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Rizwan Bhaloo and Norm Archer

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DeGroote School of Business

McMaster University

Hamilton, Ontario, L8S 4M4

Canada

bhaloor@mcmaster.ca
archer@mcmaster.ca

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ABSTRACT

The intent of this report is to examine better ways for quickly finding automated external defibrillators – devices used to help restart the hearts of individuals suffering sudden cardiac arrests - by first responders when a cardiac emergency strikes.

More and more people are either witnessing or suffering sudden cardiac arrests. Automatic External Defibrillators (AEDs) have been proven to be vital in helping to save these individuals' lives through the act of defibrillation or simply 'shocking' the heart. Studies have shown that defibrillators are capable of saving lives cost effectively when they are made available in public places. The history of AEDs in Ontario is discussed, along with the current distribution of AEDs and operations of municipal Public Access Defibrillation (PAD) programs that work in collaboration with the Heart and Stroke Foundation of Canada. PAD programs oversee the distribution, placement, and maintenance of defibrillators in public places such as arenas, shopping malls, schools etc. The list of supported PAD programs continues to grow even as legislation supporting the mandate of distributing defibrillators and creating defibrillator registries is being enacted. The problem that arises now is to help individuals find these defibrillators quickly in situations where they observe someone having a heart attack.

Solutions to this problem that are examined in this research include: the City of Hamilton Public Access Defibrillation Program; a non-profit organization called First Aid Corps; Enhanced 911 emergency services; Location Based Services; and defibrillators with wireless communications for individuals who have no prior training in using these devices; and the creation of a browser based system.

These alternative solutions to help people find and use defibrillators have highlighted the fact that mobile communications technologies such as smartphones have platforms that could be adapted readily to locate defibrillators in emergencies. A possible smartphone solution that was examined in detail is the Apple platform. This platform was chosen for detailed study because Apple currently has the largest consumer market share and has the greatest number of applications available to run on its mobile devices. An application (or just plain "app") is a smartphone program which enables users to engage in a wide variety of online activities such as banking, finding restaurants, or even searching the Internet. This s study investigates the possibility of creating different versions of a smartphone application which could help people locate nearby defibrillators during a cardiac emergency.

The design, functionality and cost of several versions of the proposed smartphone application as well as other alternatives are evaluated. A cost analysis is done to rank what the researchers believe are the most cost efficient applications and alternative strategies. Challenges and opportunities are discussed to give a sense of the problems involved in developing, implementing, and maintaining an application of this type. The strengths, weaknesses, opportunities and threats are also laid out to demonstrate the potential of an AED finder application, and to indicate the direction that needs to be taken to actually implement a suitable reliable system.

These combined evaluations demonstrate that the creation of a smartphone app which aids in finding nearby AEDs is feasible. However, it would need to work in conjunction with existing Public Access Defibrillation programs in Ontario that are managed by municipal Emergency Medical Service (EMS) operations, since EMS operators are aware of the geographical coordinates of local AEDs. Providing AED location information maps and related instructions through smartphones would enhance alternative emergency 911 operator information for quickly finding nearby AEDs. Concurrently, public education programs and ongoing awareness campaigns about the availability of the smartphone solutions would need to be used to popularize their availability and enhance current education and training in the use of AEDs and CPR. These programs would give users the awareness and confidence in their ability to work as first responders in emergency cardiac arrest situations, not only with AEDs and CPR but also with mobile communications technologies.

The next phase proposed for this work is to develop an application and work with Hamilton Ontario EMS services to conduct a pilot study that assesses the usefulness, feasibility and effectiveness of such an application for the growing population of smartphone users who may be faced with such emergencies.

The final study conclusions indicate that there are numerous possibilities for combining health interventions such as defibrillators with new mobile communications technologies, and that this combination promises solutions that will help first responders to find nearby AEDs and save the lives of people undergoing cardiac arrest.

INTRODUCTION

The world-wide prevalence of sudden cardiac arrests (SCAs) is increasing. In Canada, 35,000 to 40,000 people die of SCAs each year (Gardiner, M., Leather, R., Koon, T, 1999). An SCA is the unexpected and immediate loss of heart function in an individual. The heart has an internal electrical system which dictates the rhythm of the heartbeat. Problems such as arrhythmias or abnormal heart rhythms can arise that lead to SCA. During an arrhythmia the heart can beat too fast or too slow or not beat at all. These cardiac emergencies are related to two typical heart rhythms known as ventricular fibrillation or ventricular tachycardia. To restore a normal heart rhythm, otherwise known as a normal sinus rhythm, the application of a defibrillator is needed (Torpy, Lynn, & Glass, 2006). Defibrillation is carried out by applying a biphasic form of energy that is used to 'shock' the heart into resuming a functional rhythm. Defibrillation is the only effective treatment for ventricular fibrillation and tachycardia (Torpy et al., 2006).

About 70% of cardiac arrests occur in out-of-hospital settings where there are no medical personnel (De Maio, 2003). Out of this demographic only 5% survive to be discharged home (Stiell, 1998). If cardiac arrests occur in a hospital setting, survival rates to discharge range from 10% to 25%. The critical aspect when attending to a cardiac arrest is the time from when it occurs to when it is treated. If defibrillation occurs within 8 minutes of cardiac arrest, the outcome of survival improves significantly (Stiell, 1999). For every minute that is delayed in defibrillating the heart from onset of arrest, the probability of survival decreases by 10% (Larsen, 1993).

Unfortunately a response time of 8 minutes is frequently not met by trained personnel in out-of-hospital settings and even within hospital settings. Coupled with the lower survival rates in out-of-hospital settings when compared to those occurring in hospitals, there is a need to not only meet this mandate of 8 minutes but to create strategies that will result in treating people in a shorter time frame.

People who are observers and helpers to a cardiac arrest victim are labeled 'first responders'. First responders could be regular bystanders, firefighters, police officers and community volunteers – all are "good Samaritans" (Stiell, 1998). In hospitals they would most likely be nurses (Mancini, 1998). If the victim is to have a chance of survival, all first responders need to manage cardiac arrests through a sequence of steps referred to as the chain of survival (Vaillancourt, 2004).

According to the Heart and Stroke Foundation (HSF) Position Statement (*Position statement*2008) , the chain of survival consists of a series of four links that give the victim of a heart failure emergency the best chance of survival. These links are:

- Early access to emergency care
- Cardio Pulmonary Resuscitation (CPR)
- Defibrillation, and
- Advanced cardiac care

The HSF Position Statement also states that defibrillation is the key link in the chain of survival. Defibrillation is supported by a device called an Automated External Defibrillator (AED) which analyzes a patient's heart rhythm and delivers a shock if required. This easy to use device comes with voice instructions to lay users such as first responders, and may be used to deliver early defibrillation in out-of-hospital and other settings (Medical Advisory Secretariat, 2005).

In Ontario, defibrillators can be found in a wide variety of public places, ranging from malls, arenas, community centers, schools, hospitals, and long-term care facilities to private places including businesses, and even individuals' homes. The availability and distribution of AEDs in the public domain is increasing continuously. AEDs are becoming more available, but a major question remains: How do people know where the AEDs are? If a cardiac arrest is witnessed in any of the public places mentioned it is essential that first responders be able to find an AED, if one is available, as quickly as possible. This paper will examine how mobile technology can play a role in finding defibrillators in emergencies in public or private areas. The objectives of this work are to examine the feasibility of developing a system that will help people with mobile communication devices to find the nearest AED quickly, including:

a) To evaluate the history, life-saving capabilities and cost-effectiveness of AEDs and to explain how a suitable distribution for these devices in public and private locations can be advantageous to health in emergency situations

b) To examine the supporting agencies and the current distribution of defibrillators in Ontario, including: the agencies responsible for purchasing and maintaining these devices, actual usage data, the makes and vintages of the devices being used, operating procedures stored with the devices, and communications links to emergency services

c) To estimate the cost of building and maintaining a platform and suitable applications for operating a defibrillator finder system through wireless networks that service commonly used mobile communication devices such as smart phones

d) To evaluate the cost-effectiveness of a wireless defibrillator finding system based on the current distribution of defibrillators in public areas in Ontario

e) To outline the challenges and opportunities of building an infrastructure that will facilitate first responders in finding AEDs in public places during emergencies, through mobile communication technology

AED HISTORY IN ONTARIO

The Heart and Stroke Foundation of Canada (HSF) and its related provincial agencies is the major body advocating and leading cardiac resuscitation in Canada. Since 1966 the HSF has been training medical, allied health, and other professionals on the skills and use of Cardio-Pulmonary Resuscitation (CPR). The HSF has transformed cardiac care in Canada and supported the creation of Canadian guidelines that effectively took CPR out of the hospital setting and into the public domain (*The heart restart program.*2010). One of the legislative policies that it promoted and which was enacted is the Good Samaritan Act, otherwise known as

Bill 20. This was enacted in 2001 to protect persons such as health care professionals and lay persons from liability when offering voluntary emergency medical or first aid services.

The pivotal turning point which really brought AEDs into the public scene in Ontario was the death of a young hockey player due to cardiac arrest. At the age of 11 Chase McEachern of Barrie, Ontario (*The heart restart program.*2010) became an advocate of AEDs in the public space, but in 2006 he died due to lack of oxygen that resulted in brain damage, a spiral of events that all started with a cardiac arrest. This motivated his family to start the Chase McEachern Tribute Fund, which today works hand in hand with the HSF to bring public awareness to heart health and to assist in the distribution of AEDs in public places.

In 2007 Bill 71: The Chase McEachern Act – Heart Defibrillator Use Civil Liability Act (*The heart restart program.*2010) was passed by the Ontario Government. This was an extension of Bill 20 that also covered liability for health professionals and lay persons in the application and use of AEDs for individuals experiencing cardiac arrest.

Although this was the first time that AEDs and their use were widely publicized in the province, individual municipalities in conjunction with their local emergency medical, fire and police services had started their own Public Access Defibrillation (PAD) programs long before 2006. However, the Chase McEachern Act galvanized the distribution of AEDs in the public domain in Ontario. Unfortunately, at the same time there was no overarching attempt to centralize information on the geographical location of these AEDs.

PAD sites work under a separate funding agenda and mandate from the HSF, and basically process their municipal goals as they see fit. This created an environment of friction that worked against developing and maintaining a central database of all the AEDs distributed in Ontario. This situation also creates a problem for the purpose of this study, which could frustrate the use of mobile communications that would access a central database to assist in finding AEDs at different PAD sites across the province.

It is unclear how the individual PAD programs started, but what is clear is that legislation is needed that would support the coordination of the good work that has been done and continues to be done by all the PAD programs and the HSF. Such coordination would contribute towards what these organizations set out to do, which is to assist the public to save lives through the usage of publicly available AEDs.

Another benefit of the PAD programs and their unification with the HSF program is that the issue of having AEDs available in public places has caught the eye of politicians and government. As a result, in May 2010, Bill 41 – The Defibrillator Access Act, passed its second reading unanimously in the Ontario legislature. If this legislation is enacted, it would be the first of its kind in Canada. The legislation would mandate AED installation in all public spaces, including schools, fitness facilities, and hockey arenas. This Act is a natural progression of the 2007 Chase McEachern Act (heart defibrillator civil liability act).

If Bill 41 is enacted it will become far more effective if, at the same time, an official trace and registry of the locations of these devices is also formulated. An important outcome would also be the creation of a continuing collaboration between the HSF and the individual municipal PAD programs. Figure 1 is a map of the HSF AED and PAD Program Partnerships as of 2010. To date the HSF has been able to deploy 2,262 AED units and to train 18,000 in CPR and AED use. This has helped to save 22 lives across Ontario (*The heart restart program.*2010). The map shows the Municipalities, Counties, and First Nations Communities that have distributed AEDs, along with the lives saved (shown by the small heart symbols in each case).

Figure 1. HSF and PAD Partnership AED Programs in Ontario (*The heart restart program.*2010)

In this study, a number of the PAD sites in Southern Ontario were contacted to determine if available AED registries could be shared. This step was important because it would yield potential local registries that could be used to evaluate the feasibility of whether mobile communication technology could be used to locate such devices in these municipalities. Out of ten PAD sites contacted, the Halton, Durham and Hamilton sites replied with positive feedback about helping with this study.

LIFE SAVING CAPABILITIES – EFFECTIVENESS AND BENEFITS OF EARLY DEFIBRILLATION

There are many published journal studies which outline the life-saving capabilities of defibrillation, and to discuss the entire breadth of these studies would be beyond the scope of this paper. However it is beneficial to mention a few of these studies, since this will help in the understanding of the motivation for making AEDs readily available at public sites.

The first successful electrical defibrillation occurred in 1947, when Clarke Beck used open chest massage and alternating current internal defibrillation to resuscitate a 14 year old boy whose heart was in ventricular fibrillation (Brown, 2000). Today, defibrillation is considered the standard treatment for anyone undergoing ventricular fibrillation – by applying electrical stimulation to the heart to counteract cardiac arrest.

For the last two decades the HSF and the American Heart Association (AHA) have promoted the previously mentioned Chain of Survival concept in an effort to improve survival from cardiac arrest. These steps, including early defibrillation as a key component, have resulted in improved survival after sudden cardiac arrest (G. Nichol, 1998). AED is the technology that supports these improved outcomes.

Essentially, a publicly available AED (see Figure 2) uses a built-in microcomputer to analyze the victim's cardiac rhythm and advises the rescuer if a shock is indicated (Brown, 2000). The typical AED weighs between 4 and 9 lbs and costs between $2500 and $5000. Many AEDs have 1-button technology and audible voice prompts to instruct the rescuer in the proper procedure. The simplicity of having this form of technology is important because research has discovered that the interval from cardiac arrest to defibrillation is a major determinant of successful survival and hospital discharge. To reiterate, with each minute that defibrillation is delayed, the chances of successful resuscitation decreases in the range of 2% to 10% (Stiell, 1999). Therefore it is vital that defibrillation, if indicated, should occur as early as possible. A number of studies have reinforced this point (Capucci, 2002; Myerburg, 2002; Page, 2000; Valenzuela et al., 2000). This has resulted in great efforts by emergency services and others to shorten the time from cardiac arrest collapse to defibrillation in out-of-hospital scenarios. Since research has demonstrated that specially trained non physicians could safely and effectively operate a manual defibrillator (Liberthson, Nagel, Hirschman, & Nussenfeld, 1974), there has been a focus on placing defibrillators within easy reach of non-hospital based first responders (Brown, 2000).

Regardless of this evidence there are numerous communities which still have poor survival rates because of long response times of emergency personnel and delays in delivering definitive therapy with defibrillation (Hallstrom et al., 2004). To address these limitations in the chain of survival, the concept of public access defibrillation has been promoted to expand the use of immediately available defibrillators for minimally trained first responders such as civilians, police officers, firefighters, security guards, flight attendants, and trained professionals (England, 2006). The trend to public access defibrillation started with Eisenberg in the 1980s (Eisenberg, 1980). Using a quasi-experimental design, Eisenberg demonstrated that patients who received care from emergency personnel with defibrillation for cardiac arrest achieved higher rates of survival than patients who were treated with only CPR. Both studies were conducted in out-of-hospital settings. Subsequently, after Weaver (Weaver, 1988) showed that first responders such as firefighters and police officers could safely use AEDs to treat ventricular fibrillation, the notion of first responder defibrillation was endorsed throughout North America (Brown, 2000). Given the simplicity of AEDs, it was just a matter of time before public access defibrillation became mainstream for treatment of out-of-hospital cardiac arrest.

Proof of efficacy and safety of AED use by trained laypeople for early defibrillation was demonstrated by the Public Access Defibrillation trial (Hallstrom et al., 2004). 993 communities in 24 North American regions were utilized in this randomized trial that included CPR training and response alone by emergency personnel or CPR by a trained layperson combined with AED use. Survival rates in the AED group were two times greater (Hallstrom et al., 2004). Out of the 129 cardiac arrests in the CPR plus AED community, 29 patients survived. Of the 103 cardiac arrests in the communities trained in CPR only, 15 survived. This trial demonstrated that training and equipping individuals within a structured response system increases the number of survivors after out-of-hospital sudden cardiac arrest in public locations, and that trained laypersons can use the AED safely and effectively (England, 2006). Because of these benefits, AEDs are increasingly being used in both public and private locations (Myerburg, 2003).

Apart from the PAD trials, another study that has had an influential role in making AEDs publicly available in Ontario is the Ontario Pre-hospital Advanced Life Support Study (OPALS). The OPALS study was the largest multi center trial ever conducted in a pre-hospital setting, seeking to provide evidence- based information that would support the maintenance and improvement of EMS services (Stiell, 2005). This study was conducted in 20 communities across Ontario in 3 phases. Phase 2, which is the most pertinent to our discussion, implemented rapid defibrillation programs for cardiac arrest patients. It demonstrated a significant improvement in survival across the study communities (3.9 percent to 5.2 percent; P=.03) (Stiell, 1999). This 33 percent relative increase equates to 21 additional lives saved each year in these communities, which have a total population of 750,000 people (Stiell, 1999). Apart from the implications of these findings for public decision makers, the study also demonstrated that the links in the chain of survival are intertwined. The major conclusions of the study were that the links are optimized when there is: 1) better public awareness and recognition of cardiac arrest 2) improved citizen CPR knowledge and use, and 3) a system wide approach to providing rapid defibrillation response (Stiell, 2005).

Distribution and Placement of AEDs

To justify the continued distribution and placement of AEDs, policy makers must always be assured that the program is cost effective. But before evaluating the economics of AED placement it is important to overview the experience with sudden cardiac arrests in populated areas.

Generally, the placement of AEDs at locations with the highest likelihood of future cardiac arrests would maximize cost-effectiveness and survival rates (Gold, 2007). The highest rates of arrests that have been accounted for have been in fitness centers, golf courses, public transit facilities, and meeting complexes such as malls (Reed, 2006). Another study by Becker et. al in King County, Washington concluded that the highest incidences of cardiac arrest were at airports, county jails, a large shopping mall, sport venues and again golf courses (Becker, 1998).

Even though these studies did not evaluate the cost-effectiveness of AED placement, several other articles have addressed this issue as follows. The economics of AED cost effectiveness and outcome is usually measured in the cost of the intervention and the resulting Quality-Adjusted Life Years (QALY) per cardiac arrest. A QALY is a measure of a health burden which takes into account both the quantity and quality of life generated by healthcare interventions. It is an arithmetic product of life expectancy and a measure of the quality of the remaining life years (Phillips & Thompson, 2001). QALYs provide a common currency to assess the extent of the benefits gained from a variety of interventions in terms of health-related quality of life and survival for the patient. When combined with the costs of providing the interventions, cost–utility ratios result; these indicate the additional costs required to generate a year of perfect health (one QALY). Comparisons can be made between interventions, and priorities can be established based on comparing those interventions that are relatively inexpensive with those that are relatively expensive per QALY (Phillips & Thompson, 2001). These comparisons are then evaluated to determine if the intervention is cost-effective and where healthcare resources should be allocated. In our case the consideration is with the public placement of AEDs.

Nichol et. al (2009) conducted a trial from July 2000 to September 2003 at sites in Canada and the United States that randomly assigned 993 community units (e.g., office buildings, public areas) at 24 sites to an emergency response system, using lay volunteers trained in CPR only or CPR plus AED usage. Cost and quality of life data were collected along with effectiveness data. The primary analysis evaluated the incremental cost-effectiveness of defibrillator use in public locations by Markov modeling. The results showed that CPR-only had a mean of 0.58 (95% CI 0.28 to 0.88) discounted quality-adjusted life-years and a mean $42,400 (95% CI $22,100 to $62,600) discounted costs._CPR+AED had a mean of 1.14 (95% CI 0.44 to 1.83) discounted quality-adjusted life-years and a mean of $68,400 (95% CI $28,300 to $108,400) discounted costs. Defibrillation by volunteers was associated with an incremental cost of mean $46,700 (95% CI $23,100 to $68,600) per quality-adjusted life-year (G. Nichol et al., 2009). The authors also concluded that training and equipping lay volunteers to defibrillate victims of heart failure in public places may have an incremental cost-effectiveness that is similar to that of other common health interventions such as pravastatin therapy for newly diagnosed diabetic patients with increased serum cholesterol levels, but without a history of coronary artery disease (G. Nichol et al., 2009).

Another study by Cram et al used a Markov model to compare the clinical and economical consequences of a layperson using public access AED with defibrillation, delayed until emergency medical services (EMS) arrived on scene(Cram, 2003). They established that each publicly placed AED would cost $30,000 QALY, a conservative number when assuming society is willing to pay $50,000 per QALY (Cram, 2003). The authors concluded that AEDs were much more cost-effective in public locations, and that placement of AEDs in public places is as cost effective as other medical procedures, a finding consistent with the study by Nichol et al.

In Ontario the Medical Advisory Secretariat conducted a Health Technology Assessment (Medical Advisory Secretariat, 2005) which detailed an economic evaluation of the use of defibrillators for cardiac arrest. Using a very detailed Ontario-based economic analysis, the report broke down cost effectiveness from public, aircraft, home, high-school, hospital and other out-of-hospital settings. Combining these results with a systematic review, the report found that cost effectiveness varies from setting to setting. It also stated that general use of AEDs by laypersons would not be cost-effective, and that special programs are needed in out-of-hospital settings for the cost-effective use of AEDs (Medical Advisory Secretariat, 2005). Thus it is important at this juncture to discuss in more detail the previously introduced Public Access Defibrillation Programs in Ontario and the related distribution of AEDs.

PUBLIC ACCESS DEFIBRILLATION IN ONTARIO

PAD programs exist in many Ontario municipalities, and the Heart and Stroke Foundation has built relationships with municipalities across the province to develop these programs within their communities. As mentioned earlier these relationships are expanding. While some PAD programs already existed, new ones are being formed. Program supervision is typically through the Emergency Medical Services, Fire, Parks and Recreation Departments and Health units of each municipality and the HSF. These relationships allow for the funding and provisioning of AEDs, training programs, and raising public awareness of heart health and public access to defibrillators.

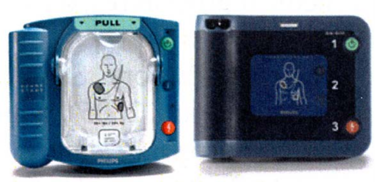
Across Ontario and throughout Canada there are 7 suppliers that have been approved through Health Canada (*The heart restart program.*2010) to sell AEDs. Each PAD program supervisor is in charge of selecting which AEDs their municipality or sector will install distribute and maintain. Figure 2 shows the approved AEDs.

Cardiac Science Corporation
Manufacturers of Powerheart AEDs

Defibtech
Manufacturers of LifelineTM/ReviveTM

HeartSine Technologies
Manufacturers of Samaritan PAD

Philips
Manufacturers of HeartStart



Physio-Control/Medtronic of Canada Ltd.
Manufacturers of LIFEPAK AEDs

Welch Allyn
Manufacturers of AED-10 & AED-20

Zoll Medical Corporation

Figure 2. AEDs Approved by Health Canada (The Heart and Stroke Foundation, 2010)

Profile of AED Management and Use in an Ontario PAD Programs

During this investigation, three PAD programs were contacted successfully. The Hamilton PAD was one of these, and will be profiled in this document. The reasons for this include the full co-operation of the Hamilton EMS in this study, and the fact that Hamilton, as host to McMaster University, would be very convenient as a possible pilot study site.

According to Statistics Canada (*Tables by metropolitan area: Hamilton.*2010), Hamilton hosts a diverse population of 505,000 people and spans approximately 1200 km^2. Traditionally a steel and manufacturing industry centre, Hamilton is seeing a shift towards the service sector and in particular health sciences. This is where the Hamilton Emergency Medical Services plays a pivotal role. The Hamilton EMS receives 61,000 calls per year for paramedic service, and in over 41,000 of those cases the patient is taken to the hospital (Browett, 2010). With life threatening situations where the speed of medical interventions is critical, the Hamilton EMS is supported by Fire Services and other first responders through their active PAD program to enhance response times and improve success in sustaining the lives of citizens who undergo cardiac arrests in public places.

The Hamilton PAD program started in 2007 when 400 City of Hamilton staff members were trained in the use of AEDs. 44 defibrillators were installed in city owned facilities such as stadiums, local arenas, recreation centers and seniors' centers.

The Hamilton PAD program has chosen mostly the Zoll AED 7 and some Phillips AEDs for its initiative. The program puts in a Request for Proposal (RFP) to the HSF for funding of AED units. The city owns the installed units, and EMS is in charge of maintenance. This includes making sure the unit is functional and operational, battery life is at 100%, and that all components such as AED pads and unit placements are safe and secure. Any costs associated with the maintenance of these units are absorbed by the EMS budget.

Over the span of 2 years the PAD program has witnessed 4 individuals who have had a defibrillator applied on scene when having a heart attack. All of these individuals were then admitted to the hospital and all but one survived successfully to out-of hospital discharge. An additional benefit from the program that has resulted in saved lives is the one time CPR/AED training that is an integral component of the program. This is for a maximum of 15 people over a 4 hour period which the PAD provides for each facility when it has received an AED. The PAD program also hosts CPR training 3 to 5 times per annum to maintain learning and retention rates. CPR and AED usage training is vital for improved survival when emergencies occur. To date the program has installed 115 AEDs in 102 locations. In addition all Firefighter trucks and stations, and all Ambulances and their stations carry AEDs. These are all accounted for and do not need to be tracked, whereas the 80 publicly available AED locations of Hamilton's PAD program are tracked through a GIS database. GIS tracking works as follows: When a bystander or first responder witnesses an individual undergoing a Sudden Cardiac Arrest (SCA), it is hoped that they will instinctively call the emergency number 911. Central Hamilton Dispatch responds to the emergency call and, if it involves a patient with vital signs absent who appears to have undergone an SCA, the dispatcher will use their GIS to guide the caller to the nearest AED for resuscitation purposes. While this GIS information and dispatch system works well in Hamilton, it is not widely used across other Ontario PADs. Among the ten Ontario PAD programs contacted, the Halton PAD also has incorporated GIS in its system.

Figure 3 is a map which (blue stars indicate AED placement) is available for central dispatch to use when assisting a caller to locate the nearest AED.

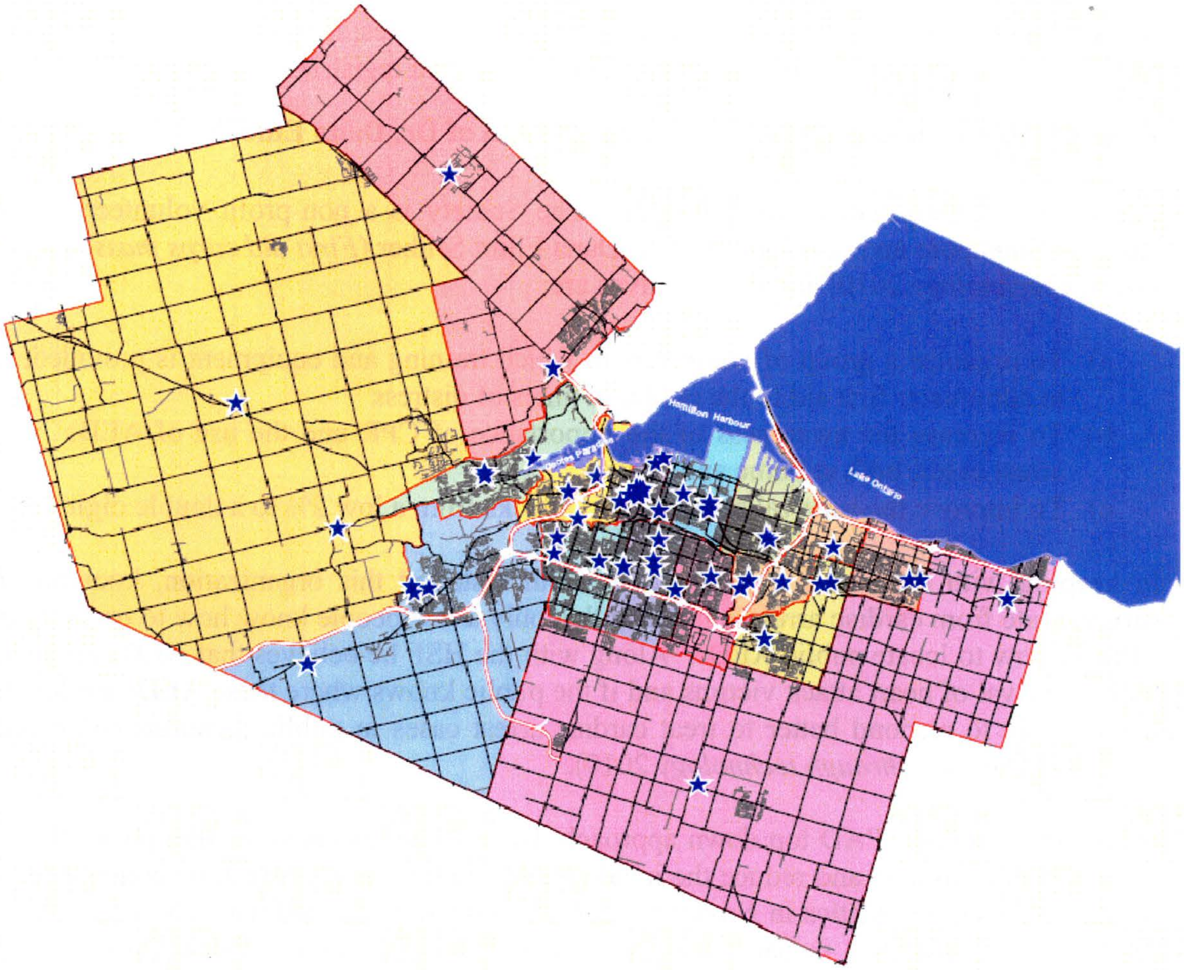


Figure 3. GIS Map of AED Distribution in Hamilton, Ontario (Hamilton EMS, 2010)

The use of a GIS AED map is an ideal basis for exploring the role that mobile communications devices could play in helping to locate an AED in the case of an emergency. The interface of such a technology with AED location information will be discussed further in the sections that follow.

ALTERNATIVES FOR MOBILE COMMUNICATIONS TO SUPPORT PUBLIC AED EMERGENY USE

Hamilton PAD Program

The Hamilton EMS defibrillation program is based on a model which links municipal emergency services with the HSF. This relationship has allowed the PAD program to become established, maintained, and continuously updated. As stated before, the HSF has organized such relations across the province of Ontario and additional PAD programs will be established in the future (*The heart restart program.*2010). It is this top down organizational approach that allows for a platform where EMS and the HSF become the support for making AEDs available in public places and for creating such registries. This model has spanned a spectrum of relationships across Ontario between the HSF and individual municipalities; however this is not the case when we turn to the global arena of recorded AED locations and registries.

First Aid Corps (documented with the permission of Dr. Dana Elliot Srither)

The First Aid Corps, otherwise known as The Society is a non-profit volunteer organization based in Singapore and developed by Dr. Dana Elliot Srither (*First aid corps mass collaboration through technology*.2010) and its objectives are:

a) To organize a group of volunteers to which training and equipment is provided, in order to administer first aid to the public in times of distress
b) To increase the awareness of the importance of CPR and the use of AEDs in cardiac arrest cases, both at home and at work
c) To improve the survival rates of heart attacks from a low 2% to a double digit percentage.

In keeping with the above objectives Dr. Srither started this organization, knowing that the survival rate from cardiac arrest is low and that only a few people know how to properly perform CPR, or how to locate public AEDs. Along with the HSF he believes that AEDs are a vital link to the survival of heart attack victims and if the public knows where these AEDs are located they will be able to respond better to treat cardiac arrest cases in public locations (*First aid corps mass collaboration through technology*.2010).

Unlike the Hamilton PAD top down approach, Dr. Srither has taken another path. By trying to raise public awareness and reduce the incidence of sudden cardiac arrest, he coupled technology with crowd sourcing tactics in November 2009. First Corps teamed with The Extraordinaries, a social business platform in San Francisco, and asked people around the world to send photos, location descriptions and GPS coordinates of public AEDs (*First aid corps mass collaboration through technology*.2010). Simultaneously First Aid Corps also created a free smartphone app for the iPhone and Android called "AED Nearby" and "ShowNearby AED" that helps the public locate the nearest AED.

In a sense, those who send in the pictures are volunteering for the cause, on a micro-level, and thus are participating in a phenomenon known as micro-volunteering. It's an act that takes seconds or minutes but helps toward the greater good. These good acts are helping organizations deliver their mission via a volunteer's available free minutes (*First aid corps mass collaboration through technology*.2010).

Essentially First Aid Corps has called upon the public to locate unregistered publicly available AEDs and thereby has created its own public AED registry. It has mapped more than 200 AEDs around the world and with its many affiliations this list is rapidly becoming larger.

A Google map has been generated for these locations and it can be viewed at www.firstaidcorps.org. To give the reader a sense of this approach, Figure 4 is an overview of North America, where the Red Cross signs indicate lives saved and the heart signs indicate AED locations.

Figure 4. AED Locations in North America (*First aid corps mass collaboration through technology.*2010)

This nonprofit organization has taken a bottom-up approach and is quite different from the Hamilton PAD alternative mentioned. However, both approaches work and both are striving to make a difference by saving lives.

Enhanced 911

When PDAs and cell phones mated and produced offspring called smartphones, location services soon became standard. In part, this was because the mobile phone system needed to be able to detect cellphone locations for 911 services. Older phones did not have GPS for emergency calling, but today most of the more recent models have full-fledged GPS functionality (*TechRepublic - A resource for IT professionals.*2010).

The concept of emergency calling has given rise to enhanced 911, better known as E911. Essentially E911 is a North American telecommunications based system that automatically associates a physical address with the calling party's telephone number and routes the call to the most appropriate Public Safety Answering Point (PSAP) (*Wireless 911 services.*2010). E911 has made it easier to locate a person who is using a cellphone to make a 911 emergency call. This is particularly important in emergency situations where the caller is unable to speak or cannot identify his or her location (*Wireless enhanced 911 (E911) services.*2010). To enhance the safety and security of Canadians, the Canadian Radio-television and Telecommunications Commission (CRTC) required the wireless service providers to upgrade their 911 services by February 1, 2010, at the latest.

As the CRTC explains, wireless service providers link 911 emergency calls from the nearest cellphone tower to one of the networks operated by the landline telecommunications companies. These companies are responsible for connecting the call to a 911 call centre or a PSAP that serves a specific geographic area and whose operators dispatch police, fire or ambulance personnel. The new enhanced features make use of wireless-location technologies to greatly improve the ability of emergency responders to locate a person who is using a cellphone to call 911. Wireless service providers use either the Global Positioning System (GPS) or (if the cellphone does not have GPS) triangulation technology that relies on multiple cell towers to measure distance and direction of the cellphone from the towers. This information is then used to automatically transmit the caller's location to the 911 call centre operator. This allows emergency responders to determine a caller's location generally within a radius of 10 to 300 meters from the cellphone (*Wireless enhanced 911 (E911) services.*2010). Of the 130 call centers that can support the enhanced wireless 911 services, 121 were operational as of February 1, 2010. The 9 remaining call centers were expected to be operational shortly thereafter (*Wireless enhanced 911 (E911) services.*2010).

Location Based Services

The concept of GPS integration with emergency services has also given rise to the concept of location based applications for mobile communications. In general, location based services (LBS) can be defined as services utilizing the ability to dynamically determine and transmit the location of mobile devices within a mobile network. From the mobile users' point of view, LBSs are typically services accessed with or offered by their mobile terminal (Virrantaus et al., 2001). An example scenario is a user looking for a suitable restaurant and then ordering a taxi in a city he/she is visiting. All this can be supported via a mobile device running applications enabling LBS. Other examples are checking oneself into locations such as hotels, retail establishments, etc. and publishing that information via social networking sites, receiving coupons through LBS on what stores are nearby when browsing through a mall, weather forecasts, local train station schedules, etc. The implementation of LBS is so ingrained into mobile communications that the number of users worldwide of these services is set to double to 95.7 million this year, up from 41 million a year ago (Parr, 2010). As long as smart phones continue to grow in popularity, location-based services will spread until they become as common as the cellphone itself. With more mobile communication platforms such as iPhone, Blackberry, or Android taking advantage of more readily available GPS and LBS technology, we have to ask: what's next for location-based services (Parr, 2010)?

The integration of Geographical Information Systems (GIS), Global Positioning Systems (GPS) and Location Based Services (LBS) can also be used to find AED's in public places. This would create a format which can link through E911 services but also allows users to find nearby AEDs. Since a GIS is an information system that processes geographic data, an LBS system can be considered to be a specialized GIS (Virrantaus et al., 2001). The approach we will use is to examine the use of existing features of GIS to support the development of more advanced LBSs. This will require both GPS and GIS services (Virrantaus et al., 2001). Although the E911 model is intended to locate mobile devices, coupling this model with advanced LBS can be adapted to finding nearby AEDs. A fuller explanation of the technologies mentioned here is included in the appendix.

Wireless Communications for AEDs and the Untrained Lay Person

None of the PAD programs the investigators contacted had AEDs with capabilities for direct wireless communication with emergency services dispatch. However, some had implemented something similar in nature.

For example, the Durham PAD uses an AED cabinet for two of its AEDs. This defibrillator cabinet is constructed of a heavy steel casing and tempered glass to protect the AED inside. Some of the models include audible alarms and flashing lights, to attract attention and mobilize assistance during a cardiac emergency. If the siren is inappropriate for a particular location it can be turned off. This presents an interesting capability to be connected to a central security system so that agents or the alarm company can be informed when the AED is actually removed from its mount. This allows for a coordinated response to the emergency at hand. The alarm can also be connected to a programmable auto dialer that notifies emergency authorities that an AED has been removed and that their services should immediately be dispatched to that location (*Philips heart start carrying cases.*2010).

This model has communications originating from the cabinet itself, and ensures that, once an AED is removed by a trained bystander, emergency personnel are sent to the scene immediately. But what if the AED is removed by a person who is not equipped with CPR training or has no prior understanding of AEDs? Can they be held liable and will they be effective in their actions to help? There must be instances where not all cardiac emergencies are met with people who know how to operate an AED and apply CPR.

A study by Gundry et. al compared naive sixth-grade children with trained professionals in the use of AEDs (Gundry, 1999). The age of these children was chosen to simulate an extreme circumstance of unfamiliarity with defibrillation. The children's AED use was compared with that of professionals and results showed that their mean time to defibrillation was 90±14 seconds (range, 69 to 111 seconds) for the children and 67±10 seconds (range, 50 to 87 seconds) for the EMTs/paramedics ($P<0.0001$) (Gundry, 1999) . Electrode pad placement was appropriate for all subjects and all remained clear of the patient during shock delivery (Gundry, 1999). The authors concluded that the speed of AED use by untrained children is only modestly slower than that of professionals. The difference between the groups is surprisingly small, considering the naiveté of the children as untutored first-time users. These findings suggest that widespread use of AEDs requires only modest training (Gundry, 1999). Modest training would be required in this scenario perhaps because children of a certain age were studied. But any training at all might not always be necessary.

Caffrey et. al performed a two year study at three Chicago airports to assess whether random bystanders witnessing out-of-hospital cardiac arrests would retrieve and successfully use automated external defibrillators (Caffrey, 2002). The use of defibrillators was promoted by public-service videos in waiting areas, pamphlets, and reports in the media. The researchers assessed time from notification of the dispatchers to defibrillation, survival rates at 72 hours and at one year among persons with cardiac arrest, their neurologic status, and the characteristics of rescuers (Caffrey, 2002). The results indicated that 6 out of the 11 rescuers successfully resuscitated patients although they had no training or experience in the use of automated defibrillators. The conclusion was that most of the lay bystanders who had no duty to act and no prior training in the use of AEDs were successful in AED operation (Caffrey, 2002).

Ultimately, the ideal investigation would be to consider whether an adult lay bystander with no prior knowledge or understanding of AED resources is able to correctly apply an AED to an individual undergoing a cardiac arrest. This is the case in a study conducted by Harve et. al, (Harve, 2007) who examined whether untrained laypersons could use a defibrillator with dispatcher assistance. Fifty-four conscripts without previous medical education were recruited from the Western Command in Finland. For this study, the participants were divided at random into teams of two persons. The teams were randomized to dispatcher-assisted CPR with or without AED operation during a simulated ventricular fibrillation out-of-hospital cardiac arrest. The time interval from collapse to first shock, hands-off time, and the quality of CPR were compared between the two groups (Harve, 2007). The results showed that CPR was poorly carried out in both groups. However, even though dispatcher assisted CPR was poor, dispatcher assistance in defibrillation by a layperson not trained to use an AED was feasible and did not compromise the performance of CPR, concluding that AED application through dispatch assistance for untrained lay persons is feasible (Harve, 2007).

The previous three examples indicate that untrained lay person defibrillation can occur successfully. However, to strengthen the public's awareness, dissemination of materials in any form and public awareness in general is needed to fully engrain AED use into the public's consciousness. Luckily, Ontario has the Good Samaritan law which protects lay persons from liability for incorrect AED usage when they have the intention to help the victim. What is interesting about the last study mentioned is the communication and on-site training received from dispatchers by these lay persons. An integration of this form of communication and training for AED use seems to be promising.

Let us examine the possibility of the combination of an AED with wireless communications that is capable of contacting a remote emergency instructor and guiding a lay rescuer through a resuscitation event. The premise of this approach is taken from a patent by Kyle Bowers (Bowers, 2007). The patent suggests that, where time is critical and the emergency level is at its highest for potential AED use, rescuers may fail to use the AED correctly or may not use it at all. In addition the lack of CPR training will further reduce the victim's chance of survival from an SCA (Bowers, 2007).

The Bowers patent describes the invention of an AED with all of the basic features, (electrodes, LCD display, wires, battery etc.) but with an additional circuit and antenna capable of contacting a remote medical specialist via a wireless connection. The lay rescuer is effectively directed through a successful rescue through the online guidance of emergency personnel. The proposed AED contains a user interface which has a microphone and speaker to transmit voice and audio over the wireless communication (Bowers, 2007). Figure 5 illustrates a typical resuscitation event process.

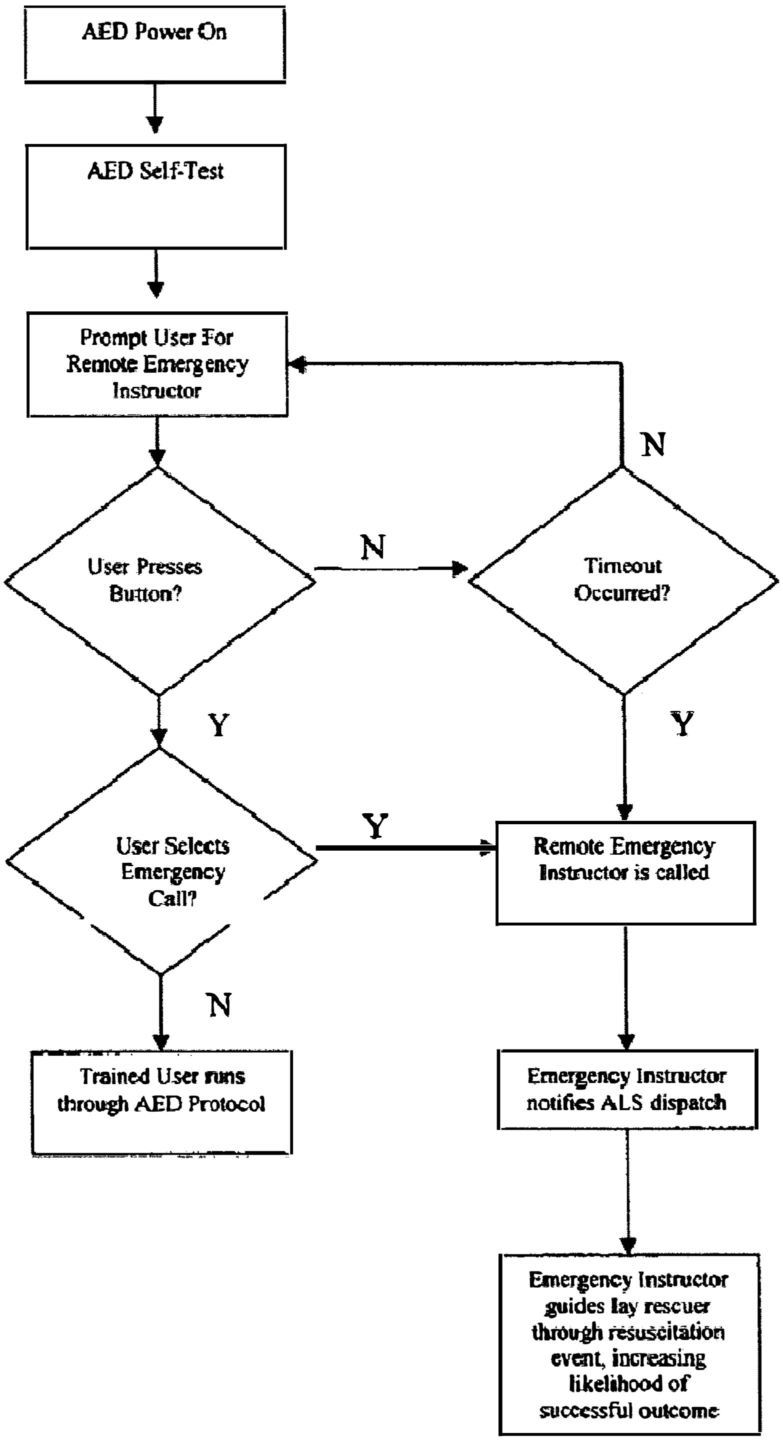


Figure 5. Resuscitation Protocol (Bowers, 2007)

Figure 6 demonstrates a remote emergency instruction protocol based on the Bowers patent.

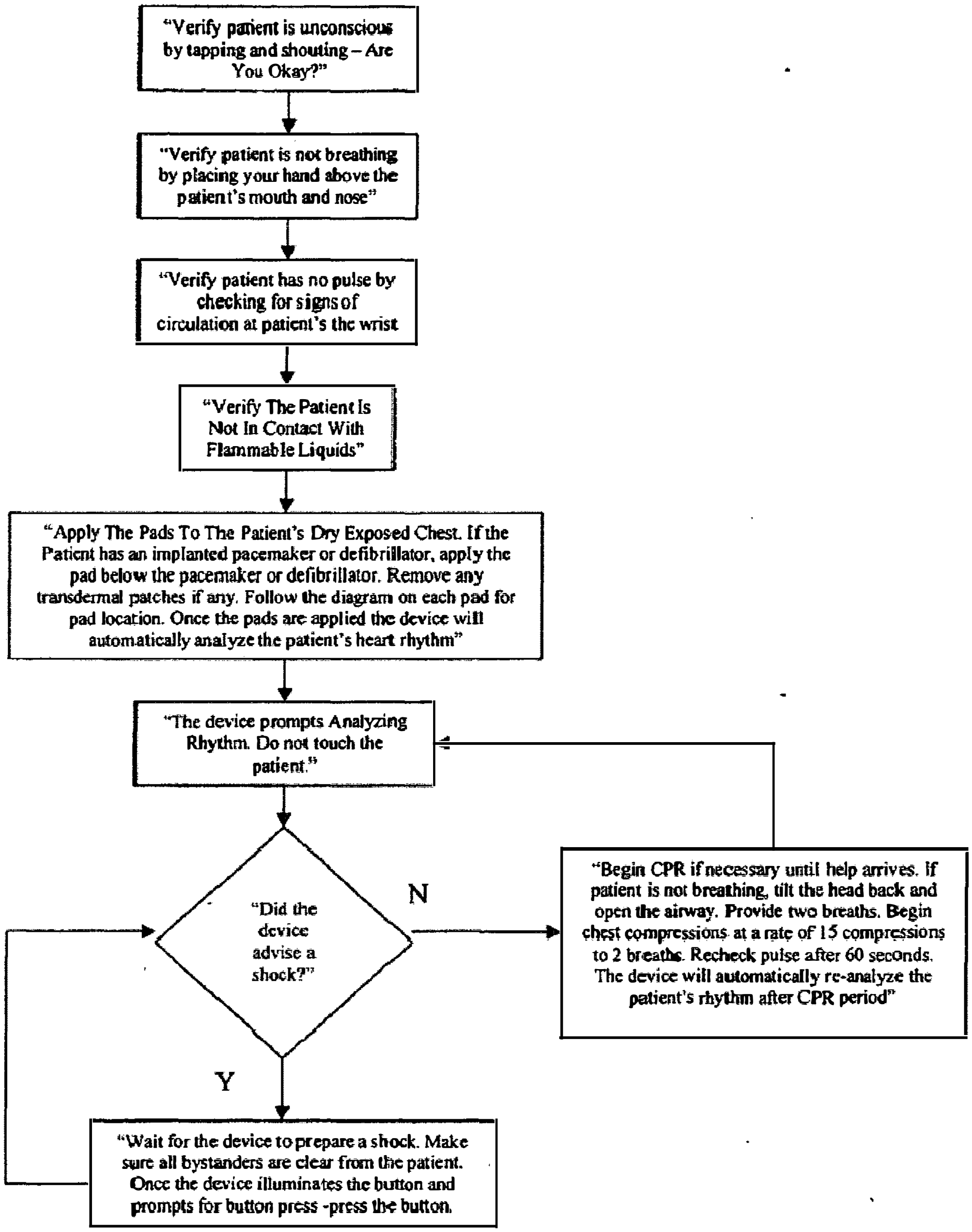


Figure 6. Remote Emergency Protocol (Bowers, 2007)

The Bowers patent presents many embodiments of the proposed AED and the ways in which it can connect wirelessly. Bowers suggests that the AED also be equipped with a GPS unit. This unit would automatically transmit the location of the AED so that emergency personnel can be dispatched to the location appropriately.

Another version of the Bowers patent includes a Bluetooth chipset that uses a remote cellphone to call the emergency personnel, and a further version suggests linking the AED through a Wi-Fi or 3G wireless network to communicate with a base station for emergency support. This version is similar to the concept of having the defibrillator cabinet linked to a security system as mentioned previously. The wireless communications of the proposed AED are configured to operate in full-duplex mode so it can simultaneously transmit and receive data (Bowers, 2007). The patent further describes an advanced version where data are received, decoded and displayed to a medical specialist so that the specialist can determine the appropriate treatment for the patient (Bowers, 2007).

The idea that the Bowers patent embodies indicates that relevant technologies are limitless and the implementation of such technologies in support of AED resuscitation in the real world is not too far in the future. There are many options and alternatives from the currently employed PAD programs that can lead to the 'ultimate' AED support system. The key is to find the best and most cost-effective characteristics of all the models mentioned and to develop a system which best suits the ability for people to locate and apply AEDs for victims of cardiac arrest.

The open discussion of all the alternatives mentioned can generate many new ideas through collaboration. This will move all organizations to reach the end goal of saving lives.

Web Based Applications

Web based applications, also known as browser based applications, are derived from the notion of the Mobile Web which refers to the use of Internet connected applications from a mobile device. Examples of browsers are Google Chrome, Mozilla Firefox, Internet Explorer, Safari, and the list goes on.

When speaking to developers of mobile device applications, otherwise known as native applications, the major difficulty which they encounter is platform proliferation. The plan to create an app for different platforms can become financially restrictive and time consuming. Apart from these restrictions, other limitations currently exist with native applications especially when evaluating an application for finding AEDs. For example, a user must have knowledge of such an application on their platforms' app store. They must then download this application; this process may also be hindered if there are associated costs with downloading. After downloading the app it becomes the user's responsibility to accept app upgrades provided by the developer to stay abreast of new AED locations and the latest published app versions. The marketing, awareness and willingness of the user to engage with an app are additional hurdles that come with platform proliferation. However this may not necessarily be the case when discussing mobile Web based applications.

Even though the popularity of smartphone applications is growing, many companies and developers are looking to create mobile applications. These applications comingle the experiences of a native app with a browser via the Internet. Advantages of browser based applications include: No installation or upgrading, availability, security, platform independence, reduced costs for developers, ease of maintenance, and simplicity of use (*Browser based application development.*2010). In fact, the difference between mobile Web applications and native apps is anticipated to become quite miniscule as mobile browsers gain direct access to the hardware of mobile devices, such as GPS and accelerometers and as the performance, speed and capability of the browser based applications improve. Users will ultimately be unable to differentiate between mobile and native applications and this will allow for Internet connected apps to reach a level of instant deployment and simplified cross compatibility that are too great to pass up (*Google says mobile web apps will win in the long Haul.*2010).

Even though there are current interoperability and usability problems with Web based applications, the availability of options definitely exists and this opens doors for creating a very technologically flexible application where people can search and find AEDs. Now developers are not only thinking about cross platform diversity but also cross browser diversity. If this report is deemed feasible, the alternative strategy mentioned will allow the researchers to also have many options in deciding how to build and host an AED application.

SMARTPHONES

Cell phones have become ubiquitous in today's society. According to Statistics Canada, at the end of 2006 there were 16.8 million wireless subscribers in Canada (*The expansion of cellphone services*2006). This number has continued to grow, reaching 20.3 million in 2007 (*Cellphone services - recent consumer trends*2010). In terms of the percentage of households reporting having a cellular phone for personal use, wireless access reached 71% in 2007 (see Table 1). This is up from 59% in 2004, with the greatest increases concentrated in the lower and middle income quintiles (*Cellphone services - recent consumer trends*2010).

Table 1. Percent of Households Reporting Having a Cellular Telephone, By Selected Income Quintile
(*Cellphone services - recent consumer trends*2010)

	Lowest	Middle	Highest
2004	31.2%	59.8%	84.5%
2005	33.5%	67.6%	88.6%
2006	39.9%	71.1%	89.9%
2007	42.5%	76.2%	90.9%

By 2007, the average expenditure per reporting household reached $773 for wireless services, $128 more than $645 for conventional services (see Figure 7) (*Cellphone services - recent consumer trends* 2010).

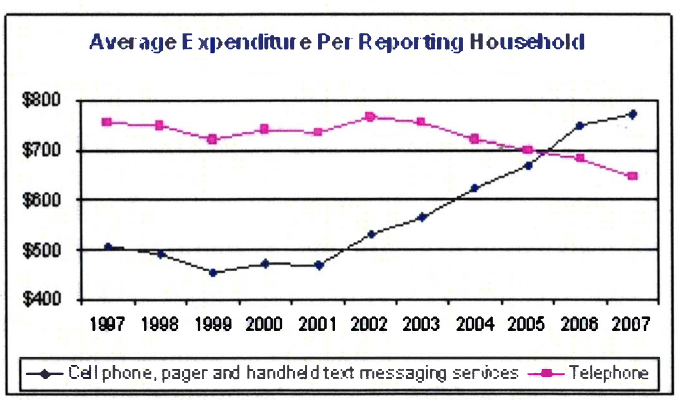


Figure 7. (*Cellphone services - recent consumer trends* 2010)

Financial forecasters have also predicted that consumers will consider that a cellphone is an essential utility, so spending for cellphone use will not decrease during a recession (*Cellphone services - recent consumer trends*2010).

Apart from the financial growth of the telecommunications sector there has also been a major change in the types of cell phones used by the public. This has resulted from the emergence of the smart phone – a super cellphone if you will, which allows users to combine a computer, digital assistant and entertainment device all in one. Users can not only make phone calls but also check emails, make calendar appointments, access multimedia while surfing the net, use GPS, and interact with a large variety of smart phone applications (apps).

Today's smart phones are equipped with their own operating systems and capable of running more advanced applications when compared with their older counterparts. These devices come with features such as a full on screen or QWERTY keyboard (an acronym which describes today's standard keyboard layout for some smartphones, mimicking a computer keyboard and allowing for quicker text messaging) more memory and storage capacity, the ability to initiate advanced locating systems through onboard applications, digital cameras, and integrated 3G and Wi-Fi connectivity (Green, 2010).

Smart phones have created a bridge between computers, wireless telephones and different forms of ecommerce and ehealth. This connection is enabled through third party applications, which are popular in both the business and consumer sectors (see Table 2). Most popular smart phone manufacturers offer some sort of "app store" where users can purchase and download a wide range of applications for productivity, information and entertainment (Green, 2010)

Table 2. Top 5 Mobile Services (Ulasien, 2009)

Service	**Percentage of all end users**
Mobile Internet	49%
Multimedia message	38%
Uploading photos	34%
Software/app download	30%
Email	28%

An in depth breakdown of the 30 % software/app download sector in Table 2 is shown in Figure 8.

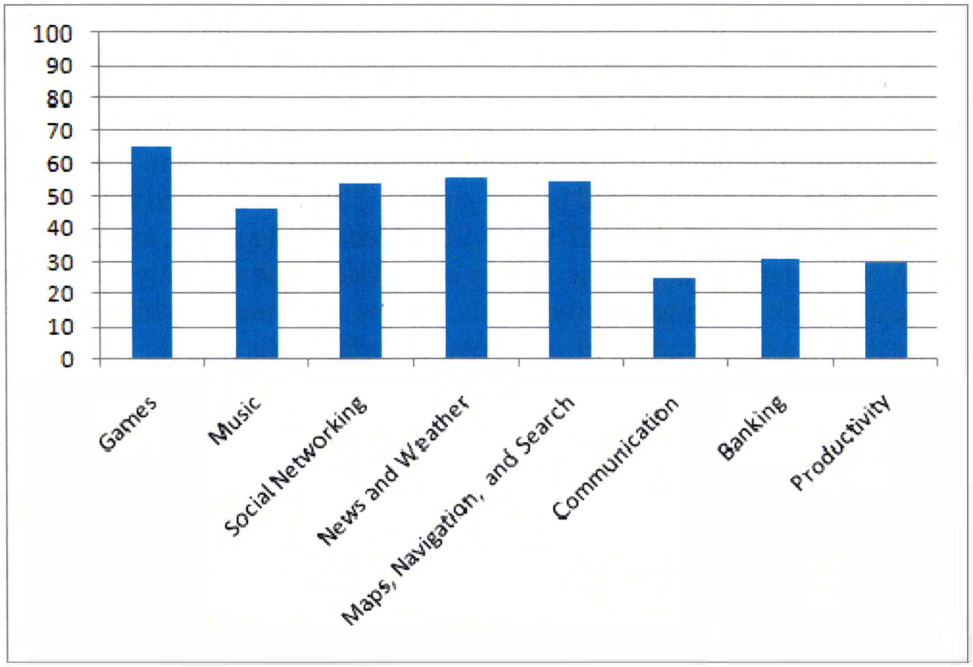


Figure 8. Percentage of Downloaded Smart Phone Applications (Green, 2010)

According to a Neilsen study, the average smart phone has had 22 applications downloaded (Green, 2010).

The Apple Platform

Apple and Research in Motion (RIM) make devices which run on their own operating systems while companies such as Google rely on third party operating systems such as Android. There are simply too many factors ranging from market share to device performance, to allow a justifiable conclusion on the best such platform. For this reason, we revert to our initial objective: to determine if designing and implementing an AED locating app would be feasible. Apple is the number one market leader in hosting the greatest amount of applications. Although the possibility of using all the popular smart phone platforms is the end goal, we will use as an example the Apple platform, its app store, app development and connectivity.

Apple has become a leading provider of consumer electronics such as the Mac computer, iPod, iPad and the iPhone, and reached worldwide annual sales of approximately $40 billion in 2009 (World's most admired companies 2010.2010; Fisher, 2008) (World's most admired companies 2010.2010). Apple's 'plug and play' approach has allowed customers to become well versed with its iTunes store. Originally developed in 2001, this interface is used to manage all the multimedia contents of Apple for their customers. The iTunes application connects to the iTunes store via an Internet connection and allows customers to purchase and download music, videos, television shows, games, audio books, podcasts, ringtones and applications. Some of the download categories are free but others require some online payment. As of September 2010, the App Store, accessible through iTunes, was reported to have more than 250,000 iOS applications (*iOS overview.*2010). iOS refers to Apple's mobile operating system which was developed originally for the iPhone. The iOS comprises technologies which are used to run applications on all the iPhones (basic 3G to the latest iPhone 4) and meeting the standards of a mobile environment. Developers planning to design applications have to become familiar with this environment as Apple does not use third party operating systems such as Android, and has its own coding language.

Anyone wishing to have an application profiled through Apple's App store must go through an intricate development and submission process. Usually this requires working with an experienced third party developer. Apple charges all developers a onetime fee of $99 to register at their Dev Centre. Once registered, developers have access to a vast array of information such as tools, frameworks, development best practices and design methods for iOS applications. Developers are also directed to the iOS reference library where they can download a Software Development Kit (SDK) which includes technical documentation on coding and tools needed to develop, test, run, debug, and tune applications for iOS. The SDK details Apple's own Xcode (based on the Cocoa touch programming framework) a tool which provides a basic editing, compilation, and debugging environment for the code that comprises the application to be designed. This also provides the launching point for testing an application on an iOS device through an iPhone Simulator, a platform that mimics the basic iOS environment but has to run on a local Macintosh computer (*iOS overview.*2010). Once a developer gains access to the SDK and an application is completed and tested, it is submitted to Apple for review. If it meets the standards that Apple has established and is a fit for the App store, it becomes available for distribution. The developer is taken through a series of steps which ensures receiving 70% of the revenue while being continuously supported via Apple's Dev Program network. This description has profiled Apple's app development process, but other smart phone operating system leaders such as BlackBerry and Android have their own specifications and logistics processes to be followed. This overview shows the complexity of designing and distributing a mobile application for locating an AED in a public place.

DESIGN, FUNCTIONALITY AND COST

To actually design an application versus plotting out its hypothetical architecture are both necessary processes. An examination of the latter is necessary to understand the basics of how the application would work when trying to integrate it into existing PAD protocols. This section will outline how the basic framework of the application might work, based on a scenario where a user who has a smartphone with a viable network connection witnesses a person who is having a heart attack.

Version 1. In this version, it is assumed that a user has downloaded the specially designed AED application from the App Store and engages it by simply touching an icon on the iPhone.

As depicted in Figure 9, the user launches the app and a screen appears, where the app notifies the user to immediately call 911, start CPR, and notify paramedics of what occurred when they arrive – initiating the chain of survival. In the background the iPhone has determined its location through GPS, and connects to the network through 3G or Wi-Fi. Thereafter the iPhone communicates through a PHP-Interface and requests the AED database server for the whereabouts of surrounding AED locations. This server is located on the Internet and has a preloaded database of all the AEDs within the local municipality. This is where the City of Hamilton PAD program registry would be incorporated, for example.

The database provides the requested information based on the location and language of the phone; this information is made available by giving the database the longitude and latitude of the iPhone position, and the language of communication for the iPhone. In Ontario, English would be the preferred language. The database is coded to provide a list of AED sites which is communicated to the iPhone. The user sees and selects the preferred AED on the list; the location of that AED is converted into a Google map. The annotations of other nearby AEDs and the original selected all appear on a Google Map and are shown to the user, and again the user can select which location is best suited for pickup. Once the AED of choice is selected, the app guides the user to the location via Google Map. The database is programmed to list only AEDs accessible within 100 meters of the iPhone. This distance is based on the assumption that a person can cover 100 meters in two minutes, with a total time of four minutes to return with the AED. There is a very narrow window for error and the AED must be applied to the victim immediately when the person returns.

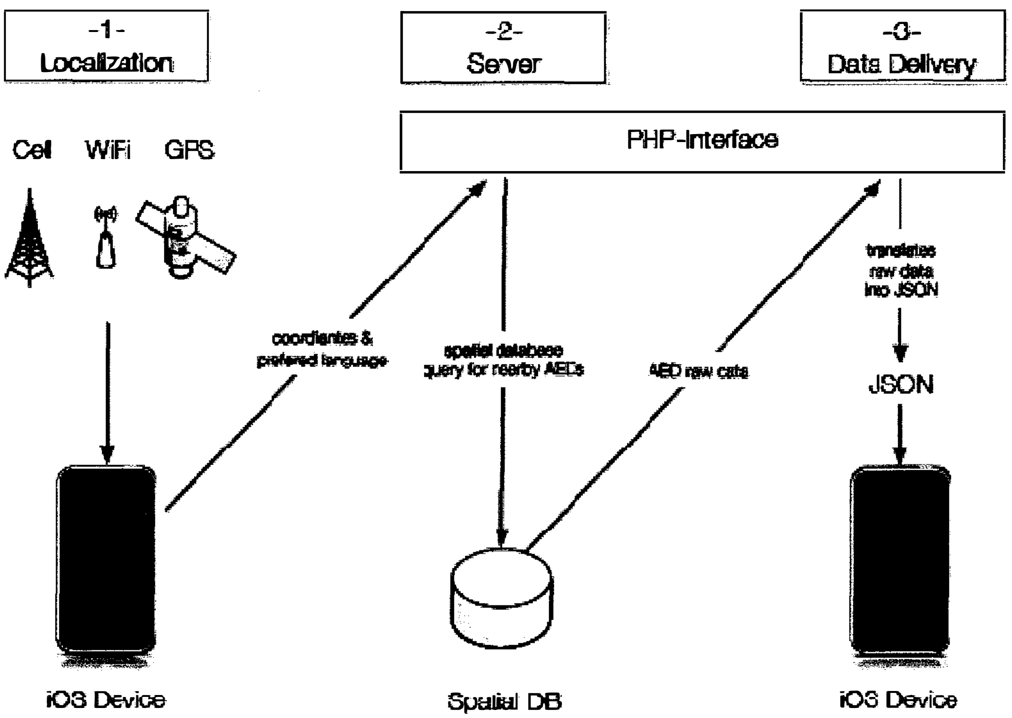


Figure 9. Depiction of the AED Finding App at a Granular Level

Definition: A PHP - Interface otherwise known as hypertext pre-processor is a general purpose scripting language for developing dynamic data from raw data. This allows the new data to be interpreted and also converted into something that is more ‘readable’, hence a JSON.

Definition: JSON stands for JavaScript Oriented Notation; this basically allows the smart phone to display the data coming from the PHP-interface into what the user can read, as opposed to computer language code.

To create the best application for locating AEDs we have come up with three other versions. When and if an app is created, these blueprints may be selected as starting points for developers.

Version 2. In version two, the user launches the app. The app calls emergency medical services dispatch for the user and simultaneously launches its services in the background. While the user is communicating with emergency services, the app is locating the user via localization GPS while the dispatcher helps the user to locate the closest AED. This of course would require that the dispatcher has a database of all the AEDs within the city or municipality (as for example in the current situation for Hamilton, Ontario). Simultaneously the dispatcher sends a text message to the user about the location of the closest AED. Now the user has a text message, voice direction, and a map via the GPS application on the phone. If for some reason the user has to end the phone call and the GPS location services via Google Maps fails, then the backup text message can always guide the user to the AED.

Version 3. In version three, we eliminate dispatch services and introduce a homing device on the AED to be located. When the user launches the app it connects with the closest AED via a 3G or Wi-FI connection. This version eliminates third party communication and keeps communications between the user and the homing device. The technology would sync hypothetically through an access point based system which would automatically connect and verify the application upon its launch. Acting as an access point the AED would be populated on Google Map. This version would also eliminate having a back end database with a full registry, and other concerns for network stability. However this version would require a homing device installed on every AED, which might be costly.

Version 4. In this final version we introduce an app which has a built in registry. When the user launches the App, it localizes the coordinates of the phone and connects with its own updated AED registry to locate the closest AED and instructions for finding it. This version would not contact a backend database. However a continuous update of the AED registry would be needed.

Cost Analysis

The purpose of this section is to provide an overview of what may be involved in developing a system to provide mobile devices with the ability to find local AEDs in emergency situations. At the same time each app and its segments is detailed, along with costs associated with these segments.

The research team contacted developers and other experts to get estimates for the costs involved. The values given should only be regarded as estimates which are, of course, subject to a certain amount of uncertainty.

Table 3 lists the estimated time to complete the various tasks involved in app development, based on conversations with several developers.

Table 3. Estimation of Human Resource Requirements for App Development

Tasks	Person-hours/subtask	Total Person-hours
Initial Architectural and Project Framework Setup		8
Map View Implementation		40
Shows and navigates map based on user's current location	24	
Connects with DBConnection	3	
Connects with Web Connection	3	
Add/mark location with map overlay	10	
List View/Table View Implementation		8
Design and Populate list with data.	6	
Add AED location	2	
AED View Implementation		7
Design of AED	4	
Format information	3	
DB Connection Implementation		8
Connects to DB and fetches Data	6	
Populates AED's Arrays	2	
Web Connection Implementation		12
Program to establish connection to web service	3	
Retrieve and format data	8	
Populate AED's arrays	1	
Web Service Implementation and Server hosting		24
Server Deployment	10	
DB for Testing	2	
Web Service Development and Deployment	12	
Testing, Debugging and QA		16
Total		**123**
In terms of weeks	10 hours/week	**13 weeks**

* The estimated time needed varied among the developers, and only averages are given in the Table. The time indicated here is to develop and submit an App to one platform of choice for approval so that it may be marketed and displayed for downloading on the App Store of choice.

Table 4. Estimated Cost – Client Side App Development

Module	Resource Used	Days	Hours	Hourly Rate (USD)	Total (USD)
Smart Phone Application	Developers	18	126	$20	$2520
	Project Manager	4	28	$25	$700
Total Development Cost					$3220

Table 5. Segment Cost Ranking for All App Versions Described

Segment	Cost Ranking
3g/Wi-Fi Connection	2
Backend Database	3
Built-in Database	4
Homing Mechanism	5
Communication with EMS	1

In Table 5, the costs associated with implementing each of the possible segments in a suitable architecture are given. Based on the following generic deductions, the researchers have ranked the costs associated with each segment on a score of 1-5, where 1 is the least costly and 5 would be the most expensive. The following explains how this cost ranking was derived.

a) 3g/Wi-Fi Connection: The given in this segment is a Wi-Fi connection. If the user enters a building and connects automatically to the provider's network connection then this cost is reflected from the provider's end and is usually free. Ideally the user will have a 3G connection via a phone data plan with their own network provider and this will be the main form of connecting, as it is usually faster and does not require authentication when entering new locations. Estimates using the largest network provider in Canada - Rogers Telecommunications - allowed an average of $15.00 to be priced as a standard data package which allows for 500mb of monthly data usage for accessing the mobile Internet (Rogers, 2010)

b) Backend database: A backend database is where a complete registry of all AEDs would exist. Evaluating the spectrum of all possible database providers and web server providers the researchers came up with a generic cost of hosting a web server which could store the Hamilton PAD sites. This cost is a very low $12 to $15/year since storage for the amount of data required is relatively minor.

c) Built-in database: This app version would have a registry which would launch from within the smart phone and not an external site. Usually all App Stores allow for continuous automatic updates of all apps a user downloads. Integration and maintenance varied among all the developers contacted. The hours and hourly rate needed to create a built in database averages to a cost of $100. Maintenance varied from developer to developer but the average cost it would take to update the database is around $20, depending on how many new locations there were. The total cost would thus be $120, including the initial development.

d) Homing Mechanism: To establish a homing mechanism for all installed AEDs would require a significant amount of political and developmental support. The technology would have to sync with the smart phone and would have to be either integrated with the wireless network(s) used by the smart phones or linked through a Wi-Fi connection. This type of infrastructure would be something of a novelty and could suffer from reliability problems. Placing a honing device on an AED to sync with smart phone could cost as much as $200 per AED, which would quickly add up to a relatively large amount if all the AEDs in Ontario are converted.

e) Communication Link with EMS: The main function of this form of communication would be to alert and inform the first responder of the location of an AED through a text messaging system. Overhead for text messages is minimal, but one caution is that the arrival of the text message may be delayed an unacceptable amount of time due to network traffic. The main cost would be in building this 24/7 functionality into the EMS system, which might amount to as much as $1000 for each Ontario municipality's EMS service.

Table 6. Cost Effective Rank of Versions

App Version	3g/Wi-Fi Connection	Backend Database	Built-in Database	Homing Mechanism	Communication with emergency services	Total Approximate Cost (CAD)	Rank
1	✓	✓				$30	1
2	✓	✓			✓	$36	2
3	✓			✓		$200	4
4	✓		✓			$135	3

Table 6 is a ranking of the cost-effectiveness of each alternative App version, although this should not be the only factor in the choice of App. App version 1 and 2 both seem quite viable and would most likely be the two App versions that could be created for testing.

Table 7. Segmented Cost Ranking for Alternatives for Mobile Communications

Segment	Cost Ranking
Hamilton PAD model	2
First Aid Corps	1
E911	4
Defibrillator with Wireless Communication	5
Web Based Applications	3

Table 7 shows a cost ranking for the alternative models that have been discussed. The following is how this ranking was deduced. This method estimated upfront capital costs, AED placement, and ongoing operational costs. There is insufficient data available from the literature and elsewhere, so a more general overview is given.

a) Hamilton PAD Model: This is a municipal program which has relationships with the provincial government and local emergency services. Funding is provided when Requests for Proposals (RFPs) are successful. Because this is a municipal investment, the overall dollars spent for an over-arching provincial implementation would, of course amount to much more. This approach is efficient because it can be duplicated in municipality PAD programs across the province. The dollar cost per AED installed is therefore reduced.

b) First Aid Corps: This approach is ranked first simply because it is a not for profit organization without many of the costs associated with the other models. It is run by a Dr. Srither and his affiliates who work without any remuneration at this point. The system appears to be self-sustainable with the help of volunteer agencies to build the AED registries and maps of installed AEDs. However, the fact that the Province would have no control over the operation of the system is problematical, and it depends on volunteers updating the database.

c) E911: This is a provincially planned and implemented system which deals with continuous networking and updating of the province wide emergency response system. Costs here are estimated to be ranked third highest of the alternatives considered. There are many affiliations with this system, such as emergency dispatches and local infrastructure which need to be updated in order for the entire system to work. New and ongoing relationships with network service providers need to be established and maintained. The E911 system is building upon an existing infrastructure and therefore this requires a substantial amount of redesign and management. Although this is clearly becoming the accepted emergency response system for wireless services, the related costs are not the responsibility of the proposed AED locator system.

d) Defibrillator with Wireless Communication: This patented device is not yet available but it is likely to be quite costly simply because of its predicted capabilities. It also will have to be well implemented with all of the existing models that have been described since it has to build relationships with new and existing infrastructures. The distribution of AEDs would be province wide and linked to all PAD programs and E911 services, at a cost that is likely to be higher than an AED locating system based on either E911 or existing PAD program.

e) Web Based Applications: When compared to its native neighbor, this classical smartphone app is becoming the renaissance of the mobile platform world. There are quite a number of variances currently between native and web based apps, and proponents and critics are defining security, privacy and technical issues which will affect usability issues for consumers. However being a novel technology, the creation of web based apps has proven to be cheaper than smartphone apps because of lower functionality characteristics and also because they can be embedded into a standardized platform, the browser. A Web based AED could possibly interact with the E911 infrastructure and that would place the creation of a Web based AED app slightly above the costs associated with E911. It can be envisioned that the AED registry would be implemented from a controlled environment such as the Hamilton PAD, ranking it slightly higher in cost from an already implemented system.

PUBLIC AWARENESS FOR ALL PROPOSED STRATEGIES

The public needs to know about all of the available options for finding AEDs, otherwise they simply won't be aware of them, and it doesn't matter how well the technology works since it will not be used. All of the alternative strategies mentioned lack strategic public awareness campaigns. For example, First Aid Corps has a solution to finding AEDs via an app, however there is no strategic implementation to educate the public on the availability of AEDs and the use of smart phone technology. This is an important aspect of any mobile technology initiative. It could be that the novelty of the technology supersedes the placement of public awareness and that plans are in place to implement such initiatives. However what is key is that the public be educated simultaneously as these technologies are introduced rather than one option occurring after the other.

The introduction of such awareness campaigns is in the hands of governments and training agencies such as the Heart and Stroke Foundation. A key mandate to their objectives of education, training and awareness should be the introduction of smart phone technologies, their capabilities in helping people to find AEDs, and other strategies mentioned. For example, launching a browser based app with a phone call to Emergency Services would automatically introduce users to an available technology which allows them to find AEDs. Other free standing technologies and their characteristics such as Bowers' wireless AED need to be introduced harmoniously when individuals are trained for CPR and AED. This harmonious mingling of technology, public education, and training, must occur with all strategies mentioned and it must continue even after the initial introductory phases.

Pre-Hospital planners, politicians and officials alike must also advocate strengthening the notion of the Chain of Survival, thereby ensuring access to AEDs by responders in all Canadian communities. As efforts to expand the use of AEDs increase, so too should efforts on raising public knowledge about training and the integration of smartphone technology and its role as an essential part of the solution for AED placement. In fact it can easily be envisioned that the Chain of Survival might be expanded to add the usage of mobile technology as one of the key components in providing an effective solution to resuscitating individuals undergoing sudden cardiac arrest. This might empower users responding to cardiac emergencies with an increased level of awareness and confidence in their own abilities. This form of bridge building should also extend to legislation which mandates making AEDs publicly available. That is, raising public consciousness of what AEDs are, training with CPR, and the options available through mobile communications, would provide public awareness campaigns as a third supportive peg in the foundational tripod of emergency response to sudden cardiac arrest situations.

CHALLENGES AND OPPORTUNITIES

It is evident that people's lifestyles are changing and their mobility is demanding solutions on the go. Communication devices such as smartphones to suit the needs of consumers support this evolving environment. Applications are continuously being developed to cater to various business and leisure needs.

In thinking of developing the AED locator application that has been discussed, it is also important to think about what opportunities and obstacles may stand in the way of a successful implementation. The proposed app that has been showcased in this study has been formulated to locate AEDs and save peoples' lives in emergencies. However there are many independent factors which have to work synergistically to yield a positive end result. The challenge essentially is to locate an AED quickly. This involves the active cooperation of an updated registry of current AED locations, a network connection through Wi-Fi or 3G, an enabled and functional AED that can be accessed readily, and suitable software as apps on the more popular smartphones, or web sites that can be accessed easily by smartphone browsers. Each of these requirements already exists on a standalone basis. The difficulty lies in the coordination that will make these work together to provide the necessary assistance reliably, quickly, and cost effectively. Active participation of developers, policy makers, connectivity providers, software developers, and user centered participants are all required.

From the developers we contacted it would take about one month to develop a software application of this nature. Multiple groups within a company would be involved, including a usability lab, marketing department, business analysts, software developers and the legal department. As an example, privacy is very important, and according to one of the developers the software app would have its data stored using 128-bit asymmetric encryption.

At present the versions that we have suggested do not have the ability to connect to other applications. Most Emergency Medical Services are in the process of changing their systems from paper based to a more digital format, thus allowing for standardization and ubiquity across all forms of healthcare. As envisioned, when this is in place the app should be able to send reports to hospital electronic medical records or even connect to ambulance electronic systems. In the long run, perhaps a user centered environment will be developed, where consumer awareness of health through an online health care network will result, making use of a wide variety of smart phone software Apps.

The main criterion of the development of this app or browser based system was a user centered approach which is integrated with EMS. This should lead to early adoption as user agencies such as PADs become enrolled to take the movement forward and spread the word, allowing weaknesses to turn into strengths and advantage can be taken of opportunities.

To better describe the benefits and problems of designing such a system and an application a SWOT analysis has been undertaken. This SWOT analysis demonstrates the Strengths, Weaknesses, Opportunities, and Threats of the proposed application. The SWOT analysis is basically a summary of the findings of this paper. It highlights the weaknesses and threats as they are perceived to be barriers to this development but it also shows that these barriers can be surmounted and an integrated system can be developed that helps first responders to locate AEDs quickly and reliably.

STRENGTHS	WEAKNESSES
1. The AED Locator is built in or downloadable from iApp store or developer's site on to an iPhone 2. The AED Locator enables location of AEDs instantly 3. Sends AED report directly to the ambulance or even the hospital and this syncs with the patients electronic medical and personal health records 4. Increasing chances of survival for people undergoing heart attack 5. Introduces the chain of survival – call 911, start CPR, apply AED, wait for Paramedics – as applicable 6. User-friendly txt message can be sent from emergency services dispatch for easy locations finding 7. Due to its nature support can be generated by iPhone manufacturer Apple 8. Networks are continuously evolving and with the advent of 4G and mini cell towers network stability is now greater 9. Integrates the usage of IT with Health Care 10. Huge number of sympathizers available through Social Media like Face book and Twitter that can be enrolled in the movement of awareness of the AED Locator iApps 11. Medical support and linkages available through Web 12. Political support available as this is a public health issue 13. Creates bridges with emergency medical services/other non-profit organizations	1. People who may be in this particular scenario may not carry a smart phone 2. Adequate AED data not readily available 3. The AED Locator is not downloaded by every user due to unawareness 4. There is network instability and the app cannot be properly loaded 5. User will have depend on Networks or service providers and that may be costly in a voluntary situation making the facility redundant 6. The lack of public awareness, training, education about AEDs, CPR and mobile communications technology will be a hurdle in usage, proliferation and retention of these technologies
OPPORTUNITIES	**THREATS**
1. Greater interaction on Social Media allows growth of confidence for the notion of participatory health 2. Greater coverage beyond geographical or political boundaries 3. Raises awareness about heart health and introduces living a healthier lifestyle 4. Training and awareness of AEDs and CPR will increase 5. Pushes for the greater distribution and placement of AEDs 6. Creates the possibility to have a complete database/registry for the placement of all AEDs locally, nationally and globally 7. Allows for grounds to test, debug and create a better app with greater functionality. 8. Allows for legislation to pass creating a registry for AEDs, making the distribution of AEDs a public mandate and safeguarding those who participate in the usage of AEDs by creating laws Provisioning their protection	1. Sensitive data may be viewed by unauthorized persons and misused by hackers 2. Hackers may also play with the location of AEDs – a need for a stable network which is encrypted 3. Building owners that give out their blueprints might be jeopardizing their security 4. Industries where AEDs are located do not want to be responsible for possible damage if any by the misuse of an AED 5. Funding issues regarding the creation of an AED app or its sub elements, i.e. creating a honing device for every AED not feasible for all locations restrict usability. 6. Wi-Fi or 3g connectivity is not available at all locations making the iApp redundant

CONCLUSION

The possibility of first responders being able to locate Automated External Defibrillators with the help of mobile communications technology is becoming a reality. The evolving world of healthcare and technology is continuously intermingling and developing, so this relationship can only be forecasted to become stronger. As issues for health care problems arise it is safe to predict that there will be some form of technology which will provide a solution. In this case it is the use of smart phones to help locate AEDs. Partnerships with provincial bodies and academic institutions will give rise to innovation and development of such solutions. In this study the researchers have evaluated the effectiveness of AEDs in the public realm and linked how mobile communications can assist in helping people to find them faster in situations where individuals are undergoing sudden cardiac arrest. The next step in this research would be to conduct a pilot study in a controlled area to evaluate exactly how this process would occur and to learn from the observations. To simply say that it is feasible for mobile communications to locate AEDs in the public would not be justified without conducting a formal pilot study of this nature. Therefore, even though it is foreseeable that this can occur, further research would solidify what the researchers believe is just the beginning for mobile communication technology to assist in making emergency use of defibrillators more effective in saving lives.

APPENDIX

Technology and Network Support

Network connectivity and stability are important factors when considering the use of a mobile application that is publicly available to support individuals in finding the closest AED in emergencies. The communications world has seen a parallel growth of Internet and mobile telephone services over the last decade. The Internet has enabled services such as "follow-me-anywhere and always on" which bridges from personal computers to smart phones. The convergence of telephone and Internet services has also allowed for voice to data networking and interactive wireless multimedia services. Wireless services allow one to be on the move while being connected. The two types of technologies which allow for such a connection are labeled 3G in the International Mobile Telecommunications (IMT-2000) family of standards, and Wi-Fi Wireless Local Area Network (WLAN) technology, an Institute of Electrical and Electronics Engineers (IEEE) 802.1 1b standard.

This section will focus on 3G, Wi-Fi, LBS such as GIS and GPS. Other services such as Blue Tooth technologies, and various transitional technologies such as 3.5G or 4G, are not considered in order to focus on the four most widely used technologies and their uses for mobile device AED location applications.

3G

The International Mobile Telecommunications-2000 (IMT-2000) also known as 3G or 3rd generation is a set of standards for mobile phones and telecommunication services which fulfill specifications by the International Telecommunication Union (Smith & Collins, 2002).

3G is a technology for mobile service providers and is intended for today's smart phones allowing users to have simultaneous speech and data capabilities. Furthermore 3G's high operational speed is ideal for downloading information and sending it over the Internet, while receiving large multimedia files. These smart phones then become like mini-laptops with equipped location applications, email and streaming video capacity.

Mobile services are provided by service providers that own and operate their own wireless networks and sell mobile services to end-users, usually on a monthly subscription basis. Mobile service providers use licensed spectrums to provide wireless telephone coverage over large geographic areas (Lehr, 2003). In the past this coverage might have included a city area, however in today's time it covers entire countries.

From a user perspective, the key feature of mobile service is that it offers near ubiquitous and continuous coverage (Lehr, 2003). That is, a consumer can carry on a telephone conversation and interact with data services while driving along a highway at 100km/h or being seated idly inside a restaurant. Typically smart phones equipped with 3G service have increased bandwidth and transfer rates to accommodate web-based applications and phone based audio-video files.

These transfer rates have potential speeds of up to 3 Mbps (about 15 seconds to download a 3 minute MP3 song). In comparison the fastest 2G phone would achieve a rate of 144 Kbps (8 minutes to download a 3 minute song) (*3G speeds.*2010) .
To support this service, mobile operators maintain a network of interconnected and overlapping mobile base stations that hand-off calls as those customers move among adjacent cells. Also, each mobile base station may support users up to several kilometers away. The cell towers are connected to each other by a backhaul network that also provides interconnection to the wire line network (Lehr, 2003).

Wi-Fi

If you have recently been at an airport, library or even coffee shop, chances are you have been right in the middle of a wireless network. Of course wireless networking or Wi-Fi which aids people to connect to the Internet only in their homes is a notion of yesterday. In the near future and if not already wireless technology will also become so ubiquitous that it will be available at anytime, anywhere.

Wireless Fidelity, another abbreviation for Wi-Fi, is the wireless Ethernet 802.11b standard for WLANs. These wire line local area networks, which came about in the 1980s, allowed PCs to share resources such as printers, servers and other devices. One of the most popular LAN technologies was Ethernet (Lehr, 2003). Over the years, the IEEE (the Institute of Electrical and Electronics Engineers) approved a lineage of Ethernet standards which support higher capacity LANs for a diverse array of media such as video telephony and location services. The 802.11x family of Ethernet standards are for wireless LANs. 802.11n is the newest standard which is widely available and can reportedly achieve speeds as high as 140 Mbps. However with network congestion these rates are reduced quite significantly (*IEEE standards working group areas.*2007).

Unlike 3G, Wi-Fi operates using unlicensed spectrums in the 2.4 GHz band. WLANS are deployed to offer the last hundred meter connectivity to a wire line infrastructure whether it be a corporate or private institution such as a campus network. The base station equipment is owned and operated by the end-user community as part of a corporate enterprise, campus, or government network (Lehr, 2003). Sometimes the end users do not pay fees as the network is subsidized by the organization hosting the Internet.

Unlike 3G WLAN technology was not designed to support high-speed hand off associated with users moving between base station coverage areas. WLANs originated to support data communications and not accommodate this contiguous hand off. In the early 2000s, many cities announced plans for city-wide Wi-Fi networks. In 2005, Sunnyvale, California announced that it would offer city wide Wi-Fi (Graychase, 2007). However with the emergence of WiMax, also known as 802.16 cities and countries are looking at implementing broadband wireless access to allow anytime, anywhere access and connection to end users.

This brief discussion of the two technologies is important because it explains two important platforms that are used by today's smart phones to connect to the Internet when launching applications, or better yet smart phone apps. It also paves a path to see how connectivity is an important factor when discussing cost effectiveness and viability of a smart phone app which helps locate AEDs.

GIS

Apart from being able to connect to a network through 3G or Wi-Fi services, smartphones now also are being equipped with a new class of services called Location Based Services (LBS). This intertwines two major systems: Geographical Information Systems (GIS) and Global Position Systems (GPS).

Let us examine the first. A GIS integrates hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information. The first true GIS originated and operated in Ottawa in 1962 by the Canadian federal Department of Forestry and Rural Development (Foresman, 2007).

A GIS generally allows users to view, understand and interpret data in ways which reveal relationships, patterns, and trends in the form of maps, globes, reports, and charts (*What is GIS.*2010). More specifically, GIS offers specialized knowledge about spatial data collection and processing, data modeling as well as modeling of spatial processes for analysis purposes, methods based on mathematics, statistics, modern numerical and computation tools as well as the knowledge on visualization (Virrantaus et al., 2001).

The most important component for any GIS data set is its geographic reference. Geographic reference may be annotated as: x, y and z coordinates; Latitude, Longitude; Postal or Zip code; Highway marker and other control identifiers (Longley, Goodchild, Maguire, & Rhind, 2005). Thus any information that can be located spatially can be used in a GIS.

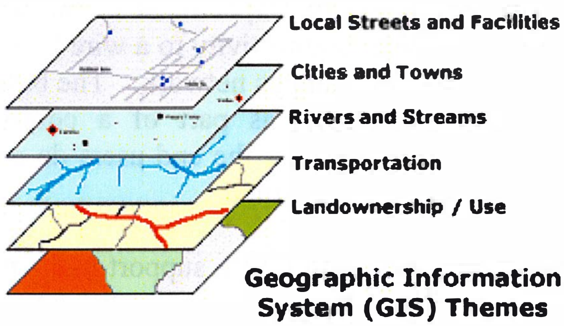


Figure 10. Layer information referenced by location (Longley et al., 2005).

By combining theoretical knowledge and applying it into a computerized environment many enterprise information system frameworks have integrated GIS, ranging from precision agriculture, natural resource management, urban planning, navigation and even emergency management. Analysts in these areas may use GIS to calculate response times in the event of a disaster, map demographics for a location, the features present in that demographic and the patterns which emerge when these features are further observed (*What is GIS.*2010).

From an EMS perspective the integration of a GIS allows for the most precious commodity which is time, to be saved. The Hamilton PAD program which has integrated GIS takes advantage of this technology to place ambulances in the best possible locations, track vehicles in real-time, and provide intelligent time of day based routing which improves response capabilities of its entire fleet. The result is of course faster response times.
To provide the best AED placement and location, a GIS system can provide preplanning, real-time resource tracking, incident response and post cardiac event capture analysis, and deployment of personnel and resources (*Esri - the geographic advantage.*2010). Essentially, A GIS can allow analysts to correctly deploy defibrillators in areas where the incidence of cardiac arrest is high. With regards to integration of mobile communications the future of GIS and wireless technologies seem promising when speaking of LBS and the usage of GPS.

GPS

The Global Positioning System or GPS is a satellite based navigation system that sends and receives radio signals from a constellation of earth orbiting satellites. When people speak about GPS they are usually referring to a GPS receiver which acquires these signals and provides the necessary information. Through GPS technology one can determine location (within a few meters), time and velocity, 24 hours a day anywhere on earth.

GPS, formally known as NAVSTAR (Navigation Satellite Timing and Ranging) Global Position System, was originally developed for the United States military in the mid 70's (Office of Science and Technology Policy National Security Council, 1996). Because of its popularity and evolution into a small, inexpensive form of equipment, the US which owns this technology made the system available for civilian use in 1996 (Office of Science and Technology Policy National Security Council, 1996). The US government owns GPS technology and the Department of Defense maintains it (*GPS beginner's guide*2008).
GPS technology requires three segments: space, control, and user. The space segment is made up of at least 24 satellites which orbit the earth in a specific pattern. These satellites are spaced so that a GPS receiver anywhere in the world can receive signals from four of them. The control segment is responsible for monitoring satellite health and signal integrity from the ground and lastly the user segment consists of the GPS receiver which collects information from the satellites in view and uses this information to display ones location, speed and time (*GPS beginner's guide*2008).

The GPS receiver's ability to locate the four satellites is based on a mathematical principle called triangulation. The keep the explanation of this principle simple the GPS receiver has to know two things: The location of at least three satellites and the distance between the receiver and each of those satellites (*GPS beginner's guide*2008).

The variation of receivers for civilian use vary from marine, land and even air. However what is interesting is the integration of today's GPS into mobile communications. Accounts of GPS integration with handheld computers or Personal Development Assistants started in the early 2000's (*Global positioning systems.*2010). These systems however did not come built in, rather the user had to buy a GPS receiver that plugged into an expansion card slot, install the navigation software, and download and install the maps for areas they expected to visit. It worked but not as well or conveniently as a dedicated GPS. With regards to today's mobile communications GPS users are seeing a profound improvement and functionality when it comes to Location Based Services. Hence the concept of an AED locating application for smart phone platforms becomes very useful.

Class Diagram

Figure 11 is a diagram of the proposed capabilities of the AED application to be developed. It is intended to give the reader a sense of an overview of what the possibilities of creating such an app could be. Earlier a very generic diagram was displayed, whereas this one is in greater detail.

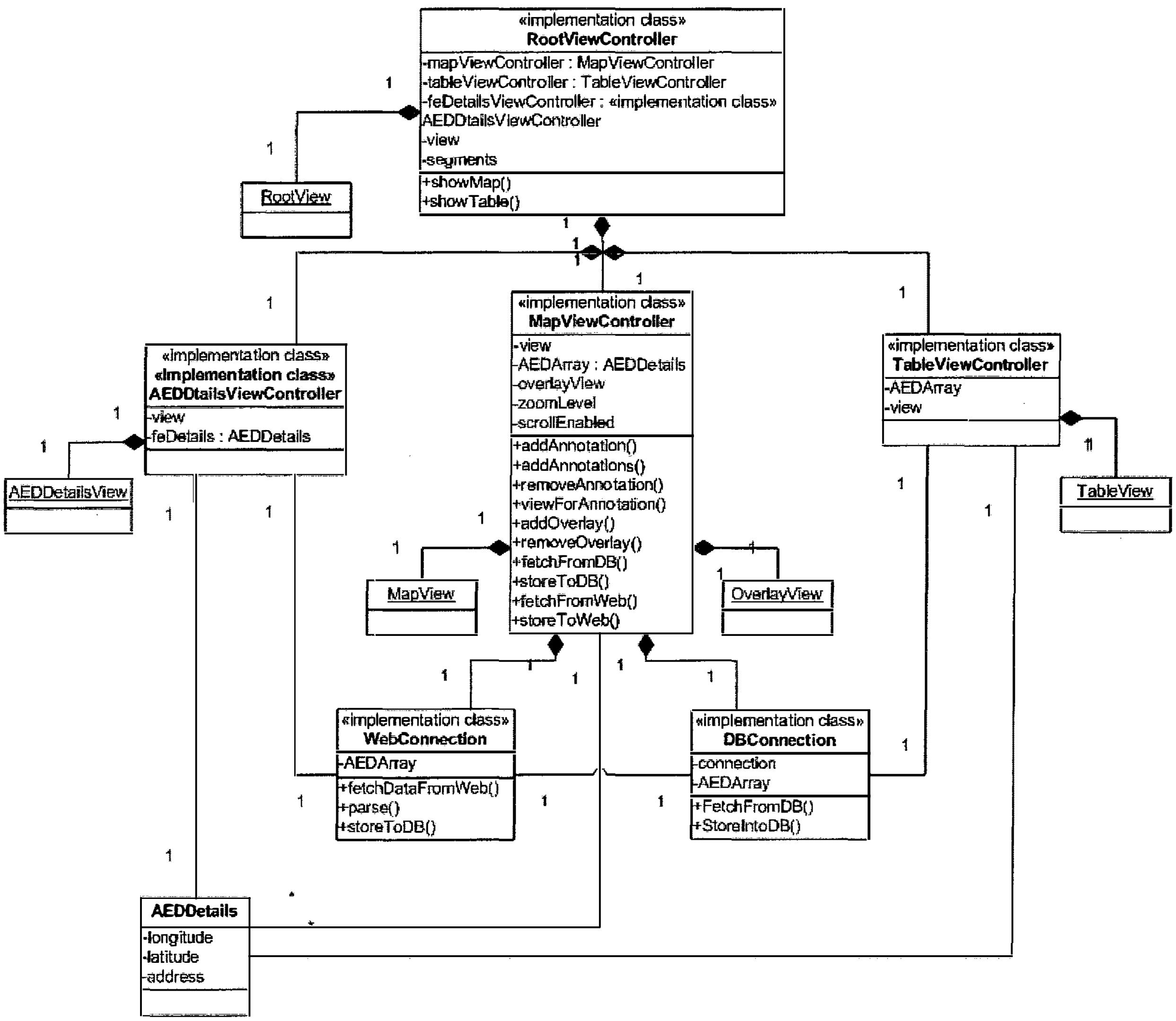


Figure 11. Class Diagram of Proposed AED Application (contributed by Ken Nwosu)

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McMaster University
1280 Main St. W. DSB A202
Hamilton, ON
L8S 4M4

Tel: 905-525-9140 ext. 23956
Fax: 905-528-0556
Email: ebusiness@mcmaster.ca
Web: http://merc.mcmaster.ca