# Design and Implementation of a New Serverless Conversational Survey System

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***Abstract*—Conversational agents or chatbots have great potentials in improving survey responses and accessibility. However, it is still a challenge for researchers without programming skills to create voice-enabled chatbots to conduct customizable surveys. This paper presents a new easy-to-use serverless survey chatbot system based on the existing TigerAware mobile survey platform, called TigerAware chatbot. This chatbot system enables non-technical persons to build and deploy customized surveys on mobile devices as text or voice-based conversations. The system is based on Dialogflow and Firebase Realtime database, supports voice input and social dialog, and provides visual responses for users to select answers among several options. The chatbots can be deployed on any iOS and Android mobile device and platform that support Google Assistant. Survey question types that have been implemented include yes/no, multiple-choice, free response, numeric entry, date/time picker, and scale. This system is more efficient and effective than existing survey chatbot systems.**

***Keywords—survey chatbot, conversational survey, serverless computing***

## I. Introduction

Surveys utilize structured questionnaires to obtain data and information from many participants. Based on Pew Research Center's latest survey in 2021, 85% of the population uses smartphones in the United States, increasing almost 50% since 2011. In younger communities, these smart devices are even more common, with 96% of Americans between the ages of 18 and 29 owning one [1]. Smartphones have become convenient and reliable tools for collecting information. They run voice assistants to perform searches and complete actions. Diverse disciplines have adopted smartphones as research platforms and built various conversational survey agents.

However, building a conversational survey agent usually requires intensive programming and Internet services to support the chatbot. Users with no programming background have difficulty in creating or modifying their conversational agents. First, researchers have to design a conversational survey chatbot. Then they have to decide which specific mobile platforms to deploy their chatbot and hire programmers to build the survey chatbot. The software development could take a few months. If researchers want to make any changes to the surveys, they have to ask the developers to change the chatbot programmatically.

This paper presents a new easy-to-use serverless survey chatbot system based on the existing TigerAware mobile survey platform [2], called TigerAware chatbot. TigerAware chatbot is a generic and customizable system that allows researchers to create conversational agents to conduct customized surveys, such as psychological assessments and campus climate surveys. It has the following salient features. First, researchers without a programming background can build conversational agents easily by themselves. Second, conversational agents can be deployed on the most popular mobile platforms, including iOS and Android smartphones and smart speakers. Third, researchers can easily modify survey questions anytime they want. Finally, software developers can add more functionalities to their chatbots after deployment.

This paper describes TigerAware chatbot architecture and components, and technologies used in the implementation. TigerAware chatbot uses Function as a service (FaaS) framework and serverless computing, in particular Google Cloud Function, for creating and launching an app. Its serverless architecture dynamically handles the allocation of machine resources and simplifies deploying code into production. The Cloud Function provider handles scaling, capacity planning, and maintenance operations. TigerAware chatbot system is hosted on the Dialogflow platform. In Dialogflow, fulfillment is implemented to save the answers to survey questions into the Firebase database. During a survey conversation, fulfillment uses the data extracted from the processing of natural language by Dialogflow to produce dynamic responses or trigger back-end action. Survey answers are stored in real-time to Firebase database. Compared to existing chatbot systems for surveys, TigerAware chatbot achieves significant improvement in two aspects: a) it is highly flexible and generic, allowing researchers to create, edit, and deploy conversational survey agents with minimal efforts, and 2) it enables developers to easily change and add functionality to their chatbots.

## II. Background and Related Work

In recent years, there has been an increasing amount of work on using chatbots for surveys. Most researchers use existing commercial platforms, such as SurveyMonkey and Quatrics, which could be expensive depending on user requirements, deployment platforms, etc. Free systems, such as MobileCoach, require programming knowledge. In human-chatbot conversations, researchers found an almost 30-fold average rise in profanity relative to human-human conversations [3]. The study showed that most users would feel more comfortable talking freely or giving their sensitive information when talking to a chatbot compared to talking to a person. Some popular chatbot survey systems that represent

the state-of-the-art in this field are summarized as follows.

SurveyMonkey (https://www.surveymonkey.com/) has a web-based chatbot survey system. Questions are text-based with predefined answers. SurveyMonkey's conversational survey format presents survey questions as a chat conversation in a messaging app. Survey conversations are recommended for surveys with less than 100 questions and no more than five answer options for each question.

CONEY (https://coney.cefriel.com/) has a web application for survey chatbot, which is implemented in Angular and Rete.js. CONEY Collect is the back end that collects and stores the data related to both the survey design and user responses. CONEY Inspect is a dashboard for the researchers to analyze the conversational survey's answers. Previous study found that conversational surveys had the same reliability, but a higher response quality compared with traditional surveys [4].

Juji.io (https://juji.io/) is a system for creating and deploying customizable chatbot surveys. It supports long conversations and has data-driven user intent prediction. Different from SurveyMonkey and CONEY, this system supports natural language processing and can handle free-form text responses to open-ended questions, which delivers an engaging user experience as interview chatbots [5]. Juji was also applied to discover the relationships between students' personality traits collected from their interaction with chatbots and their team outcomes, and to recommend team formation for optimal teaming experience and outcomes [6]. Recently, a chatbot based on Juji was created to provide COVID-19 pandemic information [7].

MobileCoach (https://www.mobile-coach.eu/) is an open-source platform for creating conversational survey chatbots on mobile devices. Its chatbot provides a simple chat-based interface with questions and predefined answer options for the users. Hauser-Ulrich designed a smartphone-based chatbot for 2-month cognitive behavior therapy (CBT) intervention related to pain self-management in patients [8]. This platform requires in-depth programming experience, which makes most researchers difficulty to develop and configure their chatbots.

Previously, a TigerAware chatbot prototype system was created to demonstrate the feasibility of creating survey chatbots in the TigerAware platform [9]. This paper presents a much improved version based on a new version of Google Assistant to support more survey question types, voice input, and question visualization, such as basic cards and suggestion chips like buttons. The chatbot uses Google Dialogflow to interpret the user's natural language input and match it to an appropriate intent, which triggers the actions via cloud functions. Firebase cloud functions perform complex fulfillment based on user input and return answers formatted via the Google Assistant interface. The TigerAware platform provides an intuitive web dashboard for the researchers to create surveys, which can be converted into chatbots easily without coding. Table I presents a comparison of existing survey chatbot systems. The current TigerAware chatbot implementation supports more features than other existing systems.

TABLE I. A COMPARISON OF EXISTING SURVEY CHATBOT SYSTEMS

| Functionalities | Qualtrics | Survey Monkey/ CONEY | Juji.io | RED Cap | Mobile Coach | Previous TigerAware Chatbot | New TigerAware Chatbot |
|---|---|---|---|---|---|---|---|
| **Deployable Sources** | Browser | Browser | Browser | Mobile | Mobile | Mobile and Smart Speaker | Mobile and Smart Speaker |
| **Text Survey** | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| **Conversational Survey Format** | No | Yes | Yes | No | Yes | Yes | Yes |
| **Open-domain Social Dialog** | No | No | Yes | No | No | Yes | Yes |
| **Voiced Input** | No | No | No | No | No | Yes | Yes |
| **Question Visualization (Basic card)** | No | No | No | No | No | No | Yes |
| **Suggestion Chips** | No | No | No | No | No | No | Yes |
| **AI and NLP** | No | No | Yes | No | No | Yes | Yes |

## III. TIGERAWARE CHATBOT DESIGN AND IMPLEMENTATION

### *A. Design considerations*

A Chatbots have been developed to interact with humans through natural languages in a more user-friendly fashion to generate better responses than web surveys. Recently, many researchers applied chatbots for answering frequently asked questions, education, and evaluations [4], [10], [11].

The TigerAware chatbot system leverages recent advances of modern artificial intelligence (AI) and natural language processing technologies, allowing it to communicate with humans via text or voice as a natural conversation. Cloud platforms, such as Google Assistant, Microsoft Azure, and Amazon Alexa, help create chatbots quickly and easily. In 2020, Google announced that every month on smartphones, TVs, and smart home devices, 500 million people use Google Assistant. Pham [10] recommended using Google Dialogflow for its ability to handle complex user intents. Dialogflow works well with Google Firebase Realtime database. Therefore, TigerAware chatbot is designed based on Dialogflow and Firebase. In Dialogflow, we create intents to receive user's answers and take appropriate actions. Data are stored in Firebase on Google Cloud. Google Cloud allows us to deploy chatbots without our own servers.

TigerAware chatbot system aims to improve conversational survey response rate and response quality. Web-based and email surveys have some significant limitations. They use text-based input and not suitable for open-ended questions. Open-ended questions are useful for collecting valuable information and deeper insights. However, they often come with cognitive burdens and survey-taking fatigue, and users likely skip this kind of question or provide low-quality or even irrelevant responses, which reduces

survey validity and reliability of data. Celino & Re Calegari [4] reported that when users met complex choices, they preferred to choose an option that was good enough instead of wasting time and money on seeking the best possible or ideal choice. The participants are more likely to skip open-ended questions and jump to closed questions.

An advantage of open-ended questions is that they allow researchers to find more than they expected. Participants might share their motivations and mention behaviors and concerns. Some researchers investigated the percentages of responses for open-ended questions at different positions of surveys. If an open-ended question is at the beginning or in the middle of a survey, it has higher percentages of responses than at the near-end of a survey . For open-ended questions near the beginning of a survey, 68% of participants provided an answer, whereas when it is in the middle of a survey, 79% of participants provided an answer. When it is near the end of a survey, 24% of participants provided an answer.

Some researchers used text-based chatbot surveys to increase the participant response rate. However, most of the answer choices were predefined and the chatbots did not have a user-friendly and human-like conversation process. When chatbots are designed with predefined conversation flow branches, they do not understand the user's utterances and can't interact with users adaptively [4]. Some researchers found it is difficult to enable chatbots to handle complex and diverse input, such as free responses [12]. For open-ended questions, users need to type the answers into the field box, which leads to low response rates. Through message exchanges between a user and a chatbot, a well-adapted conversation with customized messages could enhance user and chatbot interaction and survey response.

TigerAware chatbot system is designed to make chatbot creation and deployment simple and easy and make chatbots adaptive in response to participants' answers. The chatbots can run on multiple platforms, including smartphones and smart speakers. They can support various research purposes, such as diabetes assessment and self-management, ecological momentary assessment (EMA) studies, bilingualism and Aphasia Study, driving after drinking alcohol study [2]. Fig. 1 shows the TigerAware system architecture and components. TigerAware ecosystem builds with modularity and generic design. This resulted in broad cross-platform integration, fast development for adding features and, easy to use interface. The center is a NoSQL database (Firebase), which is used to deliver survey and store survey data. Researchers use a web dashboard to create and deploy a survey, and access and visualize survey responses. The chatbot component is built on top of existing TigerAware platform [9]. Chatbots retrieve survey questions from the database, collect answers from users, and upload them to the database. Firebase cloud functions implement Dialogflow Fulfillment and connect to the Firebase database. TigerAware chatbot has the following benefits: a) Supporting text-based and voice-based survey interaction in a conversational flow, which is especially useful for open-ended questions [12]; and b) Enabling adaptive interactions in natural languages, not just predefined selections for questions. The chatbot could understand a user's diverse inputs, deliver a more engaging user experience, and elicit higher-quality user responses.

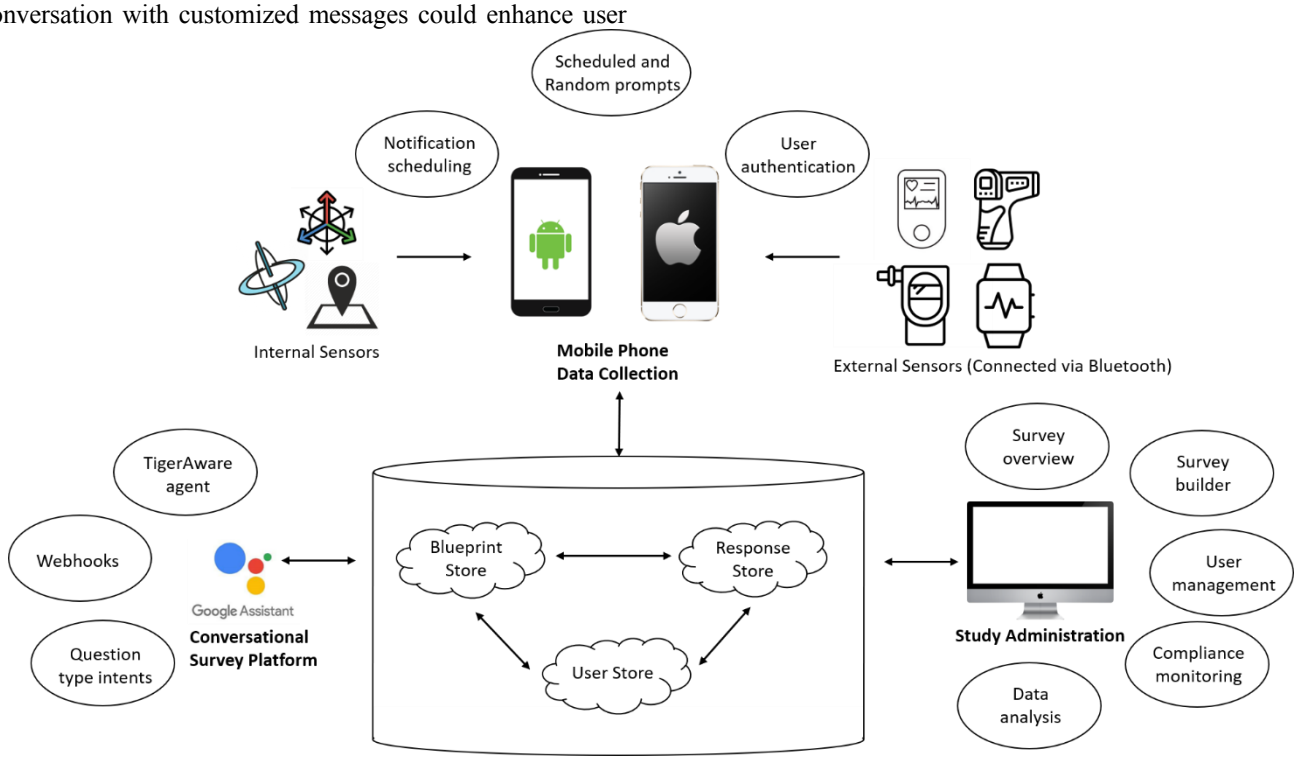



Fig. 1. TigerAware system architecture and components.

*B. TigerAware Chatbot Architecture and Implementation*

Fig. 2 shows the TigerAware chatbot system architecture. Users interact with a chatbot through Google Assistant. During a survey, user inputs are transformed from speech to text by the chatbot and sent to Dialogflow fulfillment, and chat responses are presented with audio and visual elements. The researchers can design surveys on the TigerAware dashboard, which can be stored in Firebase in real-time. They can access survey data and see visual report on the dashboard.

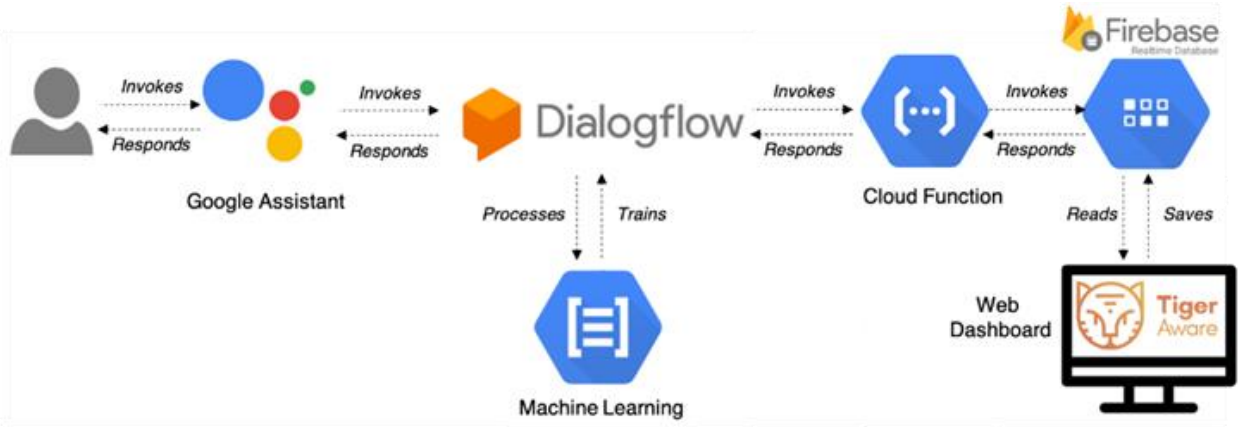



Fig. 2. TigerAware chatbot system architecture.

On the Web dashboard, users first register and login into the application. Firebase makes it easy to create an authentication mechanism for the application and performs user management. The entire authentication process for registering new users, session management and password management are just a few function calls. Researchers can perform administrative operations on each of their chatbots, edit surveys, and create different types of questions on the dashboard. A researcher is an administrator who can add users as participants to their surveys. The administrator interface allows administrators to add and delete users as participants of their surveys.

After an administrator creates a survey on the dashboard, it will be saved into structured data in blueprints. The following is the sample conversational survey created by the dashboard and deployed. Each question has a field called type, corresponding the question type that defines the expected response a chatbot is expected to receive.

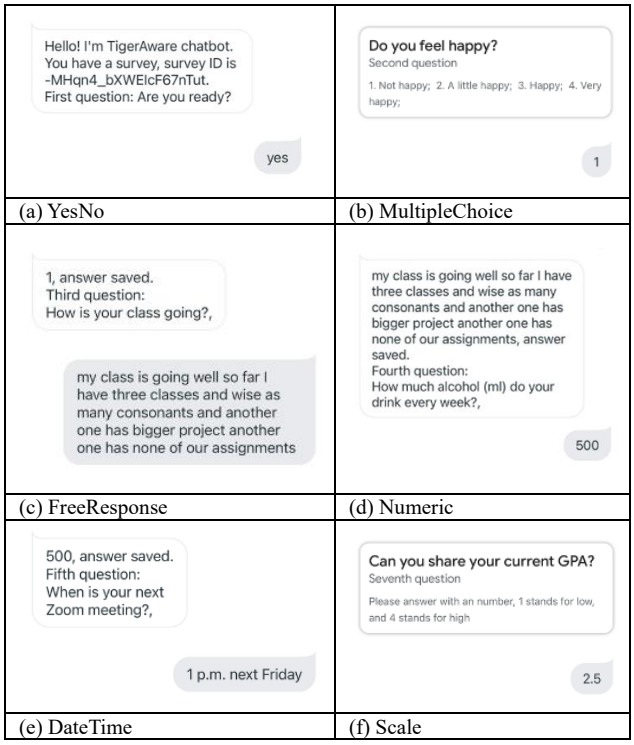
The following six question types are supported by the chatbot:

- "YesNo": yes or no answer
- "MultipleChoice": multiple-choice answer
- "Numeric": number answer
- "DateTime": date and time answer
- "Scale": scale answer
- "FreeResponse": free form answer

Dialogflow uses AI and natural language understanding to analyze and understand user's intent. Interpreting natural language responses requires a robust language parser that is capable of understanding the nuances of language, where Dialogflow excels. Dialogflow supports over 20 languages, such as Spanish, French, Japanese, etc. Dialogflow can expand on the list of synonyms in various ways.

TigerAware chatbots use different entities to extract user input, such as yes/no response, multiple choices, and actions. System entities are available for extracting dates, times, and locations from natural language inputs. Fulfillment is the code that responds to an HTTP request in a messaging format specific to Dialogflow, which contains the logic for handling intents and dynamically constructing responses to send to the user. Firebase cloud functions are used by fulfillment to implement actions, such as retrieving questions from blueprints and storing answers into database.

Users use a TigerAware chatbot by calling it in Google Assistant, saying "Talk to TigerAware chatbot". Fig. 3 shows examples of the six types of questions and answers in Google Assistant. These types of questions are enough to create campus climate assessments. Basic cards in the multiple-choice and scale questions help users identify the questions' key points easily to enhance their experience.




(a) YesNo (b) MultipleChoice

(c) FreeResponse (d) Numeric

(e) DateTime (f) Scale

Fig. 3. Question types in Google Assistant.

The taking survey workflow in TigerAware chatbots shows in Fig. 4. After the default welcome intent, participants are required to log in to the system. If they log in successfully, the chatbot uses participants' profiles to check new surveys. The chatbot loads questions one by one and checks if the answers match the predefined format. If all survey questions are completed, the chatbot automatically submits the survey answers to the database and finishes the current survey.

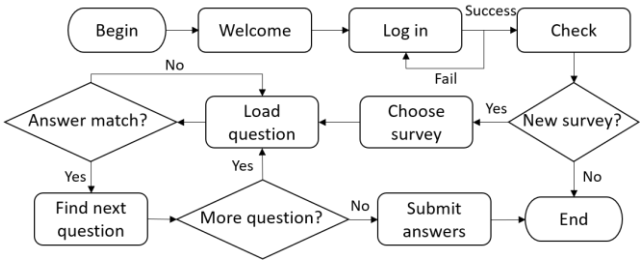



Fig. 4. Workflow of the TigerAware chatbot.

The participants might be taking multiple surveys. However, not every survey is available when participants are activating the chatbot since there might exist some availability limit for each survey. Fig. 5 shows the checking survey availability procedure for each participant. There could be three restrictions for each survey: day attempt limit, time window limit, and date window limit. Each one is optional. The chatbot will check if each type of restriction exists, then check if the current status meets the requirements. Only when all existing requirements are met, current survey is available. One exception is, if the day attempt limit does not exist, it does not mean there is no restriction for the current survey. Instead, the available survey could not have any existed answers.

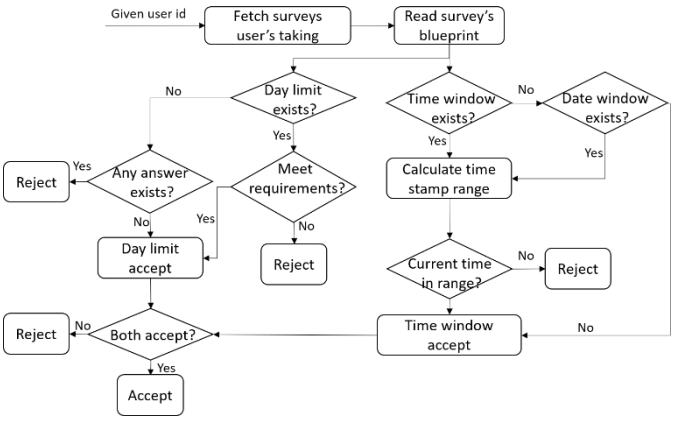



Fig. 5. Survey availability checking.

## IV. Applications

The new TigerAware chatbot system is being tested in several applications and got some promising results. One application is campus climate assessment for universities and communities. In assessing campus climate and its influence on specific populations, it is crucial to understand the complexities of identities and avoid treating identities in isolation. Paper-based and web-based surveys had low response rates. For example, the University of Missouri-Columbia campus climate assessment response rate from students was 22% in 2016.

The 2016 MU campus climate survey was implemented by TigerAware chatbot system. Fig. 6 shows Question 1, "what is your primary position at the University of Missouri?" This is a multiple-choice question, and can be displayed in the text format or card format in the chatbot. Most of the questions in the climate assessment are multiple-choice questions.

Fig. 7 shows Question 2 and 15 in the chatbot, which are also multiple-choice questions. Because the chatbot can understand different phrases, such as Comfortable, I agree, I strongly disagree, users have more flexibility to answer the questions based on their own styles. If users do not want to use voice input, the chatbot also provides visual buttons for them to select answers. In addition, users can skip a question, repeat a question, or back to the previous question if they want to answer the question again.

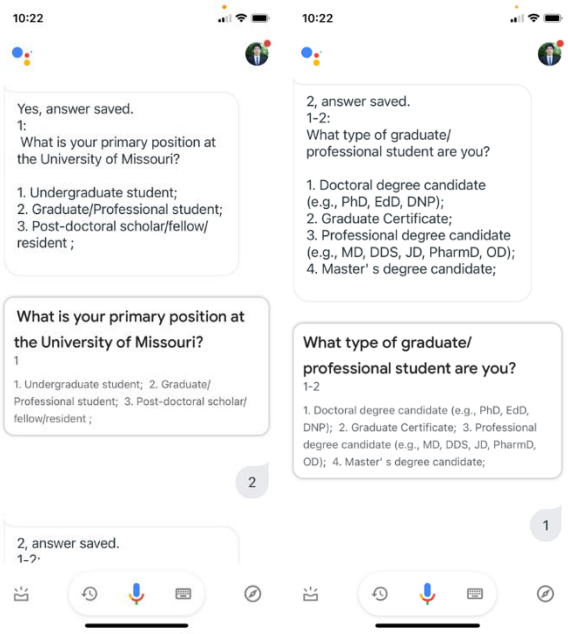



Fig. 6. MU campus climate assessment Question 1 as implemented in TigerAware chatbot.

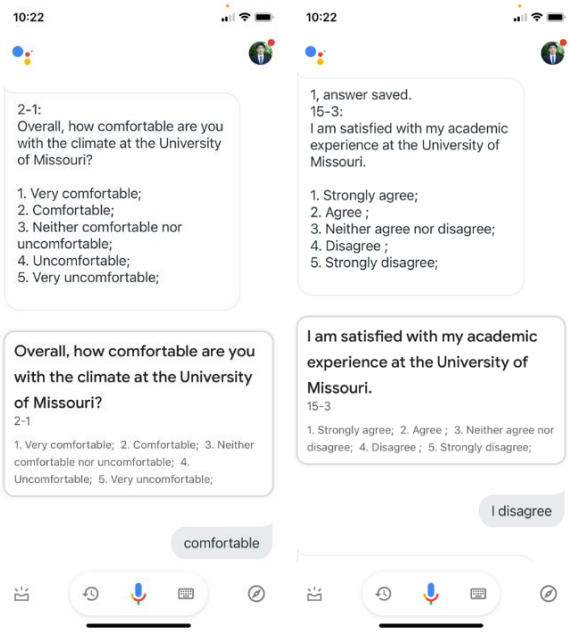



Fig. 7. MU campus climate assessment Question 2 and 15 as implemented in TigerAware chatbot.

Fig. 8 shows Question 54, 76 and 118, which are of different question types. Question 54, "What is your age?" is of numeric type. Question 74, "What was your cumulative grade point average?" is of continuous scale question. Question 118, "Are your experiences on campus different from those you experience in the community surrounding campus?" is a yes/no question, for which a user can provide different positive answers, such as yes, I think so, and yeah. Question 118-1, a follow-up question, asks "How are these experiences different?" which is a free response question. Users use voice input to answer the question, which reduces

the burden of typing text on small screens of smartphones.

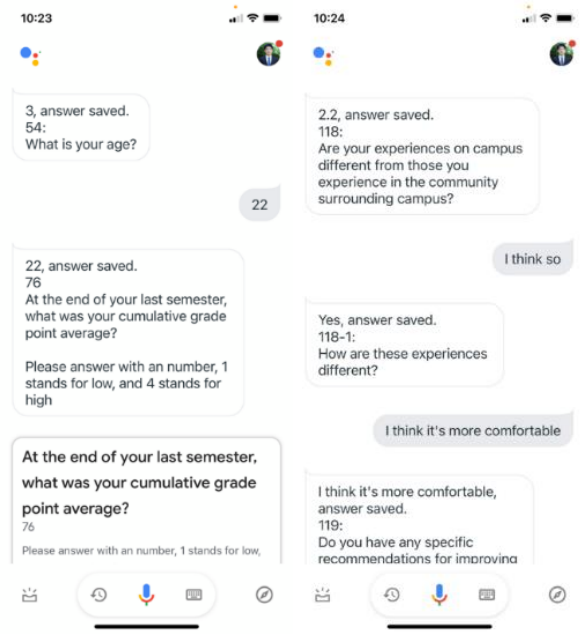



Fig. 8. MU campus climate assessment Question 54, 76, and 118, as implemented in TigerAware chatbot.

## V. Conclusion

Developing TigerAware chatbots using serverless architecture has involved using some of the latest AI and Cloud technologies, including Google Assistant, Dialogflow, and Firebase. This system embraces a modular and generic design to enable cross-platform capabilities as well as rapid development of new functionalities. Researchers can use a convenient Web dashboard to develop and deliver conversational surveys. A rich set of question types and voice-based interaction make users more willing to answer survey questions and increase response rate.

TigerAware chatbot helps people without programming knowledge to build and deploy customized conversational surveys. Google Dialogflow and Firebase Realtime database are used to create chatbots that support text- or voice-based input and open dialogs. The chatbot also provides visual responses for users to select a choice between several options. Basic cards of the questions help users identify the questions' key points easily so that questions can be answered quickly. Suggestion chips help users navigate the questions to enhance their experience. The chatbot can be deployed on any iOS and Android mobile devices and platforms that support Google Assistant.

## VI. Limitations and Future Work

Dialogflow has a response time limit for waiting information comes from webhook, it is usually fine and make it more user friendly, since it prevents user from waiting too long. However, it could lead to error when dealing with multiple queries in one intent calling if Dialogflow didn't receive any response from webhook in time.

In addition, Dialogflow doesn't handle time zone issue very well, i.e., one chatbot only supports one time zone, no matter where user is. It wouldn't be a problem if all participants are local, or they live in same time zone. However, we have to consider such situation that participants might come from all over the US, even all over the world. Location information needs be fetched from user, and a proper time zone handler could be designed to deal with such issue.

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