If there is feedback from the users that indicates some of the changes are good while others are not, the developers would know which areas need improvement and learn what they should iterate on for future versions of the chatbot. This form of feedback is crucial to creating the best user experience possible, and it prevents negative reactions from users if a new version is released without testing and people end up hating it. This continuous testing will be necessary as long as the bot is in production.

4f. Operational Plan

This chatbot will run alongside Zillow's main website, and a prompt for the bot will appear once you visit the site. It will start off with a simple message greeting the user and stating that it is available to help with any questions or search inquiries they may

have. The chatbot will be available to help during their entire session on the website, until there are no responses and the conversation eventually times out. The reasoning behind the chat timeout length being 20 or more minutes is because of the importance of purchasing a property. This is not a decision that users should make quickly, and there are a lot of factors to consider before inquiring about a tour or a purchase. Users may spend a lot of time viewing images of one property, or even showing the pictures/features to others to get a second opinion. Therefore, after 10 minutes the bot will ask if they are still there, and if they say they're just looking at the property the bot will allow them to take more time without ending the conversation. But if there is a full 20 minutes without a response, the user likely walked away from the website and is not going to respond further during that session. The contextual recall in this system will allow a user to return later on and continue the chat if necessary, which can also lead to more discussions about the financial side of things or scheduling an open house appointment for the property.

After a conversation is complete, a summary of the chat may be created and used to collect data about improvements in the conversational flow or places where errors occurred. Some technologies utilized in this project are also meant to detect abnormal responses from the chatbot which can assist developers in finding and fixing errors. These technologies are necessary for the continual improvement of this chatbot and the continuous testing process throughout this bot's life in production. New versions of the chatbot will be released over time that enhance the quality of the user's experience and add additional error handling when necessary. Throughout the A/B testing process, the development team will learn to fine tune this chatbot to meet the

user's requirements. Additional features and functionality could be added over time as well, if the users desire assistance with other areas of the property buying process that the bot was not originally intended to handle. Overall, this project will continue to be iterated upon over time to make improvements, and tested constantly to ensure the most accurate and current information is being provided to the customers.

5. Closing Summary

A chatbot for Zillow's website would be a worthwhile investment for the company because of its ability to attract new customers while also enhancing the experience of existing users. The bot provides a useful tool that can help people navigate through their property search and assist with questions they may have along the way. It can simplify the process of finding information on property listings, addressing financial concerns, and facilitating connections with real estate agents for open house tours. The search experience will feel more user friendly since the bot can take specific requirements and turn them into personalized recommendations based on the user's feedback. This will also directly lead to increased engagement with the website since users may spend additional time talking to the bot than they normally would searching on their own. The ease of use can generate more positive customer reviews about the website which will lead to even more users in the future. And with the help of this chatbot, there may be more scheduled property tours and more realtors making sales through Zillow. As the online real estate market continues to grow, a chatbot is an essential feature for giving customers an enjoyable website experience.

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