Protecting People on the Move through VIRTUAL PERSONAL SECURITY

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Abstract. Ensuring personal safety for people on the move is becoming a heightened priority in today's uncertain environment. Traditional approaches are no longer adequate in meeting rising demands in personal security. In this paper, we describe VIRTUAL PERSONAL SECURITY, a research prototype that demonstrates how technologies, such as ubiquitous surveillance cameras, location-aware PDAs and cell phones, wireless networks, and Web Services can be brought together to create a virtualized personal security service. By incorporating automatic service discovery, situated sensing and multimedia communication, the novel solution provides consumers with increasing availability, lower cost, and high flexibility. It also creates a new market for just-in-time micro security services, providing the owners of surveillance cameras a new revenue stream.

1 Introduction

Today, businesses and individuals alike spend millions of dollars each year on security services to protect their physical assets, such as factory plants, offices, and homes. Yet, they take a big risk at neglecting a more important asset -- people. After the September 11th tragedy in the United States, safety concerns, especially personal safety, have crept into daily news headlines. While governments at the federal, state, and local levels have made concerted efforts to prevent potential terrorist attacks, ensuring personal safety is ultimately the individual's responsibility. That is, each and every one of us can take more initiatives to ensure the safety of ourselves, especially by taking advantage of technologies.

When we travel to a new place, or walk through a neighborhood in a familiar city during late hours, we want to make sure that our personal safety is guarded. At present, the options available to us are somewhat limited. If we happen to be on a private property such as a university or corporate campus, or a suburban shopping mall, and we need to get to our car parked a few blocks away, we might ask the private security on duty to walk us there. However, this option is not always practical, especially when we are on the road. As a result, we sometimes take unnecessary risks by taking the matter into our own hands. With technologies such as surveillance cameras and mobile devices, we may soon have access to a new solution for personal security, which will be available anytime, anyplace. In the following sections, we will

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describe such a prototype solution called VIRTUAL PERSONAL SECURITY, including its underlying technologies, current implementation, and commercial implications.

2 Beyond Passive Surveillance

Surveillance cameras have long been used in both public and private spaces to monitor what is happening in their surrounding environments [1]. Aside from providing valuable archival footages for crime solving, studies have shown that the mere presence of these cameras has positive effects as deterrence for potential crimes in urban areas [2]. With their rapidly declining costs and increasing concerns about personal safety, especially in large cities, surveillance cameras are becoming even more ubiquitous in recent years. Figure 1, for example, shows the high density of surveillance cameras in Lower Manhattan [3]. In downtown Chicago, there are on an average three surveillance cameras in each block [4]. While this omni-presence of surveillance cameras has raised concerns about individual privacy among civil libertarians, such a trend is most likely to continue accelerating, especially in light of rising security concerns among the general public.

Figure 1: Surveillance cameras in Lower Manhattan [3]

Despite their popularity, traditional surveillance cameras have limitations. A vast majority of these cameras, for example, are based on analog, closed-circuit (CCTV) technology, which requires special wiring and storage infrastructure. As a result, they are quite expensive to install and maintain. Furthermore, video streams from these cameras are stored on analog media such as video tapes, which are difficult to view and analyze. And finally, these cameras are quite “dumb” in a sense that they don’t know who they are, and what they are pointing. However, these problems are disappearing with a new generation of surveillance cameras, which are essentially interactive Web cams. These cameras come with built-in Web servers, and capable of originating real-time stream videos over the Internet. With this new capability, they can be used beyond just passive surveillance. As they become more ubiquitous, these cameras may be used to actively monitor any moving target in the physical world, such as a person on the move, by sequentially "turning on" the cameras along with the path, provided that we know the real-time location of the target, and the direction to which the target is moving.

3 Location-aware Mobile Devices

Another important recent technology trend is the increasing popularity of mobile devices, including cell phones and PDAs. In many parts of the world, such as Europe and Asia, cell phones are the most omni-present technology around. The new generation of cell phones is full-fledged computing devices, featuring built-in cameras and color displays, as well as multimedia and location awareness. It is interesting to note that the earliest use of cell phones is for personal safety and emergency purposes. Yet, until recently when we make a 911 emergency call, the recipient has no way of determining the exact location of the caller. With the Enhanced 911 (E911) mandate from the US federal government [5], cell phone carriers in the US are required to provide locationing capabilities by the year 2004. In other countries such as South Korea and Japan where mobile phones are more advanced, such capabilities are already widely available.

At the same time, PDAs are undergoing a different kind of evolution, moving from being a computing device to a communication device. Newer Pocket PC models, for example, feature powerful processors and built-in 802.11b (i.e., Wi-Fi) – the fastest growing wireless network technology in the US. The use of Wi-Fi also enables PDAs to become location-aware. With the steady improvement of Voice over IP (VoIP), PDAs are also increasingly used for voice communication. The convergence of cell phones and PDAs has led to hybrid devices like Handspring's Treo and T-Mobile PocketPC phone.

4 Toward VIRTUAL PERSONAL SECURITY

Imagine this scenario: you get off from a late meeting at your client site, and you have to walk to your car parked about half a mile away. Fearful of walking alone in the dark, you pull out your iPaq and say, "Personal Security, please." The application responds by looking up in an online registry of security service providers, and selecting the most appropriate one based upon your preference in quality, trust, pricing, and the provider's current availability. Once the connection is established, the remote security agent turns his full attention on to you. Since your iPaq knows where you are at the very moment, the application uses this information to locate and "turn on" the surveillance cameras in your area. Sitting in front of his multi-monitor service desk, the security agent can see from multiple angles about what is happening in your immediate environment. If you tell him which direction you're heading, he can "preview" the path by checking on the surveillance cameras along the way to make sure it is safe to proceed. If not, he may suggest an alternate route. A service like this may last between five minutes and half an hour or longer. And it can be called upon anytime, anywhere.

The concept of VIRTUAL PERSONAL SECURITY, as depicted here, is centered on the keyword *virtual*, which implies that the service provider and its recipient don't have to be physically together in the same place at the same time. Instead, the co-presence is created by the seamless integration of three different technologies: location-aware mobile devices, fixed-location, Web-enabled surveillance cameras, and Web Services. The mobile device (i.e., PDA or cell phone) is the real-time personal locator. The exact locationing mechanism and the accuracy may vary depending on the specific type of devices being used. For example, most cell phones use a combination of GPS and cell-based triangulation, and their accuracy ranges from 5 to 50 meters. Most PDAs, in contrast, use 802.11 signals to pinpoint the location of the device holder. Its accuracy can reach as high as one meter in outdoor settings [6]. Besides locationing, the mobile device also serves as the primary interface between the user and the service provider. To that end, it supports wireless voice and data. The voice channel is important in that it provides the remote service provider auditory clues (i.e., "ears") to the user environment.

The surveillance camera is the situated "eyes" for the security service provider, allowing them to see remotely what is happening in real-time. Since the recipient is constantly moving, the key here is to be able to quickly determine and select which cameras to view. Since the application knows the real-time location of the recipient, and that each surveillance camera also publishes its own coordinates and orientation, the application can automatically determine which cameras are relevant at any given moment. As the recipient moves, the views are shifted from one camera to another. Depending on the camera density in the area where the recipient happens to be, and the service provider selected, multiple camera views can be supported at the same time. This ensures that most or all directions of the scene are covered.

The third enabling technology is Web Services, or more specifically, the Universal Description, Discovery, and Integration (UDDI) [7]. In a nutshell, Web services are a set of open standards (e.g., XML, SOAP, UDDI) that enable applications of different sources (e.g., languages, platforms, and organizations) to automatically find, link and interact with one another over the Internet, sharing data and performing tasks, all without human intervention. As the name implies, UDDI provides a standard framework for application publishing, discovery, and dynamic integration. At its core is a registry that contains detailed descriptions of businesses and services. UDDI specifies an API that allows programmatic publishing and searching in this registry.

Underlying the virtual personal security application are two UDDI registries: surveillance cameras and security service providers. Each geo-coded surveillance camera has an entry in the first registry, and each entry contains information like camera type, coordinates, orientation, owner, and possibly price. Each security service provider maintains an entry in the second registry, which provides detailed specifications about the service, including current availability, price, and interface details required to invoke the service. Given the user's requirements and location, the application makes use of the standard UDDI API to discover the right service provider and closest surveillance cameras. Figure 2 provides a summary of these key components of VIRTUAL PERSONAL SECURITY.

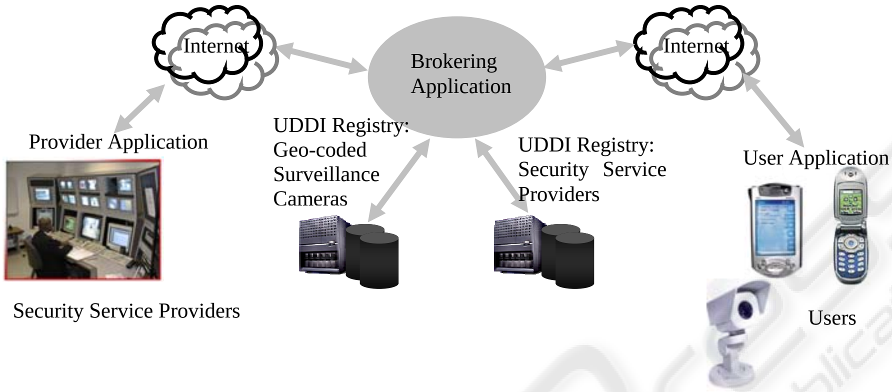

Figure 2. Components of VIRTUAL PERSONAL SECURITY

5 The Prototype

To demonstrate the conceptual viability and the technical feasibility of VIRTUAL PERSONAL SECURITY, we built an initial research prototype. For the ease of control, we selected an indoor environment, i.e., the 36th floor of our office in downtown Chicago. On this floor, we installed 33 Axis 2100 Web cams that point at various sections of the floor: entrances, hallways, enclosed offices, break areas, and meeting rooms. The floor is also covered with an 802.11 wireless local area network. The mobile device we use is iPAQ 3860 running Microsoft PocketPC operating system. The iPAQ is equipped with a dual-slot extension sleeve, which is used for Orinoco Wi Fi card and Veo Travel Photo camera, respectively. To provide two-way voice over the IP network on the iPAQ, we use Running Voice IP from Pocket Presence. The locationing function is built upon the Ekahau 802.11b locationing engine [6], which is capable of offering up to one-meter accuracy.

The application consists of three modules: user, provider, and brokering, each is running on a separate machine that is connected to the same local area network. The user application runs on the iPAQ the user carries around. It is the primary interface between the user and the security service provider. Figure 3 shows a sample user screen. After the user makes a request for service, the control is passed over to the brokering module, which maintains two UDDI registries: one for all the surveillance cameras on the floor and another for the list of service providers available. For the prototype, the first registry contains 33 entries, one for each surveillance camera on the floor. The second registry contains half a dozen of service providers. The Web services interface is implemented using Microsoft UDDI Server SDK.

As soon as a right service provider is found, a connection is automatically made between the user application and the provider application. Figure 4 shows a view of the provider application, which includes a three-monitor setup. The center screen shows the real-time user location on a map, along with the view from the Veo camera attached to the iPAQ. The two side screens provide the views from two surveillance cameras nearby the user. The maps next to them show where those cameras are located. Collectively, these three different camera views provide the remote security agent a good sense of what is happening in the user surrounding environment. In the real-world setting, a professional security company is most likely to support an even larger number of views. In the event of an emergency, an alarm can be locally sounded, either by the user or remotely by the security agent, whoever discerns the situation first. Local help from law enforcement agencies could be immediately notified and dispatched when necessary.

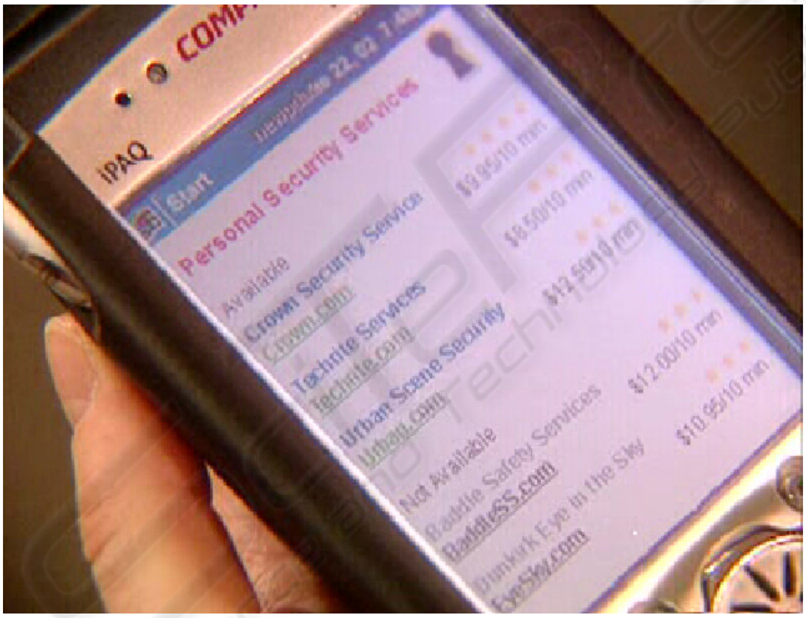

Figure 3. A sample screen from the user application running on an HP iPAQ 3860.

6 Implications and Discussions

VIRTUAL PERSONAL SECURITY is an early stage conceptual prototype that demonstrates how ubiquitous technologies, including surveillance cameras, location aware mobile devices, the Internet and Web Services, can be brought together to create a new alternative for personal safety, especially in situations where a physical security escort is either unavailable or too expensive. Our approach is novel in that it combines the best features of the two forms of ubiquitous computing: mobile and embedded. Being mobile, devices like PDAs and cell phones provide a convenient delivery channel for services for people on the move. They also serve as a good location sensor for tracking the real-time location of the device holder. However, these devices offer limited vision – perhaps the most important sensory data for security applications -- in part due to their limited bandwidth and power. On the other hand, surveillance cameras are rich sensors embedded in our environments dedicated to safety/security purposes. They provide high-fidelity views of the area being covered. Their locations are not only known but often strategic. Furthermore, they are becoming increasingly pervasive and Web enabled, which makes them accessible anywhere. The combination of the two enables rich sensing of the user environment, and therefore provides sufficient context for viable security services.

Figure 4. An example view for the security service provider's application.

We envision a service like VIRTUAL PERSONAL SECURITY to be initially offered in closed-end spaces like university campuses and private parking lots or structures. With Web enabled surveillance cameras, wireless broadband, and location aware devices become more ubiquitous, we expect that such a service eventually becomes feasible on a massive scale. When this happens, a new marketplace for virtual personal security will emerge. Today, surveillance cameras, which are owned by different public and private entities, are severely under-utilized resources. In this new marketplace, these cameras can be made available to licensed security companies as extra eyes to ensure personal security. For the owners of surveillance cameras, this represents a new source of revenue streams. Security firms also do not need to spend valuable resources to install a vast surveillance infrastructure. Instead, they can take advantage of a distributed infrastructure that is already in place and, as a result, offer the service at an affordable level.

To make the concept of VIRTUAL PERSONAL SECURITY a reality on a large scale, however, we will still need to overcome three key technological barriers. First, surveillance cameras must continue to become cheaper, more powerful, and perhaps most importantly, truly ubiquitous. While today they are already pervasive in large cities, it may still take some time before they cover every street corner in every city neighborhood. Second, surveillance cameras must become more open, and Web enabled. In other words, real-time video streams from these cameras need to be available over the Internet so that they are viewable anywhere. And finally, the locationing capabilities of mobile devices must also improve. While the 50-meter requirement from the US federal government may be adequate to pinpoint a 911 emergency caller, it is too coarse for locating closest surveillance cameras, especially when the camera density is high. Despite these hurdles, however, we already witness early signs of progress made on all three fronts. Thus, we believe that the technological infrastructure required for realizing the vision of VIRTUAL PERSONAL SECURITY will soon be in place.

7 Conclusions and Future Work

In this paper, we presented a novel prototype application called VIRTUAL PERSONAL SECURITY, which aims to monitor and protect people on the move, just like what ADT does to property security. One main premise of our approach is that such a service can be offered by using mostly existing infrastructure, such as the Internet. To that end, it brings together a number of emerging technologies, including Web-enabled surveillance cameras, location aware mobile devices, and Web Services. While our initial prototype is implemented in a somewhat limited, artificial indoor setting, it clearly demonstrates the viability of the concept and its technical feasibility. Currently, we are in an active discussion with a major university in Chicago to pilot the concept on their campus, where 802.11b network is already in place. As locationing capabilities become more readily available on cell phones in the US, we also plan to implement another version of the prototype using cell phones.

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