Increasing Understanding of a New Environment using Location-Based Notification Systems

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Abstract

The rise in the ubiquity of wireless internet access and handheld computing devices has opened several avenues for Location-Based and Location-Aware applications. Our work introduces an adaptation of a notification system based on Location-centric events and features. Real-time information can be used in order to increase a users' comprehension of his environment. Our prototype system, seeVT, provides a location-based solution for visitors to the Virginia Tech campus. The system uses handheld computers as an embodiment of a tour guide to introduce visitors to campus (initial pilot only for Computer Science department). We utilized VT's WLAN infrastructure to interpolate the users' current location and notify them about points of interests in the area. The notification information is also tailored as per user types and preferences. The goal of the system is to provide sufficient information to impart a long lasting comprehension of features in the user's environment.

1 **Introduction –** What are Location-Based Notification Systems?

As pervasive computing devices become more common place, we will begin to see several applications based on a user's location. Creating applications for such cases carries several technical challenges such as: determining current location, detecting artefacts in the environment, real-time tracking of parameters that the user' want information about, etc. In order to serve this purpose, Munson & Gupta [1] introduce a class of notification systems called Location-Based Notification-Systems (LBNS). A typical scenario would be a campus tour guide system that could notify users about events and features in their vicinity upon entry into a new location. Another example would be a local grocery store that sends advertisements to users when they are in the certain proximity of a store. Therefore, in general, LBNS are systems that need real-time tracking capabilities and efficient mechanisms to deliver information to users while they are in a relevant scenario. The creation of this kind of LBNS was the motivation for seeVT.

2 **Increasing Understanding using a LBNS –** What's in my environment?

The main objective of location-based systems is to enhance the users understanding of certain events based on his location. The ingredients for a successful location-based system would—generally—contain components such as a Location Tracker, to track the user's location, an environment scanner, to comprehend artifacts in the user's environment, and an efficient information delivery system. The system would only be as good as each of these components. For example, if the system notifies you of a traffic jam when you have reached a point at which you cannot avert the jam is not successful in delivering the information, which in this case is "mission-critical". Since getting information in real-time whilst you are still in the environment is the fundamental motivation for employing one, location-based systems can be categorized as mission-critical systems.

For seeVT, our aim was to increase a visitor's understanding of the VT campus. Therefore, providing the user with information pertaining to the user's current location was critical. Apart from the information, the interface was also a major area for study. The following sub-sections discuss the key issues in greater depth.

2.1 **Location-Specific Information –** The critical pillar

Attributes about a particular location make it unique. When a person is near the library, information about the library is more relevant to the context as compared to information about the administrative building across the field. Another purpose served by an LBNS is providing information about a place that is conventionally not available. For example, while walking around a store in a mall a person discovers that the store is shut and he might not be able to buy what he needs, but in this case if he had a system that would take him to the vendors webpage, he would be able to order the product over the web. Therefore location-specific information is a critical pillar to the field of LBNS themselves. Because eventually, the system is only as good as the data it provides.

2.2 Location-Specific Notification – Stop. React.

Notification systems are interfaces that provide reaction to and comprehension of valued information in an efficient and effective manner without introducing unwanted interruption to a primary task. The three critical parameters that define user goals in using notification systems are interruption, reaction, and comprehension, abbreviated IRC—creating a three-dimensional design space (see [2] for details). General purpose notification systems (GPNS) are used in divided-attention or multitasking environments. Traditionally notification systems have been designed only for the desktop environment, but as we see pervasive computing devices beginning to move around with users, the need to customize notifications as per the users' location becomes critical. The user may be interested in knowing information about his current environment. An LBNS needs to be able to deliver appropriate notifications to the user while they are still relevant to him. As we discussed earlier about the traffic jam scenario, getting the information in real time is crucial to the motivation of using a LBNS in the first place.

2.3 Embodiment – Can we replace an actual person?

Based on Paul Dourish's work on embodied interaction [3], we believe that embodied interaction with the system was a central aspect of our design. Since our system aims to replace a traditional tour guide with a digital alternative, it is crucial that the user be at-home with the interface and flow of the system. For example, while taking a walking tour, patrons would ask the guide more about a particular artefact; providing the user with a intuitive way to accomplish that task with our system was critical. Moreover, being-in-the-world cannot itself be understood as a certain relation between a central body and the surrounding world, but has to be understood in terms of the tasks that need to be accomplished [4]. Understanding the user's tasks in a real environment is central to achieving a successful embodiment of a physical activity. Thus to be an effective interface we analyse the users tasks and create a general flow to emulate real-world interaction

2.4 Design of Notification Metrics – We claim…

The success of a notification system hinges on accurately supporting attention allocation between tasks, while simultaneously enabling utility through the access to additional information. We used Rosson & Caroll's principles of Scenario-Based Design to conduct the requirements analysis and evaluation procedures. In order to do this, we came up with several high and low level claims, these included claims on activities, interaction and information scenarios. [5]

To better understand the relationships amongst these claims we created a design method called a *claims map*. The accompanying figure shows a claims map for a couple of problem scenarios. Problem scenarios translated into one or more activity scenarios and these in turn translated into a couple information/interaction claims.

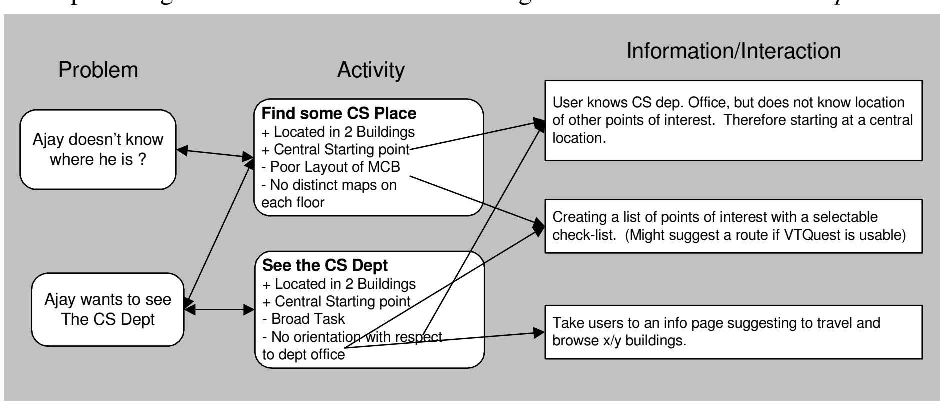
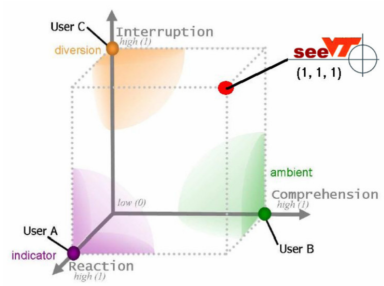


Figure 1: Claims Map →

Such an interactive picture of our design claims helped us to quickly analyze the stakes involved in making decisions. It gave us a holistic understanding of the system along with making us realize the importance of each and every claim, and how design handoffs would affect other attributes of the system.

2.4.1 Interruption, Reaction and Comprehension Ratings (IRC Ratings)

Parameterization of notification claims into IRC ratings was a key element of our design goals. Being able to classify this system in the IRC Cube shown in Figure 2 here was as important as building the prototype itself. IRC ratings are used to quantify the Interruption, Reaction and Comprehension prompted by a notification system. Since a location-based notification system is always assessing the user's current location, we can classify it as a constant activity monitor.



The main purpose of seeVT is to notify the user with information about his new location, in a timely and effective manner. In order to satisfy these objectives we decided that our system would have very high values for I, R & C and hence be a (1,1,1) system.

← **Figure 2: IRC Cube**

Interruption: As described earlier, it is critical for a LBNS to notify a user about an artefact in his immediate surrounding. In order to achieve high levels of interruption, our system used an inter-play of auditory and visual cues. Upon detecting a change in the user's location, seeVT plays a sound to interrupt the user from whatever task he is performing. As the change is a critical part of the activity, highest degree of interruption was chosen. Thus an Interruption(I) rating of 1.0.

Reaction: As a complement to achieving high interruption, demanding the user to react to the highly interruptive message was the next step. To demand the highest level of reaction we used a highly contrasting yellow colour notification message as shown in a snapshot on the following page. This cognitive affordance would instantly demand the user's attention and hence prompt him to react to the new piece of information. Along with the contrasting colour, we embedded a button that must be clicked to remove the notification message from the screen of the application. Thus a Reaction(R) rating of 1.0.

Comprehension: The central theme of our endeavour was to increase a user's understanding in his new environment. To cement a prolonged understanding of the environment, we provided the user with information such as webpages pertaining to artefacts in the environment, maps to enhance an overall image of the neighbourhood, and the ability to take notes. A combination of this set of tools could provide all classes of users with features they could use to better grasp events/artefacts around them. Since our efforts are focused heavily on increasing comprehension, the parameter Comprehension(C) is definitely 1.0 in this case too.

3 **Implementation Details -** seeVT

3.1 **High-Level Model –** The approach

This model is an adaptation from research described in [1] and shown in Figure 3: the high-level model of seeVT.

- Location Determination
  The flow of any LBNS starts first with location determination. The device must be aware of its location at the earliest stage upon entering a particular location.
- Proximity Detection
  After a device knows its location, attributes to the location are gathered, in our case, points of interest.
- Notification Composition
  It is vital to create a notification that will be most relevant for the user. Filtering user preferences and creating a notification that will best suit the type of user is critical.
- Notification Delivery
  Conveying an effective notification the user is a key element in a successful notification system.

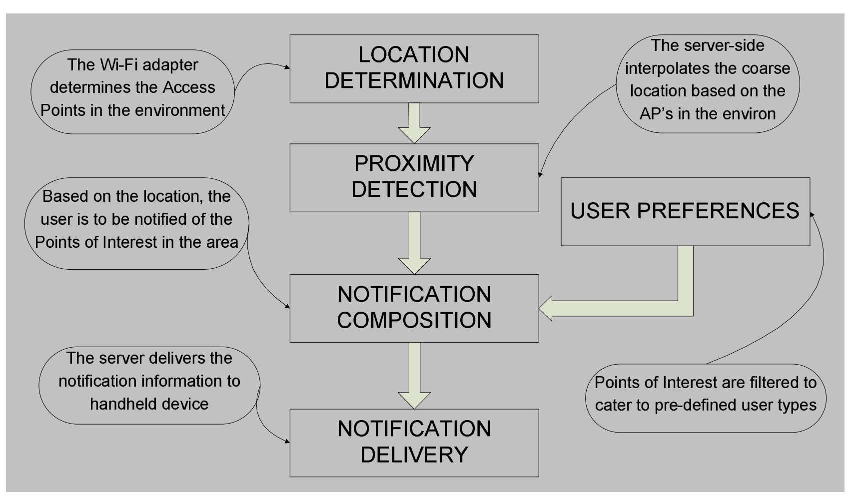


Figure 3: High-Level Architectural model, from [1]

3.2 **Location Tracking Architecture –** The solution

seeVT has been written for the Windows CE platform. It runs on a hand-held device such as a PocketPC. The back-end architecture of the application is shown in Figure 4. One implementation goal was to reduce the computation requirement on the PocketPC. Having a server store location information and web services to communicate between the handheld and the server, objects with strings were sent to the server and, after computation, objects with strings were returned to the hand-held, reducing the computation the PocketPC has to do.

Location tracking is done using wireless access points in the area. This requires geographic understanding of access points' location. Through the help of the Communication Network Services of Virginia Tech, we populated a database, residing in the MSSQL server, which returned location information. At any given point, at least five to six access points are visible to a hand held. To be accurate in our location tracking, a probabilistic algorithm was devised which was able to select the closest floor and region.

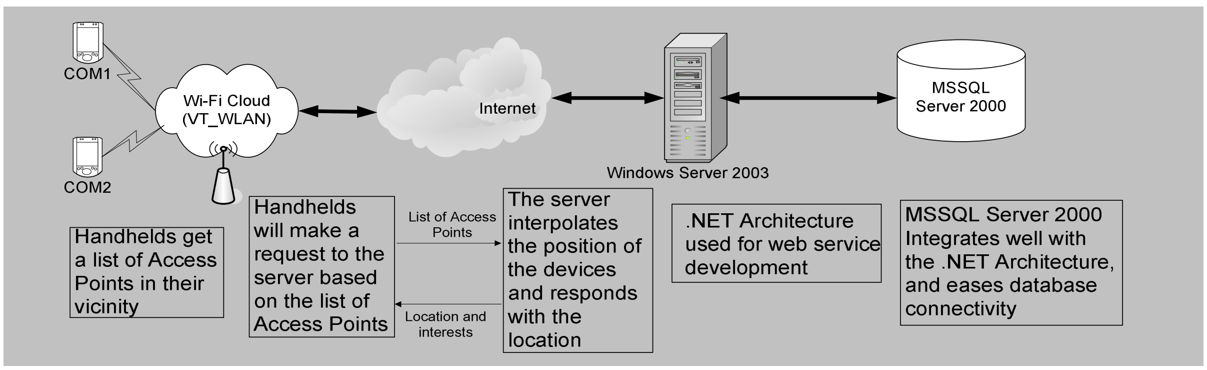


Figure 4: seeVT's location tracking architecture

3.3 **The Application –** The product

Figure 4 shows screen shots of the seeVT application. From left to right we first see the user inputting their user information. Based upon the chosen user type, points of interest pertaining to it are shown. The second image shows the notification to the user upon entry into a new location. In color, this is a yellow and blue notification contrasting the overall grey of the application. Next we see the main screen of the application where users are able to navigate and learn about the different points of interests in the location they are currently in. Navigation leads them to; a webpage, if available; a notes feature where note can be viewed, added, and edited; and a map feature which shows them a map of their current position, the last image.

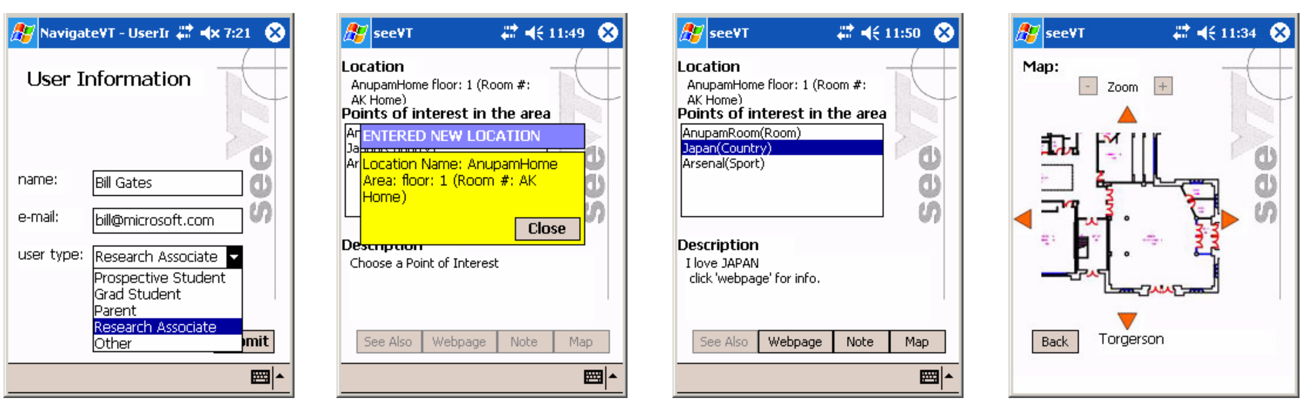


Figure 5: Screen shots of seeVT

4 Conclusions and Future Direction – What's next?

Our goals for this work were to create a location-based system that would serve as an alternative to campus tour guides. The successful implementation of our location determination infrastructure was a significant achievement in itself; however we did not stop there. The interface as it appears was decided upon after several iterations of design and evaluation by our peers. Another core area of focus for us was the enabling data. Hard work was put into compiling information about each location and making it available in a format suitable for the small form-factor devices. In the future we intend to work on the following aspects:

Pilot Production We plan to deploy a pilot production system for the CS Department here at Virginia Tech. The targeted audience in this case are prospective graduate students visiting VT campus during the Graduate Week held biannually. Handheld devices running the seeVT application will be handed to patrons. This will give us a better dataset to evaluate the effectiveness of the features supported by our interface, and help us achieve proof-of-concept.

Interactive Maps Improvements will be made to the map feature of the application. An intermediate Scalable Vector Graphics engine will be deployed to enable zooming, and moving the map making it more interactive for the user. Points of interest would be highlighted and a route could also be constructed using this interactivity.

Other Mobile Platforms Smartphones, Tablet PC's, or even large-screen displays. We plan to evaluate the usability of this application on a host of platforms and understand the dynamics of porting it to other form-factors. A Windows Smartphone version of seeVT is also on the cards.

Better Data As the application is going to be only as effective as its dataset, we wish to explore other pieces of information about a location that might enhance understanding. Apart from other attributes we will also focus our energies on formatting all the information using XML style sheets and making the application compatible to them. This will ensure ease of adding data in the future.

Other Scenarios We plan to explore scenarios other than campus tours. Museums, hospitals, security personnel, and so on, are some of the many possible scenarios that can be targeted for LBNS. Understanding how the system would need to adapt to each new scenario is of considerable concern.

References

[1] Gupta, Vineet K., Munson Jonathan P. (2002). "Location-Based Notification as a General-Purpose Service". In *Proceedings of the International Conference on Mobile Computing and Networking*.

[2] McCrickard, D. Scott, Chewar, C. M., Somervell, Jacob P., and Ndiwalana, Ali (2003). "A Model for Notification Systems Evaluation--Assessing User Goals for Multitasking Activity." *ACM Transactions on Computer-Human Interaction (TOCHI)*, volume 10, number 4, pp. 312-338.

[3] Dourish, Paul. Where the Action Is: The Foundations of Embodied Interaction. First MIT Press, Massachusetts Institute of Technology: London 2001 (p 100-101).

[4] Dourish, Paul. Where the Action Is: The Foundations of Embodied Interaction. First MIT Press, Massachusetts Institute of Technology: London 2001 (p 104)

[5] Rosson, M.B., Caroll, J.M. (2002), Usability Engineering: Scenario-Based Development of Human Computer Interaction, Morgan Kaufmann, New York.

[6] Communications Network Services, Virginia Tech, http://www.cns.vt.edu/