

Leveraging Oracle APEX to Develop a Multilingual Application for COVID Vaccination Scheduling and Administration Engine (VASE)

Ashraf Syed

Virginia Department of Health
Richmond, VA 23219 USA

Corresponding Author: Ashraf Syed (e-mail: ashraf.syed@vdh.virginia.gov).

Abstract

In recent years, the demand for multilingual applications has surged as organizations strive to meet the needs of increasingly diverse user populations. The Oracle Application Express (APEX) is a powerful low-code development platform that offers an array of unique and comprehensive built-in globalization features designed to ease the creation of multilingual applications. This paper describes the development of a multilingual application using APEX for scheduling and administering vaccination. This application serves as an integrated solution aimed at streamlining the COVID-19 vaccination campaign by the State of Virginia Department of Health during the pandemic. This study underscores the importance of precise and accurate language in healthcare applications, where clear communication can significantly impact patient outcomes and accessibility. The substantial benefits of using the APEX platform compared to generic translation tools, such as Google Translate, in the context of this application are highlighted in this paper. Furthermore, several potential enhancements that can be incorporated into the application are discussed.

Keywords: COVID, Epidemic, Globalization, Google Translate, Healthcare, Localization, Multilingual Applications, Oracle APEX, Pandemic, Translation, Vaccination Administration, Vaccine scheduling

I. INTRODUCTION

A. BACKGROUND

On March 11, 2020, the WHO declared COVID-19 a pandemic after the Severe Acute Respiratory Syndrome Coronavirus or SARS-CoV-1 spread to more than 114 countries [1]. On March 13, 2020, the US government declared a nationwide emergency due to the pandemic [1]. To minimize the devastating effects of the outbreak, authorities had to establish safe testing sites, implement effective tracking strategies, and conduct large-scale vaccination campaigns. It is also essential to improve data tracking and recording systems and launch educational initiatives that raise public awareness about the importance of

vaccines. Vaccination is believed to be the safest approach to achieve herd immunity against this virus [2]. Approximately 60-70% of the entire population must be vaccinated to achieve herd immunity [3], [4].

It is the first pandemic in history where technology has been leveraged on a massive scale in an effort to keep people safe, informed, and productive [5]. As communities faced unprecedented challenges, various healthcare applications to facilitate multiple operations to fight the pandemic, like COVID testing scheduling, vaccination appointment scheduling systems, vaccine administration platforms, immunization information repository systems, and Electronic Health Records (EHR), emerged as vital instruments for orchestrating large-scale testing, tracking, and vaccination initiatives globally.

However, there was much misinformation and negative coverage about the vaccination campaigns and efficacy of the vaccines themselves, although emergency use authorization (EUA) was provided by the Center for Disease Control (CDC). Vaccine hesitancy and delay in acceptance pose an unprecedented challenge for concerned authorities [6]. Therefore, it is imperative for both federal and state government authorities to create awareness and ensure effective communication with accurate information for the entire population.

B. REQUIREMENT FOR MULTILINGUAL SUPPORT

COVID-19 has also highlighted the critical need for multilingual applications with clear, accurate, and accessible communication within various healthcare applications, especially when addressing populations from diverse linguistic and cultural backgrounds. These barriers can profoundly and seriously impact the overall vaccination rate. These barriers can result in missed appointments, where patients may not fully understand the scheduling process, leading to significant delays in receiving necessary medical attention. Furthermore, critical instructions can be easily misunderstood by putting patients at risk. For instance, a patient might incorrectly fill out a questionnaire designed to gather vital information about their current health condition, medical history, and vaccination history, or they may misinterpret consent forms stipulated by regulatory agencies such as the CDC.

To address these challenges, multilingual functionality becomes indispensable to ensure that all individuals can access accurate information and support regardless of their language or cultural background. Multilingual functionality is essential in multicultural nations like the United States of America (USA), where a rich tapestry of languages and cultures coexists. By breaking down language barriers, essential information can be ensured to reach all citizens, empowering them to make informed decisions during times of great uncertainty and fear.

By providing information in multiple languages, this application ensures that users clearly understand how to navigate the vaccination process, including when, where, and how to receive their vaccinations. This clarity is essential for promoting public health and ensuring that all community members have equal access to the vaccines. By localizing and accurately translating such critical information, healthcare staff at vaccination centers can greatly enhance accessibility and usability for non-native speakers, ultimately fostering a more inclusive and safer environment and achieving herd immunity.

C. ORACLE APEX

Oracle Application Express (APEX) is a robust, cloud-based, low-code development platform designed to empower users to swiftly and efficiently create secure, scalable applications. Recognized as the world's most popular low-code application platform [7], APEX streamlines the development process, allowing for the rapid deployment of robust and complex software solutions. Its seamless integration with the Oracle

database further enhances its capabilities, making it well-suited for constructing sophisticated database applications.

APEX provides an extensive and feature-rich declarative framework complemented by robust libraries that enable developers to craft exceptional applications easily. By simplifying the coding process, APEX allows developers to shift their focus toward the core aspects of application logic and functionality. This means that they can prioritize user experience and design, avoid the distractions of intricate technical requirements and enable them to deliver innovative solutions efficiently.

Another standout feature of APEX is its comprehensive support for its application in globalization. This key component allows developers to create multilingual applications that can support more than 100 languages. By facilitating translations and localization, APEX addresses various cultural, regional, and linguistic nuances, ensuring that applications can effectively cater to diverse audiences around the globe. This capability not only enhances the user experience but also broadens the reach and impact of applications developed on the platform.

D. GOOGLE TRANSLATE

Among the various translation engines available, Google Translate (GT) is the most popular and is widely used worldwide. This application utilizes AI technologies, specifically neural networks, to translate languages in real time. Key features of Google Translate include text-to-text translation, speech-to-text translation, handwritten recognition and translation, and text recognition and translation [8].

Google Translate is powered by Google Neural Machine Translation (GNMT), which translates entire sentences rather than individual words. GNMT aims to determine the most appropriate translation for the whole sentence, and then rephrase it to sound more natural, as if a human was speaking [9].

II. SELECTION OF APEX PLATFORM

Developing a multilingual application is a complex task that requires consideration of both the technical and contextual requirements. The application can be translated by client-side implementations, server-side implementations, or both. Each method has a unique set of features, potential benefits and applications. While client-side translations allow the flexibility of content translation in real-time by leveraging internal or third-party APIs, server-side translation allows deeper customizations with greater control over the nuances of the language and its contextual meaning. Several factors, such as the diversity of possible application users, criticality of the application, context of the app usage, sensitivity of the content, and legal implications, if any, involve considering a more appropriate translation method. [10].

APEX globalization features provide server-side translations and more options for localization. APEX stores all relevant translated data within its database, enhancing data integrity, privacy, and security. Globalization components allow for more customizations and flexibility, allowing developers to set up metadata for more precise translations within the application context. Apart from translations, localization is another crucial aspect, allowing the application to align with the local and unique nuances of the language and to reflect on and respect the legal standards of the country or region where the application is being used. This results in a more inclusive and user-friendly experience. However, this cannot be achieved in real-time, and although it is less, it requires some time.

Google Translate, a client-side architecture powered by GNMT, allows real-time translation of the application page. It will enable users to switch to another language by simply using browser (Chrome) options for one of the many supported languages. The capability of sentence-based translation significantly improves the translation accuracy [11]. However, the accuracy of translation can vary when using Google

Translate for different language pairs. In a 2010 accuracy assessment study, translation accuracy was determined to be poor among Asian languages such as Hindi, Vietnamese and certain Eastern European languages but good among common European languages such as French, Swedish and Italian. [12]

Finally, the Oracle APEX platform was considered for globalization of the application because of the following considerations:

- The application should be publicly accessible and be used by all residents of the state from diverse backgrounds.
- It should be HIPAA compliant to, ensure data security and patient privacy across all languages.
- It should comply with CDC and other regional guidelines.
- A readily available language switcher component should be available when accessing an application through any device or browser.
- To avoid legal challenges, it is critical to have an accurate translation of the health questionnaire and consent form within the application for a given language.

A few other benefits of using Oracle APEX globalization have also been discovered and are illustrated in the Discussion section of this paper.

III. GLOBALIZATION USING APEX

According to Francis Mignault, globalization in a web application has two significant aspects: translation and localization. Translation allows the application to be switched to different languages without duplicating the logic. Localization display the application content in accordance with the location of the end user [13].

Translations: Translations in APEX are based on the concept of shadow applications. After the principal (primary) application is developed, a copy of the application is saved in metadata for every language added to the application [14].

The following are different steps involved when translating the application:

- Configuring the globalization attributes.
- Mapping the primary application ID with the translated (shadow) application ID for each added language.
- Seeding the translated text to the translation repository.
- Translating static texts, dynamic texts, and programmatic texts in the application.
- Publishing the applications after translations.

Configuring globalization attributes: The very first step of globalization is to configure globalization attributes such as date, datetime, timestamp, and timestamp timezoneformats for the applications as shown in Fig. 1. In addition, character value comparison behavior can be defaulted to Database Session NLS settings in the globalization section of the shared components.

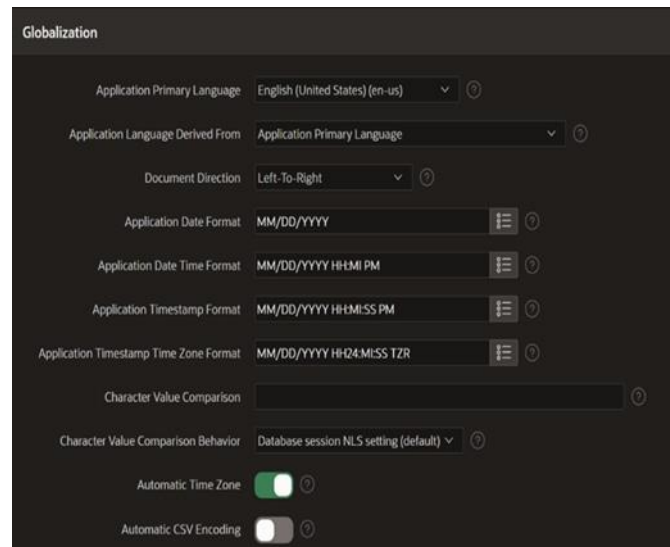


FIGURE 1. Configuration of globalization attributes.

Adding more application languages: All languages to which the application can be translated must be added to the Define Application Language section. A unique translation application ID must be specified for each language, as shown in Fig. 2. These IDs are mapped with the primary application for the corresponding language to generate an application with translated data. An appropriate Document Direction (Left-To-Right, Right-To-Left) must be selected for a given language. As many mappings as required can be created for each language the primary language can be translated into [13].

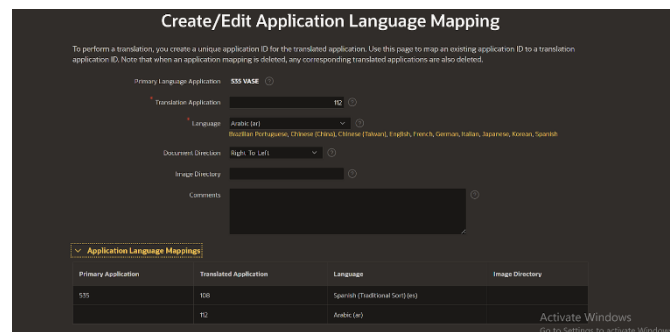
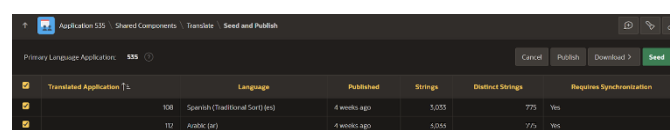


FIGURE 2. Adding languages and mapping.

Seeding the translated text: The APEX database schema (APEX_240100 for the latest version) comprises of a set of tables used for translations, which is called as a translation repository [13]. Once the languages have been added and mapped, all metadata of the primary language must be seeded into the translatory repository, as shown in Fig. 3 [15]. The seeding process extracts all the translatable content of the primary application and populates it in the translation repository.



Translated Application	Language	Published	Strings	Distinct Strings	Requires Synchronization
T08	Spanish (Traditional Sort) (es)	4 weeks ago	5,035	775	Yes
T2	Arabic (ar)	4 weeks ago	5,035	775	Yes

FIGURE 3. Seeding translation applications.

Translating Text: Once translation repository has been seeded, the translated values can be updated either by using the option to download, translate, and upload the XLIFF files or by manually updating the records in the repository. The APEX platform provides an option to translate platform-specific strings, text added through dynamic actions, JavaScript functions, etc., and even the data that will be rendered in various components such as lists of values, interactive reports, and any dynamic regions in the page using multiple translation utilities in the translated section in shared components as shown in Fig. 4 [16], [17].

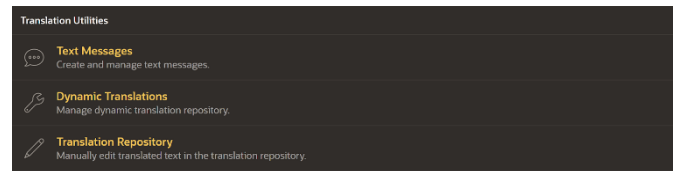


FIGURE 4. Translation Utilities in APEX App builder shared components.

Publishing the applications: After all the translatable text has been updated in the translation repository, the application must be published, as shown in Fig. 5. The publishing process creates a translated version by combining the metadata of the primary application with the translated text from the repository [7]. Every time the primary application is modified, the seeding and publishing process must be repeated for the modified changes to be reflected in the translated application [15].

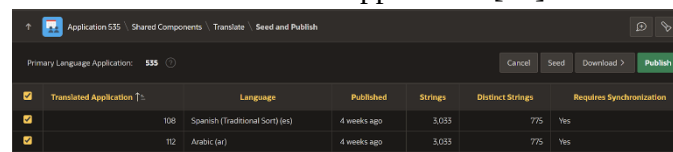


FIGURE 5. Publishing translation applications.

Language Switcher: Fig. 6 shows another vital component of globalization in the APEX platform is the addition of a language switcher component in the application, allowing users to easily change the application's current language preference. APEX switches to the corresponding application internally based on the selected language. While rendering the page, the metadata for the primary application page are retrieved, and the corresponding content is dynamically switched with the translated data.



FIGURE 6. Language Switcher component added to the right corner of the application title banner.

Localization: Developers can further localize the application based on the geolocation of the end user and the selected language to update the globalization attributes such as date, datetime, and timestamp formats and to handle the nuances of the local culture, language, and legal considerations.

By harnessing these excellent globalization features, a comprehensive multilingual vaccination schedule and administration application has been meticulously designed to meet the needs of all residents of Virginia. This innovative tool is mainly aimed at serving diverse communities, with particular attention given to the Hispanic and Arab populations. This ensures that language barriers are minimized, allowing

individuals from various backgrounds to navigate easily, including answering the sensitive health questionnaire and providing consent in the vaccination scheduling and administration process during the pandemic.

IV. DISCUSSION

In addition to the benefits of APEX globalization and the probable shortfalls discussed in the second section of this paper, that is, the Selection of the APEX platform, a few other observations have been made when comparing APEX with Google Translate after the development and globalization of the application. This section presents the following observations.

1) APEX translation utilizes only the texts found in the translation repository. If a translation was not available in the repository or metadata, the original text was displayed. Consequently, only the metadata are translated as needed, whereas any data entered by end-users in forms, reports, and similar outputs remains untranslated. This approach complies with the established requirements. However, Google Translate dynamically translates everything rendered within the page, including the data entered by the end-user or rendered from the database. This scenario may have a significant impact, especially when verifying the patient's vaccination history, insurance details, and so on.



FIGURE 7. Registrant Information in English.

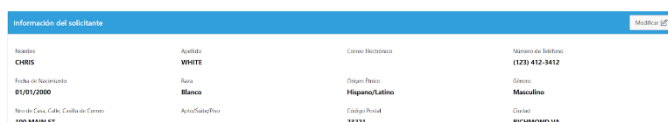


FIGURE 8. Registrant Information in Spanish with APEX translation.

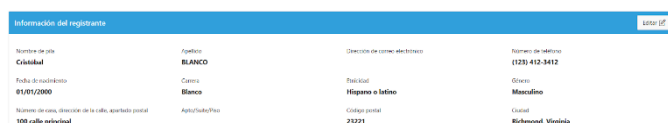


FIGURE 9. Registrant Information in Spanish with Google Translate.

Fig. 7 is a section of the page in the primary application that shows the registrants' details in English. Fig. 8 illustrates the same section when Spanish was selected from the language switcher on the page for APEX translation. Fig. 9 shows the same section translated into Spanish using Google Translate. It is worth noting that even the first and last names of registrants have been translated, irrespective of the application's context.

2) The document direction will be updated based on the selected language attributes and mapping in APEX translation. This option is not available in Google Translate.

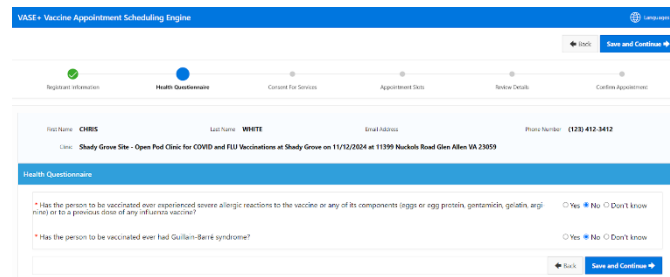


FIGURE 10. Health Questionnaire in English

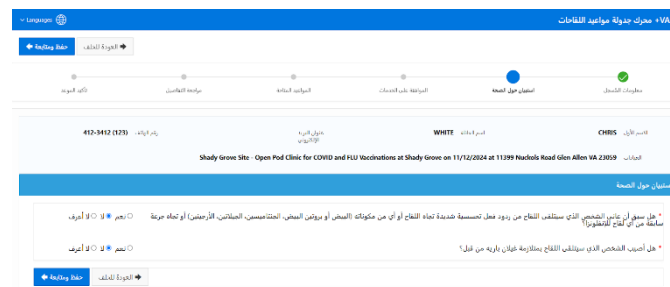


FIGURE 11. Health Questionnaire in Arabic with APEX translation.

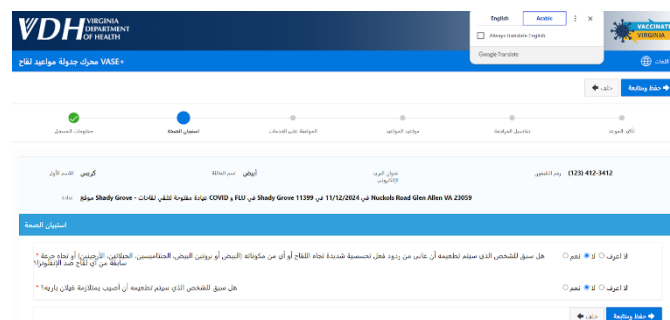


FIGURE 12. Health Questionnaire in Arabic with Google Translate.

Fig. 10 shows a section of the primary application of the Health Questionnaire. Fig. 11 shows the same section when Arabic is selected in the language switcher for the APEX translation. It is evident that the entire layout of the application has changed to a "Right-To-Left" direction, which is appropriate for the Arabic language. In contrast, Fig. 12 illustrates the same section translated into Arabic using Google Translate. Although the text has been translated, the page layout remains in a "Left-To-Right" direction, which is not user-friendly.

3) For APEX translation, the preferred language must be set only once, and this language remains consistent across all pages within a given session. In contrast, Google Translate requires the user to translate the page each time they navigate to a new page; this preference is not retained.

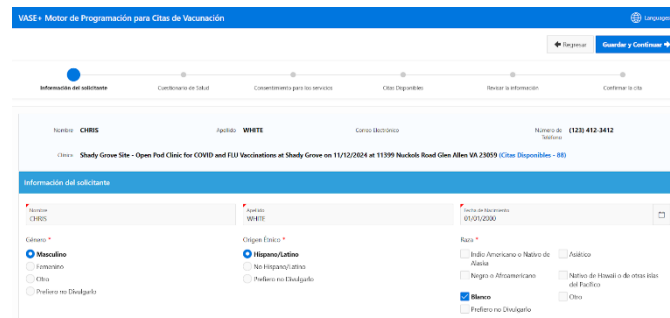


FIGURE 13. Registrant Information in Spanish with APEX translation.



FIGURE 14. Health Questionnaire in Spanish with APEX translation.

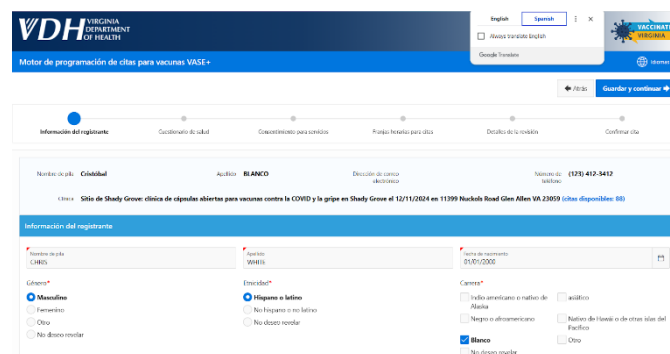


FIGURE 15. Registrant Information in Spanish with Google Translate

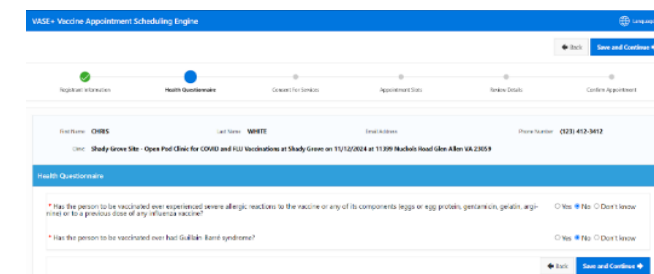


FIGURE 16. Health Questionnaire (next page) switching back to English.

Fig. 13 shows the first page, Registrant Information, which was translated into Spanish. Fig. 14 illustrates the subsequent page, Health Questionnaire, in the appointment scheduling process, clearly indicating that the page has been rendered in Spanish without needing to reselect the language, as it is set as the preferred language for the session. By contrast, Fig. 15 shows the first page of the app after

manually selecting Spanish using Google Translate. However, Fig. 16 shows the next page, which was rendered in English instead of the previously selected Spanish. Users of the application

4) The language switcher component is located in the app title section and function independently of the device or the browser. While Google Translate is available by default in the Chrome browser, users must install an extension to access it in other browsers such as Microsoft Edge or Safari.

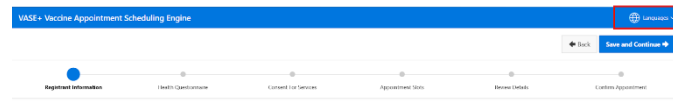


FIGURE 17. Language switcher component in Google chrome.

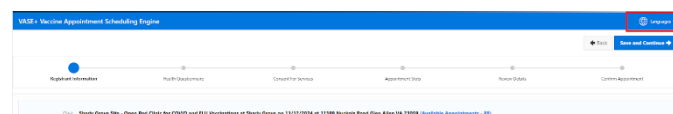


FIGURE 18. Language switcher component in Microsoft edge.

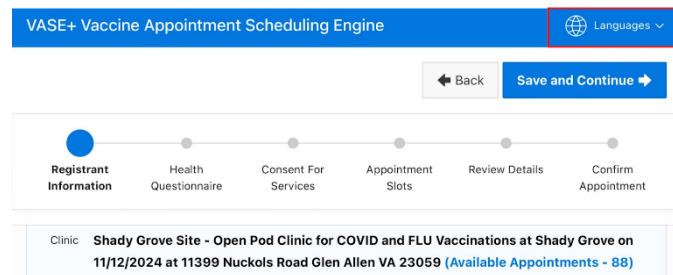


FIGURE 19. Language switcher component in Apple safari.

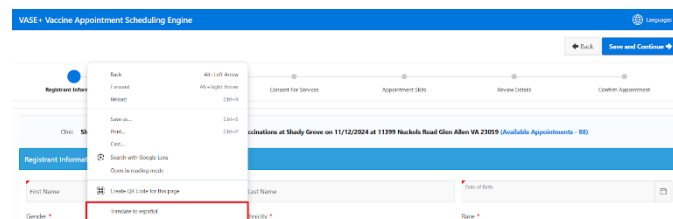


FIGURE 20. Google Translate option in Google chrome browser.

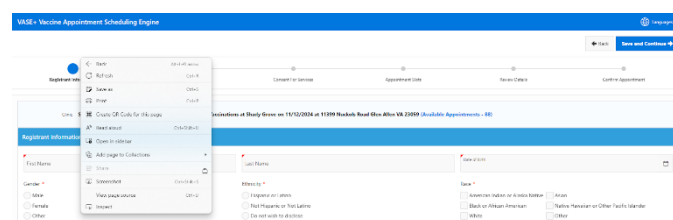


FIGURE 21. Google Translate option missing in Microsoft Edge browser (by default).

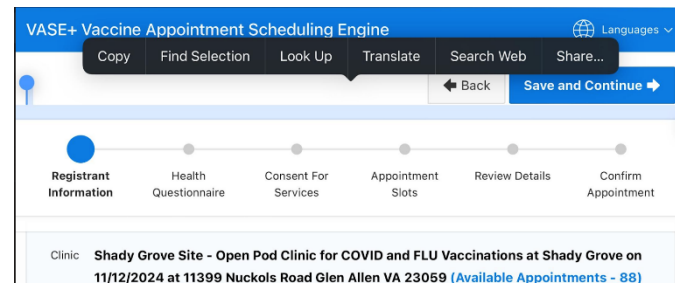


FIGURE 22. Google Translate option missing in Apple safari browser (by default).

Fig. 17, 18, and 19 illustrate the availability of the language switcher component on Google Chrome, Microsoft Edge, and Safari, respectively. As shown in Fig. 20, the Google Translate option is available by default on the Chrome browser. By contrast, Microsoft Edge features its own translation option, as depicted in Fig. 21, and the same is true for Safari, as shown in Fig. 22. Microsoft Edge and Apple Safari have their own translation options. Without the installation of an extension, the Google Translate option would not be available for third-party browsers.

V. FUTURE WORK OUTLOOK

While the feedback for the application has been overwhelmingly positive, there have been several requests from Local Health Departments to include more languages apart from Spanish and Arabic. Considering the demand for several other languages and the limitations of resources, it can be challenging to include translations within APEX for all the requested languages. However, it is recommended that the application be upgraded with the following changes to create an optimal solution.

Upgrade the application to a hybrid model with existing built-in translations for popular languages such as Spanish and Arabic and an optional integration feature to utilize the Google Translate API for other on-demand languages.

The language switcher displays a segregated list of application-defined languages and other languages supported by Google Translate. When an application-defined language is selected, the page should be rendered with translated metadata from the database, and when another language is selected, the Google Translate API can be invoked to translate the page to that language.

A disclaimer banner can be displayed dynamically at the top of the page. The disclaimer should effectively communicate with the user about any probable inaccurate accuracy and should be well drafted to legally protect the organization.

To expedite the process of adding a new language to the application of APEX globalization, that is, populating the metadata with translations for the new language, a translation workflow module can be developed in which professional translators have access to save the translated text for a given metadata text in a given language, which can be verified and approved by the application owners. Once the translated text repository has been approved, metadata can be saved programmatically in the APEX translatory repository for the newly added language.

VI. CONCLUSION

Google Translate, powered by GNMT, is renowned AI translator that adopts sentence-based translation. In general, translation algorithms produce meaningful translations but may miss nuances and may not be as accurate as the original message. However, it is real-time and can be free of rich resource requirements.

The built-in globalization features of the Oracle APEX provide superior accuracy and customization, which are crucial in the healthcare sector. The application can be translated and localized securely and precisely for better user experience. However, this is not a real-time solution and requires relatively more resources.

This paper highlights the strengths of APEX globalization compared to Google Translate for vaccine scheduling and administration applications, with various examples when translating to Spanish and Arabic languages. Unlike Google Translate, the Oracle APEX provides the control, accuracy, and data privacy necessary for healthcare applications, making it a suitable choice for developers building multilingual applications in regulated industries.

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