Designing an Optimized Alert System Based on Geospatial Location Data

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Abstract

Optimizing responses to various crises is a critical task for the government, institutions, first responders, and everyone involved in public safety. This paper describes the design methodology of ongoing research for planning, implementing, and analyzing the operation of a software application for an optimized crisis alert system. Design decisions are based on previous research, system performance requirements, and adaptive strategies for situational changes. The development includes the creation of an application for smart phones driven by user geospatial location. In the event of a crisis, user location determines the formation of categories that are assigned a risk level based on proximity to the crisis location. Notifications are distributed to users in the immediate category followed by lower risk users further and further outward. Integration and testing will be done with the existing Virginia Tech alert system. This design will yield an optimized, reliable, and situationally customized crisis notification system.

1. Introduction

It is 10 AM on Wednesday morning. Professor Smith has just begun her lecture on an introduction to macroeconomics to 500 students in Classroom Hall. Other classes have begun on the other floors of the building. Nearby buildings are filled with students eager to learn, as other students remain in their dorms, having chosen later classes or having failed to get up at their alarm clocks. On the far end of campus students are in the gym for their morning exercises. Still, others are in the nearby veterinary clinic working on labs. Many graduate students are working in off-campus research labs while others are at conferences in Big Town. All continues as normal until a late arrival to the macroeconomics class notices a person placing a suspicious looking package outside the classroom exit door. Being aware of this unusual behavior, the student notifies the police. At this time the police recognize the need to evacuate the building and notify the rest of the campus of this threat and the potential for others. A message needs to be sent to all students immediately to make them aware of the potential threat(s). The problem is that sending a simultaneous message to all 31,000 students as well as many more faculty and staff is ineffective and likely to be extremely slow. Mass broadcast will likely notify many of the students who are not immediately threatened well before students potentially in proximate danger. Students and faculty in the macroeconomics classroom must be notified first with the rest of the campus community who are local today being notified in waves based on their current proximity to the threat. Next, students in adjacent space along with others who have a high likelihood of moving across campus in the direction of the threat must be notified. Then, the general campus community must be notified. Throughout this process, it would be wasteful to first notify anyone who is either off-campus that day, or actually not based on the main campus, but based in one of the two auxiliary campuses many miles away. This scenario describes the general situation that we are looking to address in this project. Using geospatial information, typical administrative database reports, along with information obtained from social networking, our system is able to decide on optimal notification strategies and report these to automated notification systems, or to human operators to support their decisions.

2. Related work in crisis management

There are many different scenarios and environmental factors which can give rise to a crisis. Natural crises, such as severe weather, are just the beginning and many other human contrived actions can occur that create highly life threatening and urgent situations. Case studies show the complexities of response and recovery surrounding these events. A study done after an actual incident involving a gunman in a college classroom outlines the reactions and concerns of directly and indirectly related individuals. Themes such as campus safety, response procedures, victim psychological welfare, as well as considerations for other external groups were explored. Data showed the pressing need and call for a centralized emergency plan[1]. If designed appropriately, technological

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communications and systems can aid in emergency management and planning. Some key features include providing accurate and timely information as well as personnel and organizational communication channels. Emergency plans and procedures almost never fit the exact needs required during and after a crisis as they are non-routine, highly variable, and often abrupt occasions[2]. This leads to questions of how to be equipped to properly react in an adequate time frame. When lives may be at stake efficiency and performance are a huge concern.

Information technology and systems can be utilized to create communication channels to help quickly disseminate information. Traditional alert systems make use of SMS messages as well as phone calls to reach users who are now more connected than ever, often carrying numerous devices such as tablets and most importantly smart phones. The use of social media and technology to send and gather information during and after major crises has risen. New technology paired with a photo sharing social media site, Flickr, was analyzed in relation to six chosen disasters. Emphasis is placed on the use of social media as "citizen journalism" and "self-organization" for conveying messages, spreading information, as well as providing a source to be utilized by news agencies and organizations for disaster response, recovery, and education[3]. It is known that with new technology and automation arise new concerns. Complications such as information overload and the user perception of messages as "junk" often surround the use of multiple communication channels, especially computer-mediated communication systems (CMCS's). Proper message filtering and organization are required to minimize these negative effects[4]. The importance of "fast, accessible crisis information" and the increasing use of technology to ensure quick delivery with various communications can also lead to questions of how to control the validity of the messages and prevent any illegitimate and potentially harmful communications. Future research is suggested for investigating how to mitigate these risks and analyze the effectiveness of messages delivered in response to a crisis and the technologies utilized[5].

Current systems send text messages to recipients in response to crises. The FEMA Wireless Emergency Alerts, WEA, system sends text messages for extreme weather, threatening situations, AMBER, and presidential alerts in the case of a national emergency. Geospatial location is used whereby capable cell phones within range of cell towers in the area are notified[6]. Work is being done to prepare requirements and design a Commercial Mobile Telephone Alerts System, CMAS, which allows for commercial mobile service providers, CMS, to transmit emergency alerts by text to subscribers[7]. Many universities of all sizes have adopted emergency communications systems utilizing emails, voice messages, loudspeakers, displays, and text messaging[8].

Geospatial information has been recognized as an important design goal for integrating assessments, reports, and notifications into a “common operating picture”[9]. The design guidelines for the current Virginia Tech alert system, VT Alerts, include multi-modal communications with a preference for faster text messaging over email as an estimated ninety-six percent of students at the university carry cell phones everywhere[10]. Mobile communications by location are important when fires and natural disasters affect specific geographic locations. Bomb threats often name certain buildings and reporting calls localize crisis situations. Case studies show that many human driven crisis situations also involve one location or can be tracked and localized in specific points[1], [10].

The next new phase for alert system design involves the addition of the new smart phone application capabilities of delivering push notifications to users in a massively shorter time frame. This timing is perfect for adding key optimizations and functionality to advance the system to be able to deliver communications to the most at risk users based on their current location first. Geospatial location can not only aid decision makers, but is a key element for communications. This also provides the opportunity for message differentiation, an essential step in being the most prepared to quickly and efficiently communicate specific messages to users.

3. Broader applications

This particular design methodology can be applied and expanded to meet the needs of specific crisis, emergency, or other notification or communication systems. The added functionality of prioritizing the send order and differentiating the notification messages by user location is applicable and would strengthen alert systems of all levels. It can be applied to community, state, and even national level alert systems. The technology and methods used for tracking, storing, and grouping users for notification delivery order and differentiation could be utilized with other diverse systems. Mass or group directed communications within the military could be enhanced with location data. Scenarios could include field communications and even ship or ground weapon launch verification. With the addition of user database attributes, such as military rank, messages could be sent to the highest ranking official within certain geospatial locations.

Medical personnel could benefit from this communications technology design as well. Alerts could be sent to on-call medical or crisis personnel within a desired geospatial range. Even commercial uses apply. These include logistics coordination for employees in a location radius to alert them with company messages as well as hazardous conditions such as weather notifications or traffic accidents. More uses also exist in many different fields. A communications technology system with optimized features providing user priority rankings from stored geospatial information and the ability to have reliable and fast differentiated messaging is versatile.

4. Placement and contributions to the field

Research has been conducted to support and explore different communication channel choices and design decisions for alert and emergency notification systems. In a recent collaboration between Virginia Tech researchers and the Communications Network Service (CNS) group, a smart phone application has been successfully created and integrated with VT Alerts. This research and development effort explores the alert interface and what information should be provided to users[11]. Other research has focused on the security and risk evaluation of large scale alert systems. Work has been done concerning the sociological factors of how to get people to participate in large scale alert systems[12], on sociological plus technological factors[13], and on using social network algorithms based on cell phone location to aid in crisis management decision making[14]. Research has also included surveying the impacts of using SMS-based[15] and multicast-based[16] alert systems. Protocols have been evaluated for use for mass public communications [17], but design decisions for message dissemination are not elaborated. Likewise, the social and technical factors of emergency planning have been discussed as equally important, but design implications and methods are not explored[18].

This design aims to provide an implementation of an optimized alert system which will include functionality driven by user location. The design pulls from previous research on the complex social and technical factors corresponding to emergency response and recovery. This knowledge paired with an understanding of needed performance improvements provide a complete base for the design of an optimized alert system. When dealing with often infrequent, but high-risk and variable crisis situations, speed and performance are critical variables that should shape the development process of any management or alert system. Sociological factors play a role in the choice of communication channels, methods, and overall effectiveness of any system. Social media and new technologies have been explored for their benefits to citizens and governments to improve services and communications[19]. Therefore, not only is an operationally sufficient application needed, but testing and analysis must be done to verify the chosen system functionalities and measure their appropriateness. The chosen implementation target for this system design concept is an addition to VT Alerts which allows for an in-depth design example and specific functionalities which can be integrated for future testing and analysis. The following sections provide a detailed look at the Virginia Tech alert system complete with rationale and limitations for the current design, functionality, and performance. This is followed by the case specific system development design outline including requirements for the technical and physical integration with the current system flow model and the human interaction communication channels. Next, specific choices are selected for the system development to uphold the required functionalities and performance targets. Finally, a proposed method for testing and analysis is suggested followed by concluding remarks on the limitations and theoretical contributions of the design.

5. Virginia Tech alert system

VT Alerts is a crisis and emergency management system that sends out text messages to subscribed users in the event of an emergency. These emergencies can range from bad weather conditions, to mentally disturbed assailants on campus, to terrorist actions like those of the Boston Marathon of 2013 and the attacks of September 11th, 2001. Selection of appropriate responses to these situations by individuals and first responders can be strongly driven by the available communication channels to students, university faculty, and staff. The current alert system uses SMS messages and phone calls to notify users, who choose their preferred contact method and provide primary and secondary contact phone numbers. Participation is not required for these contact methods, but is strongly encouraged. Other notification channels are mandatory. These include the Virginia Tech website homepage, emails to all vt.edu accounts, electronic message boards placed in hallways and classrooms on campus, and finally campus sirens and loudspeakers. The diversity of these communication channels shows the high commitment taken to ensure the reliability of the system and is an effort to make sure that if one channel fails to reach a user another channel may succeed[20]. For instance, if a user is walking outside and has no access to the internet or their phone, then the load speaker would be the method most likely to reach and alert him or her of an event. This variation is also an attempt to cover all possible delivery methods in case one system is prevented from functioning from circumstances of an event.

This research focuses on the voluntary, but perhaps most essential channel of communication. As mentioned, with the high prevalence of smart phones and other electronic devices, an enormous amount of people are in constant communication. Considering this, one of the most effective channels for reaching users is through mobile phones. In interviews, the Virginia Tech CNS Chief Technology Architect explained the current system functionalities as well as the rationale for future improvements[21]. The system currently utilizes SMS messaging and phone calls with an upcoming release of a smart phone application for faster push notifications. With this implementation no current geospatial data is kept or utilized other than for the separation of the Northern Virginia and Blacksburg campuses. As with any alert system, reliability and speed are critical. Crisis events are non-routine and often require highly customized emergency procedures. Notifications need to be delivered to all participating users within an acceptable time frame. VT Alerts has over 50,000 users, many with multiple contact methods. For any given alert around 100,000 notifications may be sent. Presently, the fastest notifications are SMS messages, which are sent first. These are followed by the phone calls. With system performance playing such a key role, measures have been implemented in an attempt to prevent any failures and curb delays.

4.2 Current system performance

The current Virginia Tech alert system has several methods in place to attempt to prevent known issues. These important considerations are not easily controlled and can have a devastating effect on system performance. With so many users, the system must consider delays that could come from the attempted delivery of many notifications at once. User send order randomization is used to alleviate overwhelming a single carrier or cell tower. Although this certainly works to reduce the odds of overloading the resources of one company and/or tower, the downside is the randomization itself. The strategy is reasonably effective but unrelated to the situation. The process is the same no matter the crisis or location of the users.

Another high priority consideration is the secondary effect of network congestion. This is not directly related to the processing or functionality of the system, but certainly can be an impediment once the congestion begins. Network congestion normally occurs after an alert is released as the recipients begin to search for more information. This has been addressed in two ways. A mitigation with the use of an interface which provides users with more information was researched at Virginia Tech[11]. As this by no means can be a complete solution, this congestion is still considered a major issue. Added congestion often results in carriers throttling back the network. This in turn can cause more delays which are not small in impact. For this reason the current system has implemented a "stop trying" or "user reached" functionality. The system recognizes that a user has been reached when the user either responds with a "yes" message for the SMS messages or answers a phone call notification. Only then will the system try and reduce the load of messages by attempting to pull the other contact methods for this one user out of the notification queue. This mitigation, however, is only effective if the user responds in time for the system to be able to stop the processing of the other contact methods. Otherwise, it will process every contact number and method for the user.

Overall, with the currently operating VT Alerts, about eighty percent of the registered users are notified within twenty minutes after the alert release. This is a wide span of time mostly due to the phone call notifications. Even so, this performance can be drastically enhanced with push notifications. Table 1 shows the comparison. Within this time frame, any two users in relatively the same location, even within the same building, could be notified anywhere between a few minutes to half an hour apart or more either due to the network congestion or the randomization. Depending on the severity of the alert, this timing could be deemed unacceptable. In the hopes of alleviating or reducing these issues, more situationally customized optimizations can be added to inform recipients with the highest risk level first and then continue to alert at risk users further and further outward from the crisis area. Message differentiation can also be added to enhance the relevance of messages sent to target users, beginning with their location.

Table 1. System performance comparison

System	Estimated Time to Reach 80% of Users
Present	20 Minutes
Addition of smart phone application	3 Minutes

5. Development

Current work is being done to add functionality and optimization to VT Alerts and address known major considerations so that the system will be able to notify users in an efficient and worthy time frame and provide the ability to alert the highest risk users based on the most recent location data. The current design plan defines the risk levels as immediate, high, medium, and low risk and places users into categories. The functionality is fitted into the system process cycle from the first alert release request by the police or management personnel to the processing of user location, notification formation, and message delivery.

5.1. Integration requirements

In order to make sure the optimizations and functionality fit into the process cycle and work flow, procedural information was gathered. The Virginia Tech alert system process begins with an alert triggering event, also termed as a crisis, which poses enough of a threat and risk to warrant notifying registered users. The current database information as well as information flow data initially put into the system at the time of first recognition of the crisis is undergoing changes. These changes lay the foundation to advance the system design. They provide the means to compare a crisis location with user location data and the methods needed to determine the organization of the user groups for notification delivery.

Firstly, Virginia Tech is surveying the entire campus and surrounding affiliated areas. Official street names as well as building names are being created for areas which in the past had no formal identifying name. These addresses are being added to the Master Street Address Guide, MSAG, a key component for GIS technologies such as Google Earth and Google Maps. These services and other database information play a key role in not only allowing the first responder beginning the alert process to mark or indicate an existing affected or occurrence area for a crisis, but also in the process of determining the nearby risk priority groups of users by location.

The second change currently being implemented is the conformity to the Federal Emergency Management Agency, FEMA, Common Alerting Protocol. This is a digital format to standardize data formatting for use within different alert communication systems. These standards require a noted area of influence with each alert request submission. At Virginia Tech, functionality will be developed for the dispatcher or official personnel inputting the alert request into the system web interface. The goal is to avoid pure textual input and include an interface with the ability to locate an area on a map and to draw or estimate a radius of influence, to the extent that a location is known. For Virginia Tech, the first dispatcher is often a member of the police force or crisis/emergency management team composed of university relations staff. These team members are non-police employees considered the best suited to update information for alerts or to begin the request for any follow up notifications. They are less likely to be directly involved with the physical operations and mitigations at the early time of the crisis and less likely be surrounded by distractions, thereby having a decreased cognitive load in comparison to police officers and personnel.

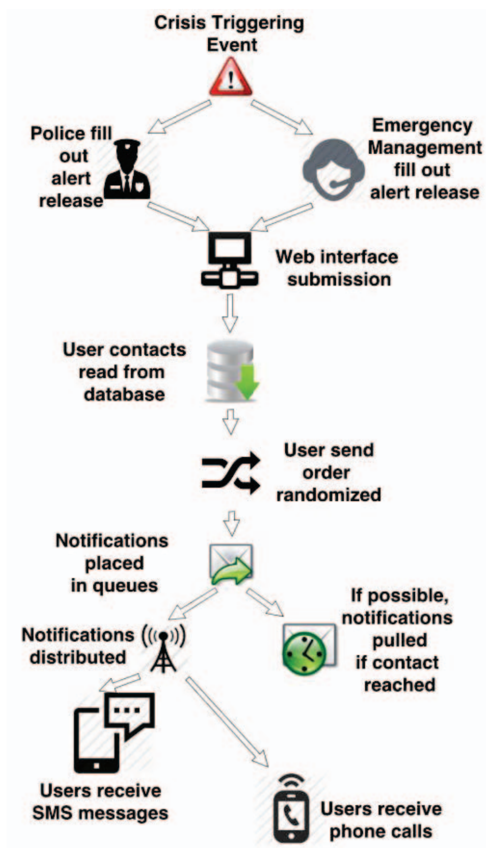

Figure 1. Process flow of current VT alert system

The final change is the release and use of a smart phone application option. It is projected that users will be both more likely to register for VT Alerts and more likely to be quickly alerted. The aim is to dramatically enhance the performance of the system itself, specifically with regard to message delivery time and customization. The new functionality is designed for seamless integration with the system with a goal to enhance and not reduce reliability or security.

5.2. Integration model

The current process flow model, outlined in Figure 1, begins at the start of a crisis triggering event. At this time the first responder, often a member of the police department, fills out an alert release form which is submitted through a web interface. Then, the system utilizes the user information stored in one master database and potentially from multiple standbys. The need for updating a database at the time of release of an alert is rare, therefore, reading is the primary function. Message queues are used as data stores during the alert sending process. SMS messages are sent first in randomized order followed by phone calls. If a user is marked as having been reached and the other contact methods have not been processed, the user's duplicate numbers are pulled. Data logging is maintained throughout the time alerts are released. The responsibility of obtaining and storing the read and time receipts of the notifications is contracted out.

The process being implemented through efforts outside of this research can be seen in Figure 2. This process includes the addition and use of the newly created addresses and street names assigned around the Virginia Tech campus. Conformance to the FEMA, Common Alerting Protocol is the second key addition being added to the system. The advancement of the current web form utilized by the police or university relations personnel to allow for the entry of more specific location information, preferably with a graphical display, ties into this conformance. Lastly, this figure shows the upcoming integration of a smart phone application. This application may later be merged with this research application for testing and analysis of the geospatially optimized and differential messaging functionality.

The final diagram, Figure 3, shows the functionality additions this research is developing and preparing for integration, testing, and analysis. This additional functionality includes a smart phone application for which permissions are set to provide the system with user location data. The location data is stored within the existing master and secondary databases linked to the individual users' data and includes timestamps to mark the time the location is stored, if it cannot be instantly computed. For users on campus, backup location data may be gathered from wireless access points. This information allows the formation of user groups for sending prioritized and differentiated messages based on risk level and user location to the crisis area of influence.

It is important to keep and maintain the existing logging data not only because it is a requirement, but because the send and read receipts give insight into the performance of the system. The number of users reached and other data can be gathered for testing and analysis. Through logging, the entire time from the submission of an alert request through delivery to all of the groups and recipients can be calculated. All other functionalities already in place as well as the reliability and security will remain. These additions aim to increase the reliability, speed, and customizability of the system. Table 2 outlines the main features of the current system, the system modifications outside this research, and the system with the modifications being designed by this optimization research.

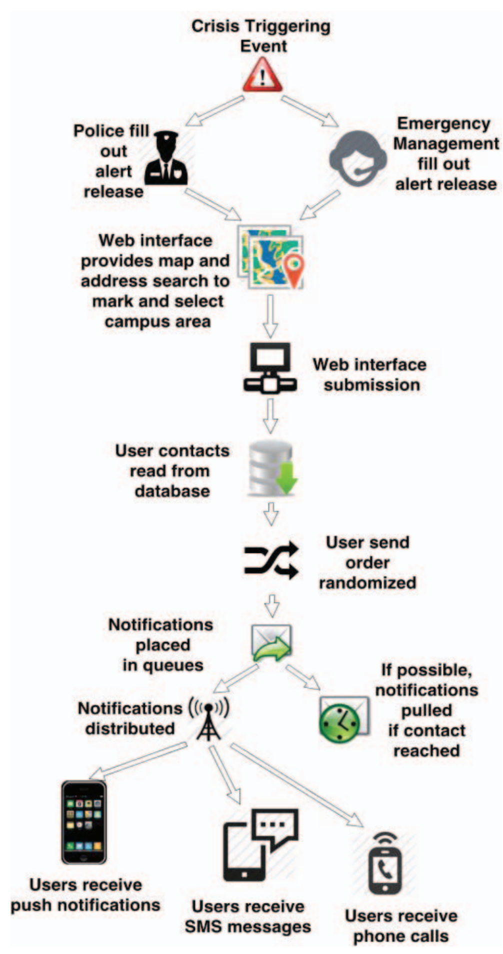

Figure 2. Process flow of VT alert system with on-going changes

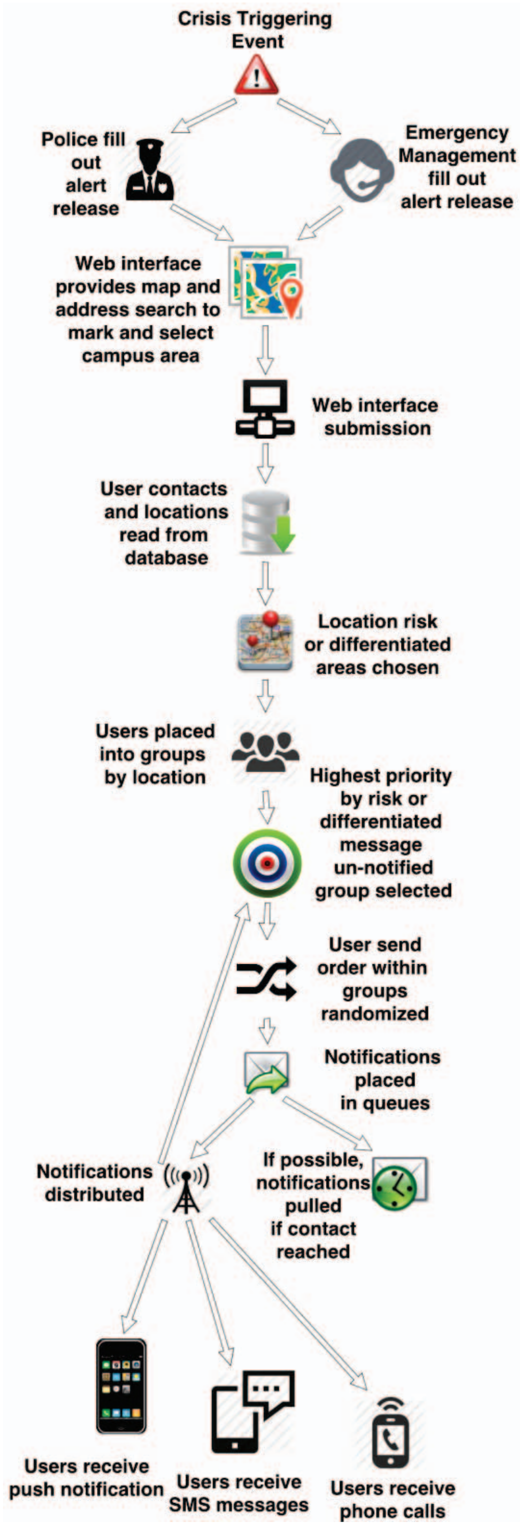

Figure 3. Process flow of VT alert system after in progress optimizations

Table 2. System features outline over time

	Current System	VT Upcoming Release	Optimization Project
Web Interface Alert Release Form	☑	☑	☑
Crisis Area of Influence Marked		☑	☑
Common Alerting Protocol Standardized		☑	☑
Randomized User Send Order	☑	☑	☑
User Reached/ Stop Trying	☑	☑	☑
SMS Messages	☑	☑	☑
Phone Calls	☑	☑	☑
Push Notifications		☑	☑
User Location Risk Assessment			☑
Differentiated Messaging			☑

5.3. Design

There are many optimization and functionality additions being integrated into VT Alerts. Several key design components for this optimization research project include:

- **A smart phone application for fast push notifications**
- **User location awareness and risk prioritized notification send order**
- **Differentiated messaging capabilities**

The design of the new features to be integrated into the Virginia Tech alert system involves the creation of a smartphone application. The application sends push notifications to the participating users in the event of an alert triggering crisis. If downloaded by a significant number of users, these push notifications will drastically decrease the amount of time needed to contact the majority of users. Push notifications are the fastest way to reach users with an estimated eighty percent notified within as little as three minutes. This constantly running application requires data location access permissions.

The next phase in development includes a module with access to the master database and secondary databases. This module quickly orders users into the desired priority ranking groups or other customized groups according to the most recent location data. The alert release form will include the location data and other information in conformance with the FEMA, Common Alerting Protocol. The interface design is out of the direct scope of the development of this application, but the information it contains is pivotal. Crisis location data dictates the rankings of immediate, high, medium, and low risk which drive the notification process. The users closest to the crisis impacted area are placed in the immediate category and notified first. Others are then notified based on risk priority level. In the case of a localized crisis requiring differentiated messages, these groups can be assigned specialized messages along with priority levels. The current method of randomization will be utilized, but within the priority groups.

In the event that the location data of a user cannot be accessed, or in the case that the permissions to access the location of a user have been disabled, there is a second way to access the participating user's location if he or she is on the Virginia Tech campus. The location can be discerned by the wireless access point to which the user may be connected. All of the geospatial information organized into meaningful polygons, such as the perimeters of buildings, is available. This is utilized to gain the location of a user all the way down to the floor and room in a campus building.

Follow up notifications, instructions, updates, or more information can be provided to the users. Having the previously mentioned ability of deferential messaging and user group formation can add highly needed functionality. Message differentiation is a critical element for an alert system depending on the situation. For example, in the event of a bomb threat specialized messages may be needed. If the threat was issued for a particular building, it is important to notify everyone to evacuate. People around the immediate area need to be notified quickly to stay clear. After these groups of users are alerted, those further away from the risk area should then be alerted. Another example in which differentiated messaging is essential is hostage situations. In the event of such a crisis it may be important to notify people in the compromised building to secure their area and shelter in place. All others, ranked in order of importance according to proximity, could be notified based on risk level. In addition, as related areas become cleared or change in risk level, users can be updated with the most recent information.

Differentiated messaging allows for situational customization and the ability to target user groups based on their proximity to the crisis. This also aids in limiting confusion by only sending messages to those who are applicable. Prioritized send orders based on user location help to avoid network congestion and delays, while adding more reliability and efficiency by notifying those in the immediate vicinity first.

6. Proposed testing and analysis

Testing will be done with the VT Alerts by issuing a test alert to users who have agreed to participate in testing. The considerations to be addressed include ensuring that users know the alert is a test. For applications investigating the human computer interaction, HCI, side of how a notification message is displayed this can be tricky. Participants must not mistake the alert for a real notification, but an accurate portrayal of an alert is needed. For this design, the user interface will be considered, but the focus is on the logged location and receipt time of the participants' notifications. The time frame must be acceptable for the category in which the user was placed. Ideally, all users in the immediate category are notified first. After this, the next highest risk category are notified and so forth until all users have been contacted.

Another method for testing is a simulated alert. It is beneficial to look at multiple tests and vary the number of participants in each category. Also, varying the start times for delivery of notifications to the different priority categories of users provides insight into how to properly manage the time between category deliveries. It is helpful to simulate network delay and the secondary effect of network congestion and explore potential delays depending on the size of the priority groups chosen.

There are several noteworthy research and implementation questions. With regard to the storage of user location, the data will be gathered either continuously or instantaneously. If gathered and stored continuously, the question to be addressed is whether the last known location is accurate enough. A timestamp is stored with the location so that if the location data is a decided amount older than is acceptable, the system can instantly poll the location or check if the user is connected to a campus wireless access point.

Another potential complication is determining what should be done when a notification is sent to the vendor and is pending for a long time. A time-out event triggered by a set wait time and followed by a re-try of sending the notification helps to alleviate this issue. It is also be important to vary the efforts made to reach a user depending on the assigned group or risk level. The system will continue to resend notifications to those in an immediate risk area for a crisis event and may not send a re-try for an all clear message to those in low or no risk areas. Finally, user willingness to participate and utilize the new system can be explored with surveys, interviews, and other polling techniques.

7. Limitations and theoretical contributions

Geospatial location is the main criteria for organizing crisis alert notifications within this system design. Relative to the VT Alerts application, the university not only has a Blacksburg and Northern Virginia campus, but has a large population of students living off of the central campus. If a crisis event occurs that can be localized to a specific area, those closest are in immediate risk and should be notified first. This also leads to the need for message differentiation, as those in the midst of a situational crisis need different information and notifications than those too far to be affected. The strength of the design is the optimizations provided by being able to quickly send information to those who need it first and to be able to quickly notify everyone else thanks to the almost instant sending capabilities of smart phone push notifications. If there is no known or relevant location for a crisis, then all groups can be notified independent of location quickly. Why not notify everyone at the same time either way? Firstly, as mentioned, different messages may be needed for specific groups of people in certain locations. Secondly, information overload and confusion may be controlled and avoided by sending appropriate and applicable messages.

Within the information systems field there are many interwoven considerations such as the communication channels chosen and user participation based on sociological factors, technological constraints and requirements, high stakes mental and physical safety concerns, varied user groups, and finally urgent and differing crisis triggering events. Designing a notification system should not just meet an end goal of notifying the users. Who is notified first, the accuracy of information sent, the time it takes to notify everyone, the resulting actions of those notified, and many more questions could become pivotal requirements for the system depending on the situation. This design balances these factors and provides multiple functionality options to best adapt and efficiently notify a given user population, in this case a university, of a crisis. The system is not utilized for trivial updates, but a communication for crisis situations utilizing the prevalent use of smart phone applications. What information to provide and to whom is a potential branch off of this research as well as research on securing user data and access.

This communication system design does not focus on the decision making and resources provided to emergency personnel. The extent of consideration in this area includes the needs of the system from operators sending out alerts. Future research will be done to widen this design to incorporate previous research on the informational needs of the alert recipients, the needs of the operators of the system, and to expand the design to include information to send to emergency response teams and organizations. The chosen example of the design is for use as an emergency notification system to users associated with Virginia Tech, and as such, to provide optimized alerts based on geospatial location. In other words, it is an optimized one-way communication of information to students. This could still be applied to two-way communication between operators and users that leads to questions of other filtering criteria. There exist projects such as Digital Humanitarians, [22], which coordinate based on technical expertise. Still other applications such as PulsePoint, [23], are driven by both location and skill, in this case CPR. Clearly the design of an electronic notification system only based on geospatial location could be enhanced to incorporate other filtering priorities, but further research is needed to evaluate its efficiency for the intended crisis or more routine emergency situations.

8. Conclusion

This research focuses on the design and the integration of an optimized method for delivering alert notifications based on user geospatial location compared to the location of a crisis. Many factors surround the development of effective crisis communication systems such as the physical environment, sociological aspects, and technical constraints and requirements. All must be considered during the design, implementation, and analysis process. Further, the basic design must be fitted to the process flow, human interaction, and target system, as shown with this VT Alerts integration model. Lastly, a design for testing and analysis is important for reliability and validity.

Crisis situations are non-routine and often life threatening events. Thereby, a customizable and optimized alert system design is key to a successful response when a notification may be the difference between life and death.

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