Taking Location-Based Alerts to the Next Level with Geofencing 2.0

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Abstract- *Location-based services (LBS), also known as geofencing, have recently become more proactive, sending out intelligent messages anytime a user enters or exits a defined geographic area. As a result, connecting several geofences over time is difficult. We present a novel way for defining complex geofencing situations as state- and transition-based geofence models. A model of this type takes into account the temporal linkages between geofences as well as the time limits for being inside a geofence or traveling between geofences. These two features are critical for dealing with complex scenarios in which alerts should be given only when a user passes a specified number of geofences in a specific order or departs a geofence after a certain amount of time.*

Keywords- Ubiquitous Computing; Location-based Services,Geofencing; Location-based notifications

I. INTRODUCTION

This article provides a step-by-step overview by specialists for writing a good journal or research paper, beginning with the conception of ideas and ending with their publication. Research papers are highly regarded in the academic community and are an essential component of the PhD curriculum. To fulfill their grades, research scientists publish their findings in prestigious journals. Furthermore, published research work carries a significant weight in gaining admission to a reputable university. Now, we'll go over the tried-and-true methods for publishing a research paper in a journal.

However, for the most part, a mobile device can only work as a reactive, intelligent system. In order to actively support the user, a mobile device must be able to initiate the interaction. Only a few services are currently permitted to interrupt the user under any circumstances or according to their own set of regulations.

The next generation of location-based services (LBS) is known as proactive LBS, and it incorporates an additional context aspect. This causes a mobile device to initiate a dialogue with the user whenever it enters or exits a geofenced area. Consider sending a geo-notification to travelers arriving at a given airport, asking them to complete a location-specific survey. If the survey structure is to take the passenger's personal history into account, such as the airport from which the passenger first departed, the trigger conditions of the location-specific survey must temporally relate at least two different geofences: the airport of departure and the airport of arrival. Otherwise, regardless of their previous locations, all passengers arriving at the desired airport would be asked the same question.

To the best of our knowledge, there isn't a modern server-based geo-notification system that can be parametrized with trigger conditions made up of geofences with time-related relationships. At the moment, manual implementation of each intricate geo-notification scenario is necessary. So, neither the non-technical device user themselves nor non-technology-related staff members of, for example, the logistics or marketing departments are able to define their specific use cases. This work presents a unique state-based method for modeling temporally connected geo-notification systems in order to address this flaw.

As a proof-of-concept, we developed an appropriate visual editor for the design and modification of arbitrary use cases and the associated proactive LBS that can handle temporally connected geofences.

II. RELATED WORK

Notifications should not be sent to mobile devices outside of the bounds of the area. The solutions that are currently commercially available on the market can be distinguished depending on how they incorporate the geofencing capability into the mobile operating system, a 3rd Party SDK, or a number of domain-specific apps, to name a few [1, 2, 3]. Geofencing is mostly known in the research community for two problems: its effect on mobile device energy consumption [4] and its effect on wireless access network traffic load [5].The privacy of a mobile phone user is also seriously jeopardized by geofencing in the event that their position is continuously determined by the network operator's infrastructure or sent to a third-party service [6]. The purpose of this study does not address these issues, despite the fact that they are significant and may even be essential for the deployment of future proactive LBS. Geofencing has become a ready-to-use technology for developers of third-party applications in the areas of regional warning systems, location-based gaming, caretaker services, electronic tourist guides, location-based recommender systems, and so on, with the emergence of geo-notification functionalities built into common mobile operating systems. The concept of a single and independent geofence, as argued in [7], is sometimes insufficient for the delivery of appropriate location based notifications. All of the aforementioned solutions, however, only associate a notification with the event of entering or leaving a single dedicated geofence. As a result, temporal dependencies between geofences are completely ignored. It is not possible to define temporally related geofences using one of the existing graphical editors, and neither are existing geo-notification systems capable of detecting mobile devices passing through different geofences in a predefined order or within fixed time slots.Only the Cascadia [9] system and the Topiary [8] tool allow for the modeling of sequences of contextual states based on RFID tags or arbitrary location representations. Cascadia, unfortunately, does not support the modeling of conditional scene transitions or looping scenes. Furthermore, neither of these approaches has been properly formalized

III. CONCEPT

There are two types of addressing schemes for geographical areas which are geofencing and symbolic. Geometric addressing uses geometric shapes for defining certain geographical areas.

Category	Addressing Scheme	Instances	Example
Spatial Geofence	Geometric	Circles, Polygons, Polylines	”Region of Berlin”
Hierarchy-based Geofences	Symbolic	Country, City, Street, Building,...	”Germany/ Berlin/Ernst-Reuter-Platz”
Network-based Geofences	Symbolic	Cell-Ids, WLAN-(B)SSID,...	”BSSID of WLAN in a McDonalds restaurant”
Semantic Geofences	Geometric and Symbolic	Combination of the above	”Close to a McDonalds restaurant”

Table 1. Categories of Geofences

This can be e.g. a circle. In contrast to geometric addressing, symbolic addressing maps a symbolic key to a certain geographical area,for example, ”Germany/Berlin/Ernst-Reuter-Platz” or ”Main Building/1stFloor/Room1001”. If an entry or exit event is recognized in a specified geofence, the first generation of geofencing systems sends out a geo-notification. However, present techniques are confined to defining a single geographical region. At the moment, it is not possible to define an advanced scenario that includes a geofence and its spatiotemporal consequences to another associated geofence. Furthermore, geofences with temporal limits cannot yet be parametrized. These types of characteristics necessitate a complete model that is powerful enough to clearly formalize intricate geo-notification scenarios. This model would also allow the use of several types of geofences in the same instance of the model and is agnostic to the geofence category utilized. Furthermore, this comprehensive model-based approach, is introduction within the following subsections. In addition, an example is given which demonstrates the capabilities of our approach to model sophisticated geo-notification scenarios.

IV. Geofence Model

In order to express complex geofences in a simple and precise manner, a suitable modeling method must be specified. In general, we carefully adhere to Dey's method of treating an object - in our case, a mobile device - to be always within a defined contextual state.

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 05 | May - 2023 SJIF 2023: 8.176 ISSN: 2582-3930

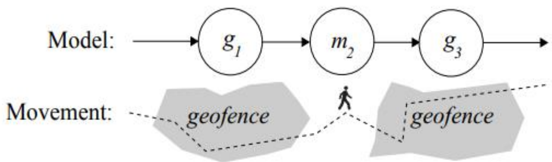


Figure 1. An exemplary abstraction of movements using a behavior model that is build upon the contextual states (circles) and its transitions (arrows).

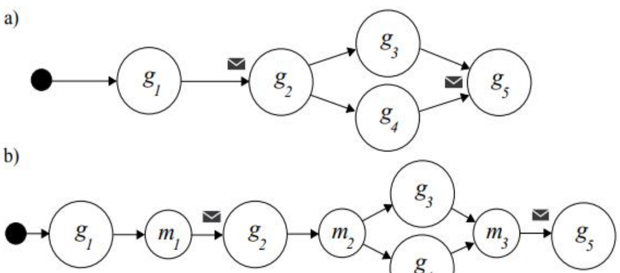


Figure 2. An example of an advanced geofence with 2 entry geo-notifications associated with the geofences g_2 and g_5 (marked by a mail icon). a) a simplified visualization with hidden motion states, b) a complete visualization including motions states

To be more specific, in a geofencing scenario, the mobile device can be either inside or outside a geofence. As a result, as seen in Figure 1, the behavior of a mobile device passing several geofences can be modeled using a state-transition model . A behavior model of a system is typically used to comprehensively describe the dynamics of a subset of a system's attributes from an abstract perspective. In our scenario, we're utilizing a behavior model to explain how a mobile device should "behave" in order to get geo-notifications. Thus, the behavior model does not represent the wide range of behaviors that a mobile device exhibits in response to its location, but rather formalizes the required behavior.

A =< G, M, π, T, Ω, ω, D, dg, dt >

with

G: set of all geofence state

M: set of all motion states

π : initial state π ∈ G

T : G × M × G transitions between geofence states

Ω: set of all notifications

ω : G × Ω × Ω mapping geofence states to notifications

D : set of all durations constraints

dg : G × D mapping geofence states to durations

dt : T × D mapping transitions to durations

Figure 3. Geofence model of a single geofence of the current generation.

A geofence model is a state-and-transition-based behavior model of an advanced geofence. A state, in the traditional sense of state machines, is thus represented by a geofence state or a motion state. Arbitrary entry and/or exit geo-notifications can be linked to a geofence in the same manner that current generation geofences can. A transition in between two geofences specifies their temporal connection. The direction of the transition determines the temporal order. A transition from g1 G to g2 G, for example, says that the geofence g2 becomes visible to a mobile device as soon as it enters geofence g1. Observable indicates that g2 is visible and will be used.

Observation at Runtime:

In the real world, a mobile device's position changes continually and without interruption. Unfortunately, a mobile device's position can only be tracked based on discrete location events. The location events are generated either by the mobile device using a device-centric positioning mechanism or by the surrounding infrastructure using a network centric positioning technique. Because a geo-notification system is in charge of tracking the location of the mobile device, it must be able to determine the contextual state of the mobile device based on these location events without ambiguity. To put it another way, every incoming location event must be mapped to either a known geofence state or a motion state.We consider the mobile device to be positioned in the basic settings..The geo notification system assumes the mobile device is in the beginning state of an analyzed geofence model in this situations provided X as the collection of all location events and the function: X G true, f also that determines if the position is within the provided geofence, the next contextual state - being within the next geofence state

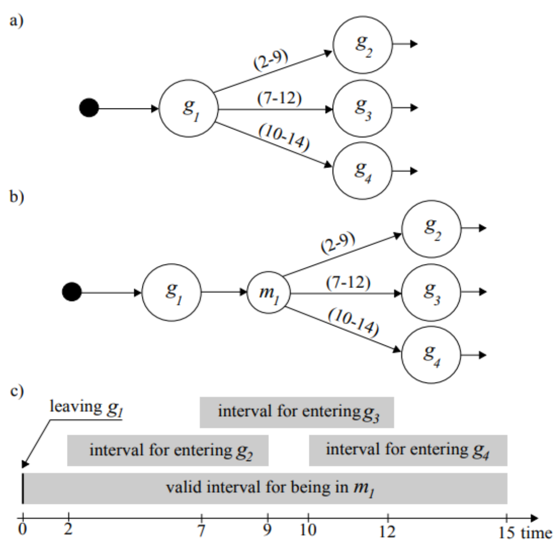
International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 05 | May - 2023 SJIF 2023: 8.176 ISSN: 2582-3930

$X \to G$ as follows

$$f_{initial}(x) = \begin{cases} \pi \text{ when } \neg\exists(\pi, m, g') \in T | \alpha(x, g') \\ g' \text{ when } \exists(\pi, m, g') \in T | \alpha(x, g') \end{cases}$$

Example:

The following informal location-based marketing example highlights the formalization capabilities of our modeling method: "Anna and her friends go to the Cinestar theater and plan to eat afterwards at the nearby McDonald's. McDonald's and Cinestarm, fortunately, collaborate by delivering advanced location-based discount coupons to each other's customers. Anna spends two hours at the movies with her friends before heading to McDonald's. Because the restaurant is nearby, it just takes her five minutes to walk there. As soon as Anna and her friends are in the neighborhood of the restaurant, they receive a discount coupon for a free hamburger that is specifically directed to Cinestar visitors. The same is true for James, who sits on a who sits on a neighboring table. He chooses to eat first at McDonald's and then go to the movies. Because he was an immediate customer at the Fast-Food restaurant he will receive a discount coupon for a blockbuster movie."



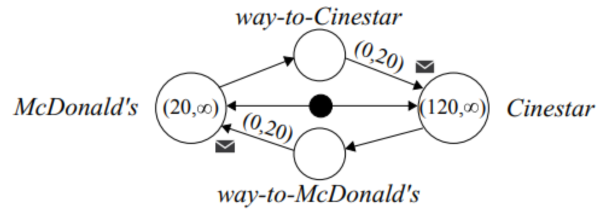


Figure 6. An example of a geofence model with 2 temporally related geofences and 2 entry geo-notifications.

The geofence model of the scenario is exemplary visualized in Figure 6 and formally described as a 9-tuple:

G	{Cinestar, McDonald's}
M	{way-to-McDonald's, way-to-Cinestar}
π	Berlin without Cinestar and McDonald's
T	{(Cinestar, way-to-McDonald's, McDonald's), (McDonald's ,way-to-Cinestar, Cinestar)}
Ω	{'Free Hamburger','20% off for new blockbusters'}
ω	{(McDonald's , 'Free Hamburger'), (Cinestar , '20% off for new blockbusters')}
D	{(0,20), (120,∞), (20,∞)}
d_g	{(McDonald's,(20,∞)),(Cinestar,(120,∞))}
d_t	{((Cinestar, way-to-McDonald's, McDonald's),(0,20)), ((McDonald's ,way-to-Cinestar, Cinestar),(0,20))}

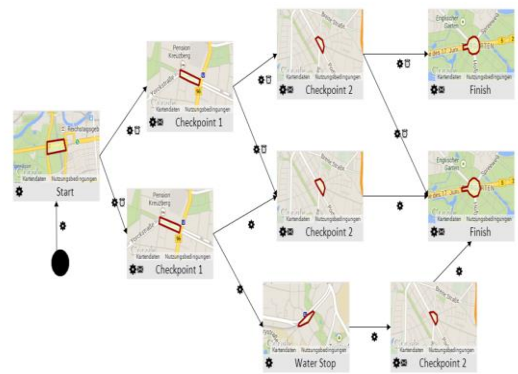
In this example, we assume that the McDonald's restaurant requires customers to remain longer than 20 minutes in order to be considered for the movie coupon. The same is true for Cinestar visitors, who must stay at least two hours in order to receive the voucher notification at McDonald's. To estimate that clients will go immediately to the other venue, we consider a maximum travel time of 20 minutes between McDonald's and Cinestar. Otherwise, a prospective coupon will not be validated and will not be delivered to the user's device.

V. PROOF OF CONCEPT

Although this modeling approach can be viewed as a general method for specifying temporally connected geofences without concern for implementation details, it must be implemented within a prototype to demonstrate its usefulness and identify implementation issues. As a result, we built a prototype of a geo-notification system that supports Geofencing 2.0 and tested it in real-world Our geofencing system, in general, consists of a geofencing server within the infrastructure and a geofencing client on a mobile device. Our prototype is a geofencing system that is controlled by a server. In this situation, the computationally intensive task of determining whether or not a mobile device is placed within a geofence is determined by the server rather than the mobile device itself. By allowing a theoretically endless number of geofences and even geofences with arbitrary geometries to be monitored by the system, such a method overcomes the battery and computational capabilities-driven disadvantages of device-based geofencing systems. Furthermore, geofences can be added or adjusted on the go at the server using, for example, our user interface, without affecting the mobile device's energy usage through a heavy-weight synchronization. However, all this comes at the price of communication. During runtime, the mobile devices are required to localize themselves on a regular basis in order to notify the server about location changes. A mobility monitoring unit on the server-side is not only in charge of monitoring the mobile device’s location with respect to geofences but is also in charge of minimizing the communication needed because it is neither necessary nor practical to notify the server about every location change.

VI. GEOFENCING SERVER

TThe geofencing server can be divided logically into two parts: the user interface for defining geofence models using a visual editor (also known as the Geofence Designer UI) and the mobility monitoring unit. The prototype is a web application that runs on an Apache Tomcat 7.0 application server. PostgreSQL's PostGIS extension is utilized to store geofences and run spatial searches, while a MySQL database is used to manage users. A User Interface for Geofence Designer A Geofence Designer UI was built, similar to the Scenario UI shown in or Topiary's Storyboard seen in , to allow regular users to easily and understandably build their own scenarios. However, we did not include a role idea because a geofence model only examines the movement and development of a single person. Geofence states and transitions are defined intuitively using familiar GUI elements. Because of the nature of our modeling approach, multiple identical usage scenarios are possible. Last but not least, geofence statuses can be coupled with geo-notifications of entry and/or exit. These notifications can contain any type of information, such as different callback-URLs to initiate a website or web service call, or message text to be displayed to the user. Because the Geofence Designer UI is based on HTML5, JavaScript, and PHP, it can be accessed with an ordinary web browser (Figure 7 shows a screenshot). Once the design of the scenario has been completed by the user, an instance of the geofence model in the form of an XML document is passed to the mobility monitoring unit. A validation check is executed on the server immediately after receiving a new scenario. It checks for the applicability of the scenarios. created scenarios and refuses corrupt ones that are not compliant with the requirements of the modeling approach.



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VII. GEOFENCE CLIENT

The prototype geofencing client was built as a standard Android app. As previously stated, this client is primarily responsible for carrying out the geofencing server's location update strategy. Because the geofencing client is on a mobile device, this must be done in an energy-efficient manner. We choose to employ the Android operating system's low-energy geofencing capabilities to monitor the safety zone. As a result, a safety zone is considered as a single circular geofence with an exit requirement on the mobile device.. Unfortunately, we noted a significant delay between exiting the safety zone and being warned by the system. To address this issue, the radius of the safety zone is reduced by a particular amount. While the safety zone and its implementation have a significant impact on overall energy consumption, an appropriate selection of a positioning mechanism must also be addressed. As a result, we apply a device-based smart combination of several positioning techniques suggested by to reduce battery consumption while maintaining sufficient position precision. Furthermore, the geofencing client makes use of recent mobile sensing capabilities provided inside the Android operating system's activity detection unit by disabling placement when a device is moved. This is especially useful for mobile users who live near a geofence's border. If the geofencing client receives notification of a geo-notification from the geofencing server, it will appear immediately as a notification.

Working :

1) Sign-up: The user can register themselves as Admin or as a client. An admin is the storekeeper who uploads their product details on the site.

2)Sign in: The User or Admin can log in with their password and email id and track their products .

3) Uploading shop details:

This section is for the admin who registered and uploaded their product details .

4)Show list: This is for users who can see different product details by login .they can track the product and see their location for order purpose.

VIII. Evaluation

The prototype was tested under real-world situations, with the emphasis on the mobile device's energy usage as well as overall functionality. Over the course of six days, four probands - who could only move by foot or bicycle - were outfitted with similarly configured LG Nexus 5 cellphones that were linked to the same 2G/3G cellular network. The probands were instructed to use the gadgets only for short-term control purposes. On the first day, we assessed energy consumption without the Geofencing client installed on the mobile device to determine its impact on overall energy use. At the second day - with a Geofencing client installed on the mobile device -, ten scenarios, comprising two temporally related geofences each (distance between 0,5 to 1 km), were uniformly distributed over the testing area (inner-circle of Berlin with approx. 89 km2) and communicated to the probands. These scenarios were active for all probands at the same time. Each single geofence had a rectangular shape with a dimension of approx. 300m x 300m. For each following day, we increased the number of scenarios by 10 because the energy-consumption is expected to increase with the number of active scenarios. At the end of each day, the probands were instructed to document the amount of false positives, false negatives and true positives. The results are shown in Table 2. As expected, there is a significant correlation between the number of location updates and the energy-consumption, although we identified some outliers. Hence, the amount of location updates is a strong criteria influencing the energy consumption, but not the only one. The activity-recognition engine (which is active while in a geofence border region) and the received-signal-strength of the cellular network signal are also depleting the battery. Furthermore, the greater the density of scenarios inside a restricted zone, the greater the likelihood of an increased location update rate. Nonetheless, the energy usage from the Geofencing client is relatively modest. Above all, an average user is unlikely to construct more than 20 personal scenarios. The number of false positives - none were recorded - was expected to be minimal since it is less likely to be mapped mistakenly to two geofences in the correct order than to a single geofence. A disproportionately high number of false negatives can be identified.

IX. CONCLUSION

We proposed a powerful strategy for modeling the next generation of geofences with spatiotemporal linkages in this research. Using a state and transition-based behavior model, our solution allows for the flexible specification of advanced geo-notification situations. Geofencing 2.0 can have an immediate and direct influence on current LBS applications while also paving the way for new. Geofencing 2.0 can have an immediate and direct influence on current LBS applications, as well as pave the way for more advanced geo-notification situations, particularly in industrial applications such as fleet management or process automation. However, mobile phone users will benefit from Geofencing 2.0 because they can easily and intuitively construct their own use cases using our Geofence Designer UI.

X. FUTURE WORK

Despite the positive evaluation results, there is still room for parameter adjustment. For example, determining an optimal trade-off between the size of a geofence border region and the required precision of geofence enter and leave detection. Furthermore, adjusting the periodic update interval at the border region based on the velocity of a mobile user might be considered. The technique can also be extended with other context elements, allowing not only geofences but - more broadly - contextual fences to be built, referred to as context fencing. Even the modeling approach itself can be modified by allowing nested contextual states or incorporating counter-constraints. These limits could be used to limit access to alerts in marketing and gamification contexts, for example."The voucher will be given to the first hundred customers." Furthermore, counter-constraints would allow scenarios with collaborative support by activating notifications only if a specific number of users are in the same contextual state. It is also important to note that our approach does not necessitate the keeping of the mobile user's specific location and trail. In fact, only the most recent contextual state is necessary, which also removes information from prior pathways. However, privacy protection can be enhanced further by employing well-known obfuscation methods.

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