UNIVERSITY of WASHINGTON

LIVABLE CITY YEAR 2017–2018
IN PARTNERSHIP WITH
CITY OF TACOMA

CITY OF TACOMA

VOICE INTERACTION FOR TACOMA CITY SERVICES INTEGRATED WITH AMAZON ALEXA

UNIVERSITY OF WASHINGTON TACOMA
INSTITUTE OF TECHNOLOGY

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LIVABLE CITY YEAR

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COVER PHOTO CREDIT: CITY OF TACOMA

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ABOUT LIVABLE CITY YEAR

The University of Washington's Livable City Year (LCY) initiative enables local governments to engage UW faculty and students for one academic year to work on city-defined projects that promote local sustainability and livability goals. The program engages hundreds of students each year in high-priority projects, creating momentum on real-world challenges while enabling the students to serve and learn from communities. Partner cities benefit directly from bold and applied ideas that propel fresh thinking, improve livability for residents and invigorate city staff. Focus areas include environmental sustainability; economic viability; population health; and social equity, inclusion, and access. The program's 2017–2018 partner is the City of Tacoma; this follows a partnership with the City of Auburn in 2016–2017.

The LCY program is led by faculty directors Branden Born (Department of Urban Design and Planning), Jennifer Otten (School of Public Health) and Anne Taufen (Urban Studies Program, UW Tacoma), with support from Program Manager Teri Thomson Randall. The program was launched in 2016 in collaboration with UW Sustainability and Urban@UW, with foundational support from the Association of Washington Cities, the College of Built Environments, the Department of Urban Design and Planning, and Undergraduate Academic Affairs.

LCY is modeled after the University of Oregon's Sustainable City Year Program, and is a member of the Educational Partnerships for Innovation in Communities Network (EPIC-N), the collection of institutions that have successfully adopted this new model for community innovation and change.

For more information, contact the program at uwlcy@uw.edu.

LIVABLE CITY YEAR

ABOUT TACOMA

The third largest city in the state of Washington, Tacoma is a diverse, progressive, international gateway to the Pacific Rim. The port city of nearly 210,000 people has evolved considerably over the last two decades, propelled by significant development including the University of Washington Tacoma, the Tacoma Link light rail system, the restored urban waterfront of the Thea Foss Waterway, the expansions of both the MultiCare and CHI Franciscan health systems, and a significant influx of foreign direct investment in its downtown core.

Washington State's highest density of art and history museums are found in Tacoma, which is home to a flourishing creative community of writers, artists, musicians, photographers, filmmakers, chefs, entrepreneurs, and business owners who each add their unique flair to the city's vibrant commercial landscape. The iconic Tacoma Dome has endured as a high-demand venue for some of the largest names in the entertainment industry.

A magnet for families looking for affordable single-family homes in the Puget Sound area, Tacoma also draws those seeking a more urban downtown setting with competitively priced condos and apartments that feature panoramic mountain and water views. The city's natural beauty and proximity to the Puget Sound and Mount Rainier draws hikers, runners, bicyclists, and maritime enthusiasts to the area, while its lively social scene is infused with energy by thousands of students attending the University of Washington Tacoma and other academic institutions.

The City of Tacoma's strategic plan, Tacoma 2025, was adopted in January 2015 following unprecedented public participation and contribution. The plan articulates the City's core values of opportunity, equity, partnerships, and accountability, and expresses the City's deep commitment to apply these values in all of its decisions and programming. Each Livable City Year project ties into the principles and focus areas of this strategic plan. The City of Tacoma is proud of its 2017–2018 Livable City Year partnership with the University of Washington and of the opportunity this brings to its residents.

Tacoma

TACOMA 2025 STRATEGIC PLAN

The *Voice Interaction for Tacoma City Services Integrated with Amazon Alexa* project supports the Civic Engagement and Equity and Accessibility goals of the Tacoma 2025 Strategic Plan and was sponsored by the City's Information Technology Department.

Goal #1 Livability
The City of Tacoma will be a city of choice in the region known for connected neighborhoods, accessible and efficient transportation transit options, and vibrant arts and culture. Residents will be healthy and have access to services and community amenities while maintaining affordability.

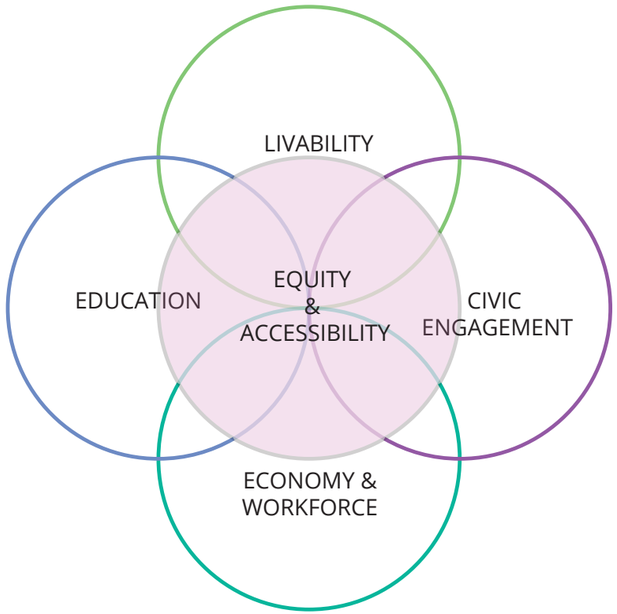
Goal #2 Economy and Workforce
By 2025, Tacoma will be a growing economy where Tacoma residents can find livable wage jobs in key industry areas. Tacoma will be a place of choice for employers, professionals, and new graduates.

Goal #3 Education
Tacoma will lead the region in educational attainment amongst youth and adults. In addition to producing more graduates from high school and college, more college graduates will find employment in the region. Lifelong learning and access to education will be prioritized and valued.

Goal #4 Civic Engagement
Tacoma residents will be engaged participants in making Tacoma a well-run city. The leadership of the city, both elected and volunteer, will reflect the diversity of the city and residents and will fully participate in community decision-making.

Goal #5 Equity and Accessibility
Tacoma will ensure that all residents are treated equitably and have access to services, facilities, and financial stability. Disaggregated data will be used to make decisions, direct funding, and develop strategies to address disparate outcomes.

tacoma2025
shared vision | shared future



RESOURCES

Tacoma 2025 Strategic Plan: https://www.cityoftacoma.org/tacoma_2025

Department of Information Technology:
https://www.cityoftacoma.org/government/city_departments/information_technology/

Livable City Year: https://www.washington.edu/livable-city-year/

UW Tacoma School of Engineering and Technology:
https://www.tacoma.uw.edu/set/about-school-engineering-technology

Executive Summary

A TOOL TO IMPROVE RESIDENTS' ACCESS TO CITY SERVICES

This report presents a tool developed by students from the University of Washington Tacoma's (UWT) Computer Science and Systems program for the City of Tacoma during the 2018 spring academic quarter. The City of Tacoma asked students to create an application program for a voice-operated, digital assistant using either Amazon Alexa or Microsoft Cortana. The City stated it desired such a system to improve residents' access to city services and information. Responding to the City's request, students created an Alexa Skill, calling it 'Tacoma FIRST 311.' This Alexa-customized skill is designed to enable residents to easily and conveniently acquire information about a range of city services from various City of Tacoma departments.

Today, digital assistants, like Amazon Alexa and Microsoft Cortana, can replace the work of human phone operators. The City of Tacoma is interested in developing such technology to improve residents' access to city services. SEATTLE MUNICIPAL ARCHIVES

This Alexa-customized skill is designed to enable residents to easily and conveniently acquire information about a range of city services from various City of Tacoma departments.

DIGITAL ASSISTANTS

A digital assistant, also referred to as a virtual assistant or an artificial intelligence (AI) assistant, is an application program engineered to understand voice commands and to perform tasks for people. Examples include Apple's Siri, Microsoft's Cortana, and Amazon Echo's Alexa. Some of the tasks that these digital assistants perform for the users that interface with them include: dictation, reading aloud text and email messages, looking up phone numbers and directions, scheduling events and meetings, and placing phone calls. Today, with an increasing number of households making daily use of one or more digital assistants, an opportunity looms for the City of Tacoma to design and use its own digital assistant to strengthen communication pathways between the City and residents. Digital assistant technology can make it easier and more convenient for residents to ask questions, file reports, and access information about city services and local government.

The Amazon Echo and Echo Dot enable users to access all skills programmed into Alexa, today's most popular digital assistant on the market. ANDRES URENA

STUDENT APPROACH

A research team of seven Computer Science and Systems undergraduate students responded to the City's request for a voice-operated digital assistant. The project provided students with an opportunity to investigate, acquire, and apply new coding competences, to create the Alexa Skill, Tacoma FIRST 311. The team worked closely with Mary Kay Larson, Supervisor of the City's Information Technology (IT) Department, to create their tool. One student acted as team leader; this person organized weekly meetings, created weekly reports to track progress, and helped team members apply coding and other technical skills.

GRAPHIC-USER AND VOICE-USER INTERFACES

Between 30 and 40 years ago, people started utilizing primarily text-based, digitized, graphic-user interfaces (GUI) to carry out common tasks, such as completing a transaction at the grocery store. Over time, technological advances have led to even more frequent use of GUIs. Today, millions of GUIs exist; they include all computer software programs and all smart phone application programs. Increasingly, application programs perform more complex, nuanced, and personalized tasks for their users. A growing number of voice-user interfaces exists as well; these make it possible for humans to interact with computers through a speech platform to retrieve information and to complete simple tasks. Many private companies and public agencies use automated voice systems in place of human operators to direct calls and to respond to basic costumer service questions. These voice systems may even initiate phone calls to solicit an individual's participation in a phone survey or to remind them of an upcoming appointment.

Digital assistants, like Amazon Alexa (released in November, 2014), are voice-user interfaces that come one step closer to interacting conversationally with humans. Digital Assistants respond to a range of verbal commands and questions, and they help their users organize their days and access information.

Amazon's apparent aim in creating Alexa is to integrate her into every area of people's lives. Her programming makes her capable of voice interaction; streaming music and podcasts; playing audio books; compiling to-do lists; setting alarms; ordering a pizza; calling an Uber; and providing weather, traffic, sports, news, and other real-time information. One of Alexa's main features is her home automation capacity; this enables her to sync up with all other smart home devices, such as smart locks, smart security cameras, and smart home thermostats. This feature makes it possible for a person to control a range of devices by voice command, without lifting a finger or batting an eye.

CHOOSING A 'LESS SMART' DIGITAL ASSISTANT

While Alexa excels at integrating various smart home devices, from the stand point of an application developer, she may be viewed as less 'smart' than other digital assistants in the sense that she possesses fewer skills and is less customizable for users. Still, based on the number of skills being developed for her, it is likely she will catch up to other digital assistants soon.

Students selected Alexa for this project because Alexa-enabled devices, like Echo and Echo Dot, currently top the best-selling lists for digital assistants. It is likely that many Tacoma residents already possess and understand how to use these devices. Since increasing

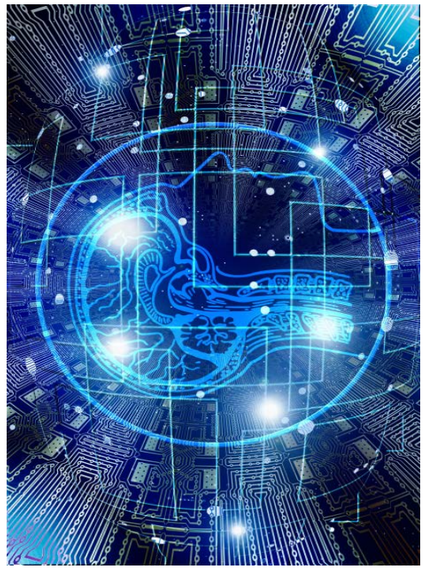
Alexa excels at her home automation capacity, which means people can use her to control other smart home devices like thermostats and security cameras. GERD ALTMANN

Choosing Amazon Alexa

The team chose Alexa over Cortana primarily because she is the best-selling digital assistant on the market, taking 69% of the market share for digital assistants in 2017 (Kinsella 2018). Students reasoned that most of the city's residents who already operate a digital assistant in their homes likely use Alexa; thus, it seemed logical to create a tool compatible with the systems already present in people's homes.

Students elected to work with Alexa for reasons of convenience and practicality, too. Amazon Web Services (AWS) allows application developers, such as the team of students involved with this project, to design digital skills for their own use and purposes. Amazon even provides a step-by-step approach for web developers to follow to set up specific skills. This facilitated the students' design of Tacoma FIRST 311 and kept their coding work to a minimum.

Students created the
Alexa Skill Tacoma FIRST 311
as a tool to improve access
to city services.



Increasingly, artificial intelligence design enables digital assistants to interface with humans conversationally, responding to questions with helpful information and picking up on linguistic variation. GERD ALTMANN

access to information about city services is part of the City's vision for harnessing the capacity of a digital assistant, it is sensible to choose a device already in use in many homes throughout the city. In addition, because the cost of purchasing an Echo Dot ($25) is less than that of purchasing a competing digital assistant, like the Google Home Mini ($40), residents may find themselves more inclined to purchase one of these digital assistants. As well, the City may be more likely to dedicate resources to deploy Tacoma FIRST 311 verbal command devices in various public spaces; this could be part of an effort to improve access to city services for community members who do not possess an Alexa device.

TACOMA FIRST 311

Students created the Alexa Skill, Tacoma FIRST 311, as a tool for the City to use to accomplish its own goal to improve access to city services by providing a new option for residents to use a digital assistant from their home. It is possible to access Tacoma FIRST 311 from any Alexa-enabled device. Instead of making phone calls, Googling city services, or navigating the City's website, residents can easily obtain information by asking Alexa a question. It is her task to sort through the information programmed into her prior to responding. Essentially, the Tacoma FIRST 311 Skill presents an alternative to dialing 311 or to using the mobile application, 'Tacoma FIRST 311,' to access information about city services. The benefit for residents is convenience. Rather than making a phone call and listening to a voice system's list of options, trying to determine which option corresponds with their reason for calling, and waiting on hold or being redirected to another line, the Alexa Skill, Tacoma FIRST 311, enables residents to get right to the heart of the matter— their particular question or concern. Tacoma FIRST 311 eliminates all the hassle and frustration people encounter in their attempts to navigate older voice systems, websites, and even relatively newer mobile applications.

Tacoma FIRST 311 eliminates all the
hassle and frustration people encounter
in their attempts to navigate older voice systems,
websites, and even relatively newer
mobile applications.

Tacoma FIRST 311 is meant to eliminate frustration many people experience searching the web for information related to city services. A user can simply ask Alexa a question and get a response. GERD ALTMANN

While the focus of this report is to introduce the basic design and capabilities of the Alexa Skill students created for the City of Tacoma, the students have also prepared a handful of recommendations for expanded uses and features the City can consider applying to this technology. A summary of recommendations follows:

1. Enable application programming interfacing (API) to open access to the City's website.
2. Create an automated telephone answering system to replace dialing 311.
3. Invest in low-cost verbal command devices to increase public access to this technology.
4. Set up garbage, recycle, and yard/food waste calendars to help residents stay organized.

Methods

PHASE I: INQUIRY AND INVESTIGATION

Students investigated how to build and test an Alexa Skill prior to creating their own. This required them to learn new coding techniques. After figuring out how to create an Alexa Skill, students applied their newly acquired knowledge to build the beta version, or test version, of Tacoma FIRST 311. At later stages in their process, students continued to research additional topics, such as how to add text and email features to an Alexa Skill.

PHASE II: DESIGNING AND TESTING THE BETA VERSION

Starting with very simple questions, like "Alexa, hello?" students began to construct a coding template for the beta version of their Skill. This enabled the students to practice coding for Alexa and to test each element of the Skill's design. The beta version of Tacoma FIRST 311 works flawlessly, according to the students who built and tested it.

For further breakdown of Alexa skill-building terminology and of the students' approach to building the Tacoma FIRST 311 Skill, see Appendix I.

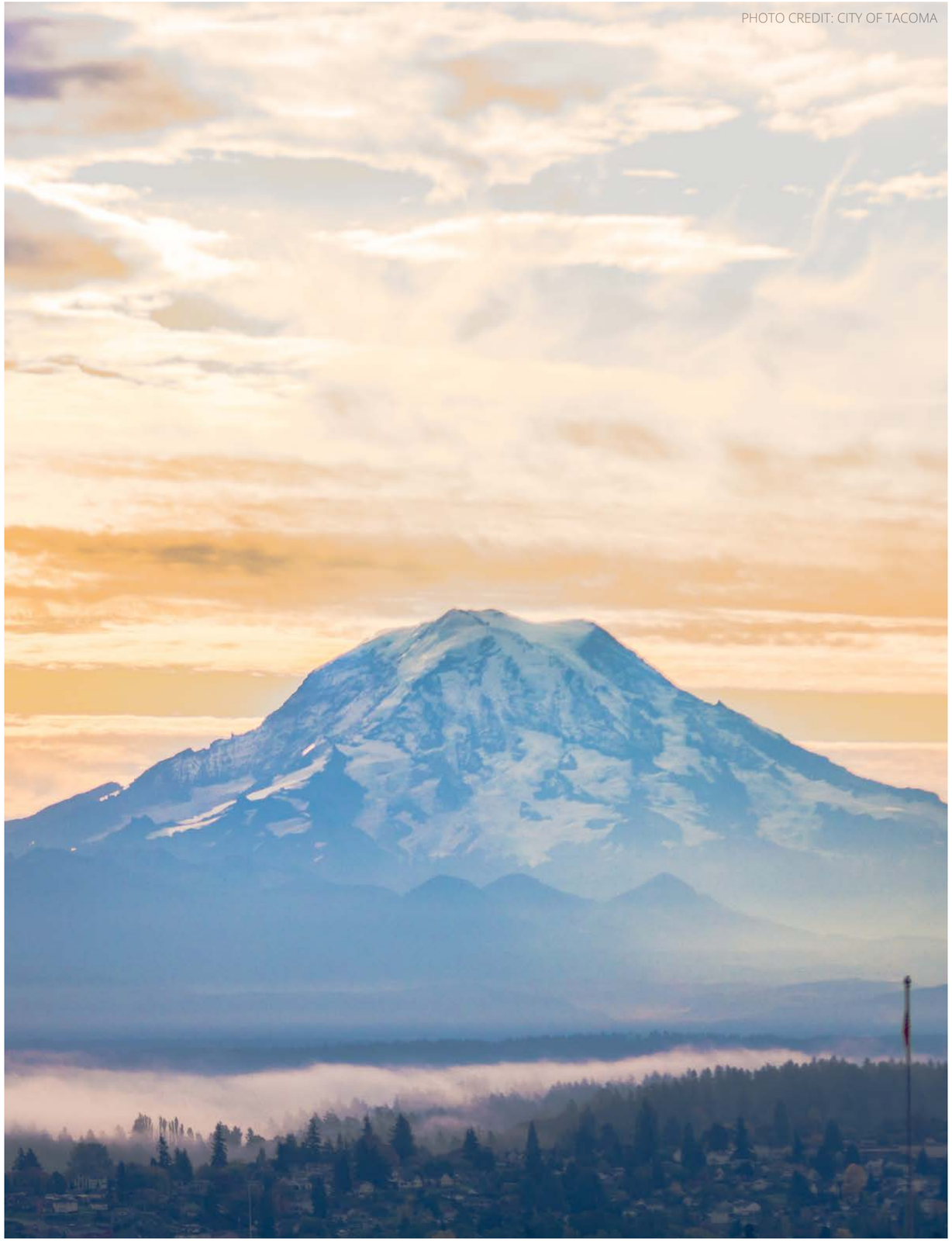


PHOTO CREDIT: CITY OF TACOMA

Building The Skill

First, students researched the current capabilities of Alexa. They looked for examples of other city and state governments that use an Alexa Skill similar to their vision for Tacoma FIRST 311. They found that three states— Georgia, Utah, and Mississippi— currently use digital assistants to facilitate communications between government agencies and residents.

Equipped with new insights gleaned from their review of real-world models, the team generated a list of features to add to Alexa's repertoire, as part of creating an Alexa Skill tailored to serve the City of Tacoma and its residents. They created a plan, determined where they would need to devote time to learning new coding techniques, and met weekly to track their progress and assign themselves new tasks. Students created a question and answer list to correspond to Tacoma's city services. They garnered much of the information for this list from the Tacoma First 311 website's "Find an Answer" section. This section contains 750 commonly asked questions related to city operations, environmental services, fire safety, police, housing assistance, jobs, and other services. From this list, students selected the top six most frequently asked questions and programmed variants of each question into the Alexa Skill, along with accurate responses.

Application developers are working all the time to create new tools and to improve and expand upon those that already exist so we can operate them seamlessly from our phones, laptops, and other devices. JASON HOWIE

Six most frequently asked questions used to build the Alexa Skill, Tacoma FIRST 311 beta version:

1. How to file a car accident report?
2. Who should I contact for residential parking at neighborhood?
3. How to report a neighbor's barking dog
4. What is chain parking
5. What is yard parking?
6. How to report a crime?

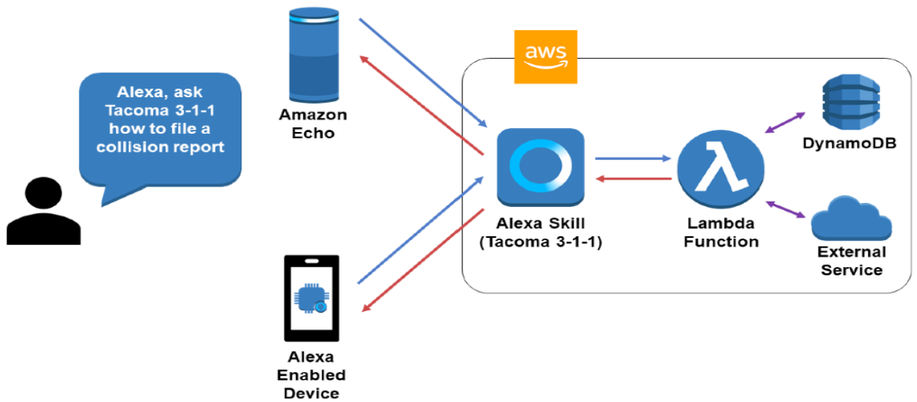
To review the complete set of questions from the City's website, visit: https://www.cityoftacoma.org/cms/one.aspx?objectId=17887

HOW THE ALEXA SKILL WORKS

The Alexa Skill, Tacoma FIRST 311, like other Alexa Skills, enables voice interfacing to occur between human users and Alexa, similar to ordinary interactions between two people. The user asks Alexa a question. Then, Alexa processes the question and responds to the user. The diagram below illustrates this feedback loop. Alexa can even be set up to respond with follow up questions to elicit more information from her users prior to offering a response.

INVOCATION NAME: SKILL ACTIVATION

A person activates any Alexa Skill by stating the specific skill's invocation name; usually, this is the name of the skill. For example, if the skill's name is, "Hello world," a user says, "Alexa, open Hello world," and this triggers the skill. In the case of the skill students created for the City of Tacoma, the skill's name is, "Tacoma FIRST 311." Once a person says, "Alexa, open Tacoma FIRST 311," the skill is activated and Alexa awaits further instructions.



From left to right: A person asks Alexa a question, saying "Alexa, ask Tacoma FIRST 311…" Alexa recognizes the person's voice and uploads the question to her AWS platform which activates the Tacoma FIRST 311 Skill. The Lambda Function represents all coding for the Tacoma FIRST 311 Skill. Once the question is processed, AWS signals Alexa to respond to the user with pertinent information. LCY TEAM

Understanding Alexa Skills

Amazon Alexa is not born with innate understanding of the City of Tacoma. In fact, the truth is she knows nothing at all at first. It is thanks to the ingenuity and vision of application developers from all over the world that Alexa's repertoire of abilities and features continually expands. Developers refer to the abilities and features they create for Alexa as, "Alexa Skills."

INTENTS: INFORMATION CATEGORIES

Intents are essentially the information categories coded into each Alexa Skill. Alexa is programmed to decipher meaning from speech well enough to match a person's request to an appropriate intent; this enables her to sort through all the information programmed into her and respond with useful information. In the case of Tacoma FIRST 311, the intents are the six most frequently asked questions (listed previously). Students coded one intent for each question and equipped Alexa to recognize various questions that correspond to each intent.

UTTERANCES: LINGUISTIC VARIATION

Coding for utterances enables Alexa to link variously worded questions and phrases to an appropriate intent within a skill. This accounts for linguistic variation, or, for the fact that humans do not construct comments and questions uniformly. For Alexa to pick up on linguistic variation, she must be programmed to interpret and match a range of phrases (utterances) to corresponding intents. On average, 15 utterances are coded for a single intent; in one case, students created 120 utterances for one intent.

The Tacoma FIRST 311 Alexa Skill could answer questions related to city services, including trash pickup. CITY OF TACOMA

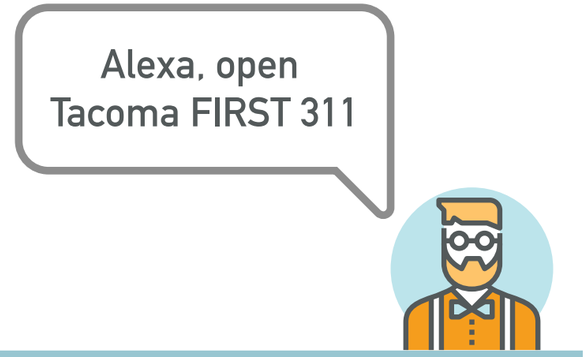
For New Users

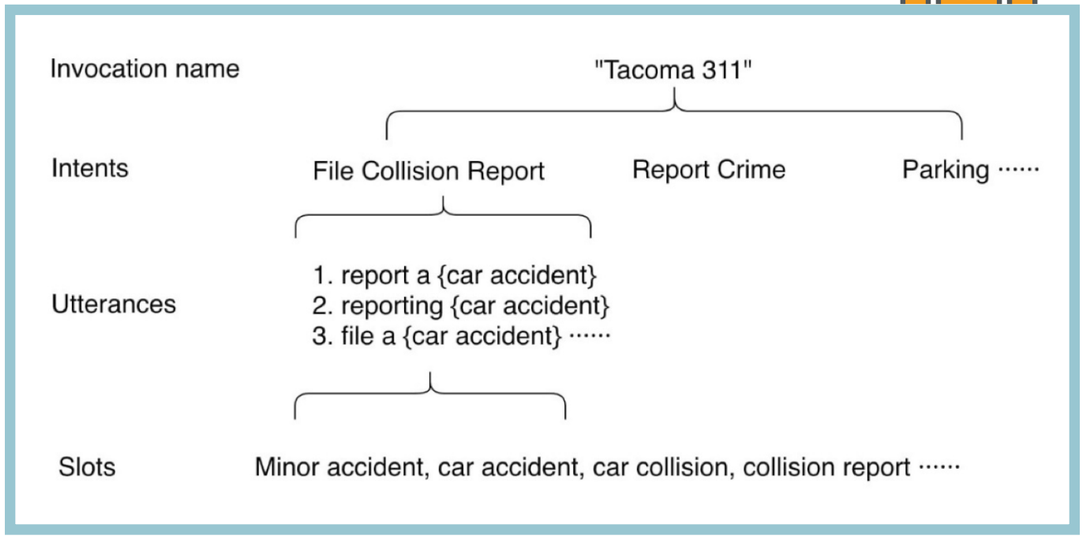
A person can access and use the Alexa Skill, Tacoma FIRST 311, through their Amazon Echo or Echo Dot, or by using the free Amazon application. First time users activate the Skill with Login with Amazon (LWA); this part of the students' design enables the Tacoma FIRST 311's email feature. After LWA, new users receive a notification in their Alexa application; this provides a link to a log-in page where they can use their Amazon username and password to set up Tacoma FIRST 311. Once activated, Alexa allows users to access Tacoma FIRST 311 at any time.

SLOTS: WORDS THAT MEAN THE SAME THING

Another layer of coding that accounts for linguistic variation is the use of slots. Slots are different words with the same or similar meaning. For example, a person might ask Alexa, "how do I report a dangerous animal?" The words "dangerous" and "animal" represent two slots and could be replaced with other words like, "threatening" and "dog." In either instance, of a person asking to report a "dangerous animal" or a "threatening dog," Alexa would understand the person and respond with helpful information.

The diagram below illustrates how a user interfaces with Alexa and how Alexa is designed to decipher her users' language.





LCY TEAM

Recommendations

In addition to building the Alexa Skill, Tacoma FIRST 311, students devised a few recommendations for the City of Tacoma to consider. The students assess that their recommendations promote efficiency and convenience, to benefit both the City and residents. One recommendation, in particular, targets social equity and suggests how the City can harness the capability of a digital assistant application to improve access to city services and information for all residents, not just for those who already possess and operate a digital assistant.

1) Application Programming Interfacing (API) to Open Access to the City's Website

The City's IT department can increase the capabilities of Tacoma FIRST 311 by allowing application programming interfacing (API) with Alexa application developers. Essentially, API would sync the Tacoma FIRST 311 Skill with the City of Tacoma's website, and enable Alexa to answer any web-searchable question related to Tacoma city services. This would increase convenience to residents seeking information from their homes, as they would no longer need to navigate the City's website. By allowing API, the City of Tacoma could even make it possible for Alexa to guide residents through the process of filling out electronic forms.

2) Automated Telephone Answering System

The City of Tacoma can cut costs by using Alexa to partially replace its human-operated 311 telephone services. While it is not possible to entirely replace humans with any digital assistant (yet), Alexa devices can be designed to interface with users to answer many of their most frequently asked questions.

One recommendation targets social equity and suggests how the City can harness the capability of a digital assistant application to improve access to city services for all residents.

3) Low-Cost Verbal Command Devices

To open access to city services to even more community members, including to those who do not possess a digital assistant in their home and to those who experience homelessness, the City could invest in low-cost, verbal command devices, and install them in public spaces, such as police substations, transit stops and depots, public libraries, community centers, shelters, and other central gathering spaces. [pull-quote, from last sentence: The City could invest in low-cost, verbal command devices, and install them in public spaces, such as police substations, transit stops and depots, public libraries, community centers, shelters, and other central gathering spaces.] This would enable all community members to access city services and information.

4) Garbage, Recycle, and Yard/Food Waste Calendars

Students created a way for Alexa to detect device location so she could be programmed to tell a user when to put out garbage, recycling, and yard/food waste bins. While this feature is not part of the beta version of the Tacoma FIRST 311 Skill, the City could easily work with an application developer to add a feature to enable residents to access the Environmental Services calendar for garbage, recycling, and yard/food waste pick-up. The Skill could also inform users of how to properly dispose of and sort waste materials.

Conclusion

This report has focused on describing the students' approach to creating a voice-user interface for the City of Tacoma to use to improve residents' access to city services and information. The City requested that such a tool be integrated with either Amazon Alexa or Microsoft Cortana. For reasons of convenience and practicality, students chose to build an Alexa-customized Skill, Tacoma FIRST 311. Students dedicated most of their time and energy on this project to researching how to create this skill and to building and testing a beta version of the tool. The beta version provides a template for the City to use to expand the Skill's capabilities.

Students encourage the City of Tacoma to allow application developers to query the City website by enabling API. This would enable Alexa to answer just about any question related to city services. The students hope the City also consider ways it can reach community members who do not own and operate Alexa-enabled devices by installing verbal command devices in public spaces.

The Tacoma FIRST 311 Amazon Alexa Skill brings the City of Tacoma one step closer to providing a digital assistant to residents. ANDRES URENA

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Appendix 1: Coding terms and definitions for application development techniques employed by students to create the Alexa Skill, Tacoma FIRST 311.

JavaScript (JS): an object-oriented computer programming language commonly used by computer scientists, and web and application developers. Students used to create the interactive capabilities of the Alexa Skill, Tacoma FIRST 311.

Node.js: an open-source, cross-platform JavaScript run-time environment that executes JavaScript code on servers. Students used the Alexa Software Development Kit (Alexa-SDK) and Amazon Web Service Software Development Kit for Node.js.

Amazon Web Service (AWS) Lambda: a low-cost computer program provided by Amazon that allows developers to run code to create skills without needing to possess or manage their own servers.

Amazon Simple Email Service (SES): a service provided by AWS that enables developers to send and receive emails using a reliable and scalable email platform.

Amazon Simple Notification Service: a fast, flexible, fully-managed messaging service provided by AWS.

Amazon Cloud Watch: a monitor for AWS which monitors the Alexa app and helps with debugging it.

Amazon Identity and Access Management (AIM): an account management system that enabled all students on this team access to the Alexa Skill, Tacoma FIRST 311.

LWA: Login with Amazon (LWA) allows users to login to registered, third party websites and applications using their Amazon username and password.

API: Application programming interface (API) refers to technology that allows developers to sync up an application with information pulled from a website.